MAR ATHANASIUS COLLEGE (AUTONOMOUS)

KOTHAMANGALAM, KERALA 686 666

NAAC Accredited 'A^{+}' Grade Institution

Email: mac@macollege.in

www.macollege.in

SCHEME AND SYLLABUS

FOR

POST GRADUATE PROGRAMME

UNDER CREDIT SEMESTER SYSTEM

MAC-PG-CSS 2020

IN

M.Sc.BOTANY

EFFECTIVE FROM THE ACADEMIC YEAR 2020-2021

BOARD OF STUDIES IN BOTANY (PG)

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Academic Council

COMPOSITION – With Effect From 01-06-2020

Chairperson : **Dr. Shanti. A. Avirah**
Principal
Mar Athanasius College (Autonomous), Kothamangalam

Experts/Academicians from outside the college representing such areas as Industry, Commerce, Law, Education, Medicine, Engineering, Sciences etc.

1. **Dr. Winny Varghese**
Secretary
Mar Athanasius College Association
Kothamangalam

2. **Prof. Dr. V.N. Rajasekharan Pillai**
Former Vice-Chairman
University Grants Commission,
New Delhi.

3. **Dr. R.K. Chauhan**
Former Vice-Chancellor, Lingaya's University,
Faridabad, Haryana -121002

4. **Dr. Sheela Ramachandran**
Pro-Chancellor,
Atmiya University
Rajkot.

5. **Prof. Kuruvilla Joseph**
Senior Professor and Dean,
Indian Institute of Space Science and Technology (IIST),
Department of Space, Govt. of India, Valiyamala, Thiruvananthapuarm

6. **Dr. M.C. Dileep Kumar**
Former Vice Chancellor
SreeSankaracharya Sanskrit University
Kalady, Kerala, India

7. **Dr. Mathew. K.**
Principal
Mar Athanasius College of Engineering,
Kothamangalam, Kerala - 686 666

8. **Adv. George Jacob**
Senior Advocate
High Court of Kerala
Ernakulam

Nominees of the university not less than Professors

9. **Dr. Biju Pushpan**
   SAS SNDP Yogam College
   Konni

10. **Dr. Suma Mary Sacharia**
    UC College
    Aluva

11. **Dr. V.B. Nishi**
    Associate Professor
    Sree Shankara College, Kalady.

Member Secretary

12. Dr. M.S.Vijayakumary

Dean – Academics

Mar Athanasius College (Autonomous)

Kothamangalam

Four teachers of the college representing different categories of teaching staff by rotation on the basis of seniority of service in the college.

13. **Dr. Bino Sebastian. V** (Controller of Examinations)

14. **Dr. Manju Kurian,** Asst. Professor, Department of Chemistry

15. **Dr. Smitha Thankachan**, Asst. Professor, Department of Physics

14. **Dr. Asha Mathai**, Asst. Professor, Department of Malayalam

Heads of the Departments

15. Dr. Mini Varghese, Head, Department of Hindi

16. Dr. Jayamma Francis, Head, Department of Chemistry

17. Dr. Igy George, Head, Department of Economics

18. Ms. Shiny John, Head, Department of Computer Science

19. Dr. Deepa. S, Head, Department of Physics

20. Dr. Rajesh. K. Thumbakara, Head, Department of Mathematics

21. Dr. Aji Abraham, Head, Department of Botany

22. Dr. Selven S., Head, Department of Zoology

23. Dr. Diana Ann Issac, Head, Department of Commerce

24. Smt. Sudha. V, Head, Department of Statistics

25. Dr. Aswathy Balachandran, Head, Department of English

26. Dr. Diana Mathews, Head, Department of Sociology

27. Dr. Jani Chungath, Head, Department of History

28. Dr. Seena John, Head, Department of Malayalam

29. Mr. Haary Benny Chettiamkudiyil, Head, Department of Physical Education

30. Ms. Shari Sadasivan, Head, Department of International Business

31. Ms. Sheeba Stephen, Head, Department of B. Com Tax Procedure and Practice

32. Dr. Julie Jacob, Head, Department of Biochemistry

33. Ms. Nivya Mariyam Paul, Head, Department of Microbiology

34. Ms. Jaya Vinny Eappen, Head, Department of Biotechnology

35. Ms. Shalini Binu, Head, Department of Actuarial Science

36. Prof. Dilmol Varghese , Head, Department of M. Sc Zoology

37. Ms. Simi. C.V, Head, Department of M.A.History

38. Ms. Bibin Paul, Head, Department of M. A. Sociology

39. Ms. Shari Thomas, Head, Department of M.Sc Statistics

BOARD OF STUDIES IN BOTANY	
Chairman	
1.	Dr. Aji Abraham Assistant Professor and Head Department of Botany Mar Athanasius College, Kothamangalam
Members	
2	Dr. Dennis Thomas Professor, Dept. of Plant Science Central University of Kerala, Kasaragod.
3	Dr. Santhosh Nampy Professor, Department of Botany University of Calicut.
4	Dr. I'ma Neerakkal Associate Professor Sacred Heart College, Thevara, Ernakulam
5	Dr. Sarala Samuel General Manager (R&D) Kerala Ayurveda Ltd. Athani, Aluva.
6	Dr. Giby Kuriakose Asst. Professor, Dept. of Botany Sacred Heart College, Thevara, Ernakulam
7	Dr. Binu Antony Asst. Professor, Dept. of Botany Mar Athanasius College, Kothamangalam
8	Dr. Siju Thomas T Asst. Professor, Dept. of Botany Mar Athanasius College, Kothamangalam
Invited members	
10	Ms. Meril Sara Kurian Asst. Professor (on contract), Dept. of Botany Mar Athanasius College, Kothamangalam
11	Ms. Meenu Elizabath Benny Asst. Professor (on contract), Dept. of Botany Mar Athanasius College, Kothamangalam
12	Ms. Soubhagya K B Asst. Professor (on contract), Dept. of Botany Mar Athanasius College, Kothamangalam
13	Ms. Sruthy Elsa Madhu Asst. Professor (on contract), Dept. of Botany Mar Athanasius College, Kothamangalam

CONTENTS

PREFACE

Biology is a rapidly advancing field of science, with recent developments throwing more light into our understanding on the process of life. The Board of Studies in Botany has taken efforts to incorporate recent advances in plant biology while restructuring the syllabus of post graduate programme. The syllabus is structured to provide basic principles of biological sciences with special references to botany and its applied branches. While attempting the reforms, the existing conditions relating to infrastructure, work load and staff pattern have been properly taken care of and provision for full utilization of the existing facility is proposed.

We gratefully acknowledge the assistance and guidance received from the management and the university and all those who have contributed in different ways in the venture. I hope this restructured syllabus and curriculum would enrich and equip the students to meet future challenges.

Dr. Aji Abraham

Chairman, Board of Studies.

LIST OF PG PROGRAMMES IN MAR ATHANASIUS COLLEGE (AUTONOMOUS), KOTHAMANGALAM

SL. NO.	PROGRAMME	DEGREE	FACULTY
1	ENGLISH	MA	LANGUAGE AND LITERATURE
2	ECONOMICS	MA	SOCIAL SCIENCES
3	SOCIOLOGY	MA	SOCIAL SCIENCES
4	HISTORY	MA	SOCIAL SCIENCES
5	MATHEMATICS	M.Sc	SCIENCE
6	CHEMISTRY	M.Sc	SCIENCE
7	PHYSICS	M.Sc	SCIENCE
8	BOTANY	M.Sc	SCIENCE
9	STATISTICS	M.Sc	SCIENCE
10	ZOOLOGY	M.Sc	SCIENCE
11	BIOCHEMISTRY	M.Sc	SCIENCE
12	BIOTECHNOLOGY	M.Sc	SCIENCE
13	MICROBIOLOGY	M.Sc	SCIENCE
14	ACTUARIAL SCIENCE	M.Sc	SCIENCE
15	FINANCE	M.Com	COMMERCE
16	MARKETING AND INTERNATIONAL BUSINESS	M.Com	COMMERCE

REGULATIONS OF THE POSTGRADUATE PROGRAMMES UNDER CREDIT SEMESTER SYSTEM MAC-PG-CSS2020 (2020 Admission onwards)

1. SHORT TITLE

1.1 These Regulations shall be called "Mar Athanasius College (Autonomous) Regulations (2020) governing Postgraduate Programmes under the Credit Semester System (MAC-PG-CSS2020)".

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

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 2020-2021 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-CSS2020).

3.2 **'Academic Week'** is a unit of five working days in which distribution of work is organized from day one to day five, with five contact hours of one hour duration on each day. A sequence of 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-CSS2020 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 programme with the same course code.

3.8 '**Core Course**' means a course that the studentadmitted to a particular programme must successfully complete to receive the Degree andwhich 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 tobe 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 alpha numeric 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 lab/field work per week for 18 weeks in a Semester. The course will beconsidered 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 theCredit (Cr) of the course **CP=GP x Cr**.

3.15 '**Cumulative Grade Point Average(CGPA)**' is the value obtained by dividing the sum ofcredit 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 theprogramme. The duration of post-graduate programme shall be 4 semesterspread over two academic years.

3.20 '**Elective Course**' means a course, which can besubstituted, by 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 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 thenumerical 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 isobtained by dividing the sum of the weighted grade point obtained in the course by the sum ofthe weights of Course.**(GPA= ∑WGP / ∑W)**

3.29 '**Improvement Course**' is a course registered by a student for improving 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 indicatesthe broad level of performance of a student for a course.

3.32 **MAC-PG-CSS2020 means Mar Athanasius College Regulations Governing Post Graduate programmes under Credit Semester System, 2020.**

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

3.34 '**Plagiarism**' is the unreferenced use of other authors' material in dissertationsand 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 a regular project work with stated credits on which the student undergo a project under the supervision of a teacher in the parent department/ any appropriate research centre in order to submit a dissertation on the project work as specified. It allows students to work more autonomously to construct their own learning and culminates in realistic, student-generated products or findings.

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

3.38 '**Semester**' means a term consisting of a minimum of 90 working days, inclusive ofexamination, 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 strength and weakness 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-CSS2020.

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 post graduate programme under thevarious Faculties. The programme shall include three types of courses, Core Courses, Elective Courses and Common core courses. There shall be a project with dissertation and comprehensive viva-voce as core courses for all programmes. The programme shall also include assignments / seminars/ practical's etc.

5.2 No regular student shall register for more than 25 credits and less than16 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 andinfrastructure in the institution and the selected group shall be the subject of specialization ofthe programme.

5.3.2 The elective courses shall be either in fourth semester or distributed among 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 facility 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 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 Project Work

5.4.1. Project work shall be completed in accordance with 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 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 fourth semester of the programme and its evaluation shall beconducted 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 semesterfor appearing at the end-semester examination shall be 75%. 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 inSports, 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 particularsemester due to 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 earlier regulation/ Scheme and could not complete the Programme due to 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-CSS2020 regulations and conditions specified in 6.3.

6.5 A student who had sufficient attendance and could not register for 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 Programmewithin a period of four years from the date of commencement of the programme.

7.3 Students are eligible to pursue studies for additional post graduate degree. They shall be eligible for award of 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 as 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 berequired to have passed an appropriate Degree Examination of Mahatma Gandhi University asspecified 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 theRegulations in force.

10. PROMOTION:

10.1 A student who registers for the end semester examination shall bepromoted to the next semester

10.2 A student having 75% attendance and who fails to register forexamination of a particular semester will be allowed to register notionally and is promoted to the next semester, provided 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 programmes underfaculty 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, shortessay type questions/problems and long essay type questions. Different types of questions shall have differentweightage.

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 direct grading system.

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

12.3 **Grade Point Average (GPA): Internal and External components are separately graded and the combined grade point with weightage 1 for internal and 3 for external shall be applied to calculate the Grade Point Average (GPA) of each course. Letter grade shall be assigned to each course based on the categorization provided in 12.16.**

12.4 **Internal evaluation:** The internal evaluation shall be based on predetermined transparent system 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 its weightages for Continuous Evaluation (CE) and End Semester Evaluation (ESE) are shown in 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 paper all the Questions shall be set in such a way that the answers can be awarded A+, A, B, C, D, E grades)

b) For Theory (ESE) (External)

Evaluation is based on the pattern of Question 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 for 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 on the basis of 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, 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 question for practical**. The pattern of questions for external evaluation of practical shall be prescribed by the Board of Studies.

12.17 **DirectGradingSystem**

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 for pass in a Course

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

12.21 **Improvement of Course**- The candidate who wish to improve the grade/grade point of the external examination of the of a course/ courses he/ she has passed can do the same by appearing in the external examination of the semester concerned along with the immediate junior batch. This facility is restricted to first and second semester 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 in 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 sum of the credit point of all courses taken by a student in a semester to the total credit for that

semester. After the successful completion of a semester, Semester Grade Point Average (SGPA) of a student in that semester is calculated using the formula given below.

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

(SGPA= Total credit Points awarded in 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 semester / 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 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 card will be issued.

l) Details of description of evaluation process- Grade and Grade Point as well as indicators, calculation methodology of SGPA and CGPA as well as conversion scale shall be shown on the reverse side of the grade card.

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

15. MONITORING COMMITTEE

There shall be a Monitoring Committee constituted by the Principal to monitor the internal evaluations conducted.

16. RANK CERTIFICATE

Rank certificate 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 of the course teacher and one senior teacher as members and the Head of the Department as Chairperson. The Committee shall address all grievances relating to the internal assessment grades of the students.

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

18. **FACTORY VISIT / FIELD WORK/VISIT TO A REPUTED RESEARCH INSTITUTE/ STUDENT INTERACTION WITH RENOWNED ACADEMICIANS** may be conducted for all Programmes before the commencement of Semester III.

19. Each student may 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 year 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 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 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. **Models of distribution of courses, course codes, type of the course, credits, teaching hours for a programme are given in the following table**

Semester Wise Distribution of Courses and Credits-M.Sc. Botany

Course Code	Title	Teaching hrs Theory	Teaching hrs Practical	Credits
	SEMESTER I			
PG20BO101	Microbiology and Phycology	27 + 45	9 + 36	4
PG20BO102	Mycology and Crop Pathology	36 + 36	36 + 18	4
PG20BO103	Bryology and Pteridology	36 + 36	18 + 36	4
PG20BO104	Gymnosperms and Evolution	27 + 27	27 + 0	3
PG20BOP1	Practicals of Microbiology and Phycology & Mycology and Crop Pathology			2
PG20BOP2	Practicals of Bryology and Pteridology & Gymnosperms and Evolution			2
	SEMESTER II			
PG20BO205	Environmental Biology and Developmental Biology	54+ 18	27+ 18	4
PG20BO206	Cell and Molecular Biology	72	36	4
PG20BO207	Plant anatomy and Principles of Angiosperm systematics	36+ 36	36+ 27	4
PG20BO208	Genetics and Biochemistry	18+ 36	18+18	3
PG20BOP3	Practicals of Environmental Biology and Developmental Biology & Cell and Molecular Biology			2
PG20BOP4	Practicals of Plant anatomy and Principles of Angiosperm systematics & Genetics and Biochemistry			2
	SEMESTER III			
PG20BO309	Research Methodology, Biophysical instrumentation, Biostatistics and Microtechnique	18 + 18 + 18 +18	9 + 18 + 18 + 27	4
PG20BO310	Plant Physiology and Plant Breeding	54 + 18	36 + 9	4
PG20BO311	Biotechnology	72	27	4
PG20BO312	Taxonomy of Angiosperms	54	36	3
PG20BOP5	Practicals of Research Methodology, Biophysical instrumentation, Biostatistics and Microtechnique & Plant Physiology and Plant Breeding			2
PG20BOP6	Practicals of Biotechnology & Taxonomy of Angiosperms			2
	SEMESTER IV			
Programme Elective: Biotechnology				
PG20BO413	Elective - Tissue culture and Microbial biotechnology	90	72	4

PG20BO414	Elective - Genetic engineering	90	54	4
PG20BO415	Elective - Genomics, Proteomics and Bioinformatics	90	54	4
PG20BOP7	Practicals of Tissue culture and Microbial biotechnology			2
PG20BOP8	Practicals of Genetic engineering & Genomics, Proteomics and Bioinformatics			2
PG20BO4P	Project			4
PG20BO4V	Viva			3

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

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

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

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

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

Project-External-ESE

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

Components	Weight (W)	Grade Awarded	Grade Point(GP)	WGP= W*GP	Overall Grade of the Course
Relevance of the topic & Analysis	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

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

Components	Weight (W)	Grade Awarded	Grade Point(GP)	WGP=W *GP	Overall Grade of the Course
Relevance of the topic & Analysis	2	B	3	6	**WGP/Total Weight= 21/5 = 4.2**
Project Content & Presentation	2	A+	5	10	
Project Viva-Voce	1	A+	5	5	
Total	**5**			**21**	**A**

Comprehensive viva-voce-External-ESE

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

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

Comprehensive viva-voce-Internal-CE

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

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

2. 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**			

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

Semester Grade Point Average (SGPA)

Course code	Titleof 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**				

4. 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 in between 4.00 and 4.49 in 7-point scale)
Therefore the overall Grade awarded in the programme is A

ELIGIBILITY FOR ADMISSION TO MSc. BOTANY

Academic eligibility should be satisfied as on the last date of submission of academic data. No candidate shall be admitted to the PG programme unless he/she possess 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 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 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 PG Programme in Botany is:

M.Sc. Botany

Graduates who have passed qualifying examination in CBCS (2017)/CBCSS (2013) pattern	**Graduates who have passed qualifying examination in CBCSS (2009) pattern**	**Graduates who have passed qualifying examination 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 core group is taken only for reckoning the eligibility for applying for the PG programmes concerned. But a candidate cannot apply for the respective PG programmes solely on the basis of the open course selected under 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' in 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 (2017),CCPA of 4.7 for CBCSS (2013), CGPA of 1.88 for CBCSS (2009)applicants and 47% marks for pre-CBCSS applicants for admission to M Sc. Programme in Botany.

(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 (2017), CCPA of 4.5 for CBCSS (2013), CGPA of 1.80 for CBCSS (2009) applicants and 45% marks for pre - CBCSS applicants for admission to M Sc. Programme in Botany.

(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 (2017), CCPA of 4.5 for CBCSS (2013), CGPA of 1.80 for CBCSS (2009)applicants and 45% marks for pre – CBCSS applicants for admission to M Sc. Programme in Botany.

M.Sc. BOTANY PROGRAMME

POSTGRADUATE PROGRAMME OUTCOME

PO No.	Upon completion of postgraduate programme, the students will be able to:
PO-1	Create, apply and disseminate knowledge leading to innovation
PO-2	Think critically, explore possibilities and exploit opportunities positively
PO-3	Work in teams, facilitating effective interaction in work places.
PO-4	Lead a sustainable life
PO-5	Embrace lifelong learning

PROGRAMME SPECIFIC OUTCOMES (PSO)

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.	**1,3,4**
PSO-2	Appraise methodologies, techniques and recent advances in Botany and its allied branches.	**2,5**
PSO-3	Analyze and evaluate experimental data using biological and statistical tools and document the findings.	**1,2**
PSO-4	Explain concepts and skills with multidisciplinary dimensions and get motivated for knowledge creation.	**3,5**
PSO-5	Acquire knowledge for problem solving, research and to pursue life-long learning.	**1,4,5**
PSO-6	Summarize and disseminate scientific ideas and research findings.	**1,2,5**
PSO-7	Create environmental consciousness among fellow citizens and work towards sustainable development of the nation and world at large.	**3,4**

Scheme and Programme Structure-M.Sc. Botany

Course Code	Title	Teaching hrs Theory	Teaching hrs Practical	Credits
	SEMESTER I			
PG20BO101	Microbiology and Phycology	27 + 45	9 + 36	4
PG20BO102	Mycology and Crop Pathology	36 + 36	36 + 18	4
PG20BO103	Bryology and Pteridology	36 + 36	18 + 36	4
PG20BO104	Gymnosperms and Evolution	27 + 27	27 + 0	3
PG20BOP1	Practicals of Microbiology and Phycology & Mycology and Crop Pathology			2
PG20BOP2	Practicals of Bryology and Pteridology & Gymnosperms and Evolution			2
	SEMESTER II			
PG20BO205	Environmental Biology and Developmental Biology	54+ 18	27 + 18	4
PG20BO206	Cell and Molecular Biology	72	36	4
PG20BO207	Plant anatomy and Principles of Angiosperm systematics	36 + 36	36 + 27	4
PG20BO208	Genetics and Biochemistry	18 + 36	18 +18	3
PG20BOP3	Practicals of Environmental Biology and Developmental Biology & Cell and Molecular Biology			2
PG20BOP4	Practicals of Plant anatomy and Principles of Angiosperm systematics & Genetics and Biochemistry			2
	SEMESTER III			
PG20BO309	Research Methodology, Biophysical instrumentation, Biostatistics and Microtechnique	18 + 18 + 18 +18	9 + 18 + 18 + 27	4
PG20BO310	Plant Physiology and Plant Breeding	54 + 18	36 + 9	4
PG20BO311	Biotechnology	72	27	4
PG20BO312	Taxonomy of Angiosperms	54	36	3
PG20BOP5	Practicals of Research Methodology, Biophysical instrumentation, Biostatistics and Microtechnique & Plant Physiology and Plant Breeding			2
PG20BOP6	Practicals of Biotechnology & Taxonomy of Angiosperms			2
	SEMESTER IV			
Programme Elective: Biotechnology				
PG20BO413	Elective - Tissue culture and Microbial biotechnology	90	72	4

PG20BO414	Elective - Genetic engineering	90	54	4
PG20BO415	Elective - Genomics, Proteomics and Bioinformatics	90	54	4
PG20BOP7	Practicals of Tissue culture and Microbial biotechnology			2
PG20BOP8	Practicals of Genetic engineering & Genomics, Proteomics and Bioinformatics			2
PG20BO4P	Project			4
PG20BO4V	Viva			3

SEMESTER 1

Course	Title	Teaching hrs	Teaching hrs	Credits
		Theory	Practical	
PG20BO101	Microbiology and Phycology	27 + 45	9 + 36	4
PG20BO102	Mycology and Crop Pathology	36 + 36	36 + 18	4
PG20BO103	Bryology and Pteridology	36 + 36	18 + 36	4
PG20BO104	Gymnosperms and Evolution	27+27	27 + 0	3
PG20BOP1	Practicals of Microbiology and Phycology & Mycology and Crop Pathology			2
PG20BOP2	Practicals of Bryology and Pteridology & Gymnosperms and Evolution			2

Field study: Students are expected to conduct field visit(s) to familiarize with the diversity of life forms dealt in the first semester syllabus. Report of the field visit(s) should be prepared and recorded as part of the practical record.

PG20BO101: MICROBIOLOGY AND PHYCOLOGY
(Theory 27 + 45 hrs; Practical 9 + 36 hrs; Credits: 4)

Objectives

- To understand the diversity of algae and microbes.
- To study the characteristic features of algae, bacteria and viruses.
- To understand bacterial genetics and viral replication.
- To appreciate the ecological and economic significance of algae.

Microbiology (27 hrs)

Module 1: Introduction to microbiology (2 hrs)

Scope of microbiology. Microbial diversity: Microbial taxonomy and phylogeny - Major groups and their characteristics (Five kingdom system and three domain system of classification).

Module 2: Bacteria (11 hrs)

(a) Bacterial morphology. Classification of Bacteria according to Bergey's manual of systematic bacteriology.

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

(c) Major groups of Bacteria: Spirochetes, Rickettsias, Chlamydias, Mycoplasmas, Actinomycetes,

Myxobacteria, Archaebacteria. Extremophiles - thermophilic, halophilic, acidophilic and alkalophilic bacteria.

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

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

Module 3: Viruses (11 hrs)

(a) Nomenclature and classification, distinctive properties of viruses, morphology (symmetry) and a general account on different kinds of viruses. Capsid and their arrangements, types of envelops and their composition. Viral genome.

(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.

(e) Pathogenesis of viral infection: Stages of infection, Epidemiology and transmission of HIV, HPV. Viral oncogenesis.

Module 4: Culture of microorganisms (3 hrs)

Methods for isolating pure cultures, types of culture media, enrichment culture techniques, maintenance and preservation of pure cultures.

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.

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9. Purohit S S (1997). *Microbiology: Fundamentals and application*. Agrobotanical.
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12. Dubey R C, Maheswari D K (2004). *Microbiology*. S Chand.
13. Sharma P D (2003). *Microbiology*. Restogi pub.
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 hrs)

Module 1: Introduction (3 hrs)

(a) History of algal classification. Detailed study of the classification by F. E. Fritsch and G. M. Smith. Modern trends and criteria for algal classification.

(b) Centers of algal research in India. Contributions of Indian phycologists – M O P Iyengar, V Krishnamurthy, T V Desikachary.

Module 2: General features of Algae (30 hrs)

(a) Details of habit, habitat and distribution of Algae.
(b) Algal components: Cell wall, flagella, eye-spot, pigments, pyrenoid, photosynthetic products.
(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 3: Algal ecology (3 hrs)

Ecological importance of Algae. Productivity of fresh water and marine environment. Algae in symbiotic association, Algae in polluted habitat, Algal indicators, Algal blooms.

Module 4: Economic importance of Algae (3 hrs)

(a) Algae as food, fodder, biofertilizer, medicine, industrial uses, and other useful products. Harmful effects of algae.
(b) Use of Algae in experimental studies.

Module 5: Algal biotechnology (6 hrs)

(a) Methods and techniques of collection, preservation and staining of Algae.
(b) Algal culture: Importance, methods; Algal culture media.

Practical (36 hrs)

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

(a) Cyanophyceae - *Gleocapsa, Gleotrichia, Spirulina, Microcystis, Oscillatoria, Lyngbya, Anabaena, Nostoc, Rivularia, Scytonema*.
(b) Chlorophyceae - *Chlamydomonas, Gonium, Eudorina, Pandorina, Volvox, Ecballocystis, Tetraspora, Ulothrix, Microspora, Ulva, Shizomeris, Cladophora, Pithophora.*
Coleochaete, Chaetophora, Drapernaldia, Drapernaldiopsis, Trentepohlia, Fritschiella, Cephaleuros, Oedogonium, Bulbochaete, Zygnema, Mougeotia, Sirogonium, Hydrodictyon.
Desmedium, Bryopsis, Acetabularia, Codium, Caulerpa, Halimeda, Neomeris, Chara, Nitella.
(c) Xanthophyceae – *Vaucheria*.
(d) Bacillariophyceae - *Biddulphia, Pinnularia*.
(e) Phaeophyceae - *Ectocarpus, Colpomenia, Dictyota, Padina, Sargassum, Turbinaria*.
(f) Rhodophyceac - *Brtrachospermum, Gelidium, Amphiroa, Gracilaria, Polysiphonia*.

2. Students are to collect and identify algae from different habitat or visit an Algal research station. Prepare and submit a report of the field work/research station visit.

References

1. Chapman V J (1962). *The Algae*. Macmillan & Co. Ltd.
2. Gilbert M Smith (1971). *Cryptogamic Botany (Vol. 1): Algae and Fungi*. Tata McGraw Hill Edition.
3. F E Fritsch (Vol. I, II) (1977). *The structure and reproduction of Algae*. Cambridge University Press.
4. Gilbert M Smith (1951). *Manual of Phycology*.
5. Harnold C Bold, Michael J Wynne (1978). *Introduction to Algae: Structure and reproduction*. Prentice Hall.
6. Pringsheim E G (1949). *Pure culture of Algae*. Cambridge University Press.
7. M O P Iyengar and T V Desikachary (1981). ICAR Publication.

CO No.	EXPECTED COURSE OUTCOME Upon completion of this course, the students will be able to	Knowledge Level
1	Interpret the scope of Microbiology	K2
2	Explain the external morphology, internal structure and reproduction of different types of microbes and algae	K5

3	Appraise the modern trends and criteria in Algal classification	K2
4	Distinguish, isolate and preserve algae and microbes.	K3
5	Utilize knowledge on fossil algae as a connecting link to present day algal diversity and variation in algal ecology	K2,K3
6	Explain bacterial genetics, viral oncogenesis and pathogenesis of viral infection	K2
7	Interpret the economic and ecological significance of microbes and algae	K5
Knowledge Levels: K1-Remembering; K2-Understanding; K3-Applying; K4-Analyzing; K5-Evaluating; K6-Creating.		

PG20BO102: MYCOLOGY AND CROP PATHOLOGY
(Theory 36 + 36 hrs; Practical 36 + 18 hrs; Credits:4)

Objectives

- To understand the thallus structure and reproduction in fungi.
- To study diversity of fungi and their interactions.
- To know different plant diseases, their transmission and control.

Mycology (36 hrs)

Module 1: General introduction (3 hrs)

General characters of Fungi and their significance. Principles of classification of fungi, Classifications by G C Ainsworth (1973) and C. J. Alexopoulos.

Module 2: Thallus structure and reproduction in Fungi (24 hrs)

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.

(g) Types of fruiting bodies in fungi.

Module 3: Fungal associations and their significance (9 hrs)

(a) Symbionts - Lichens, 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, Mucor, Aspergillus, Penicillium, Pilobolous, Saccharomyces, Xylaria, Peziza, Phyllochora, Puccinia, Termitomyces, Pleurotus, Auricularia, Polyporus, Lycoperdon, Dictyophora, Geastrum, Cyathus, Fusarium, Alternaria, Cladosporium, Pestalotia, Graphis, Parmelia, Cladonia, Usnea.*
2. Isolation of fungi from soil and water by culture plate technique.
3. Estimation of mycorrhizal colonization in root.
4. Collection and identification of common field mushrooms (5 types).

References
1. C J Alexopoulos, M Blackwell, C W Mims. *Introductory Mycology* (IV Edn).
2. Jim Deacon (2006). *Fungal Biology* (IV Edn). Blackwell Publishing.
3. L N Nair (2010). *Methods of microbial and plant biotechnology.* New Central Book agency (P) Ltd.
4. Kanika Sharma. *Manual of microbiology: Tools and techniques*.
5. G C Ainsworth, K F Sparrow, A S Sussman. *The fungi: An advanced treatise*.
6. H C Dube (1983). *An introduction to fungi.* Vikas Publ. New Delhi.
7. M E Hale. *The biology of lichens.*
8. A Misra, P R Agarwal. *Lichens.*
9. M C Nair, S Balakrishnan (1986). *Beneficial fungi and their utilization*. Sci. publ. Jodhpur.
10. V Ahamjian, M E Hale. *The Lichens*.
11. R Dayal. *Predaceous Fungi*. Commonwealth Publishers.

Crop Pathology (36 hrs)

Module 1: Introduction to crop pathology (2 hrs)
Classification of plant diseases based on; (a) Major causal agents - biotic and abiotic, (b) General symptoms.

Module 2: Process of infection and pathogenesis (4 hrs)
(a) Penetration and entry of pathogen into host tissue – mechanical, physiological and enzymatic.
(b) Host-parasite interaction, enzymes and toxins in pathogenesis.

Module 3: Defense mechanism in plants (4 hrs)
Pre-existing structural and biochemical defense mechanisms, lack of essential nutrients. Induced structural and biochemical defense mechanisms, inactivation of pathogen enzymes and toxins, altered biosynthetic pathways.

Module 4: Transmission of plant disease (3 hrs)
Spread and transmission of plant diseases by wind, water, seeds and vectors.

Module 5: Plant disease management (8 hrs)
Exclusion, eradication and protection. Chemical means of disease control – common fungicides, antibiotics and nematicides. Biological means of disease control. Biotechnological approaches to disease resistance: Fungi in agricultural biotechnology, control of fungal plant pathogens by mycofungicides. Transgenic approaches to disease resistance.

Module 6: Major diseases in plants (15 hrs)
(a) Cereals: Rice - blast disease, bacterial blight; Wheat - black rust disease.
(b) Vegetables: Chilly - leaf spot; Ladies finger - vein clearing disease.
(c) Fruits: Banana - leaf spot; Mango - Anthracnose; Citrus - bacterial canker; Papaya – mosaic, Pineapple - Mealybug wilt
(d) Spices: Ginger - rhizome rot; Pepper - quick wilt; Cardamom - marble mosaic disease.
(e) Oil seeds: Coconut - grey leaf spot, bud rot disease.
(f) Rubber yielding: *Hevea braziliensis* - abnormal leaf fall, powdery mildew.
(g) Sugar yielding: Sugarcane - red rot; root knot nematode.
(h) Cash crops: Arecanut - nut fall disease.
(i) Beverages: Tea - blister blight; Coffee - rust.
(j) Ornamental plants – Bacterial Blight of Anthurium.

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 serial dilution method.
3. Collection and preservation of specimens from infected plants. Submit 5 herbarium sheets/live specimens along with a report.
4. Tests for seed pathology – seed purity test.
5. Calculation of Spore load on seeds using Haemocytometer.

References

1. K S Bilgrami, H C Dube. *A text book of modern plant pathology*.
2. Gareth Johnes. *Plant pathology: principles and practice.*
3. R S Mehrotra. *Plant Pathology*.
4. M N Kamat. *Practical plant pathology*.
5. V K Gupta, T S Paul. *Fungi and Plant disease.*
6. Malhotra, Aggarwal Ashok. *Plant Pathology*.
7. Rangaswamy, A Mahadevan. *Diseases of crop plants in India*.
8. B P Pandey. *Plant Pathology*.
9. George N Agrios (2006). *Plant pathology* (V Edn). Elsevier Academic Press.

CO No.	EXPECTED COURSE OUTCOME Upon completion of this course, the students will be able to	Knowledge Level
1	Explain the general characters, significance and classification of different fungal groups with examples.	K2
2	Identify and analyze mycelial structure, types of fruiting body and reproduction in different fungal groups.	K3, K4
3	Examine the fungal interactions in nature and predict the adaptive strategies.	K4, K6
4	Analyze the pathogenesis of various microbes and defense mechanisms in plants	K4
5	Identify the major diseases in plants and decide control measures	K3, K5
Knowledge Levels: K1-Remembering; K2-Understanding; K3-Applying; K4-Analyzing; K5-Evaluating; K6-Creating.		

PG20BO103: BRYOLOGY AND PTERIDOLOGY
(Theory 36 + 36 hrs; Practical 18 + 36 hrs; Credits: 4)

Objectives

- To understand and familiarize general characters of Bryophytes and Pteridophytes.
- To study the external morphology, internal structure and reproduction of Pteridophytes.
- To realize the ecological and economic significance of bryophytes.
- To know economic importance of Pteridophytes.
- To understand the evolutionary trends in Bryophytes and Pteridophytes.

Bryology (36 hrs)

Module 1: General introduction (4 hrs)

Introduction to Bryophytes, their fossil history and evolution. Concept of algal and pteridophytic origin of Bryophytes. General characters of Bryophytes. History of classification of Bryophytes.

Module 2: Ecology and Economic importance of bryophytes (6 hrs)

(a) Bryophyte habitats. Water relations - absorption and conduction, xerophytic adaptations, drought tolerance, dessication and rehydration, ectohydric, endohydric and myxohydric Bryophytes.
(b) Ecological significance of Bryophytes - role as pollution indicators.
(c) Identification and conservation of bryophytes.
(d) Economic importance of Bryophytes,
(e) Economic importance of Bryophytes,

Module 3: Thallus structure (26 hrs)

Comparative structural organization of gametophytes and sporophytes in an evolutionary perspective.

Asexual and sexual reproductive structures, spore dispersal mechanisms and germination of the following groups with reference to the types mentioned in the practical (development of sex organs not necessary).
(a) Hepaticopsida (Sphaerocarpales, Marchantiales, Jungermanniales and Calobryales).
(b) Anthocerotopsida (Anthocerotales).
(c) Bryopsida (Sphagnales, Polytrichales and Bryales).

Practical (18 hrs)

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

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.
3. Chopra R S, S S Kumar (1981). *Mosses of Western Himalayas and adjacent plains*. Chronica Botanica.
4. Kumar S S (1984). *An approach towards phylogenetic classification of Mosses*. Jour. Hattori Bot. Lab. Nichinan, Japan.
5. Rashid A (1981). *An Introduction to Bryophyta*. Vikas publishing house Pvt. Ltd.
6. Richardson D H S (1981). *Biology of Mosses*. Blackwell Scientific publications, Oxford.
7. Shefield W B (1983 – '84). *Introduction to Bryology* (Vol. 1, 2). Jour. Hattori Bot. Lab, Nichinan, Japan.
8. Vashishta B R, A K Sinha, A Kumar (2003). *Bryophyta*. S Chand & Co. Ltd.
9. Udak R (1976). *Bryology in India*. Chronica Botanica Co.
10. Pandey B P (1994). *Bryophyta.* S Chand and Co. Ltd.
11. Goffinet B, A J Shaw (2009). *Bryophytic Biology* (II Edn). Cambridge University Press.
12. Dyer A F, J G Duckett (Eds) (1984). *The experimental Biology of Bryophytes*. Academic Press.
13. Bonver F O (1935). *Primitive land plants*. MacMillan & Co. Ltd.
14. Campbell, Ditt (1940). *The evolution of land plants*. Stanford University Press.
15. Srivastava S N (1992). *Bryophyta*. Pradeep Publications.

Pteridophytes (36 hrs)

Module 1: General introduction and classification (3 hrs)
Introduction, origin, general characteristics and an outline of the classification of Pteridophytes.
Module 2: Structure of the plant body (27 hrs)
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):
(I) Psilopsida (a) Rhyniales; *Rhynia* (II) Psilotopsida (a) Psilotales; *Psilotum*
(III) Lycopsida (a) Protolepidodendrales; *Protolepidodendron* (b) Lycopodiales; *Lycopodium*,
(c) Isoetales; *Isoetes* (d) Selaginellales; *Selaginella*.
(IV) Sphenopsida (a) Hyeniales (b) Sphenophyllales; *Sphenophyllum* (c) Calamitales; *Calamites*
(d) Equisetales; *Equisetum*.
(V) Pteropsida (i) Primofilices (a) Cladoxylales; *Cladoxylon* (b) Coenopteridales.
(ii) Eusporangiatae (a) Marattiales; *Angiopteris* (b) Ophioglossales; *Ophioglossum*.
(iii) Osmundales; *Osmunda*.
(iv) Leptosporangiatae (a) Marsileales; *Marsilea* (b) Salviniales; *Salvinia, Azolla* (c) Filicales; *Pteris, Lygodium, Acrostichum, Gleichenia, Adiantum.*

Module 3: Comparative study of Pteridophytes (4 hrs)
Stelar organization, soral and sporangial characters, gametophytes and sporophytes of Pteridophytes in an evolutionary perspective.
Module 4: Ecology and Economic importance (2 hrs)
Ecological and economic significance of Pteridophytes.

Practical (36 hrs)

1. Study of morphology and anatomy of vegetative and reproductive organs using clear whole mounts/sections of the following genera:
Psilotum, Lycopodium, Isoetes (no collection), Selaginella, Equisetum, Angiopteris, Ophioglossum, Osmunda, Marsilea, Salvinia, Azolla, Lygodium, Acrostichum, Gleichenia, Pteris, Adiantum, Polypodium and Asplenium.
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.

References

1. Agashe S N (1995). *Palaeobotany*. Oxford and IBH publishing House.
2. Arnold C R (1977*). Introduction to Palaeobotany*. McGraw Hill Book Com.
3. Chandra S, Srivastava M (Eds) (2003). *Pteridology in the New Millennium.* Khuwar Acad. Publishers.
4. Beddome C R H (1970). *Ferns of south India*. Today & Tommorrows Publ.
5. Dyer A F (1979). *The experimental biology of ferns*. Academic Press.
6. Gifford E M, A S Foster (1989). *Morphology and evolution of Vascular plants* (III Edn). W H Freeman & Co.
7. Khullar S P (2000). *An illustrated fern flora of West Himalayas* (Vol I, II). International Book Distributers.
8. Kubitzki K (1976). *The families and Genera of Vascular plants: Vol. I Pteridophytes*. Vikas publishing house.
9. Rashid A (1976). *An introduction to Pteridophytes*. Vikas Publishing House.
10. Sporne K R (1982). *Morphology of Pteridophytes*. Hutchinson university Press.
11. Surange K R (1964). *Indian Fossil Pteridophytes*. CSIR.
12. Louis J D (1977). *Evolutionary patterns and processes in ferns: Advances in Botanical Research*.
13. Scott. *Studies in Fossil Botany*. Haffner publications.
14. Smith, Gilbert (1972). *Cryptogamic Botany* (Vol. II). Tata McGraw Hill publications.
15. Nayar B K, S Kaur (1971). *Gametophytes of homosporous ferns*. Bot. Rev.

CO No.	EXPECTED COURSE OUTCOME Upon completion of this course, the students will be able to	Knowledge Level
1	Explain the different groups of Bryophytes and Pteridophytes, their general characters and classification with examples.	K2
2	Compare structural organization of gametophytes and sporophytes of Bryophytes in an evolutionary perspective.	K4
3	Analyze the characters of gametophytes and sporophytes of Pteridophytes in an evolutionary perspective.	K4
4	Value the economic and ecological significance of Bryophytes and Pteridophytes.	K5
5	Formulate strategies for the identification and conservation of Bryophytes and Pteridophytes.	K6
Knowledge Levels: K1-Remembering; K2-Understanding; K3-Applying; K4-Analyzing; K5-Evaluating; K6-Creating.		

PG20BO104: GYMNOSPERMS AND EVOLUTION
(Theory 27 + 27 hrs; Practical 27 hrs; Credits 3)

Objectives

- To understand the diversity in morphology and structure of gymnosperms.
- To realize the economic importance of gymnosperms.
- To know the course of evolution and role of mutation in evolution.
- To understand the types and patterns of speciation.

Gymnosperms: (27 hrs)

Module 1: Introduction (3 hrs)
Origin, general characteristics, distribution and classification of Gymnosperms (K R Sporne and C J Chamberlain). Distribution of living gymnosperms in India.
Module 2: Vegetative and reproductive structures of Gymnosperms (22 hrs)
Detailed study of the vegetative morphology, internal structure, reproductive structures, and evolution of the orders and families (with reference to the genera mentioned).
(a) Class Progymnospermopsida: *Aneurophyton*
(b) Class Cycadopsida: *Heterangium, Lyginopteris, Lagenostoma, Glossopteris, Medullosa, Caytonia. Bennettites, Williamsoniella, Nilsonia, Cycas, Zamia, Pentoxylon*.
(c) Class Coniferopsida: General account of families under Coniferales, range of form and structure of stem, leaves; range of form, structure and evolution of cones in coniferales such as *Pinus, Taxodium, Cupressus, Podocarpus, Agathis, Araucaria, Taxus and Ginkgo*.
(d) Class Gnetopsida: *Gnetum*.
Module 3: Gametophyte development and economic importance of Gymnosperms (2 hrs)
General account on the male and female gametophyte development in Gymnosperms (Cycas). Economic significance of Gymnosperms.

Practical (27 hrs)

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

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.
5. Chamberlain C J (1935). *Gymnosperms: Structure and Evolution*. University of Chicago Press.
6. Meyen S V (1984). *Basic features of Gymnosperms' Systematics and Phylogeny as evidenced by the Fossil Record*. Bot. Rev.
7. Sharma O P, S Dixit (2002). *Gymnosperms*. Pragati Prakashan.
8. Sporne A R (1974). *The morphology of gymnosperms*. Hutchinson Univ. Library.
9. Biswas C. *The Gymnosperms*. Today and Tomorrows print.
10. Coulter J M, Chamberlain C J (1977). *Morphology of Gymnosperms*. University of Chicago Press.
11. Dallimore W, A B Jackson (1964). *A Handbook of Coniferae and Ginkgoaceae* (IV Edn). Edward Arnold & Co.
12. Delevoryas T (1962). *Morphology and evolution of Fossil Plants*. Holt, Rinehart and Winston.

Evolution: (27 hrs)

Module 1: Introduction (4 hrs)

The Concept of evolution, preformation theory, Baer's law, biogenetic law, theory of catastrophism, natural selection, artificial selection, sexual selection, mutation theory, isolation theory.

Module 2: Origin of life (4 hrs)

Abiogenesis, Biogenesis experiment of Miller (1953). Theory of Organic evolution - Biochemical origin of life, place and time of origin and experimental evidences. Concept of Oparin and Haldane.

Module 3: Evidences for evolution (5 hrs)

Morphology and Comparative anatomy – Embryology, Physiology and Biochemistry, Palaentology, Biogeography. Evolutionary time scale: eras, periods and epochs. Stages in primate evolution including
Homo.

Module 4: Theories of evolution (5 hrs)

Lamarckism and Neo-Lamarckism, Darwinism and Neo-Darwinism; Mutation theory of De-Vries and the modern mutation theory.

Module 5: Mutation as an evolutionary force (2 hrs)

Mutation and genetic divergence; Evolutionary significance of mutations, genetic assimilations (Baldwin effect), genetic homoeostasis.

Module 6: Speciation (4 hrs)

Genetic drift - Salient features; species concept; subspecies, sibling species, semi species, demes. Types of speciation - Phyletic speciation and True speciation. Mechanism of speciation - Genetic divergences and isolating mechanisms. Patterns of speciation - allopatric, sympatric, quantum and parapatric speciation.

Module 7: Modern theories of evolution (3 hrs)

Modern synthetic theory of evolution, molecular evolution, concepts of natural evolution, molecular divergence and molecular clocks; molecular tools in phylogeny. Plant evolution.

References

1. Gurbachan S Miglani (2002). *Modern Synthetic theory of evolution*.
2. George Ledyard Stebbins (1971). *Process of Organic evolution*.
3. Roderic D M Page, Edward C Holmes (1998). *Molecular Evolution: A phylogenetic approach*. Blackwell Science Ltd.
4. Maxtoshi Nei, Sudhir Kumar (2000). *Molecular Evolution and phylogenetics*. Oxford University Press.
5. Katy Human (2006). *Biological evolution: An anthology of current thought.* The Rosen publishing group, Inc.
6. Monroe W Strickberger (1990). *Evolution*. Jones and Bartlett publishers.

CO No.	EXPECTED COURSE OUTCOME Upon completion of this course, the students will be able to	Knowledge Level
1	Explain the general characters, distribution and classification of Gymnosperms	K2
2	Interpret the vegetative, internal and reproductive structures of Gymnosperms.	K2
3	Summarize the concepts, process and evidences of evolution.	K2
4	Analyze various theories explaining evolution	K4
5	Appraise the ecological and economic significance of Gymnosperms	K5
Knowledge Levels: K1-Remembering; K2-Understanding; K3-Applying; K4-Analyzing; K5-Evaluating; K6-Creating.		

SEMESTER I
MODEL QUESTION PAPERS - THEORY

Semester I Course 1
Model Question Paper
PG20BO101 MICROBIOLOGY AND PHYCOLOGY
Time 3 hours Weightage 30

I. Answer any ***eight*** of the following in not less than 50 words (Weight 1 each)

1. Write short notes on;
(a) Algal bloom (b) Pyrenoids (c) Endospore (d) Heterocyst
2. Giving suitable examples, describe heterotrichous habit.
3. What are viroids? Give two plant diseases caused by viroids.
4. What are extremophiles? Give examples.
5. Describe the types of environments where you find Algae.
6. Describe the role of Algae as symbionts.
7. Describe the structure of Bacterial cell wall.
8. What are the major contributions of M O P Iyengar.
9. What are prions?
10. Write an account on the major algal research centers in India.

II. Answer any ***six*** of the following in not less than 100 words (Weight 2 each)

11. Write briefly on fossil Algae.
12. Describe briefly the following;
(a) Algae as pollution indicators (b) Pigmentation in Algae.
13. Describe the contribution of Algae to the productivity of marine environment.
14. Classify Bacteria based on Bergey's manual.
15. Describe the structure, properties, importance and replication of plasmids.
16. Give examples for algae used in experimental studies.
17. Write an account on the genetic recombination methods in Bacteria.
18. Briefly describe the procedure and applications of algal culture.

III. Answer any ***two*** of the following in not less than 250 words (Weight 5 each)

19. Describe the life cycle patterns of viruses.
20. Write a brief account on the thallus organization in different groups of Algae.
21. Citing suitable examples describe the life cycle patterns in the members of Chlorophyta.
22. Explain the stages of infection, epidemiology and transmission of HIV and HPV?

Semester I Course 2
Model Question Paper
PG20BO102 MYCOLOGY AND CROP PATHOLOGY
Time 3 hours Weightage 30

I. Answer any ***eight*** of the following in not less than 50 words (Weight 1 each)

1. What is the significance of parasexual cycle in Fungi?
2. How are fungi well adapted as decomposers?
3. Give the names of the following;
(a) An edible Fungus (b) A coprophilous Fungus (c) A mycoparasite (d) A poisonous Fungus
4. What are the common symptoms of viral diseases in plants?
5. Describe the abiotic causes of plant diseases.
6. Describe the symptoms and control of the red rot disease of sugarcane.
7. Describe biological control of plant diseases
8. Distinguish between;
(a) Zygospore and zoospore (b) Mycelium and Hypha (c) Cilia and Flagella (d) Ascospores and Basidiospores
9. What are the types of spores produced by Deuteromycetes?
10. Write a brief account on the environmental significance of lignolytic fungi.

II. Answer any ***six*** of the following in not less than 100 words (Weight 2 each)

11. Describe the unique features of Myxomycota members.
12. Write a brief account on the common diseases, their symptoms and control in cereals.
13. What are the common structural features found in plants that prevent the colonization of a pathogen?
14. Explain/Write short notes on the following;
(a) Plant quarantine (b) Prophylaxis (c) Necrosis (d) Coffee rust
15. What are fungus gardens? Describe the type of interactions found there.
16. Citing specific examples describe how genetic engineering can be used to control plant diseases?
17. Write an account on symbiotic fungi.
18. What are the major biotic causes of plant diseases?

III. Answer any ***two*** of the following in not less than 250 words (Weight 5 each)

19. Briefly describe the classification of Fungi proposed by Ainsworth.
20. Write an essay on the common strategies adopted to control plant diseases
21. Describe the process of infection and pathogenesis in plants.
22. Explain the types of fruiting bodies in fungi.

Semester I Course 3
Model Question Paper
PG20BO103 BRYOLOGY AND PTERIDOLOGY
Time 3 hours Weightage 30

I. Answer any ***eight*** of the following in not less than 50 words (Weight 1 each)

1. What is meant by an ectohydric bryophyte? Give examples.
2. Describe the role of Bryophyts as pollution indicators.
3. What is pegged rhizoid?
4. What is psuedo elator? What is its function?
5. What is synangium? Describe its structure.
6. What is meant by heterospory? Give examples.
7. Describe the structure and function of a ligule.
8. Write short notes on;
(a) Columella (b) Peristome (c) Protonema (d) Trabeculae
9. Describe algal origin of bryophytes.
10. Bring out the fossil history of bryophytes.

II. Answer any ***six*** of the following in not less than 100 words (Weight 2 each)

11. Write down ambhibious characters of bryophytes.
12. Describe the general characteristics of pteridophytes.
13. Bring out the anatomical structure of the stem of psilotum with labelled diagram.
14. Why the rhizophore of selaginella is called as an 'Organ-sui-generis'?
15. Describe the stelar anatomy of Equisetum
16. Give an account of the sporophyte of Anthoceros
17. Write an account on the economic importance of Bryophytes
18. Describe the following;
(a) Seed habit of Selaginella (b) Economic importance of Pteridophytes

III. Answer any ***two*** of the following in not less than 250 words (Weight 5 each)

19. Bring out the history of classification of Bryophytes with a critical discussion.
20. Give an account of the thallus organisation of Bryophytes in an evolutionary perspective.
21. Describe the stelar evolution in Pteridophyte stems.
22. Explain the algal origin of pteridophytes.

Semester I Course 4
Model Question Paper
PG20BO104 GYMNOSPERMS AND EVOLUTION
Time 3 hours Weightage 30

I. Answer any ***eight*** of the following in not less than 50 words (Weight 1 each)

1. What does the term gymnosperms, mean?
2. What are the 'fern' characters of the gymnosperm leaves?
3. What are coralloid roots?
4. What do you mean by Abiogenesis?
5. Define the term 'demes'.
6. Describe Phyletic speciation and True speciation.
7. Mention the evolutionary significance of mutations
8. Writ brief notes on;
(a) Epochs (b) Molecular clock
9. Compare Gymnosperms with Angiosperms?
10. Write a note on classification of Gymnosperms?

II. Answer any ***six*** of the following in not less than 100 words (Weight 2 each)

11. Describe the economic significance of Gymnosperms?
12. Explain the experiments of Miller?
13. Write a note on evolutionary time-scale?
14. What is meant by genetic drift?
15. Describe genomic equivalence and cytoplasmic determinants?
16. Explain the evolution of female cone in Pinus
17. Give an illustrated account of the anatomy of the leaflet of Cycas, and explain the function of various
tissues found therein?
18. Explain the structure of stem and leaves of Podocarpus
.

III. Answer any ***two*** of the following in not less than 250 words (Weight 5 each)

19. Write an account on the distribution, general characters, and outline classification of order coniferales.
20. Describe various theories to explain the mechanism of evolution.
21. Explain the salient features of class Gnetopsida and advanced characters of Gnetum.
22. Explain the types and mechanism of speciation.

MODEL QUESTION PAPER – PRACTICAL

MAR ATHANASIUS COLLEGE (AUTONOMOUS), KOTHAMANGALAM

M.Sc. Botany Programme

SEMESTER I - PRACTICAL COURSE I

MICROBIOLOGY, PHYCOLOGY, MYCOLOGY AND CROP PATHOLOGY

Time: 4 hours **Weightage: 15**

1. Make suitable micropreparations of A and B. Draw labeled diagrams and identify giving reasons.
(Total weight 1.5 = Preparation – 0.5, Diagram – 0.5, Identification with reasons – 0.5; 1.5 x 2 = 3)

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

3. Sort out **any four algae** from the algal mixture E and make separate clear mounts. Identify and draw labeled diagrams.
(Total weight 1 = Preparation – 0.5, Identification with diagrams – 0.5; 1 x 4 = 4)

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

5. Identify the disease in H and I and write the causative organism.
(Correct identification of the disease and causative organism – 0.5; 0.5 x 2 = 1)

6. Isolate Bacteria from the soil sample J by serial dilution and streak out by quadrate method.
(Total weight 1 = Working – 0.5, Procedure – 0.5)

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

8. Practical record
(Weight = 2)

Key to the questions:
1. A, B: Alga, Fungi/Lichen.
2. C, D - Fungi.
3. E – Algal mixture containing five filamentous types.
4. F, G – Macroscopic or microscopic specimens from algae, fungi/lichen with clear and distinguishable identifying characters.
5. H, I – Herbarium or live/dry specimen showing the symptoms of any disease specified in the syllabus
6. J - Supply necessary soil sample.
7. Credit for (fresh or dry-herbarium) specimens showing typical symptoms – include a short report on the disease.
8. Awarding 'A grade' for the record of practical work shall be considered only if all the practical works specified in the syllabus are done completely and recorded properly. This also includes field study report(s)/Lab visit report(s), if any.

MAR ATHANASIUS COLLEGE (AUTONOMOUS), KOTHAMANGALAM

M.Sc. Botany Programme

SEMESTER I - PRACTICAL COURSE II

BRYOLOGY, PTERIDOLOGY, GYMNOSPERMS AND PALEOBOTANY

Time: 4 hours Weightage: 15

1. Make stained micropreparations of specimens A, B and C. Draw labeled diagrams for each and identify giving reasons.
(Total weight 1.5 = Preparation – 0.5, Diagram – 0.5, Identification with reasons – 0.5; 1.5 x 3 = 4.5)

2. Make stained micropreparations (TS, TLS and RLS) of D. Draw labeled diagram and identify giving reasons.
(Total weight 2.5 = Preparations – 0.5 (0.5 x 3 = 1.5); Identification with reasons and diagrams – 1)

3. Identify at sight E, F, G and H.
(Total weight 1 = Genus identification - 0.5, Part displayed - 0.5; 1 x 4 = 4)

4. Write critical notes on the reproductive structures I and J.
(Correct identification with critical note - 0.5; 0.5 x 2 = 1)

5. Identify and write a critical note on K.
(Total weight 1 = Identification – 0.5, Critical note – 0.5)

6. Practical record
(Weight = 2)

Key to the questions:
1. A, B, C – one each from Bryophytes, Pteridophytes and Gymnosperm leaf.
2. D - Suitable specimen from Coniferales.
3. E, F, G, H – Suitable specimens from Bryophytes, Pteridophytes and Gymnosperms; both reproductive and/or vegetative structures; should not exceed two specimens from one group.
4. I, J – Specimens from Bryophytes, Pteridophytes or Gymnosperms.
5. K - Fossil slides/specimens/photographs of types specified in the syllabus; both vegetative and reproductive structures included.
6. Awarding ‘A grade’ for the record of practical work shall be considered only if all the practical works specified in the syllabus are done completely and recorded properly. This also includes field study report(s)/Lab visit report(s), if any.

SEMESTER II

Course	Title	Teaching hrs Theory	Teaching hrs Practical	Credits
PG20BO205	Environmental Biology and Developmental Biology	54 + 18	27 + 18	4
PG20BO206	Cell and Molecular Biology	72	36	4
PG20BO207	Plant anatomy and Principles of Angiosperm systematics	36 + 36	36 + 27	4
PG20BO208	Genetics and Biochemistry	18 + 36	18 +18	3
PG20BOP3	Practicals of Environmental Biology and Developmental Biology & Cell and Molecular Biology			2
PG20BOP4	Practicals of Plant anatomy and Principles of Angiosperm systematics & Genetics and Biochemistry			2

PG20BO205: ENVIRONMENTAL BIOLOGY AND DEVELOPMENTAL BIOLOGY
(Theory 54 + 18 hrs; Practical 27 +18 hrs; Credits 4)

Objectives

- To realize the extent of the total biodiversity and the importance of its conservation.
- To understand the structure and function of the ecosystems.
- To know various kinds of pollution in the environment, their impacts on the ecosystem and their control measures.
- To study about various environmental laws in India.
- To understand the morphology and development of reproductive parts.
- To get an insight about morphogenesis and organogenesis in plants.

Environmental Biology (54 hrs)

Module 1: Ecology and Environment (2 hrs)
Definition, history and scope of ecology, sub divisions of ecology, ecology vs environmental science. Interdisciplinary nature of environmental science.

Module 2: Autecological concepts - Population Ecology (5 hrs)
(a) Characteristics of populations - size and density, dispersion, age structure, natality and mortality.
(b) Population growth - factors affecting population growth, environmental resistance, biotic potential, carrying capacity, positive and negative interaction, migration, subsistence density, security and optional density. Ecological consequence of overpopulations.
(c) Genecology - ecological amplitude, ecads, ecotypes, ecospecies, coenospecies, k-selection and r-selection populations.

Module 3: Synecological concepts - Community ecology (5 hrs)
(a) Ecological processes of community formation, ecotone, edge effect. Classification of communities - criteria of classification, dynamic system of classification by Clement.
(b) Special plant communities - quantitative, qualitative and synthetic characteristics of plant communities, Sorenson's Index of similarity, coefficient of communities.
(c) Dynamic community characteristics - cyclic replacement changes and cyclic no-replacement changes.

Module 4: Dynamic Ecology - Ecological succession (3 hrs)
(a) The concept, definition and reasons of succession. Classification of succession: Changes -

autogenic and allogenic, primary and secondary, autotrophic and heterotrophic.
(b) Retrogressive changes or the concept of degradation, concept of climax or stable communities, resilience of communities, ecological balance and survival thresholds.

Module 5: Biosphere and Ecosystem (3 hrs)

(a) Significance of habitat, biodiversity, ecological niche, trophic level, primary and secondary productivity, food chains, food webs, ecological pyramids, energy flow and nutrient cycles.
(b) Comparative study of the major world ecosystems: Different aquatic and terrestrial ecosystems with regard to their productivity, biodiversity, energy flow, food chains and trophic levels.

Module 6: Phytogeography (4 hrs)

(a) Definition, principles governing plant distribution, factors affecting plant distribution, theories of distribution, different types of distribution of vegetations on the earth, continuous and discontinuous distribution.
(b) Climate, vegetation and botanical zones of India.
(c) Remote sensing: Definition and data acquisition techniques. Application of remote sensing in vegetation classification, understanding the key environmental issues and ecosystem management.

Module 7: Environmental pollution (16 hrs)

(a) Definition and classification.
(b) Water pollution: Water quality parameters and standards, different types of pollutants and their consequences. Types of water pollution, prevention and control - water shed management, waste water treatment. Waste water treatment with aquatic macrophytes.
(c) Air pollution: Air quality standards and index, ambient air monitoring using high volume air sampler, types and sources of air pollutants, air pollution and human health hazards, control of air pollution.
(d) Noise pollution.
(e) Radioactive and thermal pollution: Causes and hazardous effects, effective management.

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

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

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

(a) Global warming, green-house gases, acid rain, ozone depletion. Holistic relationship between air water and land pollution.
(b) Factors responsible for climate change, *El-Nino* and *La Nina* phenomenon and its consequences.
(c) Effect of climate change on reproductive biology and biogeography.
(d) Environmental laws, environmental monitoring and bio indicators, environmental safety provisions in Indian constitution, major environmental laws in free India, ISO-14000.

Module 10: Biodiversity and its conservation (8 hours)

(a) Basic principles of resource management, definition and classification of resources, problems of resource depletion, preservation, conservation and restoration, patterns of resource depletion, resource economics and resource overuse.
(b) Current biodiversity loss - concept of endemism, rare, endangered and threatened species (RET), key stone species, IUCN account of biodiversity, red data book and hot spots, reasons to stop extinction, methods to save species.
(c) Principles of conservation - *ex-situ* and *in-situ* conservation techniques. Biodiversity conservation: Species diversity, community diversity, ecosystem diversity and landscape preservation. Role of biotechnology in conservation of species.
(d) Ecotourism - positive and negative impacts.

Practical (27 hrs)

1. Analysis of water quality for; (a) Dissolved CO_2 (b) Dissolved oxygen (c) COD (d) Total dissolved minerals (e) Quantitative estimation of dissolved chloride ions and dissolved sulphate (f) Total alkalinity.
2. Quantitative estimation of dissolved chloride ions, dissolved sulphate, nitrate and total alkalinity.
2. Physico-chemical analysis of soil: (a) Total water soluble mineral ions (b) estimation of soil

organic carbon (Walkey and Black method).
3. 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.
4. Phytoplankton counting using Sedgwick Rafter counter.
5. Field visit to natural ecosystem and identification of trophic levels, food webs and food chains, plant diversity (species and community).
6. Students should be aware of the common environmental problems, their consequences and possible solutions.

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Developmental Biology (18 hrs)

Module 1: Basic concepts of developmental Biology: (3 hrs)
An overview of plant and animal development (2), Potency, Commitment, Specification, Induction, Competence, Determination and Differentiation; Morphogenetic gradients, Cell-fate and Cell lineages, Stem cells (2), Genomic equivalence and the cytoplasmic determinants (2), Imprinting. Mutants and transgenics in analysis of development (2).
Module 2: Development in flowering plants: (11 hrs)
(a) Angiosperm life cycle (6).
(b) Anther: Structure and development, microsporogenesis (7), male gametophyte development (7). Palynology: Pollen morphology, exine sculpturing, pollen kit, NPC formula. Applications of

palynology - palynology in relation to taxonomy [7]. Viability of pollen grains [7]. Pollination, pollen germination, growth and nutrition of pollen tube [6, 7].

(c) Ovule: Structure, ontogeny and types. Megasporogenesis. Embryosac – development, types, ultrastructure, and nutrition of embryosac [7]. Female gametophyte development [7].

(d) Fertilization: Double fertilization; embryo development - different types [3, 7]. Endosperm development, types of endosperm, haustorial behavior of endosperm [7]. Xenia and metaxenia. Polyembryony – types and causes [7].

(e) Seed formation, dormancy and germination [6, 7]. Apomixis, Parthenogenesis,

Module 3: Morphogenesis and organogenesis in plants: (4 hrs)

Shoot and root development [2, 3, 6]. Leaf development and Phyllotaxy [2, 3, 6]. Transition to flowering [2, 6], floral meristems and floral development [2, 3]. Homeotic genes in plants [3, 4]. Senescence, programmed

cell death and hypersensitive response in plants

Practical (18 hrs)

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

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8. Maheswari P (1950). *An introduction to the embryology of Angiosperms*. McGraw Hill.

CO No.	Expected Course Outcomes Upon completion of this course, the students will be able to	Knowledge Level
1	Explain the different concepts of Ecology	K2
2	Identify the different types of ecosystems, components and their interrelationships	K4
3	Analyze the causes of environmental problems and propose measures to reduce it	K4, K6
4	Create awareness about biodiversity, its significance, consequence of biodiversity loss and need to conserve it.	K6
5	Identify the use of remote sensing in data acquisition about phytogeography.	K2, K3
6	Analyze the basic concepts of development, organogenesis and morphogenesis in plants	K4
7	Explain various environmental laws in India	K2
Knowledge Levels: K1-Remembering; K2-Understanding; K3-Applying; K4-Analyzing; K5-Evaluating; K6-Creating.		

PG20BO206: CELL AND MOLECULAR BIOLOGY
(Theory 72 hrs; Practical 36 hrs; Credits: 4)

Objectives

- To understand the ultra structure of a cell.
- To get an insight on cell communication and signalling.
- To recognize different stages in the life cycle and death of a cell.
- To know about genome and chromosome organization.
- To understand the mechanism of DNA replication, transcription and translation.
- To know about factors that regulate gene expression.

Module 1: Intracellular compartments in eukaryotic cells (6 hrs)

Major intracellular compartments in eukaryotic cells (brief study only) [5, 7]. Detailed structure of mitochondria, chloroplast, peroxisomes and glyoxysomes with reference to their functional interrelationship [5, 7, 8]. Genetic systems in mitochondria and chloroplast, endosymbiont hypothesis on the evolution of mitochondria and chloroplast [5, 8, 14]. Structural organization of cell membranes: Chemical composition; structure and function of membrane carbohydrates, membrane proteins and membrane lipids [1, 2, 3, 4, 5, 16, 19, 28]. Membrane functions [1, 5].

Module 2: Cell communication and Cell signaling (6 hrs)

(a) Cell communication: general principles [5, 18]. Signaling molecules and their receptors [2, 3, 4, 16, 18, 19], external and internal signals that modify metabolism, growth, and development of plants [8].

(b) Receptors: Cell surface receptors – ion-channel linked receptors, G-protein coupled receptors, and Tyrosine-kinase linked receptors (RTK), Steroid hormone receptors [3, 4, 5, 14, 16, 18].

(c) Signal transduction pathways [3,5, 8, 18], Second messengers [3, 18], Regulation of signaling pathways [4]. Bacterial and plant two-component signaling systems [8].

Module 3: Life cycle of the cell (6 hrs)

(a) Cell growth and division. Phases of cell cycle, cell cycle control system; extracellular and intracellular signals [2, 3, 5, 8, 14, 16]. Cell cycle checkpoints – DNA damage checkpoint, centrosome duplication checkpoint, spindle assembly checkpoint [2, 3, 4, 5, 9, 16]. Cyclins and Cyclin-dependent kinases [2, 3, 4, 5, 9, 16]. Regulation of plant cell cycle [8].

(b) Cell division – mitosis and meiosis (brief study only). Significance of meiosis in generating genetic variation [3, 14, 20, 22, 27].

(c) Programmed cell death – molecular mechanism and control [3, 4, 5, 9].

Module 4: Cytoskeleton (3 hrs)

Functions of cytoskeleton; Structure, assembly, disassembly and regulation of filaments involved – actin filaments (microfilaments), microtubules, and intermediate filaments [1, 2, 3, 4, 5, 14, 29, 32]. Molecular motors – kinesins, dyneins, myosins [1, 2, 3, 4, 5, 29]

Module 5: Genetic material and its molecular structure (6 hrs)

(a) Identification of DNA as genetic material: Transformation experiment, Hershey Chase experiment [6, 7, 9, 22, 27]. RNA as the genetic material in some viruses [6, 7, 21, 22, 27].

(b) Important features of Watson and Crick model of DNA structure, Chargaff's rules, preferred tautomeric forms of bases [6, 10, 27].Alternative conformations of DNA – type(s) of right handed and left handed helices, DNA triplex and quadruplex [6, 10, 20, 30, 31], circular and linear DNA, single-stranded DNA[15].

(c) Structure and function of different types of RNA - mRNA, tRNA, rRNA, SnRNA, and Micro RNA [6, 7, 10, 23, 24, 25]. RNA tertiary structures [31]. Ribozymes – Hammerhead ribozyme [7, 10, 31].

Module 6: Genome and chromosome organization in eucaryotes (5 hrs)

(a) c-value paradox, DNA renaturation kinetics, Tm, Cot curve [6, 7, 9, 13]. Unique and Repetitive DNA – mini- and microsatellites [6, 7, 20].

(b)Structure of chromatin and chromosomes [3, 4, 5] - histones and nonhistone proteins [3, 4, 7, 27],

nucleosomal organization of chromatin, higher levels of chromatin structure [3, 4, 5, 7, 22, 24, 27, 31]. Heterochromatin and Euchromatin, formation of heterochromatin [3, 5]. Chromosomal packing and structure of metaphase chromosome [3, 5, 7, 9, 24, 31]. Molecular structure of the Centromere and Telomere [3,5, 7, 9, 22, 24, 31].

Module 7: DNA replication, repair and recombination (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 [6, 10, 13, 22, 24]. Process of replication – initiation, elongation and termination [13, 20, 22, 27]. Replication in the telomere - telomerase [6, 7, 10, 13, 20, 22, 24, 25].

(b) DNA repair mechanisms: Direct repair, excision repair – base excision repair and nucleotide excision repair (NER), eucaryotic excision repair – GG-NER, TC-NER. Mismatch repair, Recombination repair – homologous recombination repair, nonhomologous end joining, SOS response – Transletion DNA polymerase [6, 7, 9, 10, 20, 22, 24, 25, 26, 27, 31].

(c) Recombination: Homologous and nonhomologous recombination, molecular mechanism of homologous recombination [3, 6, 7, 13, 20, 22, 24, 31]. Site-specific recombination, transposition [6, 7, 13, 22, 27, 31] – types of transposons.

Module 8: Gene expression (20 hrs)

(a) Gene: Concept of gene; structural and genetic definitions – complementation test [7, 22].

(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 [6, 7, 13, 22, 24, 27].

(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 [6, 7, 13, 20, 22, 23, 24, 27].

(d) Post-transcriptional events: Split genes, splicing signals, splicing mechanisms of group I, II, III, and tRNA introns [6, 7, 10, 13, 20, 22, 24, 31]. Alternative splicing [6, 10, 13, 15, 22, 23, 24], exon shuffling [9, 10, 27], *cis* and *trans* splicing [10, 13, 31]. Structure, formation and functions of 5' cap and 3' tail of mRNA, RNA editing, mRNA export [6, 7, 10, 13, 20, 22, 24, 27, 31].

(e) Translation: Important features of mRNA – ORF, RBS [10, 16]. Fine structure, composition and assembly of procaryotic and eukaryotic ribosomes. tRNA charging, initiator tRNA [6, 7, 10, 13].

(f) Stages in translation: Initiation – formation of initiation complex in procaryotes and eucaryotes, initiation factors in procaryotes and eucaryotes [6, 7, 9, 10, 17, 20, 26, 27], Kozak sequence [6, 9, 10, 17, 20]. Elongation – process of polypeptide synthesis, active centers in ribosome - 3-site model, peptidyl transferase, elongation factors. Termination – process of termination, release factors [6, 13, 17, 27], ribosome recycling

(g) Genetic code: Cracking the genetic code – simulation synthetic polynucleotides and mixed copolymers, synthetic triplets [6, 10, 22, 24, 25, 27]. Important features of the genetic code [6, 7, 9, 10, 13, 22, 27], proof for the triplet code [10, 27], Exceptions to the standard code [6, 10, 22, 27].

(h) Protein sorting and translocation: Cotranslational and posttranslational – signal sequences, SRP, translocon. Membrane insertion of proteins. Post-translational modification of proteins [5]. Protein folding – self assembly, role of chaperones in protein assembly [6, 7, 16, 25, 26, 27, 31].

Module 9: Control of gene expression (10 hrs)

(a) Viral system: Genetic control of lytic and lysogenic growth in λ phage, lytic cascade [6, 7, 10, 13, 22, 25, 27].

(b) Procaryotic system: Transcription switches, transcription regulators [14]. Regulation of transcription initiation; Regulatory proteins - activators and repressors. Structure of *Lac* operator, CAP and repressor control of *lac* genes [6, 7, 10, 13, 20, 22, 24, 25, 27]. Regulation after transcription initiation – regulation of amino acid biosynthetic operons [10, 13] - attenuation of trp operon [6, 7, 9, 10, 13, 20], riboswitches [9, 7, 10, 20, 24].

(c) Eucaryotic system: Changes in chromatin and DNA structure – chromatin compaction, transcriptional

activators and repressors involved in chromatin remodelling [6, 10, 20, 22, 24, 25, 27], gene amplification, gene rearrangement [6, 9, 10, 22, 23], alternate splicing [22, 24], gene silencing by heterochromatization [9, 10, 20], and DNA methylation [6, 9, 10, 20, 24, 25]. Effect of regulatory transcription factors on transcription [6, 10, 19]. Post-transcriptional control – mRNA stability, RNA interference, micro RNA. Role of small RNA in hetero chromatization and gene silencing

Practical (36 hrs)

1. Study of meiosis in *Rhoeo*/*Chlorophytum* by smear preparation of PMCs.
2. Study of giant chromosomes in Drosophila/Chironomus.
3. Work out problems based on DNA structure, replication, gene expression and genetic code.
4. Study of mitotic index from suitable plant material.

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CO No.	Expected Course Outcomes Upon completion of this course, the students will be able to	Knowledge Level
1	Infer the structure and function of the cell, its organelles, cytoskeleton, cell cycle and cell death.	K2
2	Identify the components of cell signaling and its applications.	K3
3	Interpret the structure and function of nucleic acids and chromosomes.	K5
4	Explain about DNA replication, repair, recombination and significance.	K2, K4
5	Distinguish and compare the processes and mechanisms involved in Transcription and Translation.	K4, K5
6	Analyze and assess the regulation of gene expression in Viral, Prokaryotic and Eukaryotic systems	K4, K5
Knowledge Levels: K1-Remembering; K2-Understanding; K3-Applying; K4-Analyzing; K5-Evaluating; K6-Creating.		

PG20BO207: PLANT ANATOMY AND PRINCIPLES OF ANGIOSPERM SYSTEMATICS

(Theory 36 + 36 hrs; Practical 36 + 27 hrs; Credits 4)

Objectives

- To understand the primary and secondary structure of different plant parts.
- To know the morphological and anatomical adaptations of plants growing in different habitats.
- To realize the applications of anatomy in systematics and pharmacognosy.
- To develop insight on phylogeny of angiosperms

Plant Anatomy (36 hrs)

Module 1: Introduction (1 hr)

Scope and significance of plant anatomy, interdisciplinary relations.

Module 2: Meristem (7 hrs)

(a) Apical organization: Stages of development of primary meristem and theories of apical organization, origin of branches and lateral roots. Primary thickening meristem (PTM) in monocots. Reproductive apex in angiosperms.

(b) Secretory tissues in plants: Structure and distribution of secretory trichomes (*Drocera, Nepenthes*), salt glands, colleters, nectaries, resin ducts and laticifers. Structure of bark and

distribution pattern of laticifers in *Hevea brasiliensis.*

Module 3: Secondary structure (10 hrs)

(a) Vascular cambium and cork cambium: Structure and function, factors affecting cambial activity.
(b) Secondary xylem and phloem: Ontogeny, structure and function. Lignification patterns of xylem.
(c) Reaction wood: Compression wood and tension wood. Factors affecting reaction wood formation.
(d) Anomalous secondary growth in dicots and monocots.
(e) Wood: Physical, chemical and mechanical properties.
(f) Plant fibers: Distribution, structure and commercial importance of coir, jute, and cotton.

Module 4: Leaf and node (6 hrs)

(a) Leaf: Initiation, plastochronic changes, ontogeny and structure of leaf. Structure, development and classification of stomata and trichomes. Krantz anatomy, anatomical peculiarities in CAM plants. Leaf abscission.
(b) Nodal anatomy: Unilacunar, trilacunar and multilacunar nodes, nodal evolution.
(c) Root-stem transition in angiosperms.

Module 5: Reproductive anatomy (6 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.

Module 6: Ecological anatomy (2 hrs)

Morphological and structural adaptations in different ecological groups - hydrophytes, xerophytes, epiphytes and halophytes.

Module 7: Applied anatomy (4 hrs)

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

Practical: (36 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

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Principles of Angiosperm Systematics (36 hrs)

Module 1: Scope and significance of Taxonomy (2 hrs)

Historical background of classification - Artificial, natural and phylogenetic systems. Importance of taxonomy.

Module 2: Concepts of Taxonomic hierarchy (2 hrs)

Species/Genus/Family and other categories; species concept and intraspecific categories - subspecies, varieties and forms.

Module 3: Phylogeny of Angiosperms (6 hrs)

Important phylogenetic terms and concepts: Plesiomorphic and Apomorphic characters; Homology and Analogy; Parallelism and Convergence; Monophyly, Paraphyly and Polyphyly. Phylogenetic tree - Cladogram and Phenogram.

Module 4: Data sources of Taxonomy (4 hrs)

Concepts of character; Sources of taxonomic characters - Anatomy, Cytology, Phytochemistry and molecular taxonomy.

Module 5: Concept and principles of assessing relationships (4 hrs)

Phenetic - Numerical Taxonomy - principles and methods; Cladistic - Principles and methods.

Module 6: Botanical nomenclature (6 hrs)

History of ICBN, aims and principles, rules and recommendations: rule of priority, typification, author citation, retention, rejection and changing of names, effective and valid publication.

Module 7: Synthetic approaches to the systematics of angiosperms (4 hrs)

Chemotaxonomy, basic concepts of genome analysis – bar coding.

Module 8: Morphology of Angiosperms (8 hrs)

Habitat and habit; Morphology of root, stem, leaf, bract and bracteoles, inflorescence, flowers, fruits and seeds. Morphological features of Annonaceaea, Malvaceae, Cucurbitaceae and Convolvulaceae.

Practical (27 hrs)

1. Morphology of leaf: Leaf attachment, Stipules, Patterns of leaf, Phyllotaxy, Shapes of leaf lamina, bases, margins and tips, Venation.

2. Inflorescence: Racemose - Simple raceme, Compound raceme, Spike, Spikelet, Catkin, Spadix, Corymb, Simple umbel, Compound umbel, Panicle, Capitulum. Cymose - Solitary cyme, Mono-, Di- and polychasial cyme. Special types - Cyathium, Verticillaster, Hypanthodium, Coenanthium.

3. Morphology of stamens: Mono-, Di- and Polyadelphous; Epipetalous, Syngenesious, Synandrous, Polyandrous, Didynamous, Tetradynamous, Basifixed, Dorsifixed, Versatile.
4. Morphology of carpels: Apocarpous, Syncarpous, Gynostegium. Placentation - Marginal, Parietal, Axile, Free central, Basal and Pendulous.
5. Morphology of fruits: Berry, Drupe, Hesperidium, Pepo, Balausta, Amphisarca, Achene, Follicle, Capsule, Legume, Lomentum, Nut, Caryopsis, Cypsela, Samara, Cremocarp, Siliqua, Carcerule, Regma. Aggregate fruits; Composite fruits - Sorosis and Syconus; Pome.
6. Workout plant specimens collected locally for vegetative and reproductive characters.
7. Workout nomenclatural problems regarding priority and author citations.

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CO No.	Expected Course Outcomes Upon completion of this course, the students will be able to	Knowledge Level
1	Explain the scope & significance of anatomy and analyze its interdisciplinary relevance	K2,K4
2	Compare the structure and ontogeny of different plant parts	K5
3	Explain the morphological and anatomical adaptations of different ecological groups.	K2
3	Explain the concepts, scope, significance and data sources of taxonomy	K2
4	Identify and compare morphological and structural characters of flowers and fruits	K5
5	Outline the history of nomenclature and classification of plants and analyze recent trends in plant systematics.	K4
6	Apply anatomical techniques in systematics and research.	K3
Knowledge Levels: K1-Remembering; K2-Understanding; K3-Applying; K4-Analyzing; K5-Evaluating; K6-Creating.		

PG20BO208: GENETICS AND BIOCHEMISTRY
(Theory 18 + 36 hrs; Practical 18 + 18 hrs; Credits 3)

Objectives

- To comprehend the history of genetics.
- To know the genetic basis of linkage and cancer.
- To learn the structure and classification of carbohydrates, lipids, amino acids and proteins.
- To study enzyme kinetics and nucleotide metabolism.

Genetics (18 hrs)

Module 1: History of Genetics (2 hrs)

Transmission genetics, Molecular genetics and Population genetics (brief introduction). Mendelism – basic principles (brief study). Extensions of Mendelism, penetrance and expressivity of genes. Nonmendelian inheritance – cytoplasmic inheritance. Sex determination in animals and plants.

Module 2: Linkage and genetic mapping (6 hrs)

Linkage and Crossing over - Stern's hypothesis, Creighton and McClintock's experiments, single cross over, multiple cross over, two-point cross, three-point cross, map distances, gene order, interference and co-efficient of coincidence. Haploid mapping (*Neurospora*), Mapping in bacteria and bacteriophages. Inheritance of traits in humans; pedigree analysis, determination of human genetic diseases by pedigree analysis, genetic mapping in human pedigrees.

Module 3: Quantitative genetics (2 hrs)

Polygenic inheritance, QTL, effect of environmental factors and artificial selection on polygenic inheritance.

Module 4: Genetics of Cancer (3 hrs)

Genetic basis of cancer. Proto-oncogenes, oncogenes, conversion of proto-oncogenes to oncogenes. Tumor suppressor genes – functions, role of p53. Viral oncogenes.

Module 5: Population genetics (5 hrs)

(a) Gene pool, allele and genotype frequency. Hardy-Weinberg law and its applications, estimation of allele and genotype frequency of dominant genes, codominant genes, sex-linked genes and multiple alleles. Genetic equilibrium, genetic polymorphism.

(b) Factors that alter allelic frequencies; (i) mutation (ii) genetic drift - bottle neck effect and founder effect (iii) migration (iv) selection (v) nonrandom mating, inbreeding coefficient.

Practical (18 hrs)

1. Workout problems related to linkage, crossing over and gene mapping, human pedigree analysis.
2. Workout problems in population genetics - gene and genotype frequency, Hardy Wienberg equilibrium.

References

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Biochemistry (36 hrs)

Module 1: pH and Buffers (4 hrs)

Acids and bases [1], strength of acids – strong acids, weak acids [1, 7]. Ionization of water – Kw, pH [1, 2, 3, 4, 7, 8]. Dissociation of acids – pKa, Henderson-Hasselbalch equation [1, 2, 3, 4, 7, 8]. Buffers [7] – definition, chemical composition, requirements for a good buffer, buffer action, buffer capacity [1]. Measurement of pH – colorimetric methods and electrometric methods [1]

Module 2: Carbohydrates (5 hrs)

Structure and Biological Functions [2, 3, 4, 6, 8]. Monosaccharides: Classification, structure, [2, 3, 4, 6, 8]. Oligosaccharides: Structure, formation; common examples – sucrose, lactose [2, 6, 8]. Polysaccharides: Classification, functions – structure of cellulose, starch and glycogen [2, 3, 4, 6, 8]. Sugar derivatives: Glycoproteins, proteoglycans, mucoproteins [2, 3, 4, 6]. Lectins [2, 3].

Module 3: Lipids (4 hrs)

Classification, properties, functions [2, 3, 4]. Structure of fatty acids, essential fatty acids [2, 3, 4]. Storage lipids – triglycerols. Structural lipids – membrane lipids. Lipid biosynthesis, fat breakdown – β oxidation.

Module 4: Amino acids (2 hrs)

Structure and classification of amino acids [2, 3, 6]. Biosynthesis of amino acids [2, 9].

Module 5: Proteins (5 hrs)

Classification of proteins based on structure and function [2, 5]. Oligo- and polypeptides [2, 3, 6]. Primary structure – peptide bond [5, 6]. Secondary structure – Ramachandran plots, α-helix, β sheet [2, 3, 4, 5, 6, 8]. Tertiary structure – forces that stabilize tertiary structure [2, 3, 4, 5, 8]. Quaternary structure, domains, motif and folds [5, 6]. Protein sequencing – Edman method [2, 6, 7, 8]. Functions of proteins [2, 6].

Module 6: Enzymes (10 hrs)

(a) Principles of catalysis: Activation energy of a reaction [2, 3, 4, 6]. General characters of enzymes - specificity, catalytic power, regulation. IUB system of enzyme classification and naming.

(b) Mechanism of enzyme activity: Formation of ES complex, acid-base catalysis, covalent catalysis, metal ion catalysis, proximity and orientation effect, strain and distortion theory [2, 6, 8]. Factors affecting enzyme activity [6, 7].

(c) Enzyme Kinetics: Michaelis-Menton kinetics, Lineweaver-Burk plot [2, 4, 6, 7, 8]. Mechanism of multi substrate reaction – Ping Pong, Bi-Bi mechanism [2, 7, 8].

(d) Regulation of enzyme activity: Allosteric effect, control proteins, reversible covalent modification, proteolytic activation [2, 3, 6, 7, 8]. Enzyme inhibition – reversible and irreversible inhibition, competitive, non-competitive, uncompetitive inhibition [2, 6, 7, 8], dixon plot [7].

(e) Cofactors and coenzymes: Essential ions, Coenzymes; structure and role of metabolite coenzymes [7, 8] – ATP; structure and role of vitamin derived coenzymes – NAD^+, $NADP^+$, FAD, FMN, TPP, PLP, Biotin [8]. Isozymes [2]. (f) Ribozymes and abzymes (Brief account)

Module 7: Nucleotide metabolism (2 hrs)

Functions of nucleotides, nucleotide biosynthesis by *de novo* pathways and salvage pathways [2].

Module 8: Secondary metabolites (4 hrs)

Classification, biosynthesis, and functions of terpenoids, alkaloids, phenolics, flavonoids, coumarins [9].

Practical (18 hrs)

1. Preparation of buffers of various strength and pH.
2. Differentiating sugars based on osazone formation.
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. Preparation of molal, molar, normal and percentage solutions and their dilutions.
7. Estimation of total phenolics.
8. Estimation of peroxidase activity.
9. Estimation of catalase activity.
10. Isolation and assay of amylase enzyme from germinating Pea seeds/appropriate plant material.

References

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3. Michael M Cox, David L Nelson (2008). *Lehninger Principles of biochemistry* (V Edn). W H Freeman and company.
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CO No.	Expected Course Outcomes Upon completion of this course, the students will be able to	Knowledge Level
1	Recall the history of genetics	K1
2	Analyze the concepts involved in population genetics	K4
3	Interpret the genetic basis of linkage and cancer	K2
4	Classify and compare the structure of biomolecules	K2, K4
5	Analyze the structure of enzymes and mechanism of action	K4
6	Explain the biosynthesis and function of secondary metabolites and apply in systematics and research	K3, K4
Knowledge Levels: K1-Remembering; K2-Understanding; K3-Applying; K4-Analyzing; K5-Evaluating; K6-Creating.		

SEMESTER II MODEL QUESTION PAPERS – THEORY

Semester II Course 5
Model Question Paper
PG20BO205: ENVIRONMENTAL BIOLOGY AND DVELOMENTAL BIOLOGY
Time 3 hours Weightage 30

I. Answer any ***eight*** of the following in not less than 50 words (Weight 1 each)

1. What is ecological niche?
2. Define remote sensing.
3. What are bioscrubbers?
4. What is the significance of *El Nino*?
5. Describe ISO 14000.
6. Describe (a) Double fertilization (b) Triple fusion
7. Mention what is the N.P.C. formula?
8. Explain resilience community.
9. What is apomixes?
10. Give an account on poly embryony.

II. Answer any ***six*** of the following in not less than 100 words (Weight 2 each)

11. Briefly describe the environmental safety provisions in Indian constitution.
12. Write an account on heavy metal contamination of water and its consequences.
13. What are the principles involved in solid waste management?
14. Give an account of conservation in biosphere reserves.
15. Describe the role of biotechnology in conservation of species.
16. What are the applications of remote sensing in environmental studies?
17. What are water quality parameters and standards? Discuss the role of aquatic macrophytes in waste
water treatment.
18. What is ecological succession? Give the different types of succession and the important events in succession.

III. Answer any ***two*** of the following in not less than 250 words (Weight 5 each)

19. Which are the major ecosystems in the world? Write a comparative account of them with reference
to their productivity, biodiversity, energy flow, and food chain and tropic levels.
20. Write an account on the criteria of classification of plant communities and explain the dynamic system of classification proposed by Clement.
21. Write an essay on morphogenesis and organogenesis in plants.
22. What are the developmental changes in the shoot apex leading to floral induction? Add a note on the
structure of floral meristem and the development of flower.

Semester II Course 6
Model Question Paper
PG20BO206: CELL AND MOLECULAR BIOLOGY
Time 3 hours Weightage 30

I. Answer any ***eight*** of the following in not less than 50 words (Weight 1 each)

1. Describe the endosymbiont hypothesis on the origin of chloroplast and mitochondria.
2. Explain the role of the following enzymes/proteins;
(a) Rho protein (b) Sigma factor (c) Gyrase (d) Cro protein
3. Write a brief account on ribozymes.
4. What is the genetic significance of the fact that gametes contain half the chromosome complement of
somatic cells?
5. Describe the function and importance of the 3' to 5' exonuclease activity of DNA polymerases.
6. Explain the opposite polarity of the double stranded DNA.
7. In what sense does attenuation provide a "fine tuning" mechanism for operons that control amino acid
biosynthesis?
8. How does the spontaneous depurination of DNA repaired?
9. Describe the following; (a) Apoptosis (b) Riboswitches.
10. Explain the phenomenon of RNAi?

II. Answer any ***six*** of the following in not less than 100 words (Weight 2 each)

11. Draw the diagram of a bivalent chromosome and label the following parts: centromere, sister chromatids, nonsister chromatids, homologous chromosomes, chiasma.
12. How is RNAi involved in gene regulation?
13. Describe the self-assembly and the dynamic structure of cytoskeletal filaments.
14. Describe the experimental methods used to crack the complete genetic code.
15. Describe the genetic control of the entry of a Lambda phage into lytic or lysogenic growth.
16. Write briefly on the following;
(a) Shine-Dalgarno sequence (b) Kozak sequence (c) Amber codons (d) DNA quadruplex
17. Describe the structure and functions of glyoxysomes and peroxisomes.
18. What are transposons? Write a brief account on the types of transposons.

III. Answer any ***two*** of the following in not less than 250 words (Weight 5 each)

19. Describe the various modifications that the eukaryotic pre-mRNA usually undergoes.
20. Compare the following; (a) Eucaryotic and prokaryotic promoters (b) Eucaryotic and prokaryotic Ribosomes (c) Eucaryotic and prokaryotic RNA polymerases (d) Eucaryotic and prokaryotic DNA polymerases
21. Write a comparative account of the molecular events taking place in the 5' – 3' synthesis of RNA during transcription and the 5' – 3' synthesis of DNA during the replication of DNA.
22. What are cell-cycle checkpoints? Describe the principal checkpoints in the cell cycle.

Semester II Course 7
Model Question Paper
PG20BO207: PLANT ANATOMY AND PRINCIPLES OF ANGIOSPERM SYSTEMATICS
Time 3 hours Weightage 30

I. Answer any ***eight*** of the following in not less than 50 words (Weight 1 each)

1. Discuss the economic importance of plant fibres
2. Describe the structure and function of wood parenchyma.
3. Describe the changes in the shoot apex during leaf development
4. 'Anatomy can solve taxonomic problems'. Discuss
5. Define and discuss the theories of epigynous ovary development
6. Comment on the concept of species
7. What is the rule of priority? Comment on its importance
8. Eplain the pliesiomorphic and apomorphic characters.
9. Briefly describe different nodal patterns and their evolutionary trends.
10. Describe the seasonal activity of cambium and wood development

II. Answer any ***six*** of the following in not less than 100 words (Weight 2 each)

11. Describe the structure and development of stomata and trichomes.
12. What is Krantz anatomy? Mention its significance.
13. Briefly explain the current views on the origin of Angiosperms
14. Explain the concept of hierarchy in plant classification
15. Describe patterns of leaf and shapes of leaf with suitable diagram
16. Explain the types of stamens based on adelphy drawing suitable diagrams
17. Write an account on interrelationship between various plant structures and their function
18. How do anatomy, cytology and phytochemistry serve as characters of taxonomic importance?

III. Answer any ***two*** of the following in not less than 250 words (Weight 5 each)

19. With suitable examples and illustrations describe various anomalous primary and secondary structures in the stem of angiosperms
20. How do plants grow in extreme climates? Discuss your explanations with suitable examples
21. Critically evaluate the phenetic and cladistic approaches in plant systematics.
22. Give a deailed account on seceory tissues in plants.

Semester II Course 8
Model Question Paper
PG20BO205: GENETICS AND BIOCHEMISTRY
Time 3 hours Weightage 30

I. Answer any ***eight*** of the following in not less than 50 words (Weight 1 each)

1. Explain the relationships between the following pairs of genetic terms:
(a) Genotype and phenotype (b) Gene and trait (c) Allele and gene (c) Gene and chromosome
2. What is a double crossover? How many different kinds of double crossovers are possible?
3. Explain the following;
(a) p53 (b) QTL (c) Gene pool (d) Centimorgan
4. Derive Henderson-Hasselbalch equation
5. Describe the following;
(a) Km (b) pKa (c) Vmax (d) Kw
6. What are Lectins?
7. What are isozymes?
8. Describe the major differences of enzymes from ordinary chemical catalysts
9. Explain the following; (a) Dominance (b) Incomplete dominance (c) Codominance (d) Overdominance.
10. Describe buffer action citing suitable examples.

II. Answer any s***ix*** of the following in not less than 100 words (Weight 2 each)

11. Describe the procedure of protein sequencing by Edman degradation method.
12. Describe the following terms which are related to protein structure;
(a) Quaternary structure (b) α-helix (c) Peptide unit (d) Hydrogen bonds
13. Compare and contrast the chemical structure of Starch, Cellulose and Glycogen.
14. Describe the salvage pathway of nucleotide biosynthesis.
15. What is Hardy-Weinberg equilibrium? What are the applications of Hardy-Weinberg principles?
16. Write an account on the types and functions of common secondary metabolites found in plants.
17. 'Fatty acids, stored as triglycerides in an organism, are an important source of energy'. Explain how
the cells harness this energy source to generate ATP molecules?
18. Give a brief account on cofactors and coenzymes.

III. Answer any ***two*** of the following in not less than 250 words (Weight 5 each)

19. Write an essay on funtions of proteins in living organisms.
20. What is allele and genotype frequency? What is the relationship between them in a large, random mating, natural population? Name the processes that can change the allele frequencies in natural populations?
21. Write an account on the different methods of regulation of enzyme activity.
22. What is polygenic inheritance? Give suitable examples for polygenic inheritance. Discuss the issues
that make polygenic inheritance difficult to study.

SEMESTER III

Course	Title	Teaching hrs Theory	Teaching hrs Practical	Credits
PG20BO309	Research Methodology, Biophysical instrumentation, Biostatistics and Microtechnique	18 + 18 + 18 + 18	9 + 18 + 18 + 27	4
PG20BO310	Plant Physiology and Plant Breeding	54 + 18	36 + 9	4
PG20BO311	Biotechnology	72	27	4
PG20BO312	Taxonomy of Angiosperms	54	36	3
PG20BOP5	Practicals of Research Methodology, Biophysical instrumentation, Biostatistics and Microtechnique & Plant Physiology and Plant Breeding			2
PG20BOP6	Practicals of Biotechnology & Taxonomy of Angiosperms			2

PG19BO309: RESEARCH METHODOLOGY, BIOPHYSICAL INSTRUMENTATION, BIOSTATISTICS AND MICROTECHNIQUE
(Theory 18 + 18 + 18 + 18 hrs; Practical 9 + 18 + 18 + 27 hrs; Credits: 4)

Objectives

- To understand the methods of research and preparation of research reports.
- To study the principles and applications of instruments used in biological studies.
- To know about statistical tools used in research and analysis.
- To learn specimen preparation for microscopic studies.

Research methodology (18 hrs)

Module 1: Introduction (2 hrs)
Need for research, stages of research; Generation of a research problem, execution of work, nterpretation of results.
Module 2: Review of literature (6 hrs)
(a) Library: (i) Structure of a scientific library, journals (current and back volumes), books.
(ii) Catalogue: Types of catalogues - Card catalogue, computerized catalogue (iii) Classification of books (Universal Decimal System).
(b) Journals: Indexing journals, abstracting journals, research journals, review journals, e-journals. Impact factor of journals, NCBI-Pub Med.
(c) Other sources of references: (i) Reprints - acquisition and filing (ii) Secondary storage devices - pen drive, external hard drive, DVD and CD ROM (iii) Internet, open access initiative, INFLIBNET, INSDOC.
(d) Preparation of index cards: Author index and subject index; Open source bibliography management system.
Module 3: Preparation of project proposals (2 hrs)
(a) Title, Introduction, literature review and abstract (b) Aim and scope (c) Present status (d) Location of experiments (e) Materials and methods (f) Justification (g) Expected outcome (h) Date of commencement (g) Estimated date of completion (h) Estimated cost (i) References (j) Funding

agencies.

Module 4: Presentation and publication of research outcomes (8 hrs)

(a) Preparation of a dissertation: (i) Consolidation and analysis of data, photographs, illustration, tables and graphs (ii) Preparation of the outline (iii) Preparation of manuscript - introduction, review of literature, materials and methods, results, discussion, bibliography (methods of citing references, arrangement of references), summary (iv) Preliminary pages - title page, certificates, acknowledgements, and contents page.
(b) Preparation of research paper and short communications.
(c) Preparation of review articles.
(d) Proof reading - standard abbreviations for proof correction.
(e) Plagiarism
(f) Presentation of research findings in seminars and workshops.

Practical (9 hrs)

1. Visit a scientific library or documentation centre and submit a report.
2. Prepare a project proposal.
3. Prepare an outline of dissertation and research paper.
4. Prepare a list of references.
5. Present a small project in the class with the help of LCD projector and submit the CD for evaluation.
6. Familiarisation with softwares used in research

References

1. Anderson J, Durston B H, Poole (1970). *Thesis and assignment writing*. Wiley eastern.
2. Bedekar V H (1982). *How to write assignment and research papers, dissertations and thesis*. Kanak publications.
3. Bercy R (1994). *The research project, how to write it*. Rutledge, London.
4. Clifford Hawkins, Marco Sorghi. *Research: How to plan and speak about it and write about it*. Narosa Publishing Company.
5. Day R.A (1979). *How to write and publish a scientific paper*. Cambridge University press.
6. Joseph Gibaldi (2000). *MLA Handbook for writers of research papers*. Affiliated East West Press Pvt. Ltd.
7. Kothari. *Research Methodology*.
8.Krishnakumar K (1981). *An introduction to cataloguing practice*. Vikas Publishing house.
9. Judith Bell. *How to complete your research project successfully*. UBS Publishers and Distributors Ltd.
10. Parshar R G (1989). *Index and indexing systems*. Me dallion press New Delhi.
11. Victoria E McMillan (1997). *Writing papers in the biological sciences* (II Edn). Bedford books.
12. www.opengate.com

Biophysical Instrumentation: (18 hrs)

Module 1: Microscopy (8 hrs)

Parts of microscope, principles of microscopy. Types of microscopes - simple and compound; Stereo microscope, Phase contrast microscope, Fluorescence microscope, Polarization microscope, Confocal microscope and electron microscope (TEM, SEM and E-SEM). Micrometry, Photomicrography and microphotography.

Module 2: Principles and applications of instruments (10 hrs)

(a) Basic principles and applications of; (i) pH meter (ii) UV-visible spectrophotometers (iii) Centrifuges (Basic principles of table top centrifuge and ultra centrifuge, centrifugation techniques).
(b) Chromatography: Principles and application; paper, TLC, Column chromatography, GC, HPLC.
(c) Immunoassay systems, RIA, ELISA - ELISA reader.
(d) Electrophoresis: SDS PAGE.

(e) X-ray crystallography, Lyophilisation.
(f) Haemocytometer.

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.
5. Henry B Bull (1971). *An Introduction to physical biochemistry*. F A Devis Co.
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.
8. Friefelder D. *Physical Biochemistry*. W H Freeman and Co.
9. Mahadevan A, Sridhar R (1996). *Methods in Physiological Plant Pathology*. Sivakmi Publications.
10. Salle A J (1974). *Fundamental principles of Bacteriology*. McGraw Hill.

Biostatistics (18 hrs)

Module 1 Basic principles of Biostatistics (2 hrs)
Methods of collection and classification of data; Primary and secondary data, qualitative and quantitative data. Frequency distribution, graphical representation, normal distribution.
Module 2: Measures of central tendency (2 hrs)
(a) Mean
(b) Median
(c) Mode
Module 3: Measures of dispersion (2 hrs)
Mean deviation, Standard deviation, variance, standard error, co-efficient of variation.
Module 4: Probability (2 hrs)
Probability - Definition, mutually exclusive events – sum rule, independent events – product rule. Probability of unordered combination of events.
Module 5: Tests of significance (3 hrs)
Statistical inference – estimation - testing of hypothesis - t-test, Chi square test (goodness of fit, independence or association, detection of linkages), F-test, ANOVA.
Module 6: Correlation and Regression (2 hrs)
Linear regression and correlation (simple and multiple).
Module 7: Design of experiments (3 hrs)
(a) Experimental designs: Principles - replication and randomization.
(b) Common designs in biological experiments: Completely randomized design, randomized block design, Latin square design, Factorial design.
Module 8: Statistical tools (2 hour)
SPSS and R programming (brief study)

Practical (18 hrs)

1. Analysis of data to find the mean, median and mode.
2. Analysis of a given data for mean deviation and standard deviation.
3. Test the significance of a given data using t test, X^2 test, F-test and ANOVA.
4. Analysis of a set of data for correlation/regression.

5. Determine probability for different types of events.

References

1. Chandel R S (1975). *A handbook of Agricultural statistics*. Achal prakashan Mandir.
2. Gomez K A, Gomez A A (1984). *Statistical procedures for agricultndural research*. John Wiley and sons.
3. Gupta S P (1984). *Statistical methods*. S Chand and company.
4. Panse V G, Sukathme P V (1995). *Statistical methods for Agricultural workers*. ICAR.
5. Robert J Brooker (2009). *Genetics: analysis & principles* (III Edn). McGraw Hill.

Microtechnique (18 hrs)

Module 1: Killing and fixing (2 hrs)

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.

Module 2: Dehydration, clearing, embedding and sectioning (5 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.

Module 3: Staining (3 hrs)

(a) 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.

(b) 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.

(c) Histochemical localization of starch, protein, lipid and lignin.

Module 4: Specimen preparation for transmission electron microscopy (3 hrs)

Material collection, fixing, dehydration, embedding, sectioning (glass knife preparation, grid preparation, ultra microtome) and staining.

Module 5: Whole mounts (5 hrs)

(a) 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.

(b) Techniques of smear, squash and maceration.

(c) Mounting: Techniques, common mounting media used - DPX, Canada balsam, Glycerine jelly and Lactophenol. Cleaning, labeling and storage of slides.

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. Candidates should prepare and submit 10 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.

CO No.	EXPECTED COURSE OUTCOME Upon completion of this course, the students will be able to	Knowledge Level
1	Interpret basic concepts of research, its methodologies and significance	**K2**
2	Formulate a research proposal in a scientific and systematic manner.	**K6**
2	Develop the skills necessary to carry out research, analyse statistically, interpret results and document findings.	**K6**
3	Explain the principles and applications of instruments in the field of biology.	**K2, K3**
4	Develop temporary and permanent microscopic slides.	**K6**
Knowledge Levels: K1-Remembering; K2-Understanding; K3-Applying; K4-Analyzing; K5-Evaluating; K6-Creating.		

PG20BO310: PLANT PHYSIOLOGY AND PLANT BREEDING
(Theory 54 + 18 hrs; Practical 36 + 9 hrs; Credits: 4)

Objectives

- To develop a detailed understanding about plant functions.
- To understand the influence of environmental variables on plant metabolism.
- To acquire knowledge about methods of plant breeding and their application in crop improvement.

Plant physiology (54 hrs)

Module 1: Plant water relations (6 hrs)
Structure and properties of water [1, 4, 5]. Water transport – diffusion, bulk flow [1, 5]. Osmosis – water potential [1, 5]. Water absorption by root [1], pathways of water uptake and transport [1, 2], xylem and phloem transport [2, 5], passive and active transport [1, 2, 5]. Aquaporins [1, 2]. Water pathway in the leaf – driving force of transpiration, leaf anatomy for regulating transpiration [1]. Control of stomatal mechanism [5]. Soil-plant-atmosphere continuum [1].

Module 2: Absorption of minerals (2 hrs)
Soil characters influencing nutrient availability – size and charge of soil particles, soil pH [1]. Entry of minerals into roots; bulk flow, diffusion [1, 5]. Role of Mycorrhizae in nutrient uptake [1, 5].

Module 3: Transport of ions, solutes and macromolecules (5 hrs)
Electrical properties of membranes, Membrane potential [1, 6]. Transport across cell membranes:

Passive
– diffusion, facilitated diffusion, membrane channels; gap junctions, porins, ion channels – gatedchannels, structure and working of K^+ ion channels [1, 6, 7, 8, 9, 10, 11]. Active transport: Carrier proteins; Na^+K^+ pump, ABC transporters [1, 6, 7, 8, 9, 10].

Module 4: Photosynthesis (12 hrs)

(a) Light harvesting complexes: PS I, PSII; Structure and composition of reaction centers [1, 2, 5]. Basic principles of light absorption, excitation energy transfer, mechanism of electron transport [1, 2, 3, 4, 5], photooxidation of water [1, 5], proton electrochemical potential – photophosphorylation [2, 3, 5].
(b) Structure and function of RuBisco [1, 5], CO_2 fixation – Calvin cycle [1, 2, 5]. Photorespiration [1, 2, 5], role of photorespiration in plants [2]. CO_2 concentrating mechanisms – algal and cyanobacterial pumps, C4 cycle, CAM pathway [1, 2, 5]. Photoprotective mechanisms [1]. Synthesis of starch and sucrose [1, 2, 5], photosynthetic quantum yield and energy conversion efficiency [1]. Transport of photoassimilates – phloem loading and unloading [1, 5], mechanism of phloem translocation – pressure flow [1]. Thylakoid ET inhibitors, Photoinhibition and its tolerance mechanism.

Module 5: Respiration (10 hrs)

(a) Three stages of respiratory metabolism [1, 2, 5] (brief study only). Plant mitochondrial electron transport and ATP synthesis – structure of electron transfer complexes (complex I – IV) [1, 2, 3, 4]. ATPase – detailed structure of F1 and Fo subunits, binding change mechanism of ATP synthesis [1, 2, 3, 4]. Comparison of mitochondrial and chloroplast ATP synthesis [2, 3]. Cyanide resistant pathway - alternative oxidase, its regulation and significance [1, 2, 5].
(b) Lipid metabolism in oilseeds – glyoxylate cycle, gluconeogenesis [1, 2, 5].

Module 6: Nitrogen metabolism: (5 hrs)

N cycle [1, 5]. N fixation processes [1]. Biological N fixation – structure of nitrogenase complex [2], reduction of N [1, 2]. Symbiotic N fixation – nodule formation, leghaemoglobin [1, 2, 5]. Nitrate and ammonium assimilation [1, 2, 5]. Transport of amides and ureides.

Module 7: Stress physiology (5 hrs)

Response of plants to biotic (pathogen and insects) [2] and abiotic (water, temperature – low and high, salt, oxygen deficiency, heavy metal and air pollution) stresses [1, 2, 5]. Mechanisms of resistance to biotic stress [2] and tolerance to abiotic stress [1, 2, 5].

Module 8: Sensory photobiology (4 hrs)

Structure, function and mechanisms of action of phytochromes [1, 2, 5], cryptochromes [2, 5, 6], phytochrome mediated plant responses [2]. Photoperiodism and biological clocks – circadian rhythms [1, 5]. Floral induction and development [1, 2]

Module 9: Plant growth regulators (5 hrs)

Biosynthesis, storage, breakdown, transport, physiological effects, and mechanism of action of plant growth hormones, elicitors [1, 5].

Practical (27 hrs)

1. Measurement of Photosynthesis - Hill Reaction.
2. Estimation of proline in plant tissues under various abiotic stresses [12].
3. Estimation of phenol in plant tissues affected by biotic stress [12].
4. Determination of peroxidase activity in plant tissues affected by biotic/abiotic stresses [12].
5. Estimation of free amino acids in senescing leaves to understand the source to sink transformation phenomenon [12].
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 [12].
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.

References

1. Lincoln Taiz, Eduardo Zeiger (2002). *Plant physiology* (II Edn). Sinaeur Associates, Inc. Publishers.
2. Bob B Buchanan, Wilhelm Gruissem, Russel L Jones (2000). *Biochemistry and molecular biology of plants*. L K International Pvt. Ltd.
3. Reginald H Garrett, Charles M Grisham (2005). *Biochemistry*. Thomson Brooks/Cole
4. H Robert Horton, Laurence A Moran, Raymond S Ochr, J David Rawn, K Gray Scrimgeour (2002).
Principles of Biochemistry (III Edn). Prentice Hall.
5. Frank B Salisbury, Cleon W Ross (1992). *Plant Physiology* (IV Edn). Wadsworth Publishing Company.
6. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter (2002). *Molecular biology of the cell* (IV Edn). Garland Science, Taylor and Francis group.
7. Gerald Karp (2008). *Cell and Molecular biology: Concepts and experiments* (V Edn). John Wiley & Sons.
8. Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Matthew P. Scott, Anthony Bretscher, Hidde Ploegh, Paul Matsudaira (2007). *Molecular cell biology* (VI Edn). W H Freeman & Company.
9. William H Elliott, Daphne C Elliott (2001). *Biochemistry and molecular biology* (II Edn). Oxford
10. Jeremy M Berg, John L Tymoczko, Lubert Stryer, Gregory J Gatto Jr. (2007). *Biochemistry*. W H Freeman and company.
11. David E Sadava (2009). *Cell biology: Organelle structure and function*. CBS
12. S Sadasivam, A Manickam (1996). *Biochemical methods* (II Edn). New age international Publishers.

Plant Breeding (18 hrs)

Module 1: Introduction (3 hrs)
Objectives of plant breeding, important achievements and future prospects. Genetic variability and its role in plant breeding. Domestication and centers of origin of cultivated plants.
Module 2: Systems of reproduction in plants (3 hrs)
Reproductive systems and pollination control mechanisms; Sexual reproduction - Cross and self pollination; asexual reproduction, Incompatibility and Male sterility, their types.
Module 3: Hybridization (3 hrs)
Hybridization - role and methods, Inter-varietal, inter specific and inter generic crosses. Back-cross breeding. Heterosis, Inbreeding depression.
Module 4: Breeding for resistance (3 hrs)
Breeding for biotic (disease) and abiotic (drought) stresses; loss due to diseases, disease development, disease escape, disease resistance, vertical and horizontal resistances of biotic stress; methods of breeding for disease resistance.
Module 5: Mutation breeding (4 hrs)
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.
Module 6: Modern breeding methods (2 hrs)
Modern trends in plant breeding.

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 (1995). *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.
3. Sharma J R (1994). *Principles and practices of Plant Breeding*. Tata McGraw-Hill Publishers Company Ltd.
4. Singh B D (1996). *Plant Breeding: Principles and methods*. Kalyani Publications.

CO No.	Expected Course Outcomes Upon completion of this course, the students will be able to	Knowledge Level
1	Perceive the phenomena of absorption and transport of water and minerals	K2, K4
2	Analyze the mechanism of photosynthesis.	K4
3	Explain the significance of respiration in sustaining life	K2
4	Interpret the role of growth regulators, phytochromes and their applications	K2 K3
6	Compare different breeding techniques, its applications and limitations.	K4 K3
Knowledge Levels: K1-Remembering; K2-Understanding; K3-Applying; K4-Analyzing; K5-Evaluating; K6-Creating.		

PG20BO311: BIOTECHNOLOGY
(Theory 72 hrs, Practical 27 hrs; Credits: 4)

Objectives

- To study the principles and methods of in vitro plant propagation.
- To understand the techniques employed in genetic engineering and gene cloning.
- To learn the social and ethical issues related to biotechnology.
- To study applications of microorganisms in industry.

Module 1: History of biotechnology (1 hr)

Introduction to classical and modern biotechnology (1, 7).

Module 2: Microbial biotechnology (5 hrs)

Commercial production of metabolites using bioreactors (45). Submerged and solid state fermentation (44, 45, 48). Microbes in production of enzymes (1, 32, 33, 35, 44, 46, 47), antibiotics (1, 34, 39, 46, 47), biopolymers (1, 39, 46), bioethanol (44, 47), organic acids (32, 44, 46, 47), SCP (34, 44, 47). Microbial oxidative transformations (44, 46, 47).

Module 3: Plant tissue culture (2 hrs)

Brief history and important milestones in plant tissue culture (28, 38). Types of cultures: organized structures - meristem, shoot tip, node, embryo, root cultures (2, 36, 37); unorganized structures - callus,suspension and protoplast cultures

Module 4: Culture protocol (5 hrs)

General composition of the culture (21, 28, 36, 37, 38). Solid and liquid media – gelling agents (21, 28). Preparation and standardization of MS medium for shoot and root differentiation (27, 28, 36). Sterlization of medium, glasswares, instruments, plant material, transfer area (2, 21, 27, 28, 36, 38). Preparation of explants and inoculation, incubation. Pattern of growth and development, subculturing and hardening (28, 38).

Module 5: Cytodifferentiation and morphogenesis (4 hrs)

Cellular totipotency (21, 27, 28). Differentiation of cells in callus - tracheid formation, chloroplast differentiation (28). Factors influencing vascular differentiation (28). Organogenic differentiation: factors influencing shoot bud differentiation, induction of organogenic differentiation (28).

Module 6: Propagation *in vitro* (2 hrs)

Techniques and stages of micropropagation (27, 28, 36, 37, 38). Advantages and disadvantages of micropropagation (21). Applications of tissue culture (21, 28, 37).

Module 7: Genetic engineering (8 hrs)

Basic principles, tools and techniques (4, 8, 30); Restriction endonucleases – naming, types and reaction. Ligases – reaction, methods of blunt end joining - linkers and adaptors (4, 8, 11, 13). Vectors – necessary properties of a vector (9, 30), shuttle vectors, expression vectors (30). Construction and specific uses of plasmid, phage, cosmid, and artificial chromosomes (4, 8, 9, 13). Creation of recombinant DNA. Methods of screening and selection of recombinant cells – selectable markers, reporter systems – *Lac Z* system, GFP (4, 8, 13, 17).

Module 8: Procedure of gene cloning (in bacteria using pBR322 vector system) (5 hrs)

Isolation and purification of vector and the DNA to be cloned (8, 30), 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 (8, 30). Expression of foreign genes in host cells (31).

Module 9: Applications of genetic engineering (2 hrs)

Applications of genetic engineering – in genetic studies, agriculture, and medicine (brief study citing specific examples) (8, 30)

Module 10: Advanced tools and techniques (15 hrs)

(a) cDNA synthesis, artificial DNA synthesis (brief study) (8, 39). Construction of genomic and cDNA library.

(b) PCR - Procedure and applications, variants of PCR - Real time PCR and its applications (3, 12, 14, 17, 39).

(c) Automated DNA sequencing.

(d) *In vitro* mutagenesis and its application.

(e) Blotting techniques - procedure and applications of southern, northern, western, and dot blotting. Microarray (gene chip) technology (2, 6, 12, 14), mass spectrometry (3, 6, 12, 14).

(f) Procedure and applications of DNA profiling (3, 9, 13, 14), Footprinting (7, 12).

(g) Procedure and applications of ELISA, RIA, Immunoprecipitation, flow cytometry (24), FISH (5, 23), GISH, PFGE (40).

Module 11: Genomics (5 hrs)

Genome, genomics, and proteomics. Structural genomics - genome sequencing Functional genomics – genome annotation, gene expression study using microarrays annotation of genes (4, 5, 10).

Module 12: Bioinformatics (8 hrs)

strategies (23, 41). (23, 39), functional

Introduction, aim and importance of bioinformatics (29). Databases: primary and secondary databases (25, 26, 29). DNA sequence databases - Genbank, DNA databank, Nucleotide sequence databank (EMBI Bank) (2, 3, 4, 5, 9, 10, 18, 22, 25, 26, 29). Specialized databases (3). Protein databases - SWISS-PROT, PDB (2,18, 22, 25, 26,29). Sequence alignment: Significance; local sequence alignment, BLAST, FASTA (2, 3, 4, 5, 9, 25, 26, 29). Global sequence alignment - MILAGAN, (3, 4, 5, 25, 26).

Module 13: Immunology (6 hrs)

Innate and acquired immunity (16). Cells and molecules involved in innate and acquired immunity, humoral and cellular immunity (16, 17, 19, 20, 24), Antigens, Epitopes. Structure, function and types of antibody molecules. Antigen-antibody interactions (16, 17, 19, 20, 24). Antigen processing and presentation (24). Activation and differentiation of B cells – formation, role (16, 17, 19, 20, 24). T cells – types, roles, T cell receptors (16, 17, 19, 20, 24). Primary and secondary immune modulation, complement system (24), pattern recognition receptors – toll-like receptors (16). MHC molecules (24). Cell-mediated effector functions, inflammation, hypersensitivity and autoimmunity, congenital and acquired immunodeficiencies (16).

Module 14: Societal issues in biotechnology (4 Hrs)

Need for regulation (39), regulatory agency in India – GEAE. Patents – issues relating to patenting living organisms, their genes and other bioresources (39). Potential impact of GMOs on the ecosystem (39). GM food – effect on health and environment (1, 2, 39). Ethical problems of rDNA technology (1, 2, 9, 13).

Economic issues (39). Potential misuse of modern molecular biology tools and techniques, bioweapons, bioterrorism (1, 2, 9, 13).

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. Multiple sequence alignment and creation of phylogenetic trees using MEGA.
6. Production of amylase by solid state and submerged fermentation.

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CO No.	Expected Course Outcome Upon completion of this course, the students will be able to	Knowledge Level
1	Explain the industrial application of micro organisms	K2
2	Assess the different methods and processes involved in plant tissue culture and its role in biodiversity conservation.	K4
3	Explain the basic principles, tools and techniques involved in genetic engineering	K2
4	Appraise the role of bioinformatics in genomics and proteomics	K5
5	Infer basic processes involved in immune system	K2
6	Analyze the societal issues in biotechnology and genetic engineering	K4
Knowledge Levels: K1-Remembering; K2-Understanding; K3-Applying; K4-Analyzing; K5-Evaluating; K6-Creating.		

PG20BO312: TAXONOMY OF ANGIOSPERMS
(Theory 54 hrs; Practical 36 hrs; Credits 3)

Objectives

- To understand diversity of angiosperms.
- To know the tools and techniques used in plant systematics.
- To learn to describe angiosperms using taxonomic terminologies.
- To study the salient features and interrelationships of different families.
- To develop an insight on the scope and significance of ethnobotany.

Module 1: Classification (4 hrs)

Major systems of angiosperm classification with special emphasis on the conceptual basis of the classifications of; (i) Linnaeus (ii) Bentham & Hooker (iii) Engler & Prantl (iv) Bessey (v) Takhtajan (vi) APG.

Module 2: Tools of Taxonomy (4 hrs)

Functions of field study, herbarium, botanical gardens, BSI, Floras/Taxonomic literature and GIS (Geographic Information System). Construction of taxonomic keys – indented and bracketed - their utilization.

Module 3: Angiosperm diversity with special reference to Tropical flora (44 hrs)

Study of the following families (Bentham & Hooker) in detail with special reference to their salient features, interrelationships, evolutionary trends and economic significance.

1. Rununculaceae 2. Magnoliaceae 3. Menispermaceae 4. Cruciferae (Brassicaceae) 5. Polygalaceae 6. Caryophyllaceae 7. Guttiferae (Clusiaceae) 8. Tiliaceae 9. Geraniaceae 10. Rutaceae 11. Vitaceae 12.Rhamnaceae 13. Sapindaceae 14. Fabaceae 15. Caesalpiniaceae 16. Mimosaceae 17. Rosaceae 18. Lythraceae 19. Melastomaceae 20. Myrtaceae 21. Passifloraceae 22. Apiaceae 23. Aizoaceae 24. Rubiaceae 25. Compositae (Asteraceae) 26. Campanulaceae 27. Myrsinaceae 28. Sapotaceae 29. Loganiaceae 30. Oleaceae 31. Apocynaceae 32. Asclepiadaceae 33. Boraginaceae 34. Solanaceae 35. Scrophulariaceae 36.Bignoniaceae 37.Acanthaceae 38. Verbenaceae 39. Lamiaceae 40. Polygonaceae 41. Aristolochiaceae 42. Lauraceae 43. Loranthaceae 44. Euphorbiaceae 45. Urticaceae. 46. Orchidaceae 47. Dioscoriaceae 48. Zingiberaceae 49. Araceae 50. Cyperaceae 51. Poaceae

Module 4: Ethnobotany: (2 hrs)
Scope and importance of ethnobotany, sources and methods of ethnobotanical studies.

Practical (36 hrs)

1. Work out a minimum of two members from each family with suitable sketches and description in technical terms.
2. Study of local flora, construction of keys and use of floras in the identification up to species.
3. Preparation of dichotomous keys based on 4 sample plant materials from the same family.
4. Students should familiarize with all the economically/ethnobotanically important plants of the families mentioned in the syllabus.

Field study: A field study for not less than 5 days under the guidance and supervision of teachers and preparation of a minimum of 25 herbarium specimens of different categories with supporting field book.

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CO No.	Expected Course Outcomes Upon completion of this course, the students will be able to	Cognitive level
1	Summarize and analyze classification of angiosperms	K2, K4
2	Select and utilize the tools of taxonomy	K3
3	Identify and classify flowering plants to respective families on the basis of diagnostic characters	K4 K3
4	Construct keys and identify plants up to species level with the help of floras	K3 K6
5	Evaluate the contributions of ethno botany and traditional botanical knowledge to the advancement of plant taxonomy.	K5 K3
Knowledge Levels: K1-Remembering; K2-Understanding; K3-Applying; K4-Analyzing; K5-Evaluating; K6-Creating.		

SEMESTER III MODEL QUESTION PAPERS - THEORY

Semester III Course 9
Model Question Paper
PG20BO309: RESEARCH METHODOLOGY, BIOPHYSICAL INSTRUMENTATION,
BIOSTATISTICS AND MICROTECHNIQUE
Time 3 hours Weightage 30

I. Answer any ***eight*** of the following in not less than 50 words (Weight 1 each)

1. Describe the structure of a scientific library
2. Write brief account on different types of journals
3. Describe the principles and techniques of fixing. Write the composition and use of FAA
4. Write the preparation and uses of haematoxylin and Safranine
5. Describe the following;
(a) Primary and secondary data (b) Qualitative and Quantitative data
6. Why is a statistical test necessary to determine whether an observed set of data yields an acceptable fit
to the result expected from a particular hypothesis? What statistical test is used for this?
7. Write the principle and use of Phase contrast microscope.
8. What is ELISA? What is its application?
9. What are the different stages of research?
10. Write an essay on literature survey and its importance in research.

II. Answer any ***six*** of the following in not less than 100 words (Weight 2 each)

11. How can you prepare permanent whole mounts?
12. Explain histochemical staining and its significance. Describe the staining procedures for starch and
Protein.
13. Give an account on various sampling techniques.
14. How chi-square test is used for the detection of linkages?
15. Describe the principle of electron microscopy
16. Write a short essay on electrophoresis
17. Describe the basic principles and applications of ELISA
18. Describe the principles and applications of different chromatographic techniques

III. Answer any ***two*** of the following in not less than 250 words (Weight 5 each)

19. Prepare a sample project proposal on a taxonomic problem for submission to University Grants commission.
20. Describe various steps in making permanent serial sections
21. Describe the experimental designs used for different types of studies.
22. Explain the principle and application of TLC, GC and HPLC.

Semester III Course 10
Model Question Paper
PG20BO310: PLANT PHYSIOLOGY AND PLANT BREEDING
Time 3 hours Weightage 30

I. Answer any ***eight*** of the following in not less than 50 words (Weight 1 each)

1. What is RQ? Give the RQ for different substrates
2. Write notes on the following
(a) Purelines (b) Heterosis (c) IARI (d) Acclimatization
3. What are the apoplastic and symplastic pathways and how do they differ?
4. Given an account of the role of Gibberellins
5. Describe the intergeneric and interspecific hybridzation
6. What is the membrane potential and how is it generated?
7. Comment on Ecophysiological significance of C4 photosynthesis
8. Describe the significance and practical application of plasmolysis.
9. Write brief descriptions on
(a) Aquaporin (b) Light harvesting complexes
10. What is the role of the antenna complex in the light-dependent reactions of photosynthesis?

II. Answer any ***six*** of the following in not less than 100 words (Weight 2 each)

11. Elaborate the concept of the centers of origin of plants
12. Write a brief account on the modern trends in plant breeding
13. Explain the mechanism of electron and proton transport in the thylakoid membrane.
14. Describe the role of hybridization in plant improvement
15. Give an account of translocation in phloem
16. Write brief descriptions on the following;
(a) Cryptochrome (b) Phytochrome (c) Photoinhibition (d) Leghemoglobin
17. Describe the molecular mechanism involved in the biological Nitrogen fixation. Add a note on the structure of Nitrogenase enzyme.
18. Write an account on the methods of breeding to develop resistance to biotic and abiotic stress in plants

III. Answer any ***two*** of the following in not less than 250 words (Weight 5 each)

19. With the help of a diagram, describe the detailed structure of ATPase complex. Write the binding change mechanism of ATP synthesis.
20. What are the stresses to which plants are commonly exposed? Describe the stress tolerance mechanisms found in plants.
21. Describe the role of mutation induction in crop improvement. Enlist the advantages and disadvantages in mutation breeding.
22. Explain structure function and mechanism of action of phytochromes and cryptochromes.

Semester III Course 11
Model Question Paper
PG20BO311: BIOTECHNOLOGY
Time 3 hours Weightage 30

I. Answer any ***eight*** of the following in not less than 50 words (Weight 1 each)

1. What is sequence alignment? Explain with suitable examples
2. Describe the methods of producing and the types of probes
3. Describe the general composition of a plant tissue culture medium.
4. Differentiate between;
(a) Innate immunity and acquired immunity (b) Humoral and Cellular immunity
5. Briefly describe the advantages of micropropagation
6. How is PAM matrices formed?
7. What are the applications of GFP?
8. Describe the methods used to sterilize different types of plant explants.
9. Write an account on primary and secondary databases
10. How does PCR work? What is it used for?

II. Answer any ***six*** of the following in not less than 100 words (Weight 2 each)

11. Write an account on the important contributors and their contributions to the initial development of
plant tissue culture technique.
12. Write brief accounts on the following;
(a) Shuttle vectors (b) Insertional inactivation (c) Adaptors (d) pBR322
13. Describe the steps involved in the construction of a cDNA library
14. Write a brief account on protein structure database
15. Describe how a Southern blot is carried out. Explain what it used for.
16. What are microarrays? Explain how microarrays are used in gene expression studies?
17. Describe the methods of regeneration of plants through tissue culture. Add a note on the factors determining the regeneration
18. Explain scope and relevance of bioinformatics

III. Answer any ***two*** of the following in not less than 250 words (Weight 5 each)

19. Citing suitable examples, explain how microorganisms can be used; (a) to produce antibiotics (b) to produce biofuels (c) to produce biopolymers (d) as SCP.
20. Write an essay on the social issues generated by recent developments in biotechnology
21. Discuss briefly on sequence alignment, substitution scores and gap penalties.
22. Explain the different blotting techniques and its applications.

Semester III Course 12
Model Question Paper
PG20BO312: TAXONOMY OF ANGIOSPERMS
Time 3 hours Weightage 30

I. Answer any ***eight*** of the following in not less than 50 words (Weight 1 each)

1. Describe the primitive characters of Magnoliaceae.
2. Explain the role of herbarium in taxonomy
3. Write an account of androecium of orchidaceae
4. What are the salient features of the family polygalaceae
5. Write the binomials and families of the following plants.
(i) Coffee (ii) Guayule (iii) Chinese potato (iv) Rose wood
6. With suitable examples describe the medicinal importance of Apocynaceae
7. Give the family name and economic products of the following plants.
(i) *Mentha arvensis* (ii) *Lagenaria vulgaris* (iii) *Cymbopogon citrates* (iv) *Foeniculum vulgare*
8. What is herbarium? How herbarium is labelled?
9. Critically evaluate the Engler's system of classification based on its conceptual basis.
10. Write a comparative account of the families Verbenaceae and Lamiaceae.

II. Answer any ***six*** of the following in not less than 100 words (Weight 2 each)

11. Explain different types of keys used for the identification of plants.
12. Describe the economic importance of the members in the family Cucurbitaceae
13. Explain the floral characters of Euphorbiaceae
14. Distinguish the following pairs of families using floral characterestics;
(i) Rutaceae and Meliaceae (ii) Myrtaceae and Lythraceae
15. Comment on the systematic position and affinities of the following genera;
(i) *Nyctanthes* (ii) *Canavalia* (iii) *Luffa* (iv) *Coleus*
16. Write critical notes on; (i) Indented key (ii) BSI
17. Give critical account of Ranales giving particular stress to its evolutionary significance
18. Describe the advanced floral features in the families of disciflorae

III. Answer any ***two*** of the following in not less than 250 words (Weight 5 each)

19. Give a critical evaluation of the system of classification of angiosperm by Hutchinson and compare
it with that of Bentham and Hookers Classification.
20. Discuss the salient floral features of the following families;
(i) Umbelliferae (ii) Lauraceae (iii) Guttiferae (iv) Lythraceae
21. Compare the vegetative and floral features of the families of Bicarpellatae and bring out the evolutionary trends.
22. Discuss the salient features of families Asteraceae and Campanulaceae.

SEMESTER IV

Elective	PE course	Course title	Teaching hrs Theory	Teaching hrs Practical	Credits
Biotechnology	PG20BO413	Tissue culture and Microbial biotechnology	90	72	4
	PG20BO414	Genetic engineering	90	54	4
	PG20BO415	Genomics, Proteomics and Bioinformatics	90	54	4
Practical	PG20BOP7	Practicals of Tissue culture and Microbial biotechnology			2
	PG20BOP8	Practicals of Genetic engineering & Genomics, Proteomics and Bioinformatics			2
Others	PG20BO4P	Project			4
	PG20BO4V	Viva			3

PROGRAMME ELECTIVE - BIOTECHNOLOGY

PG20BO413: TISSUE CULTURE AND MICROBIAL BIOTECHNOLOGY
(Theory 90 hrs; Practical 72 hrs; Credits 4)

Objectives

- To understand the basics and applications of microbial biotechnology.
- To study the application of tissue culture strategies in crop improvement and conservation.

Module 1: Tissue culture regeneration of plants (13 hrs)

(a) Adventitious regeneration: Direct regeneration, indirect regeneration [(1)]. Factors influencing adventitious regeneration; genotype, explant – orientation of explant, position on mother plant.

(b) Somatic embryogenesis: General aspects [(2, 3, 8)], initiation of embryogenic cultures, maturation of somatic embryos, regeneration of plants, factors regulating somatic embryogenesis [(2, 3, 8)], differences between somatic and zygotic embryos. Encapsulation of somatic embryos [(2)], synthetic seed production; desiccated and hydrated types [(2, 3)]. Applications and limitations of synthetic seeds [(2, 3)].

Module 2: Somaclonal variation (8 hrs)

Isolation of somaclonal variants [(1, 3, 14)], 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 [(3)]. Applications of somaclonal variation [(1, 3, 14)].

Module 3: Production of ploidy variants (12 hrs)

(a) Haploids: Androgenesis [(1, 3, 8, 9, 14)] - pretreatment of anther/pollen grains, media and growth regulators, Induction and stage of pollen development, regeneration, androgenic embryos, factors affecting androgenesis [(1, 3)]. Microspore culture - protocol, advantages over anther culture [(3, 9, 14)].

(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 [3, 38].

Module 4: Protoplast culture (8 hrs)

(a) Isolation and purification of protoplasts [1, 2, 3, 8, 9, 14, 39], culture of protoplasts, cell division and callus formation, plant regeneration [1, 2, 3, 8, 9, 14, 39].

(b) Protoplast fusion (somatic hybridization) – chemical, mechanical, electrofusion [1, 2, 3, 9, 39]. Selection, isolation of heterokaryons [1, 2, 3, 9, 39], cybrids and their applications [1, 2, 3, 9, 39]. Applications of protoplast culture [2, 3, 9, 39].

Module 5: Production of secondary metabolites (6 hrs)

Culture conditions for producing secondary metabolites [1, 3, 9], selection of high yielding lines, elicitation, immobilization of cells [1, 2 3]. Hairy root culture – advantages of using hairy root culture, establishment of hairy root culture and production of secondary metabolites [3, 9].

Module 6: Germplasm conservation (6 hrs)

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 [1, 2, 3, 9, 21, 22].

Module 7: Microbial technology (16 hrs)

Screening of microbes for metabolite production [29, 31, 34] . Selection of media, sterilization of media [28, 31, 34]. Bioreactors – airlift, stirred tank, bubble column, rotary drum [7, 12, 15, 31, 32, 33]. Fermentation process - batch, fed batch, continuous fermentation [29]. Process control during fermentation - pH, aeration, agitation, temperature, foam control [29, 31]. Downstream processing [29, 33]. Large scale production of antibiotics - penicillin, streptomycin [10, 13, 16, 28, 31], industrial chemicals - ethanol, acetone, butanol, lysine [10, 11, 16, 28, 30, 31]. Microbial insecticides [4, 10, 15]. Commercial production of enzymes and their uses - amylase, cellulase, polygalacturonase [6, 28, 31, 35].

Module 8: Cell and enzyme technology (5 hrs)

Cell immobilization: Methods, advantages and applications [4, 7]. Enzyme immobilization: Preparation [6], applications [5, 6], enzymes as biosensors [35]. Enzyme engineering [7].

Module 9: Tissue engineering and Stem cell technology (6 hrs)

Regenerative medicine, methods and applications of tissue engineering [4, 13]. Stem cells – embryonic stem cell and adult stem cells – potential applications [13].

Module 10: Bioremediation and Phytoremediation (10 hrs)

Importance and advantages of bioremediation, bioaugmentation [4, 13, 36], pollutants that can be cleaned. Cleaning reactions - aerobic and anaerobic biodegradation [4, 13, 37], organisms used for bioremediation [4, 13, 37], cleaning strategies for water and soil - *in situ* and *ex situ* technologies [4, 13, 37]. Bioremediation of radioactive wastes [13]. Phytoremediation - importance [13, 36, 37]. Use of GMOs in bioremediation [13].

Practical (72 hrs)

1. Isolation and fusion of plant protoplasts [39].
2. Preparation of synthetic seeds.
3. Preparation of selective medium for drought or salinity resistance. Preparation of MS soild 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. Find out the 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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CO No.	Expected Course Outcome Upon completion of this course, the students will be able to	Knowledge Level
1	Explain regeneration methods in tissue culture.	K2
2	Interpret the somaclonal and ploidy variations.	K2
3	Explain the production of secondary metabolites from various cultures.	K2
4	Analyze various techniques of germplasm conservation and its significance.	K4
5	Evaluate the use of microbes in industry and medicine	K5
6	Explain tissue culture techniques.	K2
Knowledge Levels: K1-Remembering; K2-Understanding; K3-Applying; K4-Analyzing; K5-Evaluating; K6-Creating.		

PROGRAMME ELECTIVE - BIOTECHNOLOGY
PG20BO414: GENETIC ENGINEERING
(Theory 90 hrs; Practical 54 hrs; Credits 4)

Objectives

- To study the basic and advanced aspects of rDNA technology and gene cloning strategies.
- To learn the applications of rDNA technology.
- To understand the basics of immunology and vaccine development.

Module 1: Working with Nucleic acids (3 hrs)
Isolation and purification of DNA (genomic and plasmid) and RNA [8, 9, 18, 14].
Module 2: Chemical synthesis of DNA (11 hrs)
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: Modern cloning vectors (10 hrs)
M13 [2, 9], pUC, artificial chromosomes – YAC, BAC, PAC [1, 2, 9], HAC, [9] – important features, construction and applications of each [1, 2, 9].
Module 4: Gene library (12 hrs)
Genomic and cDNA library. Procedure for the construction of a genomic library using phage λ system [9, 20]. Identification of desirable clones from library – hybridization probing, colony and plaque hybridization probing, immunological screening [9, 16, 20, 25]. Locating and isolating a gene - *in situ* hybridization, positional cloning, chromosome walking and jumping
Module 5: Plant transformation (10 hrs)
(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].
(c) Details of the creation of Bt plants, Golden rice, *Flavr Savr* Tomato.
Module 6: Advanced transgenic technology (5 hrs)
Inducible expression systems – examples, site-specific recombination for *in vivo* gene manipulation, gene targeting, gene silencing using antisense RNA and RNAi [2, 9, 21]. *In vitro* mutagenesis - site-directed mutagenesis [3, 9, 13, 21].

Module 7: Gene therapy (8 hrs)

Approaches to gene therapy [9] - somatic cell and germline therapy [1, 9], vectors used in gene therapy [2, 9, 18, 19, 25]. *In vivo* and *ex vivo* therapy [2, 9]. Gene therapy of SCID [1, 2, 9], Cystic fibrosis [2, 9, 18, 19, 25], gene augmentation therapy [2, 9]. Problems and fears associated with gene therapy.

Module 8: Protein engineering (5 hrs)

Applications of protein engineering [2, 10, 23, 24, 31, 33], protein modification by site-directed mutagenesis, combinatorial methods [2, 10, 24, 31].

Module 9: Biosensors (6 hrs)

Design and operation [23, 29], types [23]. Applications - medical, food and agriculture, industrial, pollution monitoring [23, 29]. GMOs as biosensors [24].

Module 10: Immunology (10 hrs)

(a) Generation of antibody diversity [8, 23]. Production and uses of monoclonal antibodies [8, 23], antibody engineering [8].

(b) Vaccines: Basic strategies, inactivated and live attenuated pathogens, subunit vaccines, recombinant vaccines (e.g., Hepatitis B vaccine), DNA vaccines [2, 6, 7, 8, 9, 10, 16, 24, 32]. Modern approaches to vaccine development - edible vaccines [9, 10, 16].

Module 11: Applications of rDNA technology (10 hrs)

Uses of GM microbes: Bacteria and yeast [2, 9, 10] - producing useful proteins [2, 10], basic genetic research [2]. Applications of GM animals: In basic research, producing novel proteins; disease studies, prevention and cure diseases [2, 9, 10]. Uses of transgenic plants: Herbicide, insect and disease resistance, stress resistance. Genetic engineering for increasing nutritional and other novel qualities in plants [2, 9, 10].

Practical (54 hrs)

1. Isolation of plant genomic DNA and its quantification [14].
2. Isolation of plasmids and its purification [14], by minipreparation and midipreparation [15].
3. Isolation of bacterial genomic DNA and its quantification by using UV spectrophotometer [14].
4. Separation of DNA by agarose gel electrophoresis [14].
5. Extraction and quantification of protein by Bradford method [14].
6. Separation of proteins by PAGE.
7. PCR.

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CO No.	Expected Course Outcome Upon completion of this course, the students will be able to	Knowledge Level
1	Analyze various tools and techniques in Gene cloning	K4
2	Interpret various plant transformation techniques	K2
3	Make use of DNA isolation techniques and electrophoresis for its separation.	K3
3	Perceive the application of recombinant DNA technology in day to day life	K5
4	Analyze modern approaches in Immunology	K4
Knowledge Levels: K1-Remembering; K2-Understanding; K3-Applying; K4-Analyzing; K5-Evaluating; K6-Creating.		

PROGRAMME ELECTIVE - BIOTECHNOLOGY
PG20BO415: GENOMICS, PROTEOMICS AND BIOINFORMATICS
(Theory 90 hrs; Practical 54 hrs; Credits 4)

Objectives

- To understand the fundamentals of structural and functional genomics and proteomics.
- To study the basics of bioinformatics and its applications.

Module 1: Structural genomics (25 hrs)

(a) Basic steps in genome sequencing [3]. Shot gun sequencing of small genomes [17]. Map based sequencing: Hierarchial shot gun sequencing (clone-by-clone approach) - steps involved; Whole genome shot gun approach - steps involved [1, 2, 3, 11, 17, 28].

(b) Genome mapping: Genetic mapping and physical mapping [2, 10, 12, 17]. Cytogenetic and linkage map (brief study only) [2, 10]. Molecular markers – RFLP, RAPD, AFLP, SSLP, SNP [2, 9, 10, 13, 17]. Construction of linkage maps using molecular markers – E.g., RFLP maps [2, 17]. Physical mapping – restriction mapping, STS, SNP, EST [1, 2, 10, 11, 12, 17, 23, 28].

(c) Sequence assembly – methods used [13, 17].

(d) Next generation sequencing strategies - Pyrrosequencing [14, 17, 28].

(e) Important findings of the completed genome projects: Human genome project [6, 11, 12, 13, 16, 17, 23, 25, 28], Rice genome project, Arabidopsis genome project [16], *E. coli* genome project [16, 17], Wheat genome project, Tomato genome project.

Module 2: Functional genomics (12 hrs)

Transcriptome [1, 17, 27], expression profiling (mRNA profiling) [1, 3, 27]. Gene expression analysis using dot blotting and microarrays [2, 3, 9, 10, 27, 28]. Fabrication of microarrays – spotted arrays, *in situ* synthesis [1, 2, 27]. Chromatin immunoprecipitation (ChIP) and its applications [2, 3]. Determination of gene functions - knock out and knock down mutants, antisense RNA and RNAi, gene overexpression [3, 10, 17, 19, 28, 29].

Module 3: Comparative genomics (7 hrs)

Orthologs and Paralogs [1, 3], gene identification by comparative genomics [1], comparative genomics as a tool in evolutionary studies [1, 13]. Metagenomics [27] .

Module 4: Proteomics (8 hrs)

Proteome, proteomics [8, 17, 19, 26, 27]. Separation and identification of cellular proteins by 2D gel electrophoresis and mass spectrometry [1, 2, 5, 8, 9, 12, 16, 17, 19, 26, 27]. Protein expression analysis using Protein microarray [1, 2, 3, 9, 12, 26, 27], protein localization using GFP [3, 9], other applications of GFP.

Module 5: Bioinformatics (27 hrs)

(a) Submission and retrieval of databases – BankIt, ENTREZ.

(b) Sequence analysis – significance [21, 22]. Methods of sequence alignment – paired sequence alignment, multiple sequence alignment, scoring matrices [7, 15, 20, 21, 22]. Sequence comparison – dot matrix method, dynamic programming for sequence alignment; Global - Needleman Wunch algorithm; Local - Smith Waterman algorithms. Database similarity search – query sequence search; BLAST - different versions; FASTA - different versions [7, 20, 21, 22]. Tools for multiple sequence alignment – CLUSTAL X/W [20, 21, 22].

(c) Gene prediction strategies [1, 2, 7, 17, 21 22], ORF search, gene prediction programs – Grail/Exp, GENSCAN, ORF finder [1, 2, 7, 17, 21 22]. RNA secondary structure prediction; Protein structure and function prediction - tools used [7, 21, 22]. Protein visualization tool - Rasmol.

(d) Applications of bioinformatics in evolutionary studies – molecular phylogenetics, molecular clock [2, 9, 10, 15, 17, 21 22, 29]. Construction of phylogenetic trees - tool Phylip [2, 8, 15, 17, 21 22].

(e) Computer assisted drug design - concept, methods and practical approaches. Various computational methods applied to design drugs [21, 22, 24].

(f) Bioinformatics for enzyme and protein design [21, 22].

Module 6: Ethical, legal, and social impact of modern biotechnology (11 hrs)

Genome data availability – Problems with public availability of sequence data [3 p 313], privacy concerns,

legal problems, gene and DNA sequence patenting, patenting transgenics [27], stem cell research - EST, gene therapy – problems and concern over germline gene therapy [18, 27]. Biosafety [18].

Practical (54 hrs)

1. Protein visualization using Rasmol (supply structure of a few proteins downloaded from PDB).
2. Multiple sequence alignment using CLUSTAL X (give DNA or protein sequence).
3. Phylogenetic analysis by Phylip (give some protein or DNA sequence data).
4. Locate specific sequences like TATA box, promoters, start signals, stop signals etc. in a DNA sequence using computer programmes [22] e.g., *E. coli* promoter, human promoter.
5. Multiple sequence alignment and ontology based database searches on selected plant cytoskeletal genes to decipher the molecular phylogeny of cytoskeleton genes – record the results.

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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CO No.	**Expected Course Outcome** **Upon completion of this course, the students will be able to**	**Knowledge Level**
1	Explain the methods and principles of gene sequencing and genome mapping	K2
2	Interpret Genomics and Proteomics	K2
3	Apply bioinformatics tools for visualization of biomolecules and retrieval of data	K3
4	Construct phylogenetic trees using PHYLIP	K6
5	Analyze ethical, legal and social impact of modern Biotechnology	K4
Knowledge Levels: K1-Remembering; K2-Understanding; K3-Applying; K4-Analyzing; K5-Evaluating; K6-Creating.		

PROGRAMME ELECTIVE (BIOTECHNOLOGY)

MODEL QUESTION PAPERS - THEORY

Elective - Biotechnology
Semester IV Elective Course 1
Model Question Paper
PG20BO413: TISSUE CULTURE AND MICROBIAL BIOTECHNOLOGY
Time 3 hours Weightage 30

I. Answer any ***eight*** of the following in not less than 50 words (Weight 1 each)

1. Differentiate between stirred tank and airlift bioreactors.
2. Define the following;
(a) Totipotency (b) Synseeds (c) Haploids (d) Stem cells
3. What is androgenesis?
4. What are the causes of somaclonal variation?
5. Name four industrial chemicals produced by using microbial activities. Write the names of the microorganisms involved in each.
6. Describe the importance of using tissue culture in producing secondary metabolites.
7. What is enzyme engineering? What are the applications of it?
8. Briefly describe bioaugmentation.
9. Describe the most common use of the following chemicals in tissue culture;
(a) Agar agar (b) PEG (c) $HgCl_2$ (d) EDTA
10. Briefly describe the prospects and future of stem cell research.

II. Answer any ***six*** of the following in not less than 100 words (Weight 2 each)

11. Giving suitable examples, discuss downstream processing.
12. What are cybrids? How are they produced? Discuss the use of cybrids in crop improvement programmes.
13. Describe the method of producing triploids through tissue culture. Add a note on the significance of triploids.
14. Describe the procedure of plant protoplast isolation and purification.
15. Citing suitable examples, discuss the importance of GMOs in bioremediation
16. What is bioremediation? In what all ways it is good for environmental clean up?
17. What is germplasm? Describe the methods of germplasm conservation. Add a note on the importance of tissue culture as a method of germplasm conservation.
18. Describe the methods and stages of *in vitro* regeneration of plants.

III. Answer any ***two*** of the following in not less than 250 words (Weight 5 each)

19. Describe the procedure and applications of; (a) Hairy root culture (b) Protoplast fusion (c) Microspore culture (d) Cellulase production
20. What is tissue engineering? Describe the steps involved and the potential applications of tissue engineering.
21. Write an essay on methods, advantages and applications of cell immobilization.
22. Give a detailed account on fermentation process and its applications.

Programme Elective - Biotechnology
Semester IV Elective Course 2
Model Question Paper
PG20BO414: GENETIC ENGINEERING
Time 3 hours Weightage 30

I. Answer any ***eight*** of the following in not less than 50 words (Weight 1 each)

1. Where does T DNA come from, and how is it used in making transgenic plants?
2. Name the key tools for accomplishing the tasks of recombinant DNA technology. Also mention the functions of each tool.
3. Explain the purpose of selectable marker genes in cloning experiments.
4. Explain how edible vaccines work?
5. Distinguish between genomic library and cDNA library
6. What are the advantages of Bt plants?
7. Explain what is meant by the following terms in relation to genetic engineering;
(a) Transformation (b) Polylinkers (c) Lipofection (d) Expression vectors
8. Write the important features in pUC.
9. What is a recombinant DNA vaccine? Give two examples
10. A patient is suffering from ADA deficiency. Can he be cured? How?

II. Answer any ***six*** of the following in not less than 100 words (Weight 2 each)

11. Describe the following;
(a) BAC (b) DNA probes (c) Electroporation (d) Alternate splicing
12. Highlight any four areas where genetic modification of plants has been useful.
13. You have identified a useful gene in bacteria. Make a flow chart of the steps that you would follow
to transfer this gene to a plant.
14. Highlight different areas where biotechnology has influenced our lives.
15. Describe the important applications of Biosensors.
16. Explain the method for the isolation and purification of plasmid DNA.
17. Describe the basic principles and the steps involved in artificial DNA synthesis.
18. Describe the methods and applications of engineering proteins

III. Answer any ***two*** of the following in not less than 250 words (Weight 5 each)

19. What is monoclonal antibody? How is monoclonal antibody produced in large scale? What are the uses of it?
20.Describe the following; (a) Positional cloning (b) Chromosome walking (c) *In vitro* mutagenesis (d) Binary vectors
21. 'Genes could be silenced using RNA'. Explain the methods used with examples.
22. Describe the steps involved in the creation of a genomic library.

Programme Elective - Biotechnology
Semester IV Elective Course 3
Model Question Paper
PG20BO415: GENOMICS, PROTEOMICS AND BIOINFORMATICS
Time 3 hours Weightage 30

I. Answer any ***eight*** of the following in not less than 50 words (Weight 1 each)

1. What is multiple sequence alignment? Where is it useful?
2. What is a DNA marker? Give two examples.
3. Explain how some of the Restriction enzymes produce "sticky ends" while DNA is cut?
4. Write a brief note on metagenomics.
5. Explain the following terms related to drug design; (a) Ligand (b) Pharmacophore (c) Active site (d) Structure-based drug design
6. What is STS?
7. Distinguish between a physical map and a genetic map.
8. How is GFP useful for protein localization in a living cell?
9. Describe the major findings of HGP.
10. Write a brief note on enzyme and protein design

II. Answer any ***six*** of the following in not less than 100 words (Weight 2 each)

(a) Southern blotting (b) Antisense technology (c) Immunization (d) Binary vecto21. Write an essay on Human Genome Project: Aims and applications

11. What is comparative genomics? How is it useful in determining the evolutionary relationships between organisms?
12. Explain the features of ENTREZ
13. Explain the working and important features of BLAST?
14. Write notes on the tools for genomic comparison.
15. What are the applications of genome sequencing?
16. Describe the following; (a) Microarrays (b) Immunoprecipitation (c) Knock down mutants (d) SNP
17. Describe the different genome sequencing strategies.
18. Explain basics of drug discovery process.

III. Answer any ***two*** of the following in not less than 250 words (Weight 5 each)

19. Describe the functional genomics' strategies and methods to identify, locate and determine the function of genes in a genome sequence.
20. Write an essay on the ethical, legal, and social issues generated by modern Biotechnology.
21. Explain the application of bioinformatics in phylogenetic studies?
22. Give an account on proteomics and its applications.

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report(s)/Lab visit report(s)/Industry visit report(s), if any.21. Explain the application of bioinformatics in phylogenetic studies?