MAHATMA GANDHI UNIVERSITY

PRIYADARSINI HILLS
KOTTAYAM - 686560

SYLLABUS FOR POST-GRADUATE PROGRAMME

IN

BOTANY

UNDER THE RESTRUCTURED CURRICULUM IN CREDIT SEMESTER SYSTEM

(EFFECTIVE FROM 2012 ADMISSIONS)

Syllabus revised by
Post graduate board of studies in Botany

Chairman
Prof. K Radhakrishnan Nair,
Asso. Prof. & Head,
Dept. of Botany,
SVR NSS College, Vazhoor

Members
Shri. James Philip
Asso. Prof., Dept. of Botany,
Devamatha College, Kuravilangad.

Dr. K V Geroge,
Asso. Prof. & Head,
Dept. of Botany,
C M S College, Kottayam.

Shri. Paul V Karamthanam,
Asso. Prof., Dept. of Botany,
St. Thomas College, Pala.

Smt. K K Valsamma,
Asso. Prof., Dept. of Botany,
Maharajas College, Ernakulam.

Shri. Joshy K K,
Asso. Prof., Dept. of Botany,
SNM College, Maliankara.

Dr. P M Kuriachen,
Asso. Prof., Dept. of Botany,
U C College, Aluva.

Dr. G Mohandas Nair,
Professor and Head,
Dept of Botany, University of Kerala,
Kariavattom, Thiruvananthapuram.

Dr. C P Reghu,
Dy. Director, Germplasm division
RRII, Kottayam - 9.

Dr. George Joseph,
Asso. Prof., Dept. of Botany,
S H College, Thevara.

Smt. Molly A G,
Asso. Prof. & Head,
Dept. of Botany,
St. Peters College, Kolencherry.

CONTENTS

❖ Preface

In tune with the changing scenario in higher education, Mahatma Gandhi University decided to introduce Credit Semester System in all its regular Post-graduate programmes from 2012-2013 academic year. Regulations for the same were approved by order No. 5386/L/Acad/PGCSS (R)/2011 of Mahatma Gandhi University. Subsequently, the PG Board of studies in Botany met several times and prepared a draft syllabus conforming to the general guidelines of the curriculum for the post-graduate programmes. The draft syllabus was then subjected to a detailed review in a workshop of teachers in Botany representing all the post-graduate Colleges. Adequate modifications were incorporated into the curriculum based on the views and suggestions came up in the workshop.

These are exciting times in Biology. The world of Biology has been transformed in the last few decades. There was too much to select from. However, the Board of studies designed the programme envisioning the following objectives;

- To encourage a clear, comprehensive and advanced mastery in the field of Botany.
- To provide basic principles of biological sciences with special reference to Botany and its applied branches.
- Enabling the students to explore the intricacies of life forms at cellular, molecular and nano level.
- To sustain students' motivation and enthusiasm and to help them not only to appreciate the beauty of different life forms but also to inspire them in the dissemination of the concept of biodiversity conservation.
- To develop problem solving skills in students and encourage them to carry out innovative research projects thereby enkindling in them the spirit of knowledge creation.

The Board of Studies acknowledges the help rendered by many colleagues whose advice, thoughtful reviews, and comments have helped in the preparation of the syllabus.

Prof. Radhakrishnan Nair,
(Chairman)

'A good education is like a savings account. The more you put into it, the richer you are'.

--unknown

MAHATMA GANDHI UNIVERSITY
POST-GRADUATE PROGRAMMES
REGULATIONS FOR CREDIT AND SEMESTER SYSTEM (MGU-CSS-PG)
Salient features

I. These Regulations shall come into force from the Academic Year 2012-2013 onwards.
II. The regulation provided herein shall apply to all regular post-graduate programmes, MA/MSc/MCom, conducted by the affiliated colleges/Institutions (Government/Aided/unaided/ Self-financing, and Constituent colleges of Mahatma Gandhi University with effect from the academic year 2012-2013 admission onwards.
III. The provisions here in supersede all the existing regulations for the regular post-graduate programmes conducted by the affiliated colleges and centres of the Mahatma Gandhi University unless otherwise specified.
IV. These shall not apply for the programme conducted in distance/off campus and private registration mode which will continue to be in annual scheme.
V. Every Programme conducted under Credit Semester System shall be monitored by the College Council.

1. Important definitions

Programme - the entire course of study and Examinations.
Duration of Programme - duration of post-graduate programme shall be of 4 semesters.
Semester - a term consisting of a minimum of 90 working days, inclusive of examination, distributed over a minimum of 18 weeks of 5 working days each.
Academic week - a unit of 5 working days in which distribution of work is orgnised from day 1 to day 5, with 5 contact hours of 1 hour duration in each day. A sequence of 18 such academic week constitutes a semester.
Zero semester - a semester in which a student is permitted to opt out due to unforeseen genuine reasons.
Course - a segment of subject matter to be covered in a semester. Each Course is designed variously under lectures/tutorials/laboratory or fieldwork/seminar/project/practical training/ assignments/evalution etc., to meet effective teaching and learning needs.
Credit (Cr) - of a course is a measure of the weekly unit of work assigned for that course in a semester.
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 be considered as completed only by conducting the final examination. No regular student shall register for more than 24 credits and less than 16 credits per semester. The total minimum credits, required for completing a PG programme is 80.
Programme Core course - a course that the student admitted to a particular programme must successfully complete to receive the Degree and which cannot be substituted by any other course.
Programme Elective course - a course, which can be substituted, by equivalent course from the same subject and a minimum number of courses is required to complete the programme.
Programme Project - 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 center in order to submit a dissertation on the project work as specified.
Tutorial - a class to provide an opportunity to interact with students at their individual level to identify the strength and weakness of individual students.
Seminar - a lecture expected to train the student in self-study, collection of relevant matter from the books and Internet resources, editing, document writing, typing and presentation.
Evaluation - every student shall be evaluated by 25% internal assessment and 75% external assessment.
Repeat course - a course that is repeated by a student for having failed in that course in an earlier registration.
Improvement course - a course registered by a student for improving his performance in that particular course.
Audit Course - a course for which no credits are awarded.

Department - any teaching Department offering a course of study approved by the University in a college as per the Act or Statute of the University.
Parent Department - the Department which offers a particular post graduate progrramme.
Department Council - the body of all teachers of a Department in a College.
Faculty Advisor - a teacher nominated by a Department Council to coordinate the continuous evaluation and other academic activities undertaken in the Department.
Course Teacher - the teacher who is taking classes on the course.
College Co-ordinator - a teacher from the college nominated by the College Council to look into the matters relating to MGU-CSS-PG System
Letter Grade or simply, **Grade** - in a course is a letter symbol (A, B, C, D, E) which indicates the broad level of performance of a student in a course.
Each letter grade is assigned a **'Grade point' (G)** which is an integer indicating the numerical equivalent of the broad level of performance of a student in a course.
Credit point (P) - of a course is the value obtained by multiplying the grade point (G) by the Credit (Cr) of the course P = G x Cr.
Extra credits are additional credits awarded to a student over and above the minimum credits required for a programme for achievements in co-curricular activities carried out outside the regular class hours, as decided by the university.
Weight - a numerical measure quantifying the comparative range of an answer or the comparative importance assigned to different components like theory and practical, internal and external examinations, core and elective subjects, project and viva-voce etc.
Weighted Grade Point - is grade points multiplied by weight.
Weighted Grade Point Average (WGPA) - 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 of the grade points. 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.
Grade Point Average (GPA) - an index of the performance of a student in a course. It is obtained by dividing the sum of the weighted grade point obtained in the course by the sum of the weights of Course.
Semester Grade point average (SGPA) - the value obtained by dividing the sum of credit points (P) obtained by a student in the various courses taken in a semester by the total number of credits taken by him/her in that semester. The grade points shall be rounded off to two decimal places. SGPA determines the overall performance of a student at the end of a semester.
Cumulative Grade point average (CGPA) - the value obtained by dividing the sum of credit points in all the courses taken by the student for the entire programme by the total number of credits and shall be rounded off to two decimal places.
Grace Grade Points - grade points awarded to course/s, as per the choice of the student, in recognition of meritorious achievements in NCC/NSS/Sports/Arts and cultural activities.

2. Programme structure

(a) The programme includes two types of courses, **Program Core (PC)** courses and **Program Elective (PE)** Courses. There shall be a **Program Project (PP)** with dissertation to be undertaken by all students. The Programme also includes **assignments**, **seminars/practical** and **viva**.
(b) There are **3 PE courses** for M Sc Botany programme for the choice of students subject to the availability of facility and infrastructure in the institution and the selected one will be the subject of specialization of the programme.
(c) Project work shall be completed by working outside the regular teaching hours. Project work shall be carried out under the supervision of a teacher in the concerned department. A candidate may, however, in certain cases be permitted to work on the project in an industrial/Research Organization on the recommendation of the supervisor.
(d) There should be an internal assessment and external assessment for the project work. The external evaluation of the Project work is followed by presentation of work including dissertation and Viva-Voce. The title and the credit with grade awarded for the program project should be entered in the grade card issued by the university.

(e) **Assignments**: Every student shall submit one assignment as an internal component for every course with a weightage one. The Topic for the assignment shall be allotted within the 6th week of instruction.
(f) **Seminar Lectures** - Every student shall deliver one seminar lecture as an internal component for every course with a weightage two. The seminar lecture is expected to train the student in self-study, collection of relevant matter from the books and Internet resources, editing, document writing, typing and presentation.
(g) Every student shall undergo at least two class tests as an internal component for every course with a weightage 1 each. The weighted average shall be taken for awarding the grade for class tests.
(h) The attendance of students for each course shall be another component of internal assessment as prescribed with weightage one.
(i) No course shall have more than 4 credits.
(j) Comprehensive Viva-voce shall be conducted at the end semester of the program. Comprehensive Viva-Voce covers questions from all courses in the programme.

3. Attendance

(a) The minimum requirement of aggregate attendance during a semester for appearing the end semester examination shall be 75%. Condonation of shortage of attendance to a maximum of 10 days in a semester, subject to a maximum of two times during the whole period of post graduate programme may be granted by the University.
(b) If a student represents his/her institution, University, State or Nation in Sports, NCC, NSS or Cultural or any other officially sponsored activities such as college union/university union activities, he/she shall be eligible to claim the attendance for the actual number of days participated, subject to a maximum of 10 days in a semester based on the specific recommendations of the Head of the Department and Principal of the College concerned.
(c) A student who does not satisfy the requirements of attendance shall not be permitted to take the end semester examinations.

4. Registration/duration

(a) The duration of PG programmes shall be 4 semesters. The duration of each semester shall be 90 working days. Odd semesters from June to October and even semesters from December to April. There will be one month semester breaks each in November and May.
(b) A student may be permitted to complete the programme, on valid reasons, within a period of 8 continuous semesters from the date of commencement of the first semester of the programmes.

5. Admission

(a) The admission to all PG programmes shall be as per the rules and regulations of the University. The eligibility criteria for admission shall be as announced by the University from time to time. Separate rank lists shall be drawn up for reserved seats as per the existing rules. The college shall make available to all students admitted a Prospectus listing all the courses offered, including programme elective during a particular semester. The information provided shall contain title of the course and credits of the course.
(b) There shall be a uniform academic and examination calendar prepared by the University for the conducing the programmes. The University shall ensure that the calendar is strictly followed.
(c) There shall be provision for inter Collegiate and inter University transfer in 3rd semesters within a period of two weeks from the date of commencement of the semester.
(d) There shall be provision for credit transfer subject to the conditions specified by the Board of Studies concerned.

6. Admission requirements

(a) Candidates for admission to the first semester of the PG programme through CSS shall be required to have passed an appropriate Degree Examination of Mahatma Gandhi University as specified or any other examination of any recognized University or authority accepted by the Academic council of Mahatma Gandhi University as equivalent thereto.
(b) The candidate must forward the enrollment form to the Controller of Examinations of the University through the Head of the Institution, in which he/she is currently studying.

(c) The candidate has to register all the courses prescribed for the particular semester. Cancellation of registration is applicable only when the request is made within two weeks from the time of admission.
(d) Students admitted under this programme are governed by the Regulations in force.

7. Promotion

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

8. Examinations

(a) There shall be University examination at the end of each semester.
(b) Practical examinations shall be conducted by the University at the end of each semester.
(c) Project evaluation and viva-voce shall be conducted at the end of the programme only.
(d) Practical examination shall be conducted by one external examiner and one internal examiner. Specimens for the practical examinations shall be supplied entirely by the external examiner. Valuation of the answer scripts shall be done by both examiners in the centre itself. Project evaluation and viva-voce shall be conducted by two external examiners and one internal examiner.
(e) End-Semester Examinations: The examinations shall normally be at the end of each semester. There shall be one end-semester examination of 3 hours duration in each lecture based course and practical course.
(f) A question paper may contain short answer type/annotation, short essay type questions/problems and long essay type questions. Different types of questions shall have different weightage to quantify their range. Weightage can vary from course to course depending on their comparative importance, but a general pattern may be followed by the Board of Studies.

9. Evaluation and grading

Evaluation: The evaluation scheme for each course shall contain two parts; (a) **internal evaluation** and (b) **external 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 internal and external evaluation shall be carried out using direct grading system.
(a) **Internal evaluation**: The internal evaluation shall be based on predetermined transparent system involving periodic written tests, assignments, seminars and attendance in respect of theory courses and based on written tests, lab skill/records/viva and attendance in respect of practical courses. The weightage assigned to various components for internal evaluation is a follows.

Table 1. Components of Internal Evaluation:

Component	Weightage
(i) Assignment	1
(ii) Seminar	2
(iii) Attendance	1
(iv) Two Test papers	2

Table 2. Grade points:

Letter Grade	Performance	Grade point (G)	Grade Range
A	Excellent	4	3.5 to 4.00
B	Very Good	3	2.5 to 3.49
C	Good	2	1.5 to 2.49
D	Average	1	0.5 to 1.49
E	Poor	0	0.0 to 0.49

Table 3. Grades for Attendance:

% of attendance	Grade
> 90%	A
Between 85 and 90	B
Between 80 and below 85	C
Between 75 and below 80	D

< 75	E

Table 4. Assignment: grading components:

Component	Weight
(i) Punctuality	1
(ii) Review	1
(iii) Content	2
(iv) Conclusion	1
(v) Reference	1

Table 5. Seminar: grading components:

Component	Weight
(i) Area/Topic selected	1
(ii) Review/Reference	1
(iii) Content	2
(iv) Presentation	2
(v) Conclusion	1

Table 6. Practical: Internal assessment components:

Component	Weight
(i) Attendance	1
(ii) Laboratory involvement	2
(iii) Written/Lab test	2
(iv) Record	2
(v) Viva voce/Quiz	1

Table 7. Project evaluation: Internal assessment components:

Component	Weight
(i) Punctuality	1
(ii) Experimentation/Data collection	1
(iii) Compilation	1
(iv) Content	1

Table 8. Project evaluation: External assessment components:

Component	Weight
(i) Area/Topic selected	1
(ii) Objectives	2
(iii) Review	1
(iv) Materials and methods	2
(v) Analysis	2
(vi) Presentation	2
(vii) Conclusion/Application	2

(i) 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. There shall not be any chance for improvement for internal grade.

(ii) The course teacher and the faculty advisor shall maintain the academic record of each student registered for the course which shall be forwarded to the University through the college Principal and a copy should be kept in the college for at least two years for verification.

(b) External evaluation: The external examination in theory courses is to be conducted by the University with question papers set by external experts. 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 preferably through centralized valuation.

(i) Photocopies of the answer scripts of the external examination shall be made available to the students for scrutiny on request and revaluation/scrutiny of answer scripts shall be done as per the existing rules prevailing in the University.
(ii) The question paper should be strictly on the basis of model question paper set by BOS and there shall be a combined meeting of the question paper setters for scrutiny and finalization of question paper. Each set of question should be accompanied by its scheme of valuation.

10. Direct grading system

Direct Grading System based on a 5-point scale is used to evaluate the performance (External and Internal Examination of students).

Table 9. Direct grading system: Grade points

Letter Grade	Performance	Grade point (G)	Grade Range
A	Excellent	4	3.5 to 4.00
B	Very Good	3	2.5 to 3.49
C	Good	2	1.5 to 2.49
D	Average	1	0.5 to 1.49
E	Poor	0	0.0 to 0.49

(a) The overall grade for a programme for certification shall be based on CGPA with a 7-point scale given below:

Table 10. Overall grade: 7-point scale

CGPA	Grade
3.80 to 4.00	A+
3.50 to 3.79	A
3.00 to 3.49	B+
2.50 to 2.99	B
2.00 to 2.49	C+
1.50 to 1.99	C
1.00 to 1.49	D

(b) A separate minimum of C Grade for internal and external are required for a pass for a course. For a pass in a programme, a separate minimum grade C is required for all the courses and must score a minimum CGPA of 1.50 or an overall grade of C and above.
(c) Each course is evaluated by assigning a letter grade (A, B, C, D or E) to that course by the method of direct grading. The internal (weightage = 1) and external (weightage = 3) components of a course are separately graded and then combined to get the grade of the course after taking into account of their weightage.
(d) A separate minimum of C grade is required for a pass for both internal evaluation and external evaluation for every course.
(e) 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. There will be no supplementary examination.
(f) 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. For the successful completion of semester, a student should pass all courses and score a minimum SGPA of 1.50. However, a student is permitted to move to the next semester irrespective of her/his SGPA. For instance, if a student has registered for 'n' courses of credits C1, C2 ……, Cn in a semester and if she/he has scored credit points P1, P2……., Pn respectively in these courses, then SGPA of the student in that semester is calculated using the formula, SGPA = (P1 + P2 +…….+ Pn)/(C1 + C2 +……+ Cn)

CGPA = [(SGPA)1 x S1 + (SGPA)2 x S2 + (SGPA)3 x S3 + (SGPA)4 x S4]/ (S1+ S2 + S3 + S4)
Where S1, S2, S3, and S4 are the total credits in semesters 1, 2, 3 and 4 respectively.

11. Pattern of questions

(a) Questions shall be set to assess knowledge acquired, standard application of knowledge, application of knowledge in new situations, critical evaluation of knowledge and the ability to synthesize knowledge. The question setter shall ensure that questions covering all skills are set. He/she shall also submit a detailed scheme of evaluation along with the question paper. A question paper shall be a judicious mix of short answer type, short essay type/problem solving type and long essay type questions.
(b) Weight: Different types of questions shall be given different weights to quantify their range as follows:

Table 11. Question paper pattern:

Sl. No.	Type of questions	Weight	No. of questions to be answered
1.	Short answer type questions	1	6 out of 8
2.	Short essay (problem solving type questions)	2	7 out of 10
3.	Long essay type questions	5	2 out of 3

12. Grade card

The University under its seal shall issue to the students, a grade card on completion of each semester, which shall contain the following information.
(i) Name of the University.
(ii) Name of college.
(iii) Title of the PG Programme.
(iv) Name of Semester.
(v) Name and Register Number of students.
(vi) Code number, Title and Credits of each course opted in the semester, Title and Credits of the Project Work.
(vii) Internal, external and Total grade, Grade Point (G), Letter grade and Credit point (P) in each course opted in the semester.
(viii) The total credits, total credit points and SGPA in the semester.

The Final Grade Card issued at the end of the final semester shall contain the details of all courses taken during the entire programme including those taken over and above the prescribed minimum credits for obtaining the degree. The Final Grade Card shall show the CGPA and the overall letter grade of a student for the entire programme.

13. Award of degree

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

14. Monitoring committee

There shall be a Monitoring Committee constituted by the Vice-chancellor to monitor the internal evaluations conducted by institutions. The Course teacher, Faculty Advisor, and the College Coordinator should keep all the records of the internal evaluation, for at least a period of two years, for verification.

15. Grievence redressal committee

(a) College level: The College shall form a Grievance Redress Committee in each Department comprising of course teacher and one senior teacher as members and the Head of the Department as Chairman. The Committee shall address all grievances relating to the internal assessment grades of the students. There shall be a college level Grievance Redress Committee comprising of Faculty advisor, two senior teachers and two staff council members (one shall be an elected member) and the Principal as Chairman.
(b) University level: The University shall form a Grievance Redress Committee as per the existing norms.

Table 12. Programme courses, Teaching hours and Credit distribution: Total credits – 80

Semester	Course	Teaching Hours/Week	Credit	Total credits
I	PC-1	4	4	19
	PC-2	4	4	
	PC-3	4	4	
	PC-4	3	3	
	Practical (Pr. 1 + Pr. 2)	10	4	
II	PC-5	4	4	19
	PC-6	4	4	
	PC-7	4	4	
	PC-8	3	3	
	Practical (Pr. 3 + Pr. 4)	10	4	
III	PC-9	4	4	19
	PC-10	4	4	
	PC-11	4	4	
	PC-12	3	3	
	Practical (Pr. 5 + Pr. 6)	10	4	
IV	PE-1	5	4	23
	PE-2	5	4	
	PE-3	5	4	
	Practical (Pr. 7 + Pr. 8)	10	4	
	Project	-	4	
	Viva-Voce	-	3	

A. Consolidation of grades for internal evaluation

If B, C, B, and A grades are scored by a student for attendance, assignment, seminar and test paper respectively for a particular course, then her/his CE for that course shall be consolidated as follows:

Table 13. Internal evaluation: Consolidation of grades (Theory)

Component	Weight (W)	Grade awarded	Grade point (G)	Weighted Grade Points (W x G)
Attendance	1	B	3	3
Assignment	1	C	2	2
Seminar	2	B	3	6
Test paper	2	A	4	8
Total	6			19
Grade: Total weighted grade points/Total weights = 19/6 = 3.16 = Grade B				

The components are defined for internal evaluation of practical work and their weights are given (Table 6). If B, A, C, B and C grades are scored by a student for attendance, Laboratory involvement, Test, Record and Viva-voce respectively for a particular course, then her/his CE for that course shall be consolidated as follows:

Table 14. Internal evaluation: Consolidation of grades (Practical)

Component	Weight (W)	Grade awarded	Grade point (G)	Weighted Grade Points (W x G)
Attendance	1	B	3	3
Laboratory involvement	2	A	4	8
Written/Lab test	2	C	2	4
Record	2	B	3	6
Viva-voce/Quiz	1	C	2	2
Total	8			23
Grade: Total weighted grade points/Total weight = 23/8 = 2.88 = Grade B				

The grade of an answer paper (ESE Practical) shall be consolidated by similar procedure discussed above by assigning weights for the various components. (E.g., Procedure, Preparation, Experiment, Identification, Calculation, Accuracy of the reported values, Presentation of results, Diagrams, etc). The components identified and weights assigned for different practical examinations are given in the practical model question papers accompanying this syllabus.

B. Consolidation of grades for external (one answer paper - Theory)

The external evaluation of theory courses shall be consolidated as given below in Table 15 with different grades awarded to various questions.

Table 15. Model evaluation sheet and Grade Calculation:

Type of question	Question Nos.	Grade awarded	Grade points	Weightage	Weighted Grade Points
Short answer	1	B	3	1	3
	2	-	-	-	0
	3	A	4	1	4
	4	D	1	1	1
	5	-	-	-	0
	6	A	4	1	4
	7	B	3	1	3
	8	B	3	1	3
Short essay	9	B	3	2	6
	10	C	2	2	4
	11	-	-	-	0
	12	-	-	-	0
	13	B	3	2	6
	14	A	4	2	8
	15	C	2	2	4
	16	-	-	-	0
	17	C	2	2	4
	18	B	3	2	6
Long essay	19	-	-	-	0
	20	B	3	5	15
	21	D	1	5	5
Total				30	76
Calculation : Overall grade of an answer paper = sum of weighted grade points/ sum of the weightage = 76/30 = 2.53 = Grade B					

C. Consolidation of the grade of a course:

The grade for a course is consolidated by combining the ESE and CE grades taking care of their weights. For a particular course, if the grades scored by a student are C and B respectively for the external and the continuous evaluation, as shown in the above examples, then, the grade for the course shall be consolidated as follows:

Table 16. Consolidation of course grade

Examination	Weight	Grade awarded	Grade points (G)	Weighted Grade point (W x G)
External	3	C	2	6
Internal	1	B	3	3
Total	4			9
Grade of a course (GPA)	**Total weighted grade points/Total weights = 9/4 = 2.25 = Grade C**			

D. Consolidation of SGPA

SGPA is obtained by dividing the sum of credit points (P) obtained in a semester by the sum of credits (C) taken in that semester. After the successful completion of a semester, Semester Grade Point Average (SGPA) of a student in that semester shall be calculated using the formula given. In M Sc Botany programme, a student takes three courses each of 4 credits, one course of 3 credits and 2 practical courses each of 2 credits in the I, II, and III semesters. However, the IV semester has a different combination of courses and credits as explained below. After consolidating the grade for each course as demonstrated above, SGPA is consolidated as follows:

Table 17. Consolidation of SGPA for Semesters I, II, III.

Course code	Title of course	Credit (C)	Grade awarded	Grade points (G)	Credit Points (P = C x G)
01	--	4	A	4	16
02	--	4	C	2	8
03	--	4	B	3	12
04		3	B	3	9
05	--	2	C	2	4
06	--	2	B	3	6
Total		19			55
SGPA	**Total credit points/ Total credits = 55/19 = 2.89 = Grade B**				

Table 18. Consolidation of SGPA for Semester IV.

Course code	Title of course	Credit (C)	Grade awarded	Grade points (G)	Credit Points (P = C x G)
01	--	4	A	4	16
02	--	4	C	2	8
03	--	4	B	3	12
04	--	2	C	2	4
05	--	2	B	3	6
06	Project	4	B	3	12
07	Viva	3	A	4	12
Total		23			70
SGPA	**Total credit points/ Total credits = 70/23 = 3.04 = Grade B**				

E. Consolidation of CGPA

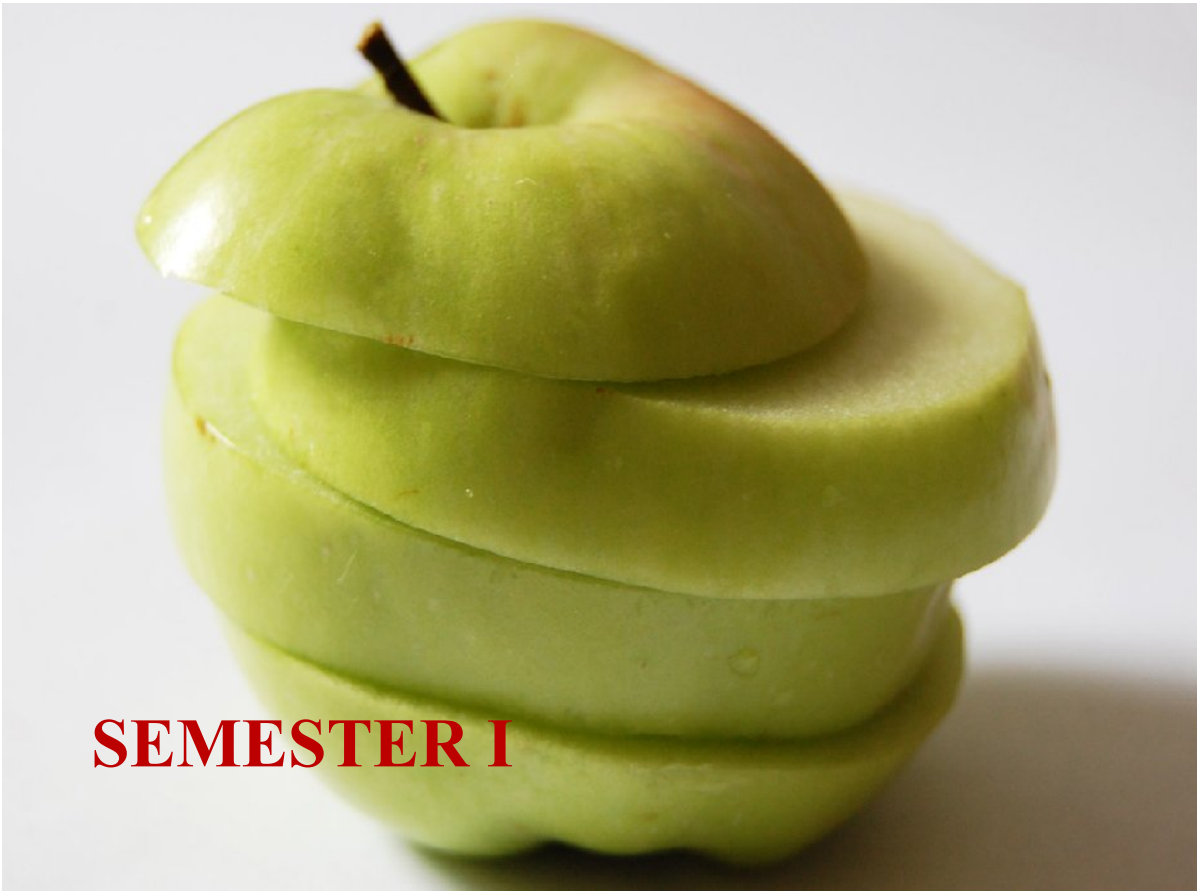
If the candidate is awarded two A grades, one B Grade and one C Grade for the four semesters and has 80 credits, the CGPA is calculated as fallows.

Table 19. Consolidation of CGPA

Semester	Credit taken	Grade	Grade point	Credit points
I	19	A	4	76
II	19	A	4	76
III	19	B	3	57
IV	23	C	2	46
Total	80			255
CGPA	**Total credit points/ Total credits = 255/80 = 3.18 (which is between 3.00 and 3.49 in 7 point scale). The overall grade awarded is B+**			

SEMESTERWISE DISTRIBUTION OF COURSES AND CREDITS

Course	Title	Teaching hrs Theory	Teaching hrs Practical	Credits
SEMESTER I				
PC 1	Microbiology + Phycology	27 + 45	9 + 36	4
PC 2	Mycology + Crop Pathology	36 + 36	36 + 18	4
PC 3	Bryology + Pteridology	36 + 36	18 + 36	4
PC 4	Environmental Biology	54	27	3
Pr. 1	Practicals of PC 1 + PC 2			2
Pr. 2	Practicals of PC 3 + PC 4			2
SEMESTER II				
PC 5	Gymnosperms + Evolution + Developmental Biology	27 + 27 + 18	27 + 0 + 18	4
PC 6	Cell and Molecular Biology	72	36	4
PC 7	Plant anatomy + Principles of Angiosperm systematics	36 + 36	36 + 27	4
PC 8	Genetics + Biochemistry	18 + 36	18 +18	3
Pr. 3	Practicals of PC 5 + PC 6			2
Pr. 4	Practicals of PC 7 + PC 8			2
SEMESTER III				
PC 9	Research Methodology + Biophysical instrumentation + Biostatistics + Microtechnique	18 + 18 + 18 + 18	9 + 18 + 18 + 27	4
PC 10	Plant Physiology + Plant Breeding	54 + 18	36 + 9	4
PC 11	Biotechnology	72	27	4
PC 12	Taxonomy of Angiosperms	54	36	3
Pr. 5	Practicals of PC 9 + 10			2
Pr. 6	Practicals of PC 11 + 12			2
SEMESTER IV				
PE 1	Biotechnology/Environmental Science/Microbiology	90	72	4
PE 2	,,	90	54	4
PE 3	,,	90	54	4
Pr. 7	Practicals of PE 1			4
Pr. 8	Practicals of PE 2 + PE 3			
Project				4
Viva				3



Course	Title	Teaching hrs Theory	Teaching hrs Practical	Credits
PC 1	Microbiology and Phycology	27 + 45	9 + 36	4
PC 2	Mycology and Crop Pathology	36 + 36	36 + 18	4
PC 3	Bryology and Pteridology	36 + 36	18 + 36	4
PC 4	Environmental Biology	54	27	3
Pr. 1	Practicals of PC 1 + PC 2			2
Pr. 2	Practicals of PC 3 + PC 4			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.				

PC 1: MICROBIOLOGY AND PHYCOLOGY
(Theory 27 + 45 hrs; Practical 9 + 36 hrs; Credits: 4)

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.

References

1. Bilgrami, Sinha. *Essentials of Microbiology*.
2. Carpenter P L (1967). *Microbiology*. W B Saunder & Co. Philadelphia.
3. Dube H C (2008). *Fungi, Bacteria and Viruses*. Agrobios.
4. Kanika Sharma (2005). *Manual of Microbiology: Tools and Techniques*. Ane Books.
5. Kumar H D (1990). *Modern concepts of Microbiology*. Vikas public. Delhi.
6. Lansing M Prescott, Harley, Klein (1999). *Microbiology*.
7. Pelczar Michael J, Adams M R, Chan E C S, Krieg Noel R (2000). *Microbiology*. Tata McGraw Hill.
8. Pelczar (1990). *Microbiology*. T M H.
9. Purohit S S (1997). *Microbiology: Fundamentals and application*. Agrobotanical.
10. Powar C B, Daginawala H F (1991). *General Microbiology* Vol II. Himalaya Publishing House.
11. Salle A J (1978). *Fundamentals of Bacteriology*. Asia TMH
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. Desmedium, Bryopsis, Acetabularia, Codium, Caulerpa, Halimeda, Neomeris, Chara, Nitella*.
(c) Xanthophyceae – *Vaucheria*.
(d) Bacillariophyceae - *Biddulphia, Pinnularia*.
(e) Phaeophyceae - *Ectocarpus, Colpomenia, Hydroclathrus, Dictyota, Padina, Sargassum, Turbinaria*.
(f) Rhodophyceae - *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.

PC 2: MYCOLOGY AND CROP PATHOLOGY
(Theory 36 + 36 hrs; Practical 36 + 18 hrs; Credits: 4)

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 - bacterial leaf blight, leaf spot; Mango - Anthracnose; Citrus - bacterial canker; Papaya – mosaic.
(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.

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.

PC 3: BRYOLOGY AND PTERIDOLOGY
(Theory 36 + 36 hrs; Practical 18 + 36 hrs; Credits: 4)

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) 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*.

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, 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.

PC 4: ENVIRONMENTAL BIOLOGY
(Theory 54 hrs; Practical 27 hrs; Credits 3)

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.

References

1. Ahmedullah M, Nayar M P (1987). *Endemic plants of India*.
2. Apha, Awwa, Wep. *Standard methods for the examination of water and waste water*.
3. Barbour M D, et. al., (1980). *Terrestrial plant ecology*. The Benjamin-Cammings Pub. Com.
4. Benton A H, Werner W E (1976). *Field biology and Ecology*. Tata McGraw Hill.
5. Clarke G L (1954). *Elements of Ecology*. John Wiley Pub.
6. Dash M C (1993). *Fundamentals of Ecology*. Tata McGraw Hill.
7. Eldon D, Enger, Bradley, Smith F (1995). *Environmental Science*. W C Brown publications.
8. *Ecological Guidelines for tropical costal developments*. UNESCO.
9. Furley P A et. al., (1983). *Geography of the biosphere: An introduction to the nature, distribution and evolution of the world life zones*. Butterworths.
10. IUCN (2000). *The IUCN red list category*. IUCN England.
11. IUCN (2007). *The 2000 IUCN red list of threatened species*. IUCN. England.
12. Jain S K, Sastry A R K (1984). *The Indian plant red data book*. BSI, Calcutta.
13. Jones H G, Vaugham R A. *Remote sensing of vegetation*. Oxford university press.
14. Kormondy E J (Ed) (1965). *Reading in ecology*. Prentice Hall.
15. Kormondy E J (Ed) (1999). *Concept of ecology*. Prentice Hall.
16. Kumar H D (1977). *Modern Concept of Ecology*. Vikas Publication.
17. Michael P (1984). *Ecological methods of field and laboratory investigations*. Tata McGraw Hill.
18. Misra K C. *Manual of plant ecology*. Oxford and IBH Pub. Com. P. Ltd.
19. Odum E P (III Edn) (1991). *Fundamentals of ecology*. Saunders and Com.

20. Pearcy R W et. al., (1989). *Plant physiological Ecology: Field methods and instrumentation*. Chapman and Hall.
21. Ramade F (1981). *Ecology of natural resources*. John Wiley and sons.
22. Sharma P D (1999). *Ecology and Environment*. Rastogy Pub.
23. Simons I G (1981). *Ecology of natural resources*. Edwin-Arnold Ltd.
24. Trivedi R. *International encyclopedia of ecology and environment* (Vol.1). IIEE, New Delhi.
25. Trivedi R K. *Practical methods in Ecology and Environmental sciences*. Envt. pub.
26. Varma P S, Agarwal V K. *Principles of Ecology*. S Chand and Co.
27. Varma P S, Agarwal V K. *Concept of Ecology*. S Chand and Co.
28. Walter (1987). *Vegetation of the earth*. Springer Verlag.

SEMESTER I MODEL QUESTION PAPERS - THEORY

Semester I Programme Course 1
Model Question Paper
PC 1: MICROBIOLOGY AND PHYCOLOGY

Time 3 hours **Weightage 30**

I. Answer any ***six*** 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.

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

9. What are prions? Describe the prion diseases in humans
10. Write an account on the major algal research centers in India.
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.

Semester I Programme Course 2
Model Question Paper
PC 2: MYCOLOGY AND CROP PATHOLOGY

Time 3 hours **Weightage 30**

I. Answer any ***six*** 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 Fungi (b) A coprophilous Fungi (c) A mycoparasite (d) A poisonous Fungi
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

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

9. What are the types of spores produced by Deuteromycetes?
10. Write a brief account on the environmental significance of lignolytic and cellulolytic Fungi.
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.

Semester I Programme Course 3
Model Question Paper
PC 3: BRYOLOGY AND PTERIDOLOGY

Time 3 hours **Weightage 30**

I. Answer any ***six*** 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

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

9. Describe algal origin of bryophytes.
10. Bring out the fossil history of bryophytes.
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.

Semester I Programme Course 4
Model Question Paper
PC 4: ENVIRONMENTAL BIOLOGY

Time 3 hours **Weightage 30**

I. Answer any ***six*** 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. What are RET species?
7. What are the consequences of eutrophication?
8. Explain resilience community.

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

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

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

19. Which are the different types of plant distribution? What are the principles governing and factors affecting the plant distributions?
20. 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.
21. Write an account on the criteria of classification of plant communities and explain the dynamic system of classification proposed by Clement.

SEMESTER I MODEL QUESTION PAPERS - PRACTICAL

Semester I Practical Course 1
Model Question Paper
MICROBIOLOGY, PHYCOLOGY, MYCOLOGY AND CROP PATHOLOGY

Time 3 hours **Weightage 20**

1. Make suitable micropreparations of A and B. Draw labelled diagrams and identify giving reasons.
(Total weight 2 = Preparation – 0.5, Diagram – 0.5, Identification with reasons – 1; 2 x 2 = 4)
2. Write critical notes on C and D.
(Total weight 1 = Identification – 0.5, Critical note – 0.5; 1 x 2 = 2)
3. Sort out any three algae from the algal mixture E and make separate clear mounts. Identify and draw labelled diagrams.
(Total weight 1.5 = Preparation – 0.5, Identification = 0.5, Diagram – 0.5; 1.5 x 3 = 4.5)
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.
(Total weight 1 = Identification – 0.5, Causative organism – 0.5; 1 x 2 = 2)
6. (a) Isolate Bacteria from the soil sample J by serial dilution - pour plate/spread plate method.
(Total weight 1.5 = Working – 1, Procedure – 0.5)

or

6. (b) Calculate spore load on the given seed sample J.
(Total weight 1.5 = Working – 0.5, Calculation, result and comments – 1)
7. Practical record
(Weight = 4)

Key to the questions:
1. A – Alga; B - Fungi/Lichen.
2. C, D - Fungi.
3. E – Algal mixture containing four filamentous types.
4. F, G – One Alga, one Fungi/Lichen.
5. H, I – Herbarium or live/dry specimen showing the symptoms of any disease specified in the syllabus
6. J - Draw lots for the two experiments. Supply necessary soil/seed sample.
7. Awarding ‘A grade’ for the record of practical work shall be considered only if all the practical works specified in the syllabus are done completely and recorded properly. This also includes field study report(s)/Lab visit report(s), if any.

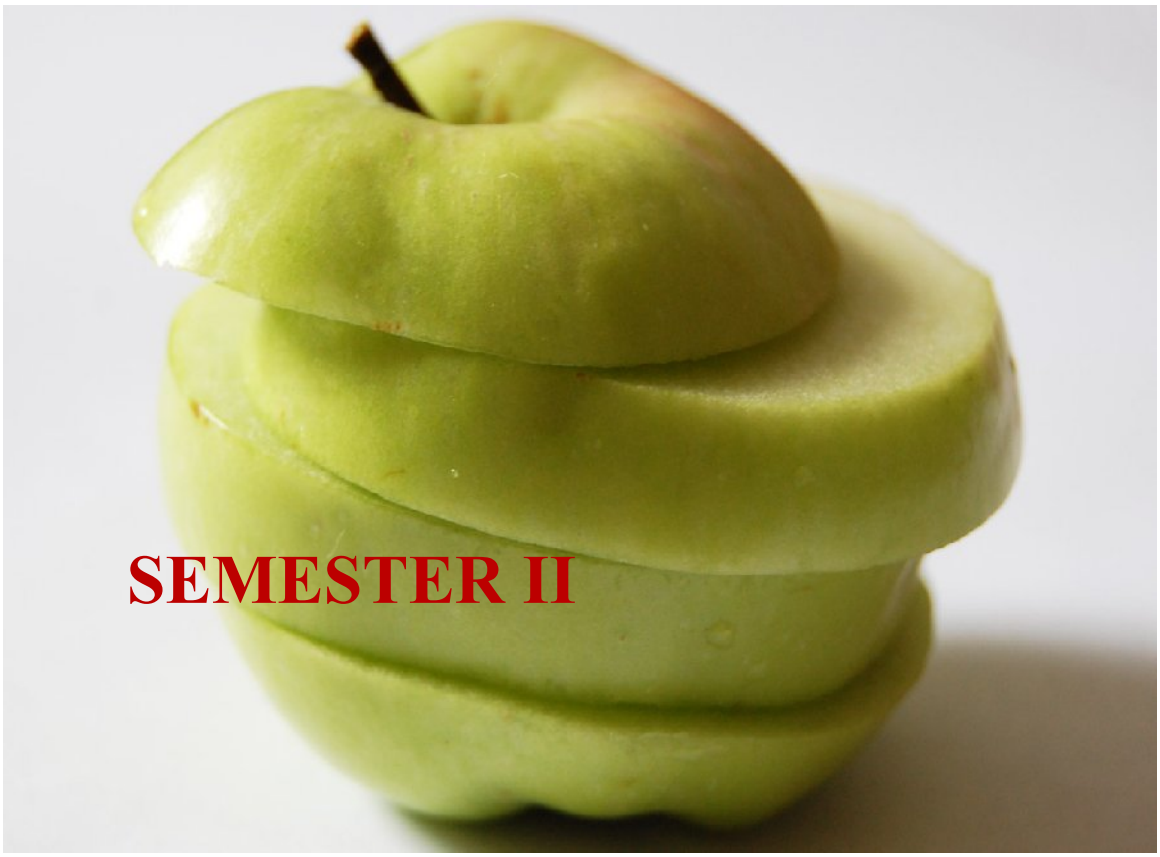
Semester I Practical Course 2
Model Question Paper

BRYOLOGY, PTERIDOLOGY AND ENVIRONMENTAL BIOLOGY

Time 3 hours **Weightage 20**

1. Make stained micropreparations of specimens A1, A2, B1 and B2. Draw labelled diagrams for each and identify giving reasons.
(Total weight 2 = Preparation - 1, Diagram – 0.5, Identification with reasons – 0.5; 2 x 4 = 8)
2. Identify at sight C, D and E.
(Total weight 1 = Genus identification - 0.5, Part displayed - 0.5; 1 x 3 = 3)
3. Quantify nitrite /phosphate /sulphate in the given sample F using Spectrophotometer/ Colorimeter.
(Total weight 2 = Working – 1, Procedure – 0.5, Result and Comments – 0.5)
4. Find out the abundance, frequency and density of species from the data of vegetation given as G. Calculate the index of similarity of the two samples.
(Total weight 2 = Abundance – 0.5, Frequency – 0.5, Density – 0.5, Similarity index – 0.5)
5. Illustrate the Environmental significance /consequence of the published diagram/ picture H.
(Weight = 1)
6. Practical record
(Weight = 4)

Key to the questions:
1. A1, A2, B1, B2 - Two suitable specimens each from Bryophytes and Pteridophytes.
2. C, D, E - Two specimens from Pteridophytes, one from Bryophytes.
3. F - Supply suitable water samples
4. G - Supply necessary data
5. H - Display a photograph or diagram of environmental importance published in popular journals/ periodicals/ dailies.
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.



Course	Title	Teaching hrs Theory	Teaching hrs Practical	Credits
PC 5	Gymnosperms, Evolution and Developmental Biology	27 + 27 + 18	27 + 0 + 18	4
PC 6	Cell and Molecular Biology	72	36	4
PC 7	Plant anatomy and Principles of Angiosperm systematics	36 + 36	36 + 27	4
PC 8	Genetics and Biochemistry	18 + 36	18 +18	3
Pr. 3	Practicals of PC 5 + PC 6			2
Pr. 4	Practicals of PC 7 + PC 8			2

PC 5: GYMNOSPERMS, EVOLUTION AND DEVELOPMENTAL BIOLOGY
(Theory 27 + 27 + 18 hrs; Practical 27 + 0 + 18 hrs; Credits 4)

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 female 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, Palaeontology, 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.

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 [3, 5, 6].

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.

References

1. Scott F Gilbert (2000). *Developmental Bilogy* (IX Edn). Sinauer Associates. (available online).
2. R M Twyman (2001). *Instant notes in Developmental Biology*. Viva Books Private Limited.
3. Lincoln Taiz, Eduardo Zeiger (2002). *Plant physiology* (II Edn). Sinaeur Associates, Inc. Publishers.
4. Robert J Brooker (2009). *Genetics: analysis & principles* (III Edn.). McGraw Hill
5. Bob B Buchanan, Wilhelm Gruissem, Russel L Jones (2000). *Biochemistry and Molecular biology of Plants*. L K International Pvt. Ltd.
6. Scott F Gilbert (2000). *Developmental Bilogy* (VIII Edn). Sinauer Associates.
7. S S Bhojwani, S P Bhatnagar (1999). *The Embryology of Angiosperms* (IV Edn). Vikas Publishing House Pvt Ltd.
8. Maheswari P (1950). *An introduction to the embryology of Angiosperms*. McGraw Hill.

PC 6: CELL AND MOLECULAR BIOLOGY
(Theory 72 hrs; Practical 36 hrs; Credits: 4)

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].

(c) 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].

(d) 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 [6, 7, 13, 27], peptidyl transferase, elongation factors. Termination – process of termination, release factors [6, 13, 17, 27], ribosome recycling [17, 31].

(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 heterochromatization and gene silencing[6, 7, 9, 10, 13, 19, 20, 22, 24, 25, 31].

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.

References

1. Wayne M Becker, Lewis J Kleinsmith, Jeff Hardin (2007). *The world of the cell* (VI Edn). Pearson.
2. Geoffrey M Cooper, Robert E Hausman (2009). *The Cell: A molecular approach* (V Edn). Sinaeur.
3. Gerald Karp (2008). *Cell and Molecular biology: Concepts and experiments* (V Edn). John Wiley & Sons.
4. Harvey Lodish, Arnold Berk, Lawrence Zipursky, Paul Matsudaira, David Baltimore, James Darnell (2000). *Molecular cell biology* (IV Edn). W H Freeman & Company.
5. 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.
6. Robert J Brooker (2009). *Genetics: analysis and principles* (III Edn). McGraw Hill.
7. Jocelyn E Krebs, Elliott S Goldstein, Stephen T Kilpatrick (2011). *Lewin's Genes X*. Jones and Bartlett Publishers.
8. Bob B Buchanan, Wilhelm Gruissem, Russel L Jones (2000). *Biochemistry and Molecular biology of plants*. I K International Pvt. Ltd.
9. Daniel L Hartl, Elizabeth W Jones (2012). *Genetics: Analysis of genes and genomes* (VII Edn). Jones and Bartlett publishers.
10. James D Watson, Tania A Baker, Stephen P Bell, Alexander Gann, Michael Levine, Richard Losick (2009). *Molecular biology of the gene* (V Edn). Pearson.
11. William S Klug, Michael R Cummings (2004). *Concepts of Genetics* (VII Edn). Pearson.
12. Daniel J Fairbanks, W Ralph Anderson (1999). *Genetics: The continuity of life*. Brooks/Cole publishing company.
13. Robert F Weaver (2002). *Molecular biology* (II Edn). McGraw Hill.
14. Bruce Alberts, Dennis Bray, Karen Hopkin, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter (2010). *Essential Cell Biology*. Garland Science.
15. Leland H Hartwell, Leroy Hood, Michael L Goldberg, Ann E Reynolds, Lee M Silver, Ruth C Veres (2004). *Genetics from genes to genomes* (II Edn). McGraw Hill.
16. 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.
17. James D. Watson, Amy A. Caudy, Richard M. Myers, Jan A. Witkowski (2007). *Recombinant DNA* (III Edn). W H Freeman.
18. William H Elliott, Daphne C Elliott (2001). *Biochemistry and molecular biology* (II Edn). Oxford.
19. Jeremy M Berg, John L Tymoczko, Lubert Stryer, Gregory J Gatto Jr. (2007). *Biochemistry*. W H Freeman & company.
20. David P Clark (2010). *Molecular biology*. Elsevier.
21. David R Hyde (2010). *Genetics and molecular biology*. Tata McGraw Hill.
22. D Peter Snustad, Michael J Simmons (2010). *Principles of genetics* (V Edn). John Wiley and Sons.
23. David A Micklos, Greg A Freyer with David A Crotty (2003). *DNA Science: A first course* (II Edn). L K Inter.
24. Benjamin A Pierce (2008). *Genetics: A conceptual approach* (IV Edn). W H Freeman and Company.

25. Anthony J F Griffiths, Susan R Wesler, Sean B Carroll, John Doebley (2012). *Introduction to genetic analysis*. W H Freeman & Company.
26. T A Brown (2002). *Genomes* (II Edn). Bios.
27. Robert H Tamarin (2002). *Principles of genetics*. McGraw Hill.
28. David E Sadava (2009). *Cell biology: Organelle structure and function*. CBS.
29. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter (2010). *Essential Cell Biology* (III Edn.). Garland Science.
30. Pranav Kumar, Usha Mina (2011). *Biotechnology: A problem approach*. Pathfinder Academy.
31. Burton E Tropp (2012). *Molecular biology: Genes to Proteins* (IV Edn). Jones and Bartlett Learning.
32. Lynne Cassimeris, Viswanath R Lingappa, George Plopper (Eds) (2011). *Lewin's Cells* (II Edn). Jones and Bartlett Publishers.

PC 7: PLANT ANATOMY AND PRINCIPLES OF ANGIOSPERM SYSTEMATICS
(Theory 36 + 36 hrs; Practical 36 + 27 hrs; Credits 4)

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 (4 hrs)
Morphological and structural adaptations in different ecological groups - hydrophytes, xerophytes, epiphytes and halophytes.
Module 7: Applied anatomy (2 hrs)
Applications of anatomy in systematics (histotaxonomy) and Pharmacognosy. Research prospects in anatomy.

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.

References

1. Eames A J, McDaniel (1976). *An introduction to plant Anatomy*.
2. Edred John Henry Corner (1976). *The seeds of dicotyledons* (vol. I, II). Cambridge University Press.
3. Ella Werker (1997). *Seed Anatomy*. Borntreager.
4. Elizabeth G Cutter (1978). *Plant anatomy part I & II*. Clive and Arnald Ltd.
5. Elizabeth G Cutter (1978). *Applied Plant Anatomy*. Clive and Arnald Ltd.
6. Esau K (1965). *Vascular differentiation in plants*. Rirehant and Winston, Inc.
7. Esau K (1977). *Anatomy of seed plants*. Wiley and sons.
8. Fahn A. (1997). *Plant anatomy*. Aditya Publishers.
9. Foster A S. *Practical plant Anatomy*.
10. Chowdhuri (Ed). *Indian woods* (6 volumes). Forest research institute, Dehradun
11. Ingrid Roth (1977). *Fruits of Angiosperm*. Gebruder Borntreager.
12. Kuriachen P M, Thomas V, Dave Y (1992). *Taxonomic and phylogenetic significance of fruit walls in Asclepiadaceae*. Feddes R epertorium.
13. Kuriachen P M, Dave P Thomas V, Mercymol Sebastian (1992). *SEM studies on seed surface of some Asclepiadaceae with taxonomic significance*. Geophytology.
14. Metcalf C R, Chalk L (1950). *Anatomy of Dicotyledons and Monocotyledons*.
15. Metcalf C R, Chalk L (1983). *Anatomy of the dicotyledons: Wood structure and conclusion of the general introduction*. Oxford University press.
16. Pandey B P. *Plant Anatomy*. S Chand and Co.
17. Reghu C P (2002). *Structural features of Rubber wood*. Rubberwood Processing and utilization in India.Ganesh Publications, Bangalore.
18. Reghu C P, George B P, YA Varghese (2007). *Screening of Hevea germplasm for wood quality using Cinnamyl Alcohol Dehydrogenase (CAD) activity and lignifications pattern*. Natural Rubber Research, 20 (1&2): 1-7.
19. Sherwin John Carlquist (2001). *Comparative wood anatomy: Systematic, ecological, and evolutionary aspects of dicotyledon wood*.
20. Tharian George K, Reghu C P, Nehru CR (2000). *By-products and ancillary sources of income*. Natural Rubber: Agro management and Crop Processing, Rubber Research Institute of India, Kottayam. 507-510
21. Vasishta P C (1994). *Plant anatomy*. Pradeep publications.
22. Wardrop A B (1961). *The structure and formation of reaction wood in Angiosperm: Problems of tree physiology*. Recent advances in Botany (Vol II). University of Toronto press.
23. Wardrop A B (1964). *Reaction wood Anatomy in Arborescent angiosperms*. Formation of wood in forest trees (Ed, Zimmerman). Academic press, New York.

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.

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.

References
1. Lawrence George H M (1951). *Taxonomy of vascular plants*. Oxford and IBH Publ. Co. Pvt. Ltd.
2. Jeffrey C (1968). *An Introduction to principles of Plant Taxonomy*.
3. Cole A J (1969). *Numerical Taxonomy*. Academic Press.
4. Davis P H, Heywood V M (1973). *Principles of Angiosperm Taxonomy*. Robert E Kereiger Publ.
5. Harrison H J (1971). *New Concepts in Flowering Plant Taxonomy*. Heiman Educational Books Ltd.
6. Cronquist A (1981). *An Integrated system of classifications of flowering plants*. Columbia University Press.
7. Heywood V H, D M Moore (Eds) (1984). *Current concept in Plant Taxonomy*.
8. Naik V V (1984). *Taxonomy of Angiosperms*. Tata McGraw Hill Publ. Co. Ltd.
9. Radford A E (1986). *Fundamentals of Plant Systematics*. Harper & Row Publ.
10. Davis P H, V H Heywood (1991). *Principles of Angiosperm Taxonomy*. Today and Tomorrow Publications.
11. Stace C A (1989). *Plant Taxonomy and Biosystematics*. Etwaed Arnold.
12. Woodland D W (1991). *Contemporary Plant Systematics*. Prentice Hall.
13. Sivarajan V V (1991*). Introduction to Principles of Plant Taxonomy*. Oxford IBH.
14. Takhtajan A L (1997). *Diversity and Classification of Flowering Plants*. Columbia Univ. Press.

15 Taylor D V, L J Hickey (1997). *Flowering plants: Origin, evolution and phylogeny*. CBS Publishers & Distributors.
16. Stuessy T F (2002). *Plant taxonomy: The systematic Evaluation of comparative data*. Bishen Singh, Mahendra Pal Singh. Dehradun.
17. Gurcharan Singh (2004). *Plant Systematics: Theory and practice*. Oxford and IBH Publishing.
18. Wendy B Zomlefer (2006). *Guide to Flowering Plant Families*. Overseas Press India Private Ltd.
19. *International Code of Botanical Nomenclature* (latest)
20. Henry A N, Chandrabose M (1980). *An aid to the International Code of Botanical Nomenclature.*

P C 8: GENETICS AND BIOCHEMISTRY
(Theory 18 + 36 hrs; Practical 18 + 18 hrs; Credits 3)

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
1. Benjamin Lewin (2000). *Genes VII*. Oxford university press.
2. Gardner E J, Simmons M J, Snustad D P (1991). *Principles of Genetics* (III Edn). John Wiley and Sons Inc.
3. Snustad D P, Simmons M J (2000). *Principles of Genetics* (III Edn). John Wiley and Sons.
4. Strickberger (2005). *Genetics* (III Edn). Prentice Hall of India Pvt. Ltd.
5. William S Klug, Michael R Cummings (1994). *Concepts of Genetics*. Prentice Hall.
6. Robert J Brooker (2009). *Genetics: Analysis and principles* (III Edn). McGraw Hill.
7. Daniel L Hartl, Elizabeth W Jones (2009). *Genetics: Analysis of genes and genomes* (VII Edn). Jones and Bartlett publishers.
8. D Peter Snustad, Michael J Simmons (2010). *Principles of genetics* (V Edn). John Wiley and Sons.

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 [2, 3, 4, 6, 8].

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].

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

1. David T Plummer (1998). *An introduction to practical biochemistry*. Tata Mc Graw Hill.
2. Jeremy M Berg, John L Tymoczko, Lubert Stryer, Gregory J Gatto Jr. (2007). *Biochemistry*. W H Freeman and company.
3. Michael M Cox, David L Nelson (2008). *Lehninger Principles of biochemistry* (V Edn). W H Freeman and company.
4. Donald Voet, Judith G Voet (2011). *Biochemistry* (IV Edn). John Wiley & Sons Inc.
5. Carl Branden, John Tooze (1999). *Introduction to protein structure* (II Edn). Garland Publishing.
6. Reginald H Garrett, Charles M Grisham (2005). *Biochemistry*. Thomson Brooks/Cole.
7. Robert K Murray, David A Bender, Kathleen M Botham, Peter J Kennelly, Victor W Rodwell, P Anthony Weil (2009). *Harper's Illustrated Biochemistry* (XXVIII Edn). Mc Graw Hill.
8. H Robert Horton, Laurence A Moran, Raymond S Ochr, J David Rawn, K Gray Scrimgeour (2002). *Principles of Biochemistry* (III Edn). Prentice Hall.
9. Bob B Buchanan, Wilhelm Gruissem, Russel L Jones (2000). *Biochemistry and molecular biology of plants*. L K International Pvt. Ltd.
10. S Sadasivam, A Manickam (1996). *Biochemical methods* (II Edn). New age international Publishers.

SEMESTER II MODEL QUESTION PAPERS - THEORY

Semester II Programme Course 5
Model Question Paper
PC 5: GYMNOSPERMS, EVOLUTION AND DEVELOPMENTAL BIOLOGY
Time 3 hours **Weightage 30**

I. Answer any ***six*** 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 corralloid roots?
4. What do you mean by Abiogenesis?
5. Define the term 'demes'.
6. Describe;
(a) Double fertilization (b) Tripple fusion
7. Mention what is the N.P.C. formula?
8. Writ brief notes on;
(a) Epochs (b) Molecular clock

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

9. Compare Gymnosperms with Angiosperms?
10. Write a note on classification of Gymnosperms?
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. Write brief notes on the following;
(a) Apomixis (b) Xenia (c) Polyembryony (d) Imprinting
17. Give an illustrated account of the anatomy of the leaflet of cycas, and explain the function of various tissues found therein?
18. 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.

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. Write an essay on morphogenesis and organogenesis in plants.

Semester II Programme Course 6
Model Question Paper
PC 6: CELL AND MOLECULAR BIOLOGY

Time 3 hours **Weightage 30**

I. Answer any ***six*** 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?

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

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

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.

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

I. Answer any ***six*** 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

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

9. Briefly describe different nodal patterns and their evolutionary trends.
10. Describe the seasonal activity of cambium and wood development
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

Semester II Programme Course 8
Model Question Paper
PC8: GENETICS AND BIOCHEMISTRY

Time 3 hours **Weightage 30**

I. Answer any ***six*** 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

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

9. Explain the following giving suitable examples;
(a) Dominance (b) Incomplete dominance (c) Codominance (d) Overdominance
10. Describe the procedure of protein sequencing by Edman degradation method
11. What is polygenic inheritance? Give suitable examples for polygenic inheritance. Discuss the issues that make polygenic inheritance difficult to study.
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. Draw suitable diagrams.
14. Describe buffer action citing suitable examples.
15. Describe the salvage pathway of nucleotide biosynthesis
16. What is Hardy-Weinberg equilibrium? What are the applications of Hardy-Weinberg principles?
17. Write an account on the types and functions of common secondary metabolites found in plants
18. '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?

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

19. What is Ramachandran plot? Describe the structural details and principles based on which Ramachandran plots are constructed. Add a note on its applications.
20. 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. Describe why these forces change the frequencies?
21. Write an account on the different methods of regulation of enzyme activity

SEMESTER II MODEL QUESTION PAPERS - PRACTICAL

Semester II Practical Course 3
Model Question Paper
GYMNOSPERMS, DEVELOPMENTAL BIOLOGY, CELL & MOLECULAR BIOLOGY

Time 3 hours **Weightage 20**

1. Make stained micropreparations (TS, TLS and RLS) of A. Draw labelled diagram and identify giving reasons.
(Total weight 4 = Preparations – 0.5 each, Identification with reasons - 1, Diagrams - 0.5 each)
2. Write critical notes on B and C.
(Total weight 1 = Identification 0.5, critical note 0.5; 1 x 2 = 2)
3. Prepare a smear of the given anther D and identify any two stages of meiosis I.
(Total weight 2 = Preparation – 1, Identification with reasons – 0.5, Diagram – 0.5; 2 x 2 = 4)
4. Workout the problems E and F.
(Weight = 2; 2 x 2 = 4)
5. Dissect embryo from the given seeds G.
(Weight = 1)
6. Write critical notes on H.
(Weight = 1)
7. Practical record
(Weight = 4)

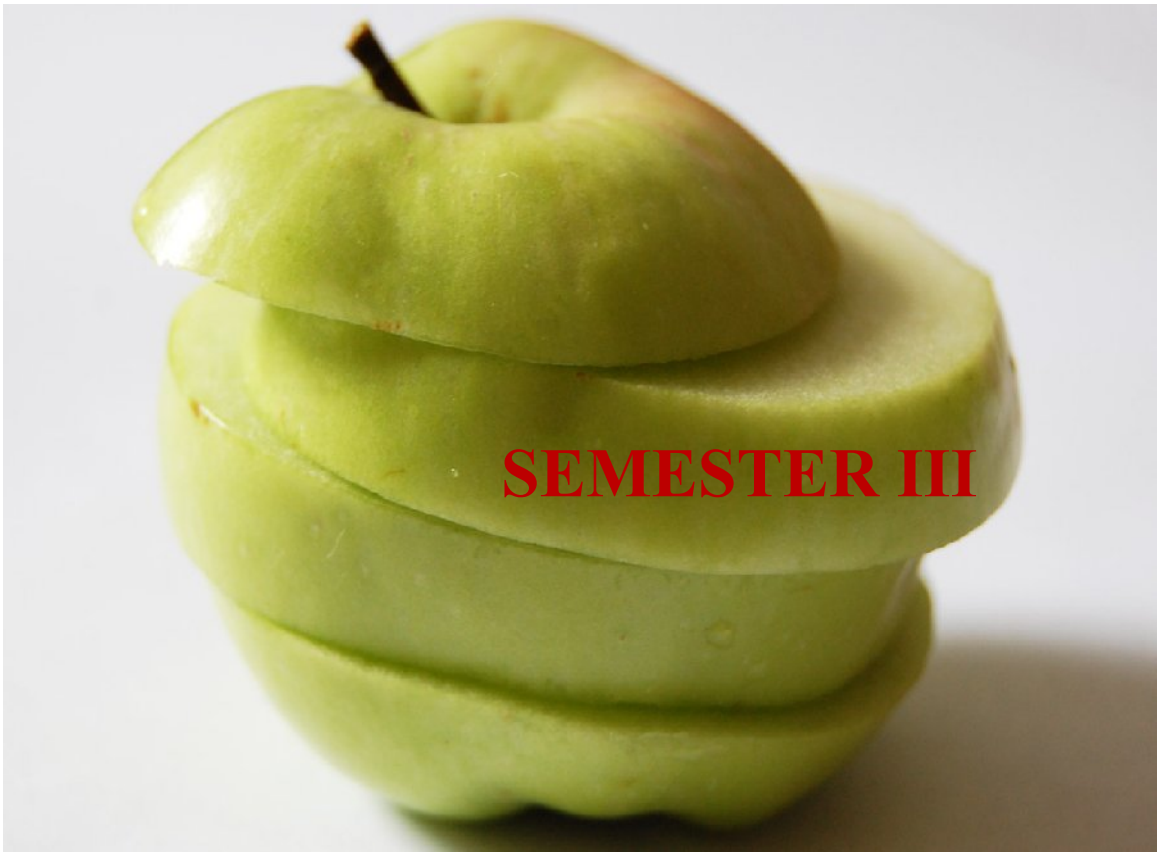
Key to the questions:
1. A - Specimens from Coniferales prescribed in the syllabus
2. B - Suitable Gymnosperm specimens; C - fossil slides/specimens specified in the syllabus
3. D - Supply fresh flower buds of *Rhoeo* or *Chlorophytum.*
4. E, F - Problems related to DNA structure/replication/gene expression/genetic code
5. G - Seeds with young embryos – maximum credit for youngest stages
6. H - Permanent slide/Photograph of embryo types, polyembryony, endosperm types, pollen grains, anther developmental stages, types etc.
7. Awarding 'A grade' for the record of practical work shall be considered only if all the practical works specified in the syllabus are done completely and recorded properly. This also includes field study report(s)/Lab visit report(s), if any.

Semester II Practical Course 4
Model Question Paper
PLANT ANATOMY, ANGIOSPERM SYSTEMATICS, GENETICS AND BIOCHEMISTRY

Time 3 hours **Weightage 20**

1. Make suitable micropreparation of specimen A. Draw diagrams, identify giving reasons.
(Total weight 2 = Preparation – 0.5, Identification with reasons – 1, Diagram – 0.5)
2. Describe and compare the stomatal type and pattern in the materials B and C.
(Total weight 1.5 = Identification of stomatal types – 0.5 + 0.5, Comparison – 0.5)
3. Describe the nodal feature of the Material D
(Total weight 1 = Identification of nodal type – 0.5, Description – 0.5)
4. Explain the given nomenclatural problem E.
(Weight = 1)
5. Identify the morphological type and write critical notes on material F
(Total weight 1 = Identification – 0.5, Critical note – 0.5)
6. Describe the given material G in technical terms. Draw L. S of the flower, floral diagram and write the floral formula.
(Total weight 3.5 = Vegetative characters – 0.5, Floral characters – 1, LS – 1, Floral diagram – 0.5, Floral formula – 0.5)
7. Workout the problems H and I.
(Weight – H - 2, I - 1)
8. Assay of amylase enzyme from germinating seeds/Appropriate plant material J.
(Total weight 3 = Principle and procedure – 1.5, Calculation – 1, Result – 0.5)
9. Practical record
(Weight = 4)

Key to the questions:
1. A – Stem showing anomalous growth, prescribed in the syllabus.
2. B and C – Leaves having distinct types of stomata
3. D – Nodal segments having type of node specified in the syllabus
4. E – Taxonomy problem related to nomenclature
5. F – Any type of fruit specified in the syllabus
6. G – Give a plant twig complete with vegetative and floral features
7. H - Problem based on linkage mapping, I – Problem in population genetics.
8. J – Give the sample and reagents necessary
9. Awarding 'A grade' for the record of practical work shall be considered only if all the practical works specified in the syllabus are done completely and recorded properly. This also includes field study report(s)/Lab visit report(s), if any.



Course	Title	Teaching hrs Theory	Teaching hrs Practical	Credits
PC 9	Research Methodology, Biophysical instrumentation, Biostatistics and Microtechnique	18 + 18 + 18 + 18	9 + 18 + 18 + 27	4
PC 10	Plant Physiology and Plant Breeding	54 + 18	36 + 9	4
PC 11	Biotechnology	72	27	4
PC 12	Taxonomy of Angiosperms	54	36	3
Pr. 5	Practicals of PC 9 + 10			2
Pr. 6	Practicals of PC 11 + 12			2

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

Research methodology (18 hrs)

Module 1: Introduction (2 hrs)
Need for research, stages of research; Generation of a research problem, execution of work, interpretation 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) 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.

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 (Table top centrifuge and ultra centrifuge).
(b) Chromatography: Principles and application; paper, TLC, Column chromatography, GC, HPLC.
(c) Immunoassay systems, ELISA - ELISA reader.
(d) Electrophoresis: SDS PAGE.
(e) X-ray crystallography.
(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 (3 hrs)

(a) Mean
(b) Median
(c) Mode

Module 3: Measures of dispersion (3 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.

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.

PC 10: PLANT PHYSIOLOGY AND PLANT BREEDING
(Theory 54 + 18 hrs; Practical 36 + 9 hrs; Credits: 4)

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 – gated

channels, 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.

PC 11: BIOTECHNOLOGY
(Theory 72 hrs, Practical 27 hrs; Credits: 4)

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 [21, 28, 37, 38].

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 strategies [23, 41]. Functional genomics – genome annotation, gene expression study using microarrays [23, 39], functional annotation of genes [4, 5, 10].

Module 12: Bioinformatics (8 hrs)

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.

References

1. Susan R. Barnum (1998). *Biotechnology: an introduction*. Thomson Brooks/cole.
2. George Acquaah (2005). *Understanding biotechnology*. Pearson.
3. James D. Watson, Amy A. Caudy, Richard M. Myers, Jan A. Witkowski (2007). *Recombinant DNA* (III Edn). W H Freeman.
4. S. B. Primrose, R. M. Twyman (2006). *Principles of gene manipulation and genomics* (VII Edn). Blackwell publishing.
5. Robert J Brooker (2009). *Genetics: Analysis & principles* (III Edn.). McGraw Hill.
6. Leland H Hartwell, Leroy Hood, Michael L Goldberg, Ann E Reynolds, Lee M Silver, Ruth C Veres (2004). *Genetics: From genes to genomes* (II Edn). McGraw Hill.
7. Robert F Weaver (2002). *Molecular biology* (II Edn). McGraw Hill.
8. Smita Rastogi, Neelam Pathak (2010). *Genetic engineering*. Oxford.
9. William J Thieman, Michael A Palladino (2009). *Introduction to biotechnology* (II Edn). Pearson.
10.David W Mount (2001). *Bioinformatics: Sequence and genome analysis*. CBS publishers & distributors.
11. Jeremy W Dale, Malcolm von Schantz (2002). *From genes to genomes*. John Wiley & Sons Ltd.
12. David P Clark (2010). *Molecular biology*. Elsevier.
13. Jeremy M Berg, John L Tymoczko, Lubert Stryer, Gregory J Gatto Jr. (2007). *Biochemistry*. W H Freeman and company.
14. D Peter Snustad, Michael J Simmons (2010). *Principles of genetics* (V Edn). John Wiley and Sons.

15. Benjamin A Pierce (2008). *Genetics: A conceptual approach* (IV Edn). W H Freeman and Company.
16. Peter J Delver, Seamus J Martin, Dennis R Burton, Ivan M Roitt (2011). *Roitt's essential immunology* (XII Edn). Wiley Blackwell.
17. Jocelyn E Krebs, Elliott S Goldstein, Stephen T Kilpatrick (2011). *Lewin's Genes X* . Jones and Bartlett Publishers.
18. Paul G Higgs, Teresa K Attwood (2005). *Bioinformatics and molecular evolution*. Blackwell publishing.
19. John L Ingraham, Catherine A Ingraham (2000). *Introduction to microbiology* (II Edn). Brooks/Cole.
20. Kathleen Park Talaro, Arthur Talaro (2002). *Foundations in microbiology*. McGraw Hill.
21. Hamish A Collin, Sue Edwards (1998). *Plant tissue culture*. Bios scientific publishers.
22. C W Sensen (2002). *Genomics and Bioinformatics*. Wiley – VCH.
23. T A Brown (2002). *Genomes* (II Edn). Bios.
24. Richard A Goldsby, Thomas J Kindt, Barbara A Osborne, Janis Kuby (2003). *Immunology* (V Edn). W H Freeman and Company.
25. Zhumur Ghosh, Bibekanand Mallik (2008). *Bioinformatics: principles and applications*. Oxford University press.
26. Orpita Bosu, Simminder Kaur Thukral (2007). *Bioinformatics: Databases tools and algorithms*. Oxford University press.
27. R A Dixon, R A Gonzales (2004). *Plant cell culture, a practical approach* (II Edn). Oxford University Press.
28. S S Bhojwani, M K Razdan (1996*). Plant tissue culture: Theory and Practice*. Elsevier.
29. Teresa K Attwood, David J Parry-Smith, Simiron Phukan (2007). *Introduction to Bioinformatics*. Pearson Education.
30. T A Brown (1995). *Gene cloning: an introduction* (III Edn). Stanley Thomas (Publishers) Ltd.
31. S B Primrose (1999). *Molecular biotechnology* (II Edn). Panima Publishing Corporation.
32. Nicholas C Price, Lewis Stevens (1999). *Fundamentals of enzymology* (III Edn). Oxford University press.
33. Trever Palmer (2004). *Enzymes: Biochemistry, Biotechnology, Clinical chemistry*. T. Palmer/ Harwood Publishing Limited.
34. E M T El-Mansi, C F A Bryce, A L Demain, A R Allman (2007). *Fermentation Microbiology and Biotechnology* (II Edn). Taylor & Francis.
35. Colin Ratledge, Bjorn Kristianson (2001). *Basic biotechnology*. Cambridge University press.
36. O L Gamborg, G C Philips (Eds.) (2005). *Plant cell, tissue and organ culture: Fundamental methods*. Narosa Publishing House.
37. *In vitro cultivation of plant cells*. Biotechnology by open learning. Elsevier.
38. D E Evans, J O D Coleman, A Kearns (2003). *Plant Cell Culture*. BIOS Scientific Publishers.
39. Bernard R Glick, Jack J Pasternak, Cheryl L Pattein (2010). *Molecular biotechnology, principles and applications of recombinant DNA*. ASM press.
40. Burton E Tropp (2012). *Molecular biology: Genes to Proteins* (IV Edn). Jones and Bartlett Learning.
41. Anthony J F Griffiths, Susan R Wesler, Sean B Carroll, John Doebley (2012). *Introduction to genetic analysis*. W H Freeman and Company.
42. Alexander N Glazer, Hiroshi Nikaido (2007). *Microbial Biotechnology: Fundamentals of applied microbiology*. Cambridge University Press.
43. Edwin F George, Michael A Hall, Geert-Jan De Klerk (2008). *Plant Propagation by Tissue Culture: The Background* (Vol I). Springer.
44. L E Casida (2005). *Industrial Microbiology*. New Age International Limited.
45. Peter F Stanbury and Allan Whitaker (1999). *Principles of Fermentation technology*. Butterworth-Heinemann.
46. S C Prescott and Cecil Gordon Dunn (2004). *Industrial Microbiology*. CBS publishers and distributors.
47. A H Patel (2000). *Industrial Microbiology*. Macmillan Publishers.
48. Ashok Pandey (2001). *Solid state fermentation in biotechnology*. Asiatech publishers.

PC 12: TAXONOMY OF ANGIOSPERMS
(Theory 54 hrs; Practical 36 hrs; Credits 3)

Module 1: Classification (5 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 (43 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. Annonaceae 4. Cruciferae (Brassicaceae) 5. Polygalaceae 6. Caryophyllaceae 7. Guttiferae (Clusiaceae) 8. Malvaceae 9. Tiliaceae 10. Geraniaceae 11. Rutaceae 12. Vitaceae 13. Sapindaceae 14. Fabaceae 15. Caesalpiniaceae 6. Mimosaceae 17. Rosaceae 18. Lythraceae 19. Melastomaceae 20. Myrtaceae 21. Cucurbitaceae 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. Convolvulaceae 35. Solanaceae 36. Scrophulariaceae 37. Acanthaceae 38. Verbenaceae 39. Lamiaceae 40. Polygonaceae 41. Aristolochiaceae 42. Lauraceae 43. Loranthaceae 44. Euphorbiaceae 45. Orchidaceae 46. Dioscoriaceae 47. Zingiberaceae 48. Araceae 49. Cyperaceae 50. 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.

References

1. Jain S K (1991). *Dictionary of Indian Folkmedicine and Ethnobotany*.
2. Paye G D (2000). *Cultural Uses of Plants: A Guide to Learning about Ethnobotany*. The New York Botanical Garden Press.
3. Hooker J D. *The flora of British India* (Vol. I – VII).
4. Gamble J S. *Flora of the Presidency of Madras*. (Vol. I – III).
5. Cronquist A (1960). *Evolution and classification of flowering plants*. Thomas & Nelson Co.
6. Cronquist A (1981). *An integrated system of classification of flowering plants*. Columbia University Press.
7. Heywood V H, Moore D M (Eds) (1984). *Current concepts in Plant taxonomy*.
8. Radiford A E (1986). *Fundamentals of plant systematics*. Harper & Row.
9. Rendle A E (1970). *Classification of flowering plants*. Vikas Co.
10. Stace C A (1989). *Plant Taxonomy and Biosystematics* (II Edn). CBS Publ.
11. Woodland D W (1991). *Contemporary Plant Systematics*. Prentice Hall.
12. Sivarajan V V (1991). *Introduction to Principles of Plant Taxonomy*. Oxford IBH.
13. Takhtajan A L (1997). *Diversity and Classification of Flowering Plants*. Columbia Univ. Press.

SEMESTER III MODEL QUESTION PAPERS - THEORY

Semester III Programme Course 9
Model Question Paper
PC 9: RESEARCH METHODOLOGY, BIOPHYSICAL INSTRUMENTATION, BIOSTATISTICS AND MICROTECHNIQUE

Time 3 hours **Weightage 30**

I. Answer any ***six*** 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?

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

9. What are the different stages of research?
10. Write an essay on literature survey and its importance in research.
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

Semester III Programme Course 10
Model Question Paper
PC 10: PLANT PHYSIOLOGY AND PLANT BREEDING

Time 3 hours **Weightage 30**

I. Answer any ***six*** 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

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

9. Write brief descriptions on;
(a) Aquaporin (b) Active transport (c) Light harvesting complexes (d) Glycolysis
10. What is the role of the antenna complex in the light-dependent reactions of photosynthesis? Include in your answer a discussion on how light energy absorbed by a pigment is transferred to the reaction center of the photosystem.
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

Semester III Programme Course 11
Model Question Paper
PC 11: BIOTECHNOLOGY

Time 3 hours **Weightage 30**

I. Answer any ***six*** 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

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

9. Write an account on primary and secondary databases
10. How does PCR work? What is it used for? What is the role of oligonucleotide primers?
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
22. Discuss briefly on sequence alignment, substitution scores and gap penalties

Semester III Programme Course 12
Model Question Paper
PC 12: TAXONOMY OF ANGIOSPERMS

Time 3 hours **Weightage 30**

I. Answer any ***six*** 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?

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

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
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
22. Compare the vegetative and floral features of the families of Bicarpellatae and bring out the evolutionary trends.

SEMESTER III MODEL QUESTION PAPERS - PRACTICAL

Semester III Practical Course 5
Model Question Paper
RESEARCH METHODOLOGY, BIOSTATISTICS, BIOPHYSICAL INSTRUMENTATION, MICROTECHNIQUE, PLANT PHYSIOLOGY AND PLANT BREEDING

Time 3 hours **Weightage 20**

1. Conduct the experiment A
(Total weight 4 = Principle, procedure and graph, if any – 1.5, Working – 1, Result – 0.5, Comments/Interpretation - 1)
2. (a) Determine the size of the given filament/pollen/spore B using micrometer
(Total weight 2 = Calibration – 0.5, Measurement, calculation and result – 1.5)
or
2. (b) Find out the number of spores /ml in the given spore suspension B.
(Total weight 2 = Counting – 0.5, Calculation – 1, Result 0.5)
or
2. (c) Find the concentration of the given sample solution B using colorimeter. Prepare a standard graph from the given values.
(Total weight 2 = Principle, procedure and graph – 1, Working – 0.5, Result – 0.5)
3. Workout the problem C
(Weight = 2)
4. Prepare a double stained micropreparation of material D and mount it as a permanent slide.
(Total weight 2 = Sectioning and staining – 1.5, Mounting – 0.5)
5. Prepare serial sections of E and mount on a glass slide
(Total weight 2 = Microtome sectioning – 1, Mounting – 1)
6. Estimate pollen sterility in the given sample F.
(Weight = 1)
7. Permanent slides
(Weight = 3)
8. Practical record
(Weight = 4)

Key to the questions:
1. A – Draw lots from the list of physiology experiments provided. A minimum of 6 experiments from the list should be included in the lots.
2. B – Draw lots for the three experiments. Give necessary samples.
3. C – Problem from Probability/Chi-square test/t-test/Standard deviation
4. D – Fresh plant material suitable for taking hand sections
5. E – Embedded paraffin blocks, mounting the ribbon in a minimum of two rows.
6. F – Staining or germination method
7. Permanent slides prepared by the student as specified in the syllabus and certified by the head of the department.
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.

List of plant physiology experiments (Question 1)

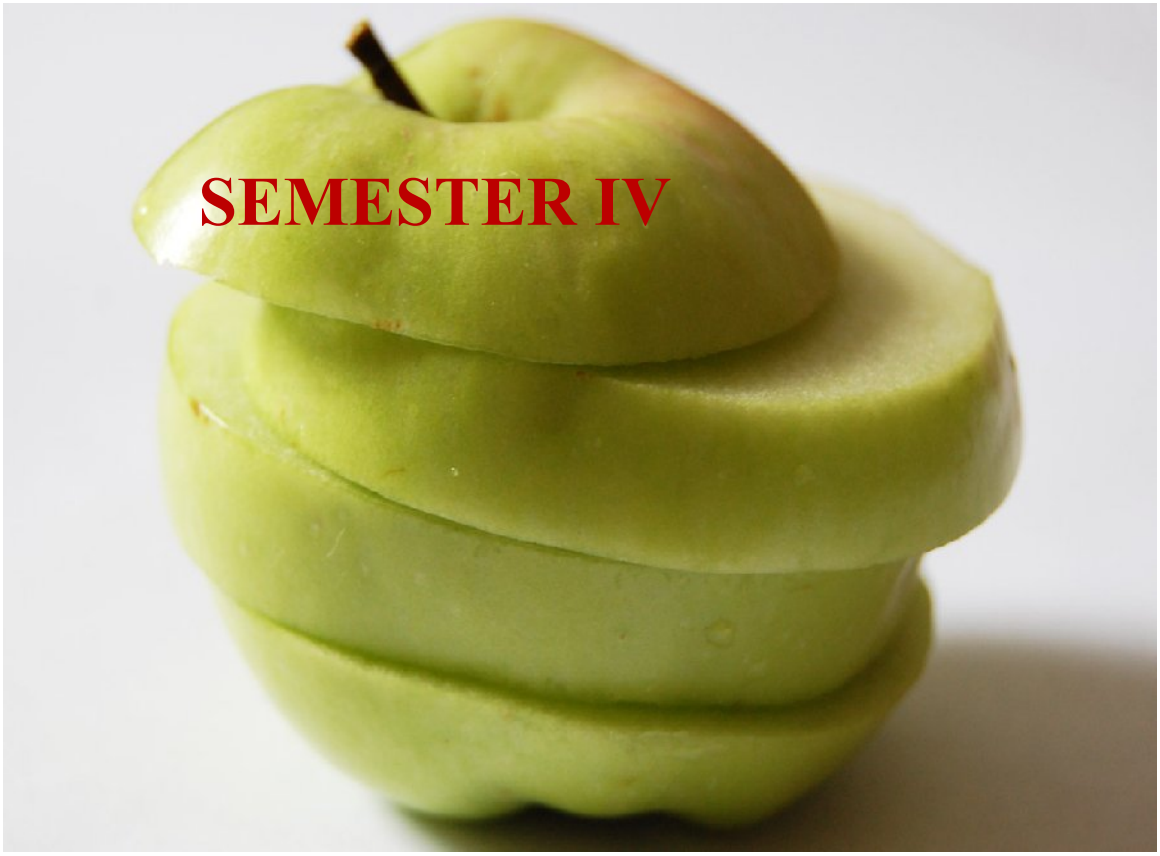
1. Separate pigments of the given leaf sample by column chromatography. Collect the pigment fragments and submit. Comment on the result.
2. Determine the osmotic potential of the given plant tissue from the values corresponding to change in weight of the tissue. Comment on the result.
3. Estimate the proline content in the control (e.g., seeds germinated in fresh water) as well as the treated (e.g., seeds germinated in 50mM NaCl) sample. Prepare a standard graph from the given values. Comment on the result.
4. Estimate the phenol content in plant tissues affected by biotic stress and compare the same with non affected portions. Prepare a standard graph from the given values. Comment on the result.
5. Determine peroxidase activity in plant tissues affected by biotic/abiotic stresses. Prepare a standard graph from the given values. Comment on the result.
6. Estimate free amino acids in senescing leaves and compare the same with young leaves. Prepare a standard graph from the given values. Comment on the result.
7. Estimate the total chlorophyll in shade leaves and sun leaves and comment on the result
8. Estimate the leghaemoglobin in the root nodules

Semester III Practical Course 6
Model Question Paper
ANGIOSPERM TAXONOMY AND BIOTECHNOLOGY

Time 3 hours **Weightage 20**

1. Identify the families of the given specimens A and B.
(Total weight 1.5 = Identification up to series with reasons – 0.5, Identification up to cohort with reasons – 0.5, Identification of the family with reasons – 1; 2 x 2 = 4)
2. Identify the given material C up to genus.
(Total weight 2 = Identification up to family with reasons – 0.5, Identification of genus with author citation – 0.5, Genus key – 1)
3. Identify the given material D up to species.
(Total weight 3 = Identification up to family – 0.5, Identification of genus with author citation – 0.5, Genus key – 0.5, Identification of species with author citation – 0.5, Species key – 1)
4. Write the Economic/ethnobotanical importance of the materials E and F.
(Weight = 0.5; 0.5 x 2 = 1)
5. Herbarium and field book.
(Weight 1)
6. Identification of herbarium specimens
Total weight 1 = genus 0.5, species - 0.5; 1 x 2 = 2)
7. Using MEGA perform multiple sequence alignment of NG_030166 nucleotide sequence with 5 related sequences and show the similarity (Identify the query).
(Weight = 1)
8. Write the protocol for the preparation for raising salt/drought resistant plants. Prepare 200ml medium containing the each of any one of the cytokinin and auxin and …….mg/l^{-1} NaCl/PEG according to the protocol submitted. Adjust the pH of the medium as specified.
(Total weight 2 = Calculation and protocol – 1, Preparation - 1)
9. Practical record.
(Weight = 4)

Key to the questions:
1. A, B – Plant materials for family identification
2. C – Material for genus identification
3. D – Material for species identification
4. E, F – Raw or finished products of economically/ethnobotanically important plants
5. Herbarium (25 nos) and field book certified by the head of the department and submitted by the student.
6. Write the binomials of the two herbarium specimens selected randomly by the examiner.
7. This is nucleotide sequence; Download this from genbank and save it in each desktop.
8. Supply stock solutions necessary to prepare MS medium.
9. Awarding 'A grade' for the record of practical work shall be considered only if all the practical works specified in the syllabus are done completely and recorded properly. This also includes field study report(s)/Lab visit report(s), if any.



Elective	PE course	Course title	Teaching hrs Theory	Teaching hrs Practical	Credits
Biotechnology	PE 1	Tissue culture and Microbial biotechnology	90	72	4
	PE 2	Genetic engineering	90	54	4
	PE 3	Genomics, Proteomics and Bioinformatics	90	54	4
Env Science	PE 1	Basic concepts in Environmental studies	90	72	4
	PE 2	Natural resources and their management	90	54	4
	PE 3	Environmental monitoring and management	90	54	4
Microbiology	PE 1	Food, Agricultural and Environmental microbiology	90	72	4
	PE 2	Clinical microbiology	90	54	4
	PE 3	Industrial microbiology	90	54	4
Practical	PE Pr Course 1	Practicals of PE 1			2
	PE Pr Course 2	Practicals of PE 2 + 3			2
Others	Project				4
	Viva				3

PROGRAMME ELECTIVE - BIOTECHNOLOGY
PE 1. TISSUE CULTURE AND MICROBIAL BIOTECHNOLOGY
(Theory 90 hrs; Practical 72 hrs; Credits 4)

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 organic acids.
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.

References

1. Hamish A Collin, Sue Edwards (1998). *Plant tissue culture*. Bios scientific publishers.
2. R A Dixon, R A Gonzales (2004). *Plant cell culture, a practical approach* (II Edn). Oxford University Press.
3. S S Bhojwani, M K Razdan (1996). *Plant tissue culture: Theory and Practice*. Elsevier.
4. Susan R. Barnum (1998). *Biotechnology an introduction*. Thomson Brooks/cole.
5. Nicholas C Price, Lewis Stevens (1999). *Fundamentals of enzymology* (III Edn). Oxford university press.
6. Trever Palmer (2004). *Enzymes: Biochemistry, Biotechnology, Clinical chemistry*. T Palmer/Harwood Publishing Limited.
7. E M T El-Mansi, C F A Bryce, A L Demain, A R Allman (2007). *Fermentation Microbiology and Biotechnology* (II Edn). Taylor & Francis.
8. O L Gamborg, G C Philips (Eds.) (2005). *Plant cell, tissue and organ culture: Fundamental methods*. Narosa Publishinh House.
9. *In vitro cultivation of plant cells*. Biotechnology by open learning. Elsevier.
10. John L Ingraham, Catherine A Ingraham (2000). *Introduction to microbiology* (II Edn). Brooks/Cole
11. Kathleen Park Talaro, Arthur Talaro (2002). *Foundations in microbiology*. McGraw Hill.
12. Colin Ratledge, Bjorn Kristianson (2001). *Basic biotechnology*. Cambridge University press.
13. William J Thieman, Michael A Palladino (2009). *Introduction to biotechnology* (II Edn). Pearson.
14. D E Evans, J O D Coleman, A Kearns (2003). *Plant Cell Culture*. BIOS Scientific Publishers.
15. Bernard R Glick, Jack J Pasternak, Cheryl L Pattein (2010). *Molecular biotechnology, principles and applications of recombinant DNA*. ASM press.
16. Alexander N Glazer, Hiroshi Nikaido (2007). *Microbial Biotechnology: Fundamentals of applied microbiology*. Cambridge University Press.
17. Anne Kathrine Hvoslef-Fide, Walter Preil (Eds) (2005). *Liquid Culture Systems for in vitro Plant Propagation*. Springer.
18. Edwin F. George, Michael A. Hall, Geert-Jan De Klerk (2008). *Plant Propagation by Tissue Culture (Vol I): The Background*. Springer.
19. Michael R. Davey, Paul Anthony (2010). *Plant Cell Culture: Essential Methods*. Wiley-Blackwell A John Wiley & Sons, Ltd.
20. Trevor A. Thorpe and Edward C. Yeung (Eds) (2011). *Plant Embryo Culture: Methods and Protocols*. Springer, Heidelberg.
21. Barbara M. Reed (2008). *Plant Cryopreservation: A Practical Guide*. Springer, Heidelberg.
22. Erica E. Benson (1999). *Plant Conservation Biotechnology*. Taylor and Francis.
23. Pritchard H W (2004). *Modern methods in orchid conservation: The role of Physiology, Ecology and Management*. Cambridge University Press.

24. Wen-Huei Chen, Hong-Hwa Che (2007). *Orchid Biotechnology*. World Scientific Publishing Co. Pvt. Ltd.
25. Joseph Arditti (2008). *Micropropagation of Orchids* (Vol. I). Blackwell publishing.
26. Alisher Touraev, Brian P. Forster, S. Mohan Jain (Eds) (2009). *Advances in Haploid Production in Higher Plants*. Springer, Heidelberg.
27. S Mohan Jain, H. Häggman (Eds) (2007). *Protocols for Micropropagation of Woody Trees and Fruits*. Springer, Heidelberg.
28. L E Casida.(2005) *Industrial Microbiology*. New Age international limited.
29. Peter F Stanbury, Allan Whitaker (1999). *Principles of Fermentation technology*. Butterworth-Heinemann.
30. S C Prescott, Cecil Gordon Dunn (2004). *Industrial Microbiology*. CBS publishers and distributors.
31. A H Patel (2000). *Industrial Microbiology*. Macmillan Publishers.
32. Ashok Pandey (2001). *Solid state fermentation in biotechnology*. Asiatech publishers.
33. Pauline M. Doran (1995). *Bioprocess Engineering Principles*. Academic Press Ltd.
34. M L Srivasthava (2007). *Fermentation technology*. Alpha Science Intl Ltd.
35. Gary Walsh (2002). *Proteins:Biochemistry and Biotechnology*. John Wiley and Sons.
36. Ronald M Atlas, Jim Philip (2005). *Applied Microbial solutions for real-world environment clean up*. Amer Society for Microbiology.
37. Martin Alexander (1999). *Biodegradation and Bioremediation*. Academic Press.
38. Dennis Thomas, Rakhi chaturvedi (2008). *Endosperm culture: A novel method for triploid plant production*. Plant cell and organ culture, Springer science.
39. S Ignacimuthu (2006). *Biotechnology: An introduction*. Narosa Publishing House.

PROGRAMME ELECTIVE - BIOTECHNOLOGY
PE 2: GENETIC ENGINEERING
(Theory 90 hrs; Practical 54 hrs; Credits 4)

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 [9, 20, 25]. 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 [19, 21, 22].
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 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.

References

1. James D Watson, Amy A Caudy, Richard M Myers, Jan A Witkowski (2007). *Recombinant DNA* (III Edn). W H Freeman.
2. S B Primrose, R M Twyman (2006). *Principles of gene manipulation and genomics* (VII Edn). Blackwell publishing.
3. Robert J Brooker (2009). *Genetics: Analysis & principles* (III Edn). McGraw Hill.
4. T A Brown (2002). *Genomes* (II Edn). Bios.
5. Leland H Hartwell, Leroy Hood, Michael L Goldberg, Ann E Reynolds, Lee M Silver, Ruth C Veres (2004). *Genetics: From genes to genomes* (II Edn). McGraw Hill.
6. Abul K Abbas, Andrew H Lichtmay, Shiv Pillai (2007). *Cellular and molecular immunology* (IV Edn). Elsevier.
7. Charles A Janeway Jr., Paul Travers, Mark Walport, Mark J Schiomchik (2007). *Immunobiology*. Garland science, Churchill Livingstone.
8. Richard A Goldsby, Thomas J Kindt, Barbara A Osborne, Janis Kuby (2003). *Immunology* (V Edn). W H Freeman and Company.
9. Smita Rastogi, Neelam Pathak (2010). *Genetic engineering*. Oxford.
10. Bernard R Glick, Jack J Pasternak, Cheryl L Pattein (2010). *Molecular biotechnology: Principles and applications of recombinant DNA*. ASM press.
11. S B Primrose, R M Twyman, R W Old (2001). *Principles of gene manipulation* (VI Edn). Blackwell Science.
12. Jeremy W Dale, Malcolm von Schantz (2002). *From genes to genomes*. John Wiley & Sons Ltd.
13. Daniel L Hartl, Elizabeth W Jones (2009). *Genetics: analysis of genes and genomes* (VII Edn). Jones and Bartlett publishers.

14. P Nagarajan, N Senthilkumar (2002). *Molecular biology: Principles and methods*. Sree Narmatha printers, Coimbatore.
15. Joseph Sambrook, David W Russell (2001). *Molecular cloning: A laboratory manual*. Cold spring harbor laboratory press.
16. David P Clark (2010). *Molecular biology*. Elsevier.
17. Jeremy M Berg, John L Tymoczko, Lubert Stryer, Gregory J Gatto Jr. (2007). *Biochemistry*. W H Freeman and company.
18. Desmond S T Nicholl (2010). *An introduction to genetic engineering* (III Edn). Cambridge.
19. D Peter Snustad, Michael J Simmons (2010). *Principles of genetics* (V Edn). John Wiley and Sons.
20. David A Micklos, Greg A Freyer with David A Crotty (2003). *DNA Science: A first course* (II Edn). L K Inter.
21. Benjamin A Pierce (2008). *Genetics: A conceptual approach* (IV Edn). W H Freeman and Company
22. Anthony J F Griffiths, Susan R Wesler, Sean B Carroll, John Doebley (2008). *Introduction to genetic analysis* (X Edn). W H Freeman and Company.
23. Benjamin Lewin (2006) *Genes IX*. Jones and Bartlett.
24. Kathleen Park Talaro, Arthur Talaro (2002). *Foundations in microbiology*. McGraw Hill.
25. William J Thieman, Michael A Palladino (2009*). Introduction to biotechnology* (II Edn). Pearson.
26. Carl Branden, John Tooze (1999). *Introduction to protein structure* (II Edn). Garland Publishing.
27. *Science* August 3, 2007:Vol. 317 no. 5838 pp.
28. *Science,* May 20, 2010.
29. E M T El-Mansi, C F A Bryce, A L Demain, A R Allman (2007). *Fermentation Microbiology and Biotechnology* (II Edn). Taylor & Francis.
30. T A Brown (1995). *Gene cloning: An introduction* (III Edn). Stanley Thomas (Publishers) Ltd.
31. S B Primrose (1999). *Molecular biotechnology* (II Edn). Panima Publishing Corporation.
32. Alexander N Glazer, Hiroshi Nikaido (2007). *Microbial Biotechnology: Fundamentals of applied microbiology*. Cambridge University Press.
33. Alan Fersht (1999). *Structure and Mechanism in Protein Science*. W H Freeman and Company.

PROGRAMME ELECTIVE - BIOTECHNOLOGY
PE 3: GENOMICS, PROTEOMICS AND BIOINFORMATICS
(Theory 90 hrs; Practical 54 hrs; Credits 4)

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.

References

1. S B Primrose, R M Twyman (2006). *Principles of gene manipulation and genomics* (VII Edn). Blackwell publishing.
2. Robert J Brooker (2009). *Genetics: analysis & principles* (III Edn). McGraw Hill.
3. James D Watson, Amy A Caudy, Richard M Myers, Jan A Witkowski (2007). *Recombinant DNA* (III Edn). W H Freeman.
4. T A Brown (2002). *Genomes* (II Edn). Bios.
5. Leland H Hartwell, Leroy Hood, Michael L Goldberg, Ann E Reynolds, Lee M Silver, Ruth C Veres (2004). *Genetics:From genes to genomes* (II Edn). McGraw Hill.
6. *Science*, 16 february 2001, Vol. 291.
7. David W Mount (2001). *Bioinformatics: sequence and genome analysis*. CBS publishers & distributors.
8. Jeremy M Berg, John L Tymoczko, Lubert Stryer, Gregory J Gatto Jr. (2007). *Biochemistry*. W H Freeman and company.
9. David P Clark (2010). *Molecular biology*. Elsevier.
10. D Peter Snustad, Michael J Simmons (2010). *Principles of genetics* (V Edn). John Wiley and Sons.

11. David A Micklos, Greg A Freyer with David A Crotty (2003). *DNA Science: A first course* (II Edn). L K Inter.
12. Benjamin A Pierce (2008). *Genetics: A conceptual approach* (IV Edn). W H Freeman and Company.
13. Anthony J F Griffiths, Susan R Wesler, Sean B Carroll, John Doebley (2008). *Introduction to genetic analysis* (X Edn). W H Freeman and Company.
14. Benjamin A Pierce (2008). *Genetics: A conceptual approach* (IV Edn). W H Freeman and Company
15. Paul G Higgs, Teresa K Attwood (2005). *Bioinformatics and molecular evolution*. Blackwell publishing.
16. C W Sensen (2002). *Genomics and Bioinformatics*. Wiley – VCH.
17. T A Brown (2002). *Genomes* (II Edn). Bios.
18. William J Thieman, Michael A Palladino (2009). *Introduction to biotechnology* (II Edn). Pearson
19. George Acquaah (2005). *Understanding biotechnology*. Pearson.
20. Teresa K Attwood, David J Parry-Smith, Simiron Phukan (2007). *Introduction to Bioinformatics*. Pearson Education.
21. Zhumur Ghosh, Bibekanand Mallik (2008). *Bioinformatics: principles and applications*. Oxford University press.
22. Orpita Bosu, Simminder Kaur Thukral (2007). *Bioinformatics: Databases tools and algorithms*. Oxford University press.
23. Robert H Tamarin (2002). *Principles of genetics*. McGraw Hill.
24. Robert K Murray, David A Bender, Kathleen M Botham, Peter J Kennelly, Victor W Rodwell, P Anthony Weil (2009). *Harper's Illustrated Biochemistry* (XXVIII Edn). Mc Graw Hill.
25. *Nature*, 409 (6822): 860-921, 2001.
26. S R Pennington, M J Dunn (Edts) (2002). *Proteomics: From protein sequence to function*. Viva Books Private Limited.
27. Bernard R Glick, Jack J Pasternak, Cheryl L Pattein (2010). *Molecular biotechnology, principles and applications of recombinant DNA*. ASM press.
28. Burton E Tropp (2012). *Molecular biology: Genes to Proteins* (IV Edn). Jones and Bartlett Learning.
29. Jocelyn E Krebs, Elliott S Goldstein, Stephen T Kilpatrick (2011). *Lewin's Genes X* . Jones and Bartlett Publishers.

PROGRAMME ELECTIVE (BIOTECHNOLOGY)
MODEL QUESTION PAPERS - THEORY

Programme Elective - Biotechnology
Semester IV Programme Elective Course 1
Model Question Paper
PE 1: TISSUE CULTURE AND MICROBIAL BIOTECHNOLOGY

Time 3 hours **Weightage 30**

I. Answer any ***six*** 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.

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

9. Giving suitable examples, discuss downstream processing.
10. Describe the most common use of the following chemicals in tissue culture or associated techniques;
(a) Agar agar (b) PEG (c) $HgCl_2$ (d) EDTA
11. What are cybrids? How are they produced? Discuss the use of cybrids in crop improvement programmes.
12. Citing suitable examples, discuss the importance of GMOs in bioremediation
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. Briefly describe the prospects and future of stem cell research.
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

Programme Elective - Biotechnology
Semester IV Programme Elective Course 2
Model Question Paper
PE 2: GENETIC ENGINEERING

Time 3 hours **Weightage 30**

I. Answer any ***six*** 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.

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

9. Describe the following;
(a) BAC (b) DNA probes (c) Electroporation (d) Alternate splicing
10. Highlight any four areas where genetic modification of plants has been useful.
11. What is a recombinant DNA vaccine? Give two examples
12. A patient is suffering from ADA deficiency. Can he be cured? How?
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. Describe the steps involved in the creation of a genomic library.
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.

Programme Elective - Biotechnology
Semester IV Programme Elective Course 3
Model Question Paper
PE 3: GENOMICS, PROTEOMICS AND BIOINFORMATICS

Time 3 hours **Weightage 30**

I. Answer any ***six*** 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?

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

9. Describe the major findings of HGP.
10. What is comparative genomics? How is it useful in determining the evolutionary relationships between organisms?
11. Write a brief note on enzyme and protein design
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?

PROGRAMME ELECTIVE (BIOTECHNOLOGY)
MODEL QUESTION PAPERS - PRACTICAL

Semester IV Practical Course 7
Model Question Paper
PROGRAMME ELECTIVE – BIOTECHNOLOGY
TISSUE CULTURE AND MICROBIAL BIOTECHNOLOGY

Time 3 hours **Weightage 20**

1. Selective isolation of amylase producing microbes from environment
(Total weight 3 = Experiment – 0.5, Comment/Interpretation – 1.5)
2. Isolate embryo from the given seed in aseptic conditions and inoculate in the medium
(Weight = 3)
3. Prepare synthetic seeds by inserting somatic embryo/zygotic embryo/axillary bud/apical meristem in Sodium alginate
(Weight = 2)
4. Select the anther in appropriate stage for anther culture
(Weight = 2)
5. Comment on A, B, C, D, E and F.
(Weight =1; 1 x 6 = 6)
6. Practical record
(Weight = 4)

Key to the questions:
1. Preparation of plates and isolation of microbe has to be done 2-3 days before exam.
2. Give appropriate seeds
3. Give necessary reagents and materials
4. Give appropriate amthers
5. A, B, C, D, E, F - Chemicals, Instruments, Photographs/Diagrams related to tissue culture/microbial biotechnology procedures specified in the syllabus
6. Awarding 'A grade' to the record of practical work shall be considered only if all the practicals specified in the syllabus are completely done and recorded properly. This also includes field study report(s)/Lab visit report(s)/Industry visit report(s), if any.

Semester IV Practical Course 8
Model Questions
PROGRAMME ELECTIVE – BIOTECHNOLOGY
GENETIC ENGINEERING, GENOMICS, PROTEOMICS AND BIOINFORMATICS
Time 3 hours **Weightage 20**

1. Find out the phylogenetic relationship of *Homo sapien's* NG_030288 protein sequence with other 5 organisms. Show the distance between each organism and phylogenetic tree (Identify the query).
(Weight = 3.5)
2. Using hierarchial clustering performs multiple sequence alignment of NG_030166 nucleotide sequence with 5 related sequences and show the similarity (Identify the query).
(Weight = 3.5)
3. Isolation of plant genomic DNA
(Weight = 2)
4. Separate Nucleic acid by agarose gel electrophoresis
(Total weight 5 = Running efficiency – 2.5, Band vision – 2.5)
5. Comment on A and B
(Weight 1; 1 x 2 = 2)
6. Practical record
(Weight = 4)

Key to the questions:
1. PHYLIP
2. Clustal X
3. Supply necessary tissue samples
4. Supply pure samples of DNA/RNA, and necessary buffer
5. A, B - Vectors, procedures or equipments (photographs) used in genetic engineering
6. Awarding 'A grade' to the record of practical work shall be considered only if all the practicals specified in the syllabus are done completely recorded properly. This also includes field study report(s)/Lab visit report(s)/Industry visit report(s), if any.

PROGRAMME ELECTIVE – ENVIRONMENTAL SCIENCE
PE 1: BASIC CONCEPTS IN ENVIRONMENTAL STUDIES
(Theory 90 Hrs; Practical 72 Hrs; Credits 4)

Module 1: History (5 hrs)
History of development of environmental science, scope and significance of environmental studies. Concept of the sustainable world.

Module 2: Natural environment (10 hrs)
(a) Origin and structure of earth – primary differentiation and formation of core, mantle, crust, atmosphere and hydrosphere.
(b) Physical environment: Lithosphere, Hydrosphere, Atmosphere.
(c) Biological environment: Biosphere – hierarchies in the biosphere.

Module 3: Earth and its atmosphere (20 hrs)
(a) Land and water systems: Weathering and erosion process, types and formation of soils and soil profile. Physical, chemical and biological properties of soil. Causes, effects and control of earthquakes, volcanoes, landslides, floods and storms. Groundwater – occurrence, chemistry; salt water intrusion.
(b) Aquatic environment: Hydrologic cycle, diversity of aquatic habitats. Aquatic food web and factors affecting primary productivity.
(c) General characteristics of freshwater environment: Lentic systems; Lakes – origin and classification, ecological zonation, water circulation, physical and chemical characteristics and biotic communities, fertility and productivity. Lotic systems - Ecology of streams and rivers.
(d) General characteristics of marine environment: Ocean - chemistry of sea water, circulation and ecological zonation in sea, marine biota, primary productivity, coral reefs and marine resources.
(e) Estuaries: Types, biotic communities and productivity; environmental significance of estuaries. Mangroves.
(f) Wetlands: Classification, productivity and ecosystem properties.
(g) Eutrophication: Causes and consequences, methods of control.

Module 4: Weather and Climate (20 hrs)
(a) Definitions and scope of climatology, weather and climate. Components of climate system.
(b) Earth's thermal environment, earth intercepts solar radiation, seasonal variation in intercepted solar radiation. Air temperature in relation to altitude. Global circulation of air masses, wind and earth's rotation on ocean currents, influence of temperature on moisture content of air, global pattern of precipitation, influence of topography on regional pattern of precipitation.
(c) Classification of climate - Koppen's classification and Thornthwaite's scheme, climatic types and zones.
(d) Global climatic phenomena - *El Nino* and *La Nina*, causes and factors of climate change. Effect of climate change on ecosystems and human life. Organisms and microclimate.
(e) Climate of India: Climatic regions of India, tropical monsoon climate-onset, rain bearing systems, break in the monsoon, retreat of monsoon. Monsoon in Kerala - oceanic and continental influence.
(f) Climate change – causes and effects.

Module 5: Ecosystems (15 hrs)
(a) Ecosystem organization: Structure and function of ecosystem components. Processes in ecosystem: Primary production – methods of measurement, global pattern, controlling factors. Nutrient cycles, energy flow, biogeochemical cycles, trophic relations, productivity and ecological efficiencies.
(b) Structure, function, and characteristics of; (i) Forests and tundras – temperate and tropical forests, arctic and alpine forests (ii) Deserts – arid and semi-arid (iii) Grassland and savannas (iv) Coastal and marine (v) coral reefs (vi) Wetlands – lakes, rivers, estuaries (vii) Mangroves

Module 6: Population ecology (10 hrs)
(a) Population characteristics, population growth, carrying capacity, population regulation, population interactions, population differentiation.
(b) Modeling population growth, competition and coexistence, mutualism, predation, herbivory, parasitism. Evaluating the controls on population size. Trends in human population growth. Problems with overpopulation.

Module 7: Biosphere interactions (10 hrs)
Communities and ecosystems: Structure, types and characters of communities, community gradients. Global pattern of species richness, species diversity. Community organization – ecological niche.

Practical (72 hrs)

1. Qualitative and quantitative study of freshwater/marine planktons
2. Soil texture using micrometry from two different sites. Principle and explanation
3. Determination of moisture content.
4. Determination of soil pH from at least three different locations and correlate it with the soil type
5. Determination of Chloride, calcium, magnesium, potassium and phosphorous.
6. Estimation of primary productivity in two different aquatic ecosystems and interpretation of the results. Compare the results of Dark and Light bottle method and Chlorophyll method.
7. Study of biodiversity in Forest/Grass land and Pond/River and report the species richness, abundance and animal interactions. Calculate frequency, abundance, evenness and diversity indices.
8. Identification of plants growing in different habitats and studying their adaptations

References

1. Alongi D M (1998). *Coastal Ecosystem Processes*. CRC Press.
2. Chapman G P (1977). *Human and Environmental Systems: A Geographer's Appraisal*. Academic Press.
3. Chapman J L, Reiss M J (2005). *Ecology: Principles and Applications.* Cambridge University Press.
4. Elton C S (1958). *The Ecology of Invasion by Plants and Animals.* Methuem, London.
5. Forman R T (1995). *Land Mosaics: The Ecology of Landscapes and Regions.* Cambridge University Press.
6. Forman R T T, Godron M (1986). *Landscape Ecology.* John Wiley & Sons.
7. Fox C W, Roff D A, Fairbairn D J (Eds) (2001). *Evolutionary Ecology: Concepts and Studies.* Oxford University Press.
8. Krebs C J (2008). *Ecology: The Experimental Analysis of Distribution and Abundance* (VI Edn). Benjamin Cummings Publ.
9. Krishnamurthy K V (2004). *An Advanced Textbook on Biodiversity: Principles and practice.* Oxford and IBH. Publ. Co.
10. Levin S A (Ed) (2000). *Encyclopedia of Biodiversity*. Academic Press.
11. Mayhew P J (2006). *Discovering Evolutionary Ecology: Bringing Together Ecology and Evolution*. Oxford University Press.
12. Miller G T (2004). *Environmental Science.* Thomson.
13. Odum E P, Barrett G W (2005). *Fundamentals of Ecology*. Thomson Asia Pvt. Ltd.
14. Pianka E R (2000). *Evolutionary Ecology* (VI Edn). Benjamin Cummings.
15. Primack R B (1998). *Essentials of Conservation Biology*. Sinauer Associates.
16. Pullin A S (2002). *Conservation Biology*. Cambridge University Press.
17. Ramakrishnan P S (1991). *Ecology of Biological Invasion in the Tropics*. International Scientific Publications.
18. Ramakrishnan P S (1992). *Shifting Agriculture and Sustainable Development*. UNESCO, MAB, Paris.
19. Rana S V S (2005). *Essentials of Ecology and Environmental Science*. Prentice Hall of India.
20. Rose M R, Mueller L D (2006). *Evolution and Ecology of the Organisms.* Pearson Prentice Hall.
21. Singh J S, Singh S P, Gupta S R (2006). *Ecology, Environment, and Resource Conservation. Anamaya Publ.*
22. Smith T M, Smith R L (2006). *Elements of Ecology* (VI Edn). Pearson.
23. Soule M E (Ed.) (1986). *Conservation Biology*. Sinauer Associates.
24. Steiner F (1999). *The Living Landscape: An Ecological Approach to Landscape Planning* (II Edn). McGraw Hill Inc.
25. Williamson M (1996). *Biological Invasion*. Chapman & Hall.

PROGRAMME ELECTIVE – ENVIRONMENTAL SCIENCE
PE 2: NATURAL RESOURCES AND THEIR MANAGEMENT
(Theory 90 hrs; Practical 54 hrs; Credits 4)

Module 1: Natural resources and their management (4 hrs)
Natural resources – renewable and nonrenewable. Preservation, conservation, and restoration of resources. Recycling, reuse, and substitution.

Module 2: Principles of resource management – Water resources (8 hrs)
Distribution of water resources, threats to water resources. Principles and approaches to surface water management, watershed management – catchment infiltration models, rainwater harvesting and storage, recharging of ground water. Management of degraded water resources. Drinking water quality and water treatment - desalination, ion-exchange, reverse osmosis, and disinfection of water.

Module 3: Principles of resource management – Energy resources (10 hrs)
(a) Energy sources – resource and reserves. Current national and global energy scenario.
(b) Fossil fuels: Oil, Coal, Natural gas, Shale – sources, exploration, exploitation; environmental consequences of overexploitation.
(c) Nuclear energy: Nuclear fission and fusion, nuclear minerals, nuclear fuel cycle, nuclear fuel production, nuclear reactors. Advantages and disadvantages of nuclear power. Environmental consequences – safety, terrorism, waste disposal and management.
(d) Renewable and alternate energy sources – solar energy and isolation, photovoltaic cells; hydropower; tidal power; wind power; geothermal energy; ocean energy; fuel cells – advantages and disadvantages, environmental consequences.
(e) Bio-energy: biomass as energy source, biomass production, energy farming, biomass conversion processes – thermochemical and biochemical. Biodiesel. Environmental consequences of biomass resource harnessing.

Module 4: Principles of resource management – Land resources (4 hrs)
Land as a resource, land degradation and its causes, desertification – causes and prevention.

Module 5: Principles of resource management – Food resources (5 hrs)
Food sources, effect of agriculture on the environment. World food problems, methods and strategies to alleviate food problems.

Module 6: Principles of resource management – Mineral resources (5 hrs)
Mineral resources: Formation of mineral deposits. Types of mineral resources, environmental impact of mineral exploration, mining, processing and utilization. Conservation of mineral resources.

Module 7: Principles of resource management – Biological resources (34 hrs)
(a) Forests as biological resources – importance, types of forests, deforestation, reforestation, conservation of forests.
(b) Biodiversity and its importance: Types of biodiversity - wild biodiversity, agro-biodiversity, domesticated biodiversity. Values of biodiversity, ecosystem functions and biodiversity, mobile links and valuating ecosystem services. Drivers of biodiversity loss. Tools and techniques for biodiversity estimation: Biodiversity indices; methods of biodiversity monitoring.
(c) Uses of biodiversity – source of food, medicine, raw material, aesthetic and cultural values.
Threats to biodiversity; natural and anthropogenic, species extinctions, IUCN threat categories, red data book. Extinction: Types, Causes – population growth, overconsumption, pollution, climate change. Ecological extinction, biological extinction.
Principles and strategies for biodiversity conservation - *In-situ* conservation: sanctuaries, biosphere reserves, national parks, nature reserves, preservation plots. *Ex-situ* conservation: botanical gardens, zoos, aquaria, homestead garden; herbarium; *In-vitro* Conservation: germplasm and gene Bank; tissue culture: pollen and spore bank, DNA bank. GEF-World Bank initiatives. Biodiversity hotspots and their characteristics, global distribution. National and international programmes for biodiversity conservation. CITES and TRAFFIC, Indian Biodiversity Act 2002 and Rules.
(d) Biological Invasions: Introduction - Elton's hypothesis – Invasion patterns and process - biological attributes for invasion: Reproductive potential, Allelopathy - Phenotypic plasticity - fitness to the new environment. Hypotheses for invasion success: Natural enemy hypothesis - evolution of invasiveness

hypothesis, empty niche hypothesis, novel weapon hypothesis, disturbance hypothesis and Propagule pressure hypothesis. Invasive alien species of India (plants and animals).
(e) Impacts and management of invasions: Impacts of exotics on biodiversity, productivity, nutrient cycling. Management: Bio-control programmes, mechanical and chemical control - Positive utilization. Quarantine and EIA of biological invasion.

Module 8: Environmental economics (10 hrs)

(a) Definition, scope and basic theories of environmental economics; sustainable growth.
(b) Economics of natural resources, environment cost-benefit analysis.
(c) Agricultural development and environment: Modern agriculture and its impact on environment – monoculture plantations, use of insecticides, pesticides, chemical fertilizers, hybrid seeds, water consumption, desertification, watershed problem, soil erosion, deforestation, depletion of biodiversity. Sustainable agriculture – alternate methods in agriculture.
(d) Industrial development and environment: impact of modern large scale industries on environment, problems related to modernization and urbanization. Green policies of industrialization.

Module 9: Society and Environment (10 hrs)

(a) Social perspectives of environment – Global and Indian issues.
(b) Social impacts of growing human population and affluence, production and distribution of food, hunger, poverty, malnutrition, famine.
(c) Social impacts of water crisis, global climate change, ozone depletion, nuclear accidents, acid rain, consumerism and waste products.
(d) Problems related to major dams and other developmental projects, resettlement and rehabilitation.
(e) Environment and human health – epidemiological issues.

Module 10: Environmental ethics (4 hrs)

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

Practical (54 hrs)

1. Water Quality Analysis:
a. Determination pH, Electrical conductivity, Alkalinity, Salinity, Hardness, Nitrate, Phosphate and Silica.
b. Determination of total dissolved salts (TDS).
2. Toxicity Analysis of Water: For Chlorine, H_2S, Ammonia, Copper and Chromium.

References

1. APHA-AWWA-WPCF (1990). *Standard Methods for the Examination of water and Waste water.* (XX Edn). American Public Health Association.
2. Butter G C (1988). *Principles of Ecotoxicology*. John Wiley and Sons.
3. Cockerham G L, Shane B S (Eds) (1994). *Basic Environmental Toxicology*. CRC Press.
4. Eisenbude M (1998). *Environmental Radioactivity*. Academic Press.
5. Fellenberg G (1999). *Chemistry of Pollution*. John Wiley and Sons.
6. Hayes W A (2001). *Principles and Methods of Toxicology*. CRC Press.
7. James P, Lodge J R (1971). *Methods of Air sampling and Analysis*. ISc Lewis Pub. Inc.
8. Klaassen C D, J B W Alkins (2003). *Essentials of Toxicology*. McGraw-Hill Professional.
9. Khopkar S M (2004). *Environmental Pollution: Monitoring and Control.* New Age International.
10. Lutgens F K, Tarbuek J E (1992). *The Atmosphere*. Prentice Hall.
11. Michael L McKinney, Robert M Schoch (2002). *Environmental science: Systems and Solutions*. West publishing company.
12. Niesink R J M, De Vries J, Hollinger M A (Eds) (1996). *Toxicology: Priniples and Applications.* CRC Press.
13. Oehme W F (1989). *Toxicity of Heavy Metals in Environment.* Marcel Dakkar Inc.
14. Purnima B B, A Janin, Arun K Jain (2011). *Waste Water Engineering Including Air Pollution*. Laxmi Publications (P) Ltd.
15. Samuel G (1990). *Nuclear Engineering.* Academic Press.
16. Wilber C G (1989). *Biological aspects of Water pollution.* Charles C Thomas Publishers.

PROGRAMME ELECTIVE – ENVIRONMENTAL SCIENCE
PE 3: ENVIRONMENTAL MONITORING AND MANAGEMENT
(Theory 90 Hrs; Practical 54 Hrs; Credits 4)

Module 1: Environmental Management (10 hrs)

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

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

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

(d) Environmental auditing and Standards - Eco labeling and certification, accreditation – need, objectives and benefits; Corporate social responsibility and Corporate environmental responsibility, ISO standards for environmental management systems (EMS) - ISO 14000, 14001 and 26001; OHSAS 18001.

Module 2: Ecosystem Management (10 hrs)

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

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

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

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

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

Module 3: Solid waste Management (8 hrs)

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

Module 4: Toxicology (12 hrs)

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

(b) Toxic chemicals in the Environment – Air, water and Soil. Biochemical aspects of As, Cd, Pb, Hg, CO, O_3, PAN, pesticides, MIC, Dioxins, Furans and carcinogens in air, Bioaccumulation & biomagnification.

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

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

(e) Toxicity testing: Bioassay – Definition, purpose, criteria for selection of test organism, methodology, estimation of LC50, Limitation and importance of Bioassay, Acute Toxicity (single); Sub acute Toxicity; Chronic Toxicity; Teratogenicity, Carcinogenicity and Mutagenicity.

(f) Bio-monitoring of Toxic Chemicals - Objectives, programs and parameters, concepts of bio indicators. Bio-transformation of Xenobiotics.

Module 5: Environmental Impact Assessment (10 hrs)

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

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

(c) Regulatory Framework: Environmental Impact Assessment Notification 2006 and Coastal Zone Notification 1991; Environmental Clearance Process in India; Legislative requirements (discharge requirements and area restrictions); Environmental Appraisal procedure for mining, industrial, thermal power, nuclear power and multipurpose river valley projects. EIA case studies. Life Cycle Assessment (LCA) and its significance.

Module 6: Remote Sensing and GIS (15 hrs)

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

(b) Digital Image Processing: Principles, Image Rectification and restoration, Image enhancement and Mosaicing. Image classification. Supervised, Unsupervised, Ground truth data and training set manipulation, Classification accuracy assessment.

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

Module 7: Environment versus Development (5 hrs)

Dominance of man on earth. Limits of growth. Industrial revolution and resource utilization, environmental consequences. Modern agriculture and green Revolution - environmental impacts. Conflicts of interest - mega developmental projects and issues of 3 Rs, environment and development.

Module 8: Sustainable Development (10 hrs)

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

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

Module 9: Environmental laws and policies (10 hrs)

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

(b) The salient features of the following acts and rules: The water (Prevention and control of pollution) act, 1974; The air (Prevention and control of pollution) act, 1981; The environmental (Protection) act, 1986; The public liability insurance act, 1991; The wildlife protection act, 1972; The forest conservation act, 1980; The biodiversity act, 2002; The hazardous wastes (Management and handling) rules, 1989; The noise pollution (Regulation and control) rules, 2000. Manufacture, storage and import of hazardous chemicals rules 1989, Biomedical waste (Management and Handling) rules 1998.

Practical (54 hrs)

1. Estimation of BOD and COD of polluted water.
2. Isolation and Enumeration of microorganisms in soil (TBC or TMC) - Types of Bacteria and fungi.
3. Bacteriological quality testing of water and waste water.

a. Presumptive Coliform test b. Confirmatory Coliform test.

Field Study: (Three/four days) Visit at least one Institution engaged in environment/conservation research and a sanctuary/national park and an industrial/polluted area. Submit a report of the study conducted in a ~10 page write up/print out giving the dates, methodology, results and references. Include photgraphs of the activity.

References

1. Agarwal N K (2004). *Essentials of GPS*. Spatial Networks Pvt. Ltd.
2. Agarwal N K (2002). *Eco-informatics*. APH Publishing Corporation.
3. Asit K Biswas et.al., (1987). *EIA for Developing Countries*. United Nations University, Tokyo.
4. Carter L (1996). *Environmental Impact Assessment*. McGraw Hill.

5. Coronel C, Morris S, Rob P (2009). *Database Systems: Design, Implementation and Management* (IX Edn). Course Technology.
6. Eagles P F J (1987). *The planning and Management of Environmentally Sensitive areas*. Longman Group Ltd.
7. Elachi C (1978). *Introduction to Physics and Techniques of Remote sensing*. John Wiley Pub.
8. Floyd F, Sabins W H Jr. (1987). *Remote Sensing, Principles and Interpretation* (II Edn). Freeman & Company.
9. Gadgil M, Guha R (1995). *Ecology and Equity: The Use and Abuse of Nature in Contemporary India*. Penguin India.
10. Gadgil M, Guha R (1998). *The Fissured Land: An Ecological History of India*. Oxford University Press.
11. Goldsmith B (Ed) (1992). *Monitoring for Conservation and Ecology*. Chapman and Hall.
12. Jorgensen S E (1996). *Applications of ecological modeling in environmental management.* Elsevier Sci. Co.
13. Jorgensen S E, Chon T S, Recknage F A (2009). *Handbook of Ecological Model and Informatics.* WIT Press.
14. Kang-tsung C (2000). *Introduction to GIS*. Tata McGraw Hill.
15. Knight R L, White L (2009). *Conservation for a new generation redefining natural resources management.* Island Press.
16. Lawrence D P (2003). *Environmental Impact Assessment: Practical Solutions to Recurrent Problems*. John Wiley and Sons.
17. Lillesand T M, Kiefer R F (1994). *Remote Sensing and Image interpretation*. John Wiley & Sons.
18. Maguire D, Batty M, Goodchild M (Eds.) (2005). *GIS, Spatial Analysis, and Modeling*. Esri Press.
19. Meadows D, Randers J, (2004). *Limits to Growth: The 30 Year Update.* Earthscan.
20. Meffe G K, L Nielson, R Knight, Schenborn (2002). *Ecosystem management: Adaptive, Community-based Conservation*. Plenum Press.
21. Miller GT Jr. (2004). *Environmental Science*. Thomson, California.
22. Milner-Gulland E J, Marcus Rowcliffe (2007). *Conservation and sustainable use: A handbook of techniques.* Oxford University Press.
23. Peter Calow (Ed) (1998). *Handbook of Environmental Impact Assessment*. Mc Graw Hills Inc.
24. Pullin A S (2002). *Conservation Biology*. Cambridge University Press.
25. Rao D P (Ed) (1998). *Remote Sensing for Earth Resources*. Association of Exploration Geophysicist, Hyderabad.
26. Simon Dresner (2008). *The Principles of Sustainability Solutions*. Earthscan paperbacks, *The Ecological Footprint Atlas 2010*. Oakland: Global Footprint Network.
27. Miller G T Jr. (2005). *Advantage Series: Sustaining the Earth: An Integrated Approach*. (VII Edn). Thomson/Brooks Cole.
28. Westman W E (1995). *Ecology, Impact Assessment and Environmental Planning*. John Wiley and sons.
29. World Commission on Environment and Development (1987). '*Our Common Future'*. Oxford University Press.

PROGRAMME ELECTIVE (ENVIRONMENTAL SCIENCE) MODEL QUESTION PAPERS - THEORY

Programme Elective – Environmental Science
Semester IV Programme Elective Course 1
Model Question Paper
PE 1: BASIC CONCEPTS IN ENVIRONMENTAL STUDIES

Time 3 hours **Weightage 30**

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

1. Define lithosphere and discuss its basic structure
2. What is an estuary? How are they classified?
3. Briefly describe the causes and consequences of desertification.
4. Write short notes on the following;
(a) Food web (b) Ecological pyramids (c) Ecological niche (d) Bio-magnification
5. Describe the main characteristics of a biotic community
6. Describe *El Nino* and *La Nina* phenomena
7. Briefly describe the importance of wetland ecosystems
8. Describe the main climatic regions of India

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

9. Define atmosphere. Differentiate between atmosphere and environment
10. Write a detailed account on hydrologic cycle
11. Describe the process of soil formation
12. What is soil profile? Describe the soil profile of a typical soil
13. Describe the distribution and classification of lakes.
14. What is eutrophication? Describe the causes and consequences of eutrophication.
15. Write short notes on the following;
(a) Ecotone (b) Community periodism (c) Species diversity (d)
16. Write a brief account on the important features and significance of Monsoon in Kerala.
17. Classify and describe different types of climates
18. Give a detailed account of fresh water environment. Describe the physico-chemical nature of fresh water.

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

19. Write an essay on the uniqueness and importance of coral reefs
20. Write an essay on the ecological consequences of growing human population
21. Describe the structure and characteristics of different types of forests.

Programme Elective – Environmental Science
Semester IV Programme Elective Course 2
Model Question Paper
PE 2: NATURAL RESOURCES AND THEIR MANAGEMENT

Time 3 hours **Weightage 30**

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

1. Giving suitable examples differentiate between exhaustible and inexhaustible natural resources.
2. Briefly describe;
(a) Deforestation (b) Afforestation (c) Agroforestry (d) Social forestry
3. Write a brief account on green revolution.
4. What is land degradation? What are the causes of land degradation?
5. Giving suitable examples describe biological invasion
6. What is the importance of environment cost-benefit analysis?
7. What is the importance of recycling and reuse strategy?
8. What are the characteristic features of biodiversity hot spots?

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

9. What are the various methods of conservation of natural resources?
10. Giving suitable examples, describe renewable and non-renewable natural resources.
11. Write short notes on the following;
(a) Geothermal energy (b) Wind energy (c) Tidal energy (d) Biogas
12. Describe the pros and cons of Nuclear energy
13. Write a brief account on the value of biodiversity.
14. Briefly describe the types and causes of extinction.
15. Briefly describe the consequences of growing urbanization.
16. Discuss the various reasons for biodiversity loss.
17. Write a brief account on types of minerals found in India and their uses. Add a note on the impact of overextraction of mineral resources
18. Write a brief account on world food problem giving emphasis to undernourishment and malnutrition

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

19. Write an essay on environmental ethics
20. What are natural resources? Describe the causes and remedies for the depletion of natural resources.
21. Write an essay on non-conventional source of energy with special reference to India.

Programme Elective – Environmental Science
Semester IV Programme Elective Course 3
Model Question Paper
PE 3: ENVIRONMENTAL MONITORING AND MANAGEMENT

Time 3 hours **Weightage 30**

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

1. What is WWF? Discuss its objectives.
2. List out the natural and artifical hazards of our environment
3. Define watershed management and explain its objectives
4. What are sustainability indicators?
5. What do you mean by environmental auditing?
6. Write a brief account on toxic chemicals released by the industries in India
7. Discuss the importance of vermicomposting as a method of solid waste management.
8. Suggest a few methods for domestic waste management.

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

9. Write briefly on the following;
(a) EIA (b) UNEP (c) IUCN (d) ISO 14001
10. Describe the basic principles and strategies for environment management.
11. Write a brief account on ecological labeling and certification.
12. Give an account of heavy metal toxicity
13. Giving suitable examples describe biotransformation of xenobiotics
14. Describe the salient features of the biodiversity act, 2002.
15. What is ecological footprint? What is its significance?
16. Write an account on the hazardous wastes (management and handling) rules in India.
17. What are the sources and effects of solid waste pollution? Suggest methods to reduce their hazardous effects.
18. Describe the basic principles and applications of GPS

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

19. Describe the management strategies for different types of ecosystems.
20. What is remote sensing? Describe the methods used for and the applications of remote sensing.
21. Write an essay on sustainable development.

PROGRAMME ELECTIVE (ENVIRONMENTAL SCIENCE) MODEL QUESTION PAPERS - PRACTICAL

Semester IV Practical Course 7
Model Question Paper
PROGRAMME ELECTIVE – ENVIRONMENTAL SCIENCE
BASIC CONCEPTS IN ENVIRONMENTAL STUDIES

Time 3 hours **Weightage 20**

1. Find out the abundance, frequency, density and the relative density of the species from the given data A on the two quadrats selected for study. Determine the similarity index of two quadrats.
(Weight = 3)
2. Determine the biomass of the phytoplankton of the given sample B using haemocytometer.
(Weight = 3)
3. Determine the pH of the given polluted soil sample C and identify the type of soil.
(Weight = 1)
4. Determine the chloride/calcium/magnesium hardness of the given sample D.
(Weight = 3)
5. Determine the Dissolved oxygen content of the given sample E and determine the primary productivity using light & dark bottle method.
(Weight = 3)
6. Comment on the materials F, G and H
Weight 1; 1 x 3 = 3)
7. Practical record
(Weight = 4)

Key to the questions:
1. A - Provide necessary data
2. B - Give appropriate sample
3. C - Give necessary soil sample
4. D - Give appropriate samples
5. E - Give appropriate sample
6. F, G, H – plant materials with ecological peculiarities
7. Awarding 'A grade' to the record of practical work shall be considered only if all the practicals specified in the syllabus are completely done and recorded properly. This also includes field study report(s)/Lab visit report(s), if any.

Semester IV Practical Course 8
Model Question Paper
PROGRAMME ELECTIVE – ENVIRONMENTAL SCIENCE
NATURAL RESOURCES AND THEIR MANAGEMENT, ENVIRONMENTAL MONITORING AND MANAGEMENT

Time 3 hours **Weightage 20**

1. Determine the BOD of the water sample A.
(Total weight 4 = Principle and procedure – 1, Working – 1, Calculation -1, Result – 1)
2. Estimate the Alkalinity / salinity/ Total hardness of the given sample B.
(Total weight 2 = Working – 1, Interpretation/Comments – 1)
3. (a) Determine the TDS of the given sample C.

or

3. (b) Toxicity analysis of water. Determine amount of chloride or ammonia present in the given polluted water sample C.
(Weight = 4)
4. Examine the bacteriological quality of water sample D by performing presumptive coliform test and analyze the data by MPN index table.
(Total weight 4 = Principle and procedure – 1.5, Working – 1, Data analysis and interpretation – 1.5)
5. Illustrate the environmental consequence/ significance of the published pictures E and F.
Weight = 1; 1 x 2 = 2)
6. Practical record
(Weight = 4)

Key to the questions:
1. A - Incubate the sample for 5 days before the exam. First day oxygen data can be provided. Titration to find out the final value only is done at the time of exam.
2. B – Give appropriate samples
3. C – Give appropriate samples
4. D - Day before the exam, inoculate the MPN tubes with appropriate water sample
5. E, F - Published diagram/photograph from popular journals/periodicals/dailies
6. Awarding 'A grade' to the record of practical work shall be considered only if all the practicals specified in the syllabus are done completely and recorded properly. This also includes field study report(s)/Lab visit report(s), if any.

PROGRAMME ELECTIVE - MICROBIOLOGY
PE 1: FOOD, AGRICULTURAL AND ENVIRONMENTAL MICROBIOLOGY
(Theory 90 hrs; Practical 72 hrs; Credits 4)

Food Microbiology (35 hrs)

Module 1: Food - a substrate for microorganisms (3 hrs)
Factors influencing microbial activity in food, chemical changes brought about by microbes, microbes important in food microbiology.
Module 2: Microbial flora in food and food spoilage (7 hrs)
Microbial flora of fresh food and their spoilage – cereals, sugar and sugar products, fruits, vegetables, poultry, eggs, shell fish and fin fish, milk and milk products, beverages, bread and canned foods.
Module 3: Microbiology of fermented food (5 hrs)
Fermented milk - butter milk, cultured butter milk, Yoghurt, Kefir; Cheese production; bread; oriental food; Sauerkraut.
Module 4: Food preservation (8 hrs)
General principles of food preservation: (1) aseptic handling (2) high temperature - boiling, steam under pressure, pasteurization and sterilization (3) low temperature – freezing and refrigeration (4) Dehydration (5) Osmotic pressure - in concentrated sugars with brine (6) chemicals, organic acids, smoking (7) radiation - UV and ionization.
Module 5: Food borne diseases (6 hrs)
Diseases caused by spoiled foods, diseases caused by food additives. Food borne diseases caused by bacteria - Salmonellosis, Gastroenteritis, Shigellosis, Listeriosis, Staphylococcal food poisoning, Botulism, Travellers' diarrhoea. Fungal intoxication - Aflatoxin and related components. Virus intoxication.
Module 6: Food quality (6 hrs)
Microbial examination of food - Microscopic techniques, culture techniques. Microbiological criteria for food control. Enforcement and control agencies – international agencies, federal agencies, state agencies, professional societies, private agencies, processing industry and agencies of co-operative programmes.

Agricultural microbiology (20 hrs)

Module 1: Microbes as Biofertilizers (14 hrs)
(a) Microbes as biofertilizers - bacteria, fungi, algae. Production of biofertilizers - strain selection and preparation of biofertilizers. Green manuring. Microbes producing antimicrobial agents, siderophores.
(b) Nitrogen fixing microbes – free living organotrophs, free living prototrophs, diazotrophs. Association of microbes with grasses, legumes, nodulation in nitrogen fixation legumes; nif gene - Azolla-Anabaena.
(c) Phosphate solubilizers – Bacteria and fungi as phosphate solubilizers. Mycorrhizal relationship – definition, forms and distribution of mycorrhiza. Ecto- and Endomycorrhiza. Vescicular and Arbuscular mycorrhiza, Ericaceous, Orchidaceous mycorrhiza. Physiology and function of mycorrhiza. Nutrient uptake and other effects. Carbon flow in mycorrhizal plant association. Production of mycorrhizal biofertilizers.
Module 2: Microbes as Biopesticides (6 hrs)
Microbial herbicides, bacterial insecticides - use of Pseudomonas, Bacillus. Viral insecticides. Entomopathogenic fungi.

Environmental microbiology (35 hrs)

Module 1: Microbial biodiversity (2 hrs)
Nature as a habitat of microbes, microbial diversity in various ecosystems.

Module 2: Methods in microbiology (10 hrs)
Isolation and cultivation of microbes from environment - serial dilution and pour plate method, spread plate method, streak plate method, isolation using selective or enrichment media. Methods of culturing anaerobes. Culture characteristics of microbes. Bacterial growth curve, staining techniques. Biochemical tests for bacterial identification - carbohydrate fermentation, triple sugar-Iron agar test, IMVIC test, Litmus Milk reactions, Hydrogen sulphide test, Catalase test, Oxidase test. Uncultivable microbes.
Module 3: Soil and aquatic microbiology (9 hrs)
(a) Soil as a habitat for microbes. Factors influencing soil microbial growth. Microorganisms and the formation of different soils – tropical soil, temperate soil, bog soil, cold moist area soil, desert soil, geologically heated hyperthermal soil.
(b) Microbes and their role in fresh water, brackish water and marine environments. Contamination of aquatic environment by pathogenic microbes. Detection of coliform bacteria - membrane filtration technique, Colilert defined substrate test, Multiple tube fermentation test. Quantification of Coliforms - MPN test.
(c) Waste water treatment - primary, secondary and tertiary treatment.
Module 4: Role of microbes in environment (9 hrs)
Role of microorganisms in Carbon, Nitrogen, Phosphorus, Iron and Sulphur cycles. Microbes - as pollution indicators. Biological magnification. Biodegradation of recalcitrants, Jetfacts, paper, computer chips, paints, textiles, leather, rubber, metal, concrete, wood. Role of microbes in the disposal of waste and production of organic compost, biogas. Microbial leaching; Microbial bio-films. Bio-deterioration and biodegradation of petroleum, xenobiotics, heavy metals and microbial plastics.
Module 5: Environmental biotechnology (5 hrs)
Microbes in biotechnology, bioremediation - microbial and enzymatic; *in situ* and *ex situ*. Bio-augmentation – principles, enzymes used in bio-augmentation, bio-filtration-bio-filters, microorganisms used in filters, mechanism of bio-filtration, phyto-extraction and phyto transformation. Genetically modified microbes - beneficts and hazards. Metagenomics.

Practical (72 hrs)

1. Isolation of microbes by serial dilution and pour plate/spread plate technique.
2. Isolation of microbes by streak plate method.
3. IMVIC test.
4. Oxidase test.
5. Catalase test.
6. Litmus milk test.
7. Hydrogen Sulphide test.
8. Carbohydrate fermentation test.
9. Multiple Tube Fermentation test.
10. Methylene blue reductase test for milk.
11. Motility by hanging drop method.
12. Detection of siderophore production by bacteria.
13. Estimation of Mycorrhizal colonization in roots.
14. Isolation of Azotobacter from soil.

References

1. Alcamo (1994). *Fundamentals of microbiology*. Benjamin/Cummings pub.
2. A S Rao (1988). *Introduction to microbiology*. Prentice-hall pub. Com.
3. Braude (1983). *Microbiology*.
4. G Rangaswamy. *Agricultural Microbiology*. ASIA Pub. House.
5. H D Kumar, Swasti Kumar (2001). *Modern concepts of microbiology*. Vikas pub. House.
6. H S Chawla (2005). *Introduction to biotechnology*. Oxford/IBH pub Com.
7. K G Ramawat (2004). *Comprehensive biotechnology*. Shaily Goyal.
8. Martin Alexander (1971). *Microbial Ecology*. John Wiley and sons pub.
9. M R Adams, M O Mass (2000). *Food microbiology*. New Age International P Ltd.
10. O R Arora (2003). *Text book of microbiology*. CBS Pubs.

11. P D Sharma (2001). *Microbiology*. Rastogi Pub.
12. Prescott (2002). *Microbiology*. McGraw Hill pub.
13. R Campbell (1987). *Plant microbiology*. English language book society.
14. Selman A, Waksman. *Soil microbiology*. John Wiley and Sons.
15. Sudeesh Jood, Neelam Khetar Paul (2002). *Food preservation*. Agrotech publishing academy.
16. Robert Stanil et. al., (1987). *General Microbiology*. MacMillan.
17. R C Dube (2006). *Text book of microbiology*. S. Chand.
18. Talaro. *Foundations in microbiology*. W M C Brown publishers.
19. William C Frazier (2000). *Food Microbiology*. Tata McGraw Hill.
20. Wyss, William, Galdner. *Microbiology*. John Wiley and Sons.
21. L N Nair. *Methods of microbial and plant biotechnology*.
22. Kanika Sharma. *Manual of Microbiology: Tools and Techniques*.

PROGRAMME ELECTIVE - MICROBIOLOGY
PE 2: CLINICAL MICROBIOLOGY
(Theory 90 hrs + Practical 54 hrs; Credits 4)

Module 1: Introduction to Immunology (4 hrs)
Introduction, types of immunity - innate and acquired immunity, cellular and humoral immunity. Physical and physiological barriers in immunity, phagocytosis, inflammatory response. Components of adaptive immunity - B cells and T cells.

Module 2: Cells of immune system (12 hrs)
B lymphocytes, T lymphocytes – T_H, T_C, T_S cells, Natural killer cells, mononuclear phagocytes. Structure and development of B cell (BCRs) and T cell (TCRs) receptors; Structure of CD4, CD8, MHC-I, MHC-II molecules.

Module 3: Antigens and antibodies (10 hrs)
Types of antigens, super antigens, auto antigens, haptens, antigen variation by bacteria. Basic structure of immunoglobulins, different classes of immunoglobulins and their function.

Module 4: Antigen-antibody reactions (12 hrs)
Antigen antibody interaction *in vivo* - toxin neutralization, opsonization, immune complex formation, viral neutralization, adherence inhibition. Antigen antibody interaction *in vitro* - agglutination, complement fixation, ELISA, immunodiffusion, immunoblotting, flow cytometry, immunofluorescence, immunoelectrophoresis, immunoprecipitation, neutralization, radioimmunoassay, serotyping.

Module 5: Immune disorders (9 hrs)
Hypersensitivity – acute rheumatic fever, grave's disease, systemic lupus erythematosus, Type 1 Diabetes mellitus, multiple sclerosis, rheumatoid arthritis, transplantation rejection, imuno deficiencies – SCID, AIDS.

Module 6: Viral diseases (18 hrs)
(a) Epidemiology of common viral diseases in humans. Major human viruses: HIV, Hepatitis B and C, their salient properties. Isolation and maintenance of viruses, methods for detection and assay, phage typing.
(b) Anti-viral strategies: Prevention and control of viral diseases: Host specific and nonspecific defense mechanisms (molecular level) involved in resistance to virus infections and recovery. Role of interferon in viral infections. Contributions of various host defense mechanisms in viral infections. Viral Chemotherapy: Nucleoside analogs, reverse transcriptase inhibitors, protease inhibitors.
(c) Vaccines - subunit vaccines, anti-idiotype vaccines, DNA vaccines and edible vaccines. Interferon and antiviral drugs.

Module 7: Bacterial diseases (19 hrs)
(a) Epidemiology of common bacterial diseases in humans. Normal microbiota of human body; host-parasite relationship in baterial pathogenicity: non-specific mechanisms of host defense, mechanism of bacterial virulence, genetics of bacterial virulence; chemotherapy.
(b) Antibiotics - origin, classification, chemistry and mode of action; semisynthetic antibiotics. Antibiotic resistance in bacteria, mechanism of antibiotic resistance. Common bacterial vaccines.

Module 8: Fungal and protozoan diseases in humans (6 hrs)
Epidemology of common fungal and protozoan diseases in humans.

Practical (54 hrs)

1. Blood group determination - slide agglutination test.
2. Identification of different types of WBC.
3. Radial immuno diffusion test using suitable antigen and antibody.
4. Double diffusion agar assay (Ouchterlony technique).
5. Staining of bacteria - Gram staining.
6. Spore staining of bacteria.
7. Staining of capsule in bacteria.
8. Staining of lipid granules in bacteria – Burdon's method.
9. Antibiotic sensitivity test for bacteria.

References

1. C Varma Rao. *Immunology.*
2. Lansing M Prescott. *Microbiology.*
3. F H Kayser, K A Bienz, J Eckert, R M Zinkernagel. *Medical Microbiology.*
4. L R Haahelm, J R Pattison, R J Whitley. *Clinical virology.*
5. Julius M Cruse, Robert E Lewis. *Atlas of immunology.*
6. Kuby. *Immunology.*
7. Bilgrami, Sinhah. *Essentials of Microbiology.*
8. Purohit. *Microbiology: Fundamentals and applications.*
9. Pelczar, Chan, Krieg. *Microbiology.*
10. Salle A J. *Fundamental Principles of Bacteriology.*
11. Kanika Sharma. *Manual of Microbiology: Tools and Techniques.*

PROGRAMME ELECTIVE - MICROBIOLOGY
PE 3: INDUSTRIAL MICROBIOLOGY
(Theory 90 hrs; Practical 54 hrs; Credits 4)

Module 1: Introduction to industrial microbiology (4 hrs)
Range of fermentation processes, microbial biomass, microbial enzymes, microbial metabolites and transformation processes.

Module 2: Selection and strain improvement strategies (7 hrs)
Isolation of industrially important microorganisms - primary and secondary screening. Detection and assay of fermentation products – physical-chemical, biological assays. Preservation of microbes – storage at reduced temperature, storage in dehydrated forms.

Module 3: Types of fermentation (7 hrs)
Solid state fermentation and submerged fermentation; batch, continuous and fed batch fermentation. Homo- and heterofermentation. Aerobic and anaerobic fermentation. Static and stirred fermentations.

Module 4: Media for microbial growth and fermentation (6 hrs)
Typical media, media formulation; water, energy and carbon source, nitrogen sources, minerals and vitamins, buffers, precursors, metabolic regulators, oxygen requirement.

Module 5: Bioreactors (12 hrs)
Brief study on stirred tank fermenter, air-lift fermenter, packed tower fermenter, tray fermenter, rotary drum fermenter.

Module 6: Microbial fermentation (13 hrs)
(a) Sterilization - media, fermenter, air.
(b) Inoculum preparation, inoculation.
(c) Aeration, agitation, pH control, temperature control, antifoam agents.
(d) Process parameter optimization: One factor at a time and statistical optimizations (brief study only).
(e) Scale up of fermentation (lab scale, pilot plant, industrial scale).

Module 7: Downstream processing (12 hrs)
(a) Separation of microbial cells – Filtration, precipitation, centrifugation.
(b) Cell disruption – liquid shear, freezing-thawing, ultrasonication, osmotic shock, enzyme treatment.
(c) Concentrating and purifying the products - ultrafiltration, crystallization, solvent precipitation, reverse osmosis, chromatography.
Module 8: Production of industrially important products (24 hrs)
(a) Antibiotics - Penicillin, Streptomycin.
(b) Amino acids - Lysine, Glutamic acid.
(c) Enzymes - Amylase, Cellulase, Pectinase.
(d) Organic acids - Lactic acid, Acetic acid, Gluconic acid.
(e) Biofuels – Bio-ethanol, Bio-butanol.
(f) Biopolymers - PHB, PLA.
(g) Alcoholic beverages - Wine, Beer.
(h) Microbial cells - SCP, Baker's yeast.
Module 9: Immobilization of cells and enzymes (5 hrs)
Methods of cell and enzyme immobilization. Applications of immobilized cells and enzymes.

Practical (54 hrs)

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

References

Module 1
1. L E Casida. *Industrial Microbiology.*
2. Peter F Stanbury, Allan Whitaker. *Principles of Fermentation technology.*
3. Ronald M Atlas. *Basic and Practical Microbiology.*
4. R C Dubey, D K Maheshwari. *A text book of Microbiology.*
5. Richard G Burns, J Howard Slater. *Experimental Microbial Ecology*.
6. Arnold L Demain, Julian E Davies. *Manual of Industrial Microbiology and Biotechnology.*
7. Rita Singh, S K Ghosh. *Industrial Biotechnology.*
8. John I D'Souza, S G Killedar. *Biotechnology and Fermentation process*.
9. Michael J Waites, Neil L Morgan, John S Rockey, Gary Higton. *Industrial Microbiology: An introduction.*
10. A H Patel. *Industrial Microbiology*.
11. Wulf Crueger, Anneliese Crueger. *Biotechnology: A text book of industrial microbiology*.
12. B McNeil, L M Harvey. *Practical fermentation technology*.
13. Henry C Vogel, Celeste L Todaro. *Fermentation and biochemical engineering handbook*.
14. S C Prescott, Cecil Gordon Dunn. *Industrial Microbiology*.
15. Mansi EL-Mansi, Charles F A Bryce. *Fermentation microbiology and Biotechnology.*

PROGRAMME ELECTIVE (MICROBIOLOGY) MODEL QUESTION PAPERS - THEORY

Programme Elective – Microbiology
Semester IV Programme Elective Course 1
Model Question Paper
PE 1: FOOD, AGRICULTURAL AND ENVIRONMENTAL MICROBIOLOGY

Time 3 hours **Weightage 30**

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

1. Shigellosis
2. Travellers' diarrhoea
3. Role of *Aspergillus* in food spoilage
4. Siderophores
5. Organic farming
6. Bioremediation
7. Microbial leaching
8. MPN

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

9. Methods employed to purify water
10. Methanogenic Bacteria and their role
11. Brief account of Botulism
12. Food processing
13. Fermented Milk products
14. Phosphate solubilizing organisms
15. Microbes as biopesticides
16. Role of microbes in the degradation of textiles, leather and wood
17. Explain food spoilage by microbes with examples
18. 'Just as Lichens, microbes are used as pollution indicators' - Comment

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

19. Explain the factors influencing soil microbial growth. Describe the role of microbes in the formation of different soils.
20. Briefly describe the process of sewage treatment
21. Define nitrification. Give an account of the mechanism of biological Nitrogen fixation in both leguminous and nonleguminous plants

Programme Elective – Microbiology
Semester IV Programme Elective Course 2
Model Question Paper
PE 2: CLINICAL MICROBIOLOGY

Time 3 hours **Weightage 30**

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

1. Vaccination
2. Antiserum and Antigen
3. Monoclonal antibodies
4. Sporadic diseases
5. Nk cells
6. Immunoglobulins
7. Antigen mediated immunity
8. RIA

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

9. Human diseases caused by Protozoa
10. B and T cell Biology
11. Host-parasite relationship in Bacterial pathogenicity
12. Air borne diseases caused by Viruses
13. Innate immune responses, effective against a pathogen inside an infected cell
14. Epidemiology of any one Fungal disease in Man
15. Utility of Nucleic acid probes in Viral disease diagnosis
16. Antigen-Antibody interaction *in vivo*
17. Explain different types of immune disorders
18. Classification, chemistry and mode of action of 5 important antibiotics

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

19. Explain antibody production and the mechanism of antibody mediated immune response
20. Describe the basic structure and different classes of immunoglobulins. Add a note on their function
21. Enlist 5 major water-borne diseases. Discuss their dissemination, causative agent and control measures
21. Classification, chemistry and mode of action of 5 important antibiotics

Programme Elective – Microbiology
Semester IV Programme Elective Course 3
Model Question Paper
PE 3: INDUSTRIAL MICROBIOLOGY

Time 3 hours **Weightage 30**

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

1. Broad spectrum antibiotics
2. Name 2 aminoacids produced industrially from microbes and the organisms involved
3. Biopolymers
4. Alcoholic Beverages
5. Bio-fuels
6. Metabilic regulators
7. Enzyme immobilization
8. Bioreactors

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

9. Microbial production of Streptomycin
10. Inoculum preparation and inoculation
11. Process parameter optimization
12. Scale up of fermentation
13. Principles of immobilization technique
14. Amylase production by microbes
15. Significance of fermentation technique in pharmaceutical industry
16. Various steps involved in Beer production. The significance of microbes in the process
17. Sequentially correlate the different phases of Downstream processing
18. Explain the use of microbes in mass production of antibiotics

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

19. Explain different types of fermenters and fermentation techniques
20. Describe the composition of fermentation media and their role in the process
21. Write an essay on selection and strain improvement strategies

PROGRAMME ELECTIVE (MICROBIOLOGY) MODEL QUESTION PAPERS - PRACTICAL

Semester IV Practical Course 7
Model Question Paper
PROGRAMME ELECTIVE – MICROBIOLOGY
FOOD, AGRICULTURAL AND ENVIRONMENTAL MICROBIOLOGY

Time 3 hours **Weightage 20**

1. Conduct IMVIC test of Bacteria (A). Any 3 tests.
(Total weight 2 = Procedure – 1, Result – 1; 2 x 3 = 6)
2. Calculate the percentage of Mycorrhizal colonization in the given sample B.
(Total weight 2 = Preparation – 1, Procedure and calculation – 1)
3. Demonstrate methylene blue reductase test (C).
(Total weight 2 = Procedure – 1, Experiment – 1)
4. Demonstrate motility of microbes (D) with a hanging drop culture.
(Weight = 1)
5. Demonstrate Catalase activity of the microbes E.
(Total weight 2 = Working – 1, Procedure - 1)
6. Comment on F, G and H.
(Weight = 1; 1 x 3 = 3)
7. Practical record.
(Weight = 4)

Key to the questions:
1. A - Bacterial culture is to be supplied.
2. B - supply roots fixed in FAA.
3. C - supply milk samples
4. D - root nodules or any bacterial culture.
5. E - 12 hr. old bacterial cultures – one culture positive to catalase activity and another culture negative to catalase activity.
6. F, G, H - Equipment/Cultures/Reagents/Diagrams etc., belonging to microbiology topics covered in the syllabus.
7. Awarding 'A grade' to the record of practical work shall be considered only if all the practicals specified in the syllabus are completely done and recorded properly. This also includes field study report(s)/Lab visit report(s), if any.

Semester IV Practical Course 8
Model Question Paper
PROGRAMME ELECTIVE – MICROBIOLOGY
CLINICAL MICROBIOLOGY AND INDUSTRIAL MICROBIOLOGY
Time 3 hours **Weightage 20**

1. Solid state and submerged fermentation (SSF) for amylase production and quantification of amylase produced (A).
(Total weight 5 = Experiment – 2, Procedure 1.5, Result 1.5)
2. Identify the Bacterial types B and C by Gram staining.
(Total weight 3 = Procedure – 1, Preparation – 1, Identification – 1; 2 x 3 = 6)
3. Stain Bacterial spores D supplied.
(Total weight 3 = Preparation – 1.5, Procedure – 1.5)
4. Determine the blood group of sample E.
(Total weight 2 = Preparation – 1, Procedure – 1)
5. Comment on F and G.
(Weight = 1.5; 1.5 x 2 =3)
6. Practical record
(Weight = 4)

Key to the questions:
1. A - 4 days old fungal culture (SSF) should be supplied
2. B, C – unknown bacterial cultures are to be given.
3. D – old bacterial culture having spores
4. E – any blood sample
5. F, G – Equipments/Cultures/Reagents/Diagrams related to topics covered in the syllabus.
6. Awarding 'A grade' to the record of practical work shall be considered only if all the practicals specified in the syllabus are done completely and recorded properly. This also includes field study report(s)/Lab visit report(s), if any.