RADHA GOVIND UNIVERSITY
RAMGARH, JHARKHAND

DEPARTMENT OF BOTANY

NEP FYUGP CURRICULUM
BOTANY HONOURS/
BOTANY HONOURS WITH RESEARCH PROGRAMME
SUBJECT CODE = 16

FOR UNDERGRADUATE COURSES UNDER
RADHA GOVIND UNIVERSITY

Implemented w.e.f.
Academic Session 2025-2026 & onwards

HIGHLIGHTS OF FYUGP CURRICULUM

PROGRAMME DURATION

- The Full-time, Regular UG programme for a regular student shall be for a period of four years with multiple entry and multiple exit options.
- The session shall commence from the **1st of July**.

ELIGIBILITY

- The selection for admission will be primarily based on the availability of seats in the Major subject and marks imposed by the institution. Merit point for selection will be based on marks obtained in the Major subject at Class 12 (or equivalent level) or the aggregate marks of Class 12 (or equivalent level) if the Marks of the Major subject is not available. Reservation norms of the Government of Jharkhand must be followed as amended in times.
- UG Degree Programmes with Double Major shall be provided only to those students who secure a minimum of 75% overall marks or 7.5 CGPA or higher.
- Other eligibility criteria, including those for multiple entry, will be in light of the UGC Guidelines for Multiple Entry and Exit in Academic Programmes offered in Higher Education Institutions.

ADMISSION PROCEDURE

- The reservation policy of the Government of Jharkhand shall apply in admission and the benefit of the same shall be given to the candidates belonging to the State of Jharkhand only. The candidates of other states in the reserved category shall be treated as General category candidates. Other relaxations or reservations shall be applicable as per the prevailing guidelines of the University for FYUGP.

VALIDITY OF REGISTRATION

- Validity of a registration for FYUGP will be for a maximum of **Seven years** from the date of registration.

ACADEMIC CALENDAR

- An Academic Calendar will be prepared by the University to maintain uniformity in the UG Honours/ Honours with Research Programmes and PG Diploma Programmes, running in the colleges under the university (Constituent/Affiliated).
- **Academic Year:** Two consecutive (one odd + one even) semesters constitute one academic year.
- **Semester:** The Odd Semester is scheduled from **July to December,** and the Even Semester is from **January to June**. Each week has a minimum of 40 working hours spread over 6 days.

- Each semester will include Admission, coursework, conduct of examination and declaration of results, including semester break.
- To undergo an 8-week summer internship/ apprenticeship during the summer camp, the Academic Calendar may be scheduled for academic activities as below:
  a) Odd Semester: **From the first Monday of August to the third Saturday of December**
  b) Even Semester: **From the first Monday of January to the third Saturday of May**
- An academic year comprising 180 working days in the least is divided into two semesters, each semester having at least 90 working days. With six working days in a week, this would mean that each semester will have 90/ 6 = 15 teaching/ working weeks. Each working week will have 40 hours of instructional time.
- Each year, the University shall draw out a calendar of academic and associated activities, which shall be strictly adhered to. The same is non-negotiable. Further, the Department will make all reasonable endeavours to deliver the programmes of study and other educational services as mentioned in its Information Brochure and website. However, circumstances may change, prompting the Department to reserve the right to change the content and delivery of courses, discontinue or combine courses and introduce or withdraw areas of specialization.

PROGRAMME OVERVIEW/ SCHEME OF THE PROGRAMME

- Undergraduate degree programmes of either 3 or 4-year duration, with multiple entries and exit points and re-entry options within this period, with appropriate certifications such as:
  - UG Certificate after completing 1 year (2 semesters) of study in the chosen fields of study, provided they complete one vocational course of 4 credits during the summer vacation of the first year or internship/ Apprenticeship in addition to 6 credits from skill-based courses earned during the first and second semesters.,
  - UG Diploma after 2 years (4 semesters) of study diploma provided they complete one vocational course of 4 credits or internship/ Apprenticeship/ skill based vocational courses offered during the first year or second year summer term, in addition to 9 credits from skill-based courses earned during the first, second, and third semester.
  - Bachelor's Degree after a 3-year (6 semesters) programme of study,
  - Bachelor's Degree (Honours) after a 4-year (8 semesters) programme of study.
  - Bachelor's Degree (Honours with Research) after a 4-year (8 semesters) programme of study to the students undertaking a 12-credit Research component in the fourth year of FYUGP.

CREDIT OF COURSES

The term 'credit' refers to the weightage given to a course, usually in terms of the number of instructional hours per week assigned to it. The workload relating to a course is measured in terms of credit hours. It determines the number of hours of instruction required per week over a semester (minimum 15 weeks).

a) One hour of teaching/ lecture or two hours of laboratory /practical work will be assigned per class/interaction.

One credit for Theory = 15 Hours of Teaching
One credit for Practicum = 30 Hours of Practical work
One credit for Internship = 02 Weeks of Practical experience

b) For credit determination, instruction is divided into three major components:
Hours (L) – Classroom Hours of one hour duration.
Tutorials (T) – Special, elaborate instructions on specific topics of one hour duration
Practical (P) – Laboratory or field exercises in which the student has to do experiments or other practical work of a two-hour duration.
Internship – For the Exit option after any academic year of a Four-year U.G. Programme for the award of U.G. Certificate, U.G. Diploma, U.G. Degree (Level 4.5, 5 or 5.5 respectively), Students can either complete two 4-week internships worth 2 credits each or one 8-week internship for all 4 credits. This practical experience connects academic learning with real-world applications, offering valuable exposure to professional environments in their fields of study

CHANGE OF MAJOR OR MINOR COURSES

- The change of Major or Minor courses may be allowed only once after the Second Semester and before the third Semester in the FYUG Programme, depending on the provisions laid by the FYUGP and the conditions laid by the Institution. **However, the student must clear the papers (Mid Sem & End Sem both) from the previous semesters of the new subject opted in the next Examination of the coming session.**

CALCULATION OF MARKS FOR THE PURPOSE OF THE RESULT

- Students' final marks and the result will be based on the marks obtained in the Semester Internal Examination and End Semester Examination organised taken together.
- Passing in a subject will depend on the collective marks obtained in the Semester internal and End Semester University Examination. However, students must pass in Theory and Practical Examinations separately.

PROMOTION CRITERIA

First degree programme with a single major (160+4=164 credits):

i. The Requisite Marks obtained by a student in a particular subject will be the criteria for promotion to the next Semester.
ii. No student will be detained in odd Semesters (I, III, V & VII).

iii. To get promotion from Semester-II to Semester-III a student will be required to pass in at least 75% of the Courses in an academic year, a student has to pass in minimum 11 papers out of the total 14 papers. It is further necessary to procure pass marks in minimum of 50% papers of the current semester i.e. the student has to pass in 4 papers out of 7 papers in Semester-II.

iv. To get promotion from Semester-IV to Semester-V (taken together of Semester I, II, III & IV) a student has to pass in minimum of 20 papers out of the total 26 papers. It is further necessary to procure pass marks in minimum of 50% papers of the current semester i.e. the student has to pass in 3 papers out of 6 papers in Semester-IV.

v. To get promotion from Semester-VI to Semester-VII (taken all together of Semester I, II, III, IV, V & VI) a student has to pass in minimum of 27 papers out of the total 36 papers. It is further necessary to procure pass marks in minimum of 50% papers of the current semester i.e. the student has to pass in 3 papers out of 5 papers in Semester VI.

vi. However, it will be necessary to procure pass marks in each of the papers before completion of the programme.

First degree programme with dual major (192+4=196 credits):

i. Please refer to the FYUGP Regulations for the detailed provisions of Double Major and Dual Degrees.

ii. No student will be detained in odd Semesters (I, III, V & VII).

iii. To get promotion from Semester-II to Semester-III a student will be required to pass in at least 75% of the Courses in an academic year, a student has to pass in minimum 11 papers out of the total 15 papers. It is further necessary to procure pass marks in minimum of 50% papers of the current semester i.e. the student has to pass in 4 papers out of 8 papers in Semester-II.

iv. To get promotion from Semester-IV to Semester-V (taken together of Semester I, II, III & IV) a student has to pass in minimum 20 papers out of the total 27 papers. It is further necessary to procure pass marks in minimum of 50% papers of the current semester i.e. the student has to pass in 4 papers out of 7 papers in Semester-IV.

v. To get promotion from Semester-VI to Semester-VII (taken all together of Semester I, II, III, IV, V & VI) a student has to pass in minimum 28 papers out of the total 37 papers. It is further necessary to procure pass marks in minimum of 50% papers of the current semester i.e. the student has to pass in 3 papers out of 6 papers in Semester VI.

vi. However, it will be necessary to procure pass marks in each of the papers before completion of the programme.

PUBLICATION OF RESULTS

- The examination result shall be notified by the Controller of Examinations of the University in different newspapers and the same is to be posted also on the University

website.

- If a student is found indulging in any malpractice/ unfair means during an examination, the examination taken by the student for the semester will be cancelled. The candidate has to reappear in all the papers of the session with the students of the next session, and his one year will be detained. However, marks secured by the candidate in all previous semesters will remain unaffected.
- There shall be no Supplementary or Re-examination for any subject. Students who have failed in any subject in an even semester may appear in the subsequent even semester examination to clear the backlog. Similarly, the students who have failed in any subject in an odd semester may appear in the subsequent odd semester examination to clear the backlog.

Regulations related to any concern not mentioned above shall be guided by the Regulations of the Radha Govind University for FYUGP.

COURSE STRUCTURE FOR FYUGP **'HONOURS/ RESEARCH/ PG DIPLOMA'**

Table 1: Credit Framework for Four-Year Undergraduate Programme (FYUGP) under State Universities of Jharkhand [Total Credits = 164]

Academic Level	**Level of Courses**	**Semester**	**MJ**: Discipline Specific Courses – Core or Major (80)	**AC**: Associated core courses from discipline/ Interdisciplinary/ vocational (8)		**ELC**: Elective courses may be opted from four paths [Follow table 2] (24)	**MDC**: Multidisciplinary Courses (From a pool of Courses) (9)	**AEC**: Ability Enhancement Courses (Modern Indian Language and English) (8)	**SEC**: Skill Enhancement Courses (9)	**VAC**: Value Added Courses (6)	**IKS**: (i) Indian Knowledge System (2) & **SA**: (ii) Social awareness (2)	**RC**: Research Courses (4+8)/ **AMJ**: Advanced Courses instead of Research (4+4+4)/ **PGD:** PG Diploma Level 6 (4+4+4)		**Total Credits**	**IAP**; Internship/Apprenticeship/ Project/ Vocational course/ Dissertation (4) **In between Sem I to Sem-VI**
	1	2	3 (Major- 80)	4 (Minor-32)			5	6	7	8	9	10	11	12	13
Level 4.5	Level 100-199: **Foundation or Introductory courses**	**I**	4	4	---	---	3	2	3	2	2	---	---	**20**	4
		II	4	---	4	---	3	2	3	2	2	---	---	**20**	
		Exit Point: Undergraduate Certificate provided with Summer Internship/ Project/ Vocational course/ Dissertation (4 credits)													
Level 5	Level 200-299: **Intermediate-level courses**	**III**	4+4	---		4	3	2	3	---	---	---	---	**20**	
		IV	4+4+4	---		4	---	2	---	2	---	---	---	**20**	
		Exit Point: Undergraduate Diploma provided with Summer Internship/ Project/ Vocational course/ Dissertation (4 credits)													
Level 5.5	Level 300-399: **Higher-level courses**	**V**	4+4+4+4	---		4	---	---	---	---	---	---	---	**20**	
		VI	4+4+4+4	---		4	---	---	---	---	---	---	---	**20**	
		Exit Point: Bachelor's Degree with Summer Internship/ Project/ Vocational course/ Dissertation (4 credits)												**124**	
Level 6	Level 400-499: **Advanced courses** Hons with Research (>7.5 CGPA)/ Honours/ PG Diploma	**VII**	4+4+4	---		4	---	---	---	---	---	4	4	**20**	---
		VIII	4+4	---		4	---	---	---	---	---	8	4+4	**20**	
		Exit Point: Bachelor's Degree with Honours/ Honours with Research/ PG Diploma Level 6												**164**	

Note: Honours students not undertaking research will do 3 courses for 12 credits in lieu of a Research project.

Table 2: Options for Elective Minor Courses

Path A	Path B	Path C	Path D
ELC-A; Elective courses from Interdisciplinary Subjects 1 & 2 (24)	**ELC-B**; Elective courses from discipline (24)	**ELC-C**; Elective courses from vocational (24)	**ELC-D**; Elective courses from discipline for Double Major (48)
This pathway may be recommended for students who wish to develop core competency in multiple disciplines of study. In this case, the credits for the minor pathway shall be distributed among the constituent disciplines/subjects. If students pursuing FYUGP are awarded a UG Degree in a Major discipline, they are eligible to mention their core competencies in other disciplines of their choice if they have earned 12 credits each from pathway courses of two particular disciplines. In the first three years of FYUGP, this pathway is composed of one Major discipline with 60 credits from 15 courses, and two other disciplines, with 12 credits from 3 courses in each discipline. In this pathway, if the students choose one of the two disciplines for 12 credits in one discipline then they should choose a different discipline for the other 12 credits. If the students continue to the fourth year of FYUGP, the students need to earn an additional 4 credits in both disciplines.	This pathway may be recommended to those students who wish for an in-depth study in more than one discipline with a focus on one discipline (Major) and relatively less focus on the other (Minor). If students exit at the end of the third year of FYUGP, they are awarded a Major Degree in a particular discipline and a Minor in another discipline of their choice, if they earn a minimum of 24 credits from the courses in the Minor discipline. If the students continue to the fourth year of FYUGP, they should earn a minimum of 32 credits in the Minor discipline, to be eligible for a UG Degree (Honours) with a Major and a Minor. For this, in the fourth year, they should earn an additional minimum of 8 credits through 2 courses in the Minor discipline.	This pathway may be recommended to those students who wish for exposure to a vocational discipline in addition to the in-depth study in the Major discipline. The credit requirements for Major and Vocational Minor disciplines in this pathway are the same as those for Major with Minor pathway, except that the Minor courses are in a vocational discipline. If students exit at the end of the third year of FYUGP, they are awarded a Major Degree in a particular discipline and a Minor in vocational discipline of their choice, if they earn a minimum of 24 credits from the Vocational courses. If the students continue to the fourth year of FYUGP, they should earn a minimum of 32 credits in the vocational discipline. For this, in the fourth year, they should earn an additional minimum of 8 credits through 2 courses in the Vocational discipline.	To secure the required minimum credits in each discipline, students who wish to opt for a Double Major should include the credits earned by them from the Multi-Disciplinary Courses, Skill Enhancement Courses, and Value-Added Courses offered by the respective Major disciplines. The Double Major pathway is extended to the fourth year. Shifting to a double major from a minor in the third semester will be allowed subject to clearance of the courses of double major (not studied earlier) in succeeding sessions. In the fourth year, the student can continue to earn the required credits in either Major A or Major B to qualify for a UG Degree (Honours)/ UG Degree (Honours with Research) in A or B. If he/she opts to continue with Major B in the fourth year, he/she should earn an additional 16 credits of 300-399 level in Major B through mandatory online courses. The institution will not provide the courses in physical mode in the fourth year of this segment.

Table 3: Credit Distribution in Elective Minor Courses during the Four Years of FYUGP

Academic Level	Level of Courses	Semester	Path A **ELC**; Elective courses from Interdisciplinary Subjects 1 & 2 (24)		Path B **ELC**; Elective courses from the discipline (24)	Path C **ELC**; Elective courses from vocational (24)	Path D **ELC**; Elective courses from the discipline for Double Major (64)
	1	2	3A. Subject 1	3B. Subject 2	4	5	6
Level 4.5	Level 100-199: **Foundation or Introductory courses**	**I**	---	---	---	---	4+4
		II	---	---	---	---	4+4
		Exit Point: Bachelor's Degree with Hons. with Research					
Level 5	Level 200-299: **Intermediate-level courses**	**III**	4	---	4	4	4+4
		IV	---	4	4	4	4+4
		Exit Point: Bachelor's Degree with Hons.					
Level 5.5	Level 300-399: **Higher-level courses**	**V**	4	---	4	4	4+4
		VI	---	4	4	4	4+4
		Exit Point: P.G. Diploma Degree					
Level 6	Level 400-499: **Advanced courses** Hons with Research (>7.5 CGPA)/ Honours/ PG Diploma	**VII**	4	---	4	4	4+4
		VIII	---	4	4	4	4+4
		Exit Point: (A) Bachelor's Degree with Hons. with Research/ (B) Bachelor's Degree with Hons./ (C) P.G. Diploma Degree					

COURSES OF STUDY FOR FOUR-YEAR UNDERGRADUATE PROGRAMME 2025 onwards

Table 4: Semester-wise Course Code and Credit Points for Single Major during the First Three Years of FYUGP

Semester	Common, Introductory, Major, Minor, Vocational & Internship Courses		Credits	
	Code	Papers	Paper	Semester
I	AEC-1	Language and Communication Skills (MIL-1; Modern Indian language Hindi/ English)	2	7 Papers (20 credits)
	VAC-1	Value Added Course-1	2	
	IKS-1	Indian Knowledge System-I (Foundation Course)	2	
	SEC-1	Skill Enhancement Course-1	3	
	MDC-1	Multi-disciplinary Course-1	3	
	AC-1	Associated core courses from discipline/ Interdisciplinary/ vocational	4	
	MJ-1	Major paper 1 (Disciplinary/ Interdisciplinary Major)	4	
II	AEC-2	Language and Communication Skills (MIL-1; Modern Indian language English/ Hindi)	2	7 Papers (20 credits)
	VAC-2	Value Added Course-2	2	
	SA	Social Awareness Activities	2	
	SEC-2	Skill Enhancement Course-2	3	
	MDC-2	Multi-disciplinary Course-2	3	
	AC-2	Associated core courses from discipline/ Interdisciplinary/ vocational	4	
	MJ-2	Major paper 2 (Disciplinary/ Interdisciplinary Major)	4	
III	AEC-3	Language and Communication Skills (MIL-2; MIL including TRL)	2	6 Papers (20 credits)
	SEC-3	Skill Enhancement Course-3	3	
	MDC-3	IKS as a Multi-disciplinary Course-3	3	
	ELC-1	Elective courses from discipline/ Interdisciplinary/ vocational	4	
	MJ-3	Major paper 3 (Disciplinary/ Interdisciplinary Major)	4	
	MJ-4	Major paper 4 (Disciplinary/ Interdisciplinary Major)	4	
IV	AEC-4	Language and Communication Skills (MIL-2; MIL including TRL)	2	6 Papers (20 credits)
	VAC-3	Value Added Course-3	2	
	ELC-2	Elective courses from discipline/ Interdisciplinary/ vocational	4	
	MJ-5	Major paper 5 (Disciplinary/ Interdisciplinary Major having IKS)	4	
	MJ-6	Major paper 6 (Disciplinary/ Interdisciplinary Major)	4	
	MJ-7	Major paper 7 (Disciplinary/ Interdisciplinary Major)	4	
V	ELC-3	Elective courses from discipline/ Interdisciplinary/ vocational	4	5 Papers (20 credits)
	MJ-8	Major paper 8 (Disciplinary/ Interdisciplinary Major)	4	
	MJ-9	Major paper 9 (Disciplinary/ Interdisciplinary Major)	4	
	MJ-10	Major paper 10 (Disciplinary/ Interdisciplinary Major)	4	
	MJ-11	Major paper 11 (Disciplinary/ Interdisciplinary Major)	4	
VI	ELC-4	Elective courses from discipline/ Interdisciplinary/ vocational	4	5 Papers (20 credits)
	MJ-12	Major paper 12 (Disciplinary/ Interdisciplinary Major)	4	
	MJ-13	Major paper 13 (Disciplinary/ Interdisciplinary Major)	4	
	MJ-14	Major paper 14 (Disciplinary/ Interdisciplinary Major)	4	
	MJ-15	Major paper 15 (Disciplinary/ Interdisciplinary Major)	4	
Total Credits, excluding one Internship (IAP) of 4 credits =			**120**	**120**

Note: It is mandatory to take One Internship of 4 credits in any one of the semesters during the first three years in FYUGP or before exit at any of the exit points if a student wishes to opt for the same.

Table 5A: Semester-wise Course Code and Credit Points for Single Major during the Fourth Year of FYUGP for Bachelor's Degree (Honours with Research)

Semester	Common, Introductory, Major, Minor, Vocational & Internship Courses		Credits	
	Code	Papers	Paper	Semester
VII A	ELC-5	Elective courses from discipline/ Interdisciplinary/ vocational	4	5 Papers (20 credits)
	MJ-16	Major paper 16 (Research Methodology)	4	
	MJ-17	Major paper 17 (Disciplinary/Interdisciplinary Major)	4	
	MJ-18	Major paper 18 (Disciplinary/Interdisciplinary Major)	4	
	RC-1	Research proposal – Planning & Techniques (Disciplinary/Interdisciplinary Major)	4	
VIII A	ELC-6	Elective courses from discipline/ Interdisciplinary/ vocational	4	4 Papers (20 credits)
	MJ-19	Major paper 19 (Disciplinary/Interdisciplinary Major)	4	
	MJ-20	Major paper 20 (Disciplinary/Interdisciplinary Major)	4	
	RC-2	Research Internship/Field Work/Project/Dissertation/Thesis	8	
		Total Credits, excluding one Internship of 4 credits =	**160**	**160**

Table 5B: Semester-wise Course Code and Credit Points for Single Major during the Fourth Year of FYUGP for Bachelor's Degree (Honours)

Semester	Common, Introductory, Major, Minor, Vocational & Internship Courses		Credits	
	Code	Papers	Paper	Semester
VII B	ELC-5	Elective courses from discipline/ Interdisciplinary/ vocational	4	5 Papers (20 credits)
	MJ-16	Major paper 16 (Disciplinary/Interdisciplinary Major)	4	
	MJ-17	Major paper 17 (Disciplinary/Interdisciplinary Major)	4	
	MJ-18	Major paper 18 (Disciplinary/Interdisciplinary Major)	4	
	AMJ-1	Advanced Major pape-1 (Disciplinary/Interdisciplinary Major)	4	
VIII B	ELC-6	Elective courses from discipline/ Interdisciplinary/ vocational	4	5 Papers (20 credits)
	MJ-19	Major paper 19 (Disciplinary/Interdisciplinary Major)	4	
	MJ-20	Major paper 20 (Disciplinary/Interdisciplinary Major)	4	
	AMJ-2 AMJ-3	Advanced Major paper-2 (Disciplinary/Interdisciplinary Major) Advanced Major paper-3 (Disciplinary/Interdisciplinary Major)	4 4	
		Total Credits, excluding one Internship of 4 credits =	**160**	**160**

Table 5C: Semester-wise Course Code and Credit Points for Single Major during the Fourth Year of FYUGP for Bachelor's Degree (with Postgraduate Diploma)

Semester	Common, Introductory, Major, Minor, Vocational & Internship Courses		Credits	
	Code	Papers	Paper	Semester
VII C	ELC-5	Elective courses from discipline/ Interdisciplinary/ vocational	4	5 Papers (20 credits)
	MJ-16	Major paper 16 (Disciplinary/Interdisciplinary Major)	4	
	MJ-17	Major paper 17 (Disciplinary/Interdisciplinary Major)	4	
	MJ-18	Major paper 18 (Disciplinary/Interdisciplinary Major)	4	
	JOC-1	Skill based Job Oriented paper (Disciplinary/Interdisciplinary Major)	4	
VIII C	ELC-6	Elective courses from discipline/ Interdisciplinary/ vocational	4	5 Papers (20 credits)
	MJ-19	Major paper 19 (Disciplinary/Interdisciplinary Major)	4	
	MJ-20	Major paper 20 (Disciplinary/Interdisciplinary Major)	4	
	JOC-2	Skill based Job Oriented paper (Disciplinary/Interdisciplinary Major)	4	
	JOC-3	Skill based Job Oriented paper (Disciplinary/Interdisciplinary Major)	4	
		Total Credits, excluding one Internship of 4 credits =	**160**	**160**

AIMS OF BACHELOR'S DEGREE PROGRAMME IN BOTANY

The broad aims of bachelor's degree programme in Botany are:

(i) The programme is designed to equip students with essential knowledge and technical skills to study plants and related subjects in a holistic manner.

(ii) The main aim is to train the learners in all areas of plant biology using appropriate combinations of core and elective papers with significant inter- disciplinary components.

(iii) Students would be exposed to cutting-edge technologies that are currently used in the study of plant life forms, their evolution and interactions with other organisms within the ecosystem. Students would also become aware of the social and environmental significance of plants and their relevance to the national economy.

PROGRAM LEARNING OUTCOMES

The broad aims of bachelor's degree programme in Botany are:

(i) Students will be able to understand and explain different specializations of Botany such as systematics, evolution, ecology, developmental biology, physiology, biochemistry, plant interactions with microbes and insects, morphology, anatomy, reproduction, genetics, cell and molecular biology of plants.

(ii) Students will be trained in various analytical techniques of plant biology, use of plants as industrial resources or as support system for human livelihood and will be well versed with the use of transgenic technologies for both basic and applied research in plants.

(iii) Students will be able to identify various life forms of plants, design and execute experiments related to basic studies on evolution, ecology, developmental biology, physiology, biochemistry, plant interactions with microbes and insects, morphology, anatomy, reproduction, genetics, microbiology, molecular biology, recombinant DNA technology, transgenic technology. Students are also familiarised with the use of bioinformatics tools and databases and in the application of statistics to biological data.

(iv) Students will acquire core competency in the subject Botany and in allied subject areas.

(v) They will be able to use the evidence based comparative studies approach to explain the evolution of organism and understand the genetic diversity and its significance.

(vi) The students will be able to explain various physiological and metabolic processes unique to plants.

(vii) They would be able to elaborate on the concepts of gene, genome and the molecular processes of replication, transcription and translation.

(viii) They will be able to understand adaptation, development and behaviour of different forms of life.

(ix) The students will get an understanding of functioning of ecosystem and tracing the energy pyramids through nutrient flow.

(x) Students will be able to demonstrate the experimental techniques and methods in plant sciences and have innovative research ideas.

SEMESTER WISE COURSES IN BOTANY HONOURS **2025 onwards**

Table 6: Semester-wise Course Code and Credit Points of Major Courses in Botany

Semester	Courses		Examination Structure			
	Code	Courses in NEP FYUGP Syllabus of Botany Session 2025-26 & onwards	Credits	Mid Semester Theory (F.M.)	End Semester Theory (F.M.)	End Semester Practical/ Viva (F.M.)
I	MJ-1	Microbiology, Phycology and Mycology	4	25	75	---
	SEC-1	Floriculture & Landscaping	3	---	75	---
II	MJ-2	Non-Flowering Plants and Paleobotany	4	25	75	---
	SEC-2	Minor Forest Produce	3	---	75	---
III	MJ-3	Plant Anatomy and Embryology	4	25	75	---
	MJ-4	Practical-I	4	---	---	100
	SEC-3	Elementary Computer Application Softwares	3	---	75	---
IV	MJ-5	IKS & Plant Taxonomy	4	25	75	---
	MJ-6	Ecology and Environmental Studies	4	25	75	---
	MJ-7	Practical-II	4	---	---	100
V	MJ-8	Cell Biology & Biochemistry	4	25	75	---
	MJ-9	Genetics	4	25	75	---
	MJ-10	Plant Physiology	4	25	75	---
	MJ-11	Practical-III	4	---	---	100
VI	MJ-12	Molecular Biology	4	25	75	---
	MJ-13	Plant Biotechnology	4	25	75	---
	MJ-14	Bioinformatics & Computational Biology	4	25	75	---
	MJ-15	Practical-IV	4	---	---	100
VII	MJ-16	Research Methodology	4	25	75	---
	MJ-17	Advanced Molecular Biology	4	25	75	---
	MJ-18	Practical-V	4	---	---	100
	AMJ-1/	Biological Instrumentation OR	4	25	75	---
	RC-1	Research Planning & Techniques	4	25	---	75
VIII	MJ-19	Applied Botany	4	25	75	---
	MJ-20	Practical-VI	4	---	---	100
	AMJ-2	Integrative Botany	4	25	75	---
	AMJ-3/	Practical-VII	4	---	---	100
	RC-2	Project Dissertation/ Research Internship/ Field Work	8	50	---	150

***** It is mandatory to take Either One Internship of 4 credits or Two Internships of 2 credits each in any one of the semesters during the first three years in FYUGP or before exit at any of the exit points if a student wishes to opt for the same.

Table 7: Semester-wise Course Code and Credit Points of Minor Courses in Botany

Courses		Examination Structure			
Code	**Minor Courses in NEP FYUGP Syllabus of Botany** Session 2025-26 & onwards	**Credits**	**Mid Semester Theory (F.M.)**	**End Semester Theory (F.M.)**	**End Semester Practical/ Viva (F.M.)**
MN-A	Introductory Botany	4	15	60	25
MN-B	Biodiversity	4	15	60	25
MN-C	Plant Ecology and Taxonomy	4	15	60	25
MN-D	Plant Anatomy & Embryology	4	15	60	25
MN-E	Plant Physiology & Metabolism	4	15	60	25
MN-F	Cytogenetics and Molecular Biology	4	15	60	25
MN-G	Plant Biotechnology	4	15	60	25

INSTRUCTION TO QUESTION SETTER

SEMESTER INTERNAL EXAMINATION (SIE):

There will be Only One Semester Internal Examination in Major, Minor and Research Courses, which will be organised at college/institution level. However, Only One End semester evaluation in other courses will be done either at College/ Institution or University level depending upon the nature of course in the curriculum.

A. (SIE 10+5=15 marks):

There will be two group of questions. **Question No.1 will be very short answer type in Group A** consisting of five questions of 1 mark each. **Group B will contain descriptive type** two questions of five marks each, out of which any one to answer.

The Semester Internal Examination shall have two components. (a) One Semester Internal Assessment Test (SIA) of 10 Marks, (b) Class Attendance Score (CAS) of 5 marks.

B. (SIE 20+5=25 marks):

There will be two group of questions. **Group A is compulsory** which will contain two questions. **Question No.1 will be very short answer type** consisting of five questions of 1 mark each. **Question No.2 will be short answer type** of 5 marks. **Group B will contain descriptive type** two questions of ten marks each, out of which any one to answer.

The Semester Internal Examination shall have two components. (a) One Semester Internal Assessment Test (SIA) of 20 Marks, (b) Class Attendance Score (CAS) of 5 marks.

Conversion of Attendance into score may be as follows:

Attendance Upto 45%, 1mark; 45<Attd.<55, 2 marks; 55<Attd.<65, 3 marks; 65<Attd.<75, 4 marks; 75<Attd, 5 marks.

END SEMESTER UNIVERSITY EXAMINATION (ESE):

A. (ESE 50 marks):

There will be two group of questions. **Group A is compulsory** which will contain one question. **Question No.1 will be very short answer type** consisting of five questions of 1 mark each. Group B will contain descriptive type five questions of fifteen marks each, out of which any three are to answer.

B. (ESE 60 marks):

There will be two group of questions. **Group A is compulsory** which will contain three questions. **Question No.1 will be very short answer type** consisting of five questions of 1 mark each. **Question No.2 & 3 will be short answer type** of 5 marks. Group B will contain descriptive type five questions of fifteen marks each, out of which any three are to answer.

C. (ESE 75 marks):

There will be two group of questions. **Group A is compulsory** which will contain three questions. **Question No.1 will be very short answer type** consisting of five questions of 1 mark each. **Question No. 2 & 3 will be short answer type** of 5 marks. Group B will contain descriptive type six questions of fifteen marks each, out of which any four are to answer.

D. (ESE 100 marks):

There will be two group of questions. **Group A is compulsory** which will contain three questions. **Question No.1 will be very short answer type** consisting of ten questions of 1 mark each. **Question No. 2 & 3 will be short answer type** of 5 marks. Group B will contain descriptive type six questions of twenty marks each, out of which any four are to answer.

FORMAT OF QUESTION PAPER FOR MID/ END SEMESTER EXAMINATIONS

Question format for **15 Marks**:

Subject/ Code

F.M. =15 **Time** = 1 Hr. Exam Year

General Instructions:

i. **Group A** carries very short answer-type compulsory questions.
ii. **Answer 1 out of 2** subjective/ descriptive questions given in **Group B**.
iii. Answer in your own words as far as practicable.
iv. Answer all subparts of a question in one place.
v. Numbers in the right indicate full marks for the question.

Group A

1. [5x1=5]
   i. .....
   ii. .....
   iii. .....
   iv. .....
   v. .....

Group B

2. ..... [10]
3. ..... [10]

Note: There may be subdivisions in each question asked in Theory Examination.

Question format for **20 Marks**:

Subject/ Code

F.M. =20 **Time** = 1 Hr. Exam Year

General Instructions:

i. **Group A** carries very short answer-type compulsory questions.
ii. **Answer 1 out of 2** subjective/ descriptive questions given in **Group B**.
iii. Answer in your own words as far as practicable.
iv. Answer all subparts of a question in one place.
v. Numbers in the right indicate full marks for the question.

Group A

1. [5x1=5]
   i. .....
   ii. .....
   iii. .....
   iv. .....
   v. .....
2. ..... [5]

Group B

3. ..... [10]
4. ..... [10]

Note: There may be subdivisions in each question asked in the Theory Examination.

Question format for **50 Marks**:

Subject/ Code

F.M. =50 **Time** = 1.5 Hrs. Exam Year

General Instructions:

i. **Group A** carries very short answer-type compulsory questions.
ii. **Answer 3 out of 5** subjective/ descriptive questions given in **Group B**.
iii. Answer in your own words as far as practicable.
iv. Answer all subparts of a question in one place.
v. Numbers in the right indicate full marks for the question.

Group A

1. [5x1=5]
   i. .....
   ii. .....
   iii. .....
   iv. .....
   v. .....

Group B

2. ..... [15]
3. ..... [15]
4. ..... [15]
5. ..... [15]
6. ..... [15]

Note: There may be subdivisions in each question asked in the Theory Examination.

Question format for **60 Marks**:

Subject/ Code

F.M. =60 **Time** = 3 Hrs. Exam Year

General Instructions:

i. **Group A** carries very short answer-type compulsory questions.
ii. **Answer 3 out of 5** subjective/ descriptive questions given in **Group B**.
iii. Answer in your own words as far as practicable.
iv. Answer all subparts of a question in one place.
v. Numbers in the right indicate full marks for the question.

Group A

1. [5x1=5]
   i. .....
   ii. .....
   iii. .....
   iv. .....
   v. .....
2. ..... [5]
3. ..... [5]

Group B

4. ..... [15]
5. ..... [15]
6. ..... [15]
7. ..... [15]
8. ..... [15]

Note: There may be subdivisions in each question asked in the Theory Examination.

Question format for **75 Marks**:

Subject/ Code

F.M. =75 **Time** = 3 Hrs. Exam Year

General Instructions:

i. **Group A** carries very short answer-type compulsory questions.
ii. **Answer 4 out of 6** subjective/ descriptive questions given in **Group B**.
iii. Answer in your own words as far as practicable.
iv. Answer all subparts of a question in one place.
v. Numbers in the right indicate full marks for the question.

Group A

1. [5x1=5]
   i. .....
   ii. .....
   iii. .....
   iv. .....
   v. .....
2. ..... [5]
3. ..... [5]

Group B

4. ..... [15]
5. ..... [15]
6. ..... [15]
7. ..... [15]
8. ..... [15]
9. ..... [15]

Note: There may be subdivisions in each question asked in the Theory Examination.

Question format for **100 Marks**:

Subject/ Code

F.M. =100 **Time** = 3 Hrs. Exam Year

General Instructions:

i. **Group A** carries very short answer-type compulsory questions.
ii. **Answer 4 out of 6** subjective/ descriptive questions given in **Group B**.
iii. Answer in your own words as far as practicable.
iv. Answer all subparts of a question in one place.
v. Numbers in the right indicate full marks for the question.

Group A

1. [10x1=10]
   i. ..... vi. .....
   ii. ..... vii. .....
   iii. ..... viii. .....
   iv. ..... ix. .....
   v. ..... x. .....
2. ..... [5]
3. ..... [5]

Group B

4. ..... [20]
5. ..... [20]
6. ..... [20]
7. ..... [20]
8. ..... [20]
9. ..... [20]

Note: There may be subdivisions in each question asked in the Theory Examination.

SEMESTER I

I. MAJOR COURSE –MJ 1:

MICROBIOLOGY, PHYCOLOGY AND MYCOLOGY

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	**Pass Marks: Th (SIE + ESE) = 40**

(Credits: Theory-04) **60 Hours**

Course Objectives:

On successful completion of this course the student should be able to:

1. To introduce students with lichens, their ecology, classification, characteristics, reproduction and economic Importance.
2. Study of morphology, anatomy, reproduction and developmental changes there in through typological study should create a knowledge base in understanding plant diversity, economic values, taxonomy of lower group of plants.

Course Learning Outcomes:

On successful completion of this course the student should know:

1. To learn the organ formation in early land plants that resulted to diversity of species of Lichens "Bryophytes", "Pteridophytes" and "Gymnosperms".
2. Information on the Ecological and Economic Importance of bryophytes, pteridophytes and gymnosperms will help to understand their role in ecosystem functioning.

Course Content:

Unit 1: Introduction to microbial world **(2 lectures)**

Types and Classification.

Unit 2: Viruses **(8 lectures)**

Discovery, physiochemical and biological characteristics; classification (Baltimore), general structure with special reference to viroids and prions; replication (general account), DNA virus (T-phage), lytic and lysogenic cycle; RNA virus (TMV). Economic importance of viruses with reference to vaccine production, role in research, medicine and diagnostics, as causal organisms of plant diseases.

Unit 3: Bacteria **(8 lectures)**

Discovery, general characteristics; Types-archaebacteria, eubacteria, wall-less forms (mycoplasma and spheroplasts); Cell structure; Nutritional types; Reproduction-vegetative, asexual and recombination (conjugation, transformation and transduction).

Phycology:

Unit 1: Algae **(5 lectures)**

General characteristics of Algae, Criteria for classification of algae, Fritsch (1935) system of classification. Significant contributions of eminent phycologists (F.E. Fritsch and M.O.P. Iyengar). Economic importance of algae.

Unit 2: Cyanophyta **(4 lectures)**

Brief account of ecology and occurrence; Range of thallus organisation; Cell structure; Reproduction, Morphology and life-cycle of *Nostoc* and *Oscillatoria*.

Unit 3: Chlorophyta, Charophyta and Xanthophyta **(7 lectures)**

Brief account of general characteristics; Occurrence; Range of thallus organisation; Cell structure; Reproduction Morphology and life-cycles of *Chlamydomonas, Volvox, Oedogonium, Chara, Vaucheria*.

Unit 4: Phaeophyta and Rhodophyta **(5 lectures)**

Brief account of characteristics; Occurrence; Range of thallus organisation; Cell structure; Reproduction. Morphology and life-cycles of *Ectocarpus* and *Polysiphonia.*

Mycology:

Unit 1: Introduction to Fungi (11 lectures)

Classification –Ainsworth (1966, 1973).

Brief account of allied fungi and applied mycology. Brief account of evolution. Brief account and life cycle pattern of *Synchytrium, Phytophthora, Erysiphe, Claviceps, Peziza, Puccinia, Ustilago*, *Alternaria*.

Unit 2: Phytopathology (10 lectures)

Terms and concepts; General symptoms; Etiology; Symptomology; Host-Pathogen relationships; Disease cycle and environmental relation; prevention and control of plant diseases, and role of quarantine. Bacterial diseases – Citrus canker. Viral diseases – Tobacco Mosaic viruses. Fungal diseases – Early blight of potato, Black stem rust of wheat.

Reference Books:

1. Wiley JM, Sherwood LM and Woolverton CJ. (2013) Prescott's Microbiology. 9th Edition. McGraw Hill International.
2. Pelczar, M.J. (2001) Microbiology, 5th edition, Tata McGraw-Hill Co, New Delhi.
3. Lee, R.E. (2008). Phycology, Cambridge University Press, Cambridge. 4th edition.
4. Kumar, H.D. (1999). Introductory Phycology. Affiliated East-West Press, Delhi.
5. Sharma, O.P. (2018). A text book of algae. Tata McGraw – Hill.
6. Bilgrami, K. S. and Saha, L. C. (2020). A textbook of Algae, CBS.
7. Agrios, G.N. (1997) Plant Pathology, 4th edition, Academic Press, U.K.
8. Agrios, G.N. (2011) Plant Pathology, 6th edition, Academic Press, U.K.
9. Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996). Introductory Mycology, John Wiley & Sons (Asia) Singapore. 4th edition.
10. Webster, J. and Weber, R. (2007). Introduction to Fungi, Cambridge Univ Press, Cambridge. 3rd Ed.
11. Sethi, I.K. and Walia, S.K. (2011). Text book of Fungi and Their Allies, Macmillan Pub. India Ltd.
12. Sharma, P.D. (2011). Plant Pathology, Rastogi Publication, Meerut, India.

II. SKILL ENHANCEMENT COURSE- SEC 1: FLORICULTURE & LANDSCAPING

Marks: 75 (ESE: 3Hrs) = 75	Pass Marks: Th (ESE) = 30

(Credits: Theory-03) **45 Hours**

Course Objectives:

1. Familiarise with the cultivation of flowers and ornamental crops from the time of planting to the time of harvesting.
2. It also includes production of planting materials through seeds, cuttings, budding, grafting, etc, up to the marketing of the flower and flower produce.

Course Learning Outcomes:

1. learns about identification and study important commercial varieties of the flowering crops. Preparation of ground and beds for planting specific flower crops. Layout of plots and gardens, planning for home gardens, landscape gardens. Preparation and execution of landscape plants maintenance of gardens and lawns.
2. Protected cultivation of flowers. Identifications and study of poly house, shed net house, mulching.

Course Content:

1. Global and Indian floriculture scenario with special reference to Jharkhand. **(3 lectures)**

2. Technology intervention **(15 lectures)**

Breeding: General methods of breeding suitable for sexually and asexually propagated flower crops and ornamental plants; Breeding constraints and achievements made in commercial flowers and its management and global trades in ornamental plants – Rose, China rose, Tuberose, Marigold, Gladiolus.

Micropropagation: Rose, Orchid; Harvesting and Packaging of commercial flowers (Rose, China rose, Tuberose, Marigold, Gladiolus).

3. Production technology of important flowers and foliage **(5 lectures)**

Rose, China rose, Tuberose, Marigold, Gladiolus, Palm, Asparagus, Dracaena.

4. Landscaping **(10 lectures)**

Landscape designs, Styles of garden, formal, informal and free style gardens, types of gardens; Urban landscaping; Garden plant components, arboretum, shrubbery, fernery, palmatum, arches and pergolas, edges and hedges, climbers and creepers, cacti and succulents, herbs, annuals, flower borders and beds, bamboo groves; Bio-aesthetic planning, eco-tourism, theme parks (Nakshatra Van), indoor gardening, therapeutic gardening, non-plant components, water scaping.

5. Protected Floriculture **(10 lectures)**

Prospects of protected floriculture in India; Types of protected structures – Greenhouses, polyhouses, shade houses, rain shelters; Suitable flower crops for protected cultivation; Containers and substrates, soil decontamination, layout of drip and fertigation system, water and nutrient management, weed management (Common local weeds and its control), physiological disorders, IPM and IDM; Staking and netting, Photoperiod regulation; Harvest indices, harvesting techniques, post-harvest handling techniques, Precooling, sorting, grading, packing, storage, quality standards.

6. Environmental Factors for the floriculture **(2 lectures)**

Biotic (Bacterial, Fungal, Insects and Nematodes) and abiotic factors (Light, Temperature, Humidity).

Reference Books:

1. G. S. Randhawa and A. Mukhopadhyay (1986). Floriculture in India, Allied (https://books.google.co.in/books?id=fABzMgAACAAJ)
2. Floriculture: A basic guide by K. V. Peter.
3. Floriculture Principles and Species by Dhiman Mukherjee.
4. Handbook of Flowering by Jitendra Kumar.
5. Commercial Floriculture: Principles and Practices by A.P. Mishra and V.P. Singh.

SEMESTER II

I. MAJOR COURSE- MJ 2:

NON-FLOWERING PLANTS AND PALEOBOTANY

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	**Pass Marks: Th (SIE + ESE) = 40**

(Credits: Theory-04) **60 Hours**

Course Objectives:

On successful completion of this course the student should be able to:

1. To introduce students with lichens, their ecology, classification, characteristics, reproduction and economic Importance.
2. Study of morphology, anatomy, reproduction and developmental changes there in through typological study should create a knowledge base in understanding plant diversity, economic values, taxonomy of lower group of plants.

Course Learning Outcomes:

On successful completion of this course the student should know:

1. To learn the organ formation in early land plants that resulted to diversity of species of Lichens "Bryophytes", "Pteridophytes" and "Gymnosperms".
2. Information on the Ecological and Economic Importance of bryophytes, pteridophytes and gymnosperms will help to understand their role in ecosystem functioning.

Course Content:

Unit 1: Symbiotic association (10 lectures)

Lichen – Occurrence; General characteristics; Growth forms and range of thallus organisation; Nature of associations of algal and fungal partners; Reproduction; Mycorrhiza-Ectomycorrhiza, Endomycorrhiza and their significance.

Unit 2: Bryophytes (13 lectures)

General characteristics; Adaptations to land habit; Classification; Range of thallus organisation. Morphology, anatomy, reproduction and alternation of generation of *Riccia, Marchantia, Anthoceros, Sphagnum* and *Funaria*. Ecological and economic importance of Bryophytes.

Unit 3: Pteridophytes (15 lectures)

Origin and evolution of land plants, Classification, morphology, anatomy and life cycle and alternation of generation of *Psilotum, Selaginella, Equisetum* and *Pteris*. Ecological and economic importance of pteridophytes.

Unit 4: Gymnosperms (11 lectures)

General characteristics, classification, morphology, anatomy and life cycle of *Cycas* and *Pinus*; Ecological and economic importance.

Unit 5: Paleobotany (11 lectures)

Brief introduction of paleobotanist of India. Fossils and Types of fossils; Process of fossilisation and its Significance. Geological time scale; General characteristics; Classification; Early land plants (*Cooksonia*, *Rhynia*)**.**

Reference Books:

1. Vashistha, P.C., Sinha, A.K., Kumar, A. (2010). Pteridophyta. S. Chand. Delhi, India.
2. Bhatnagar, S.P. & Moitra, A. (1996). Gymnosperms. New Age International (P) Ltd Publishers, New Delhi, India.
3. Parihar, N.S. (1991). An introduction to Embryophyta: Vol. I. Bryophyta. Central Book Depot. Allahabad.
4. Raven, P.H., Johnson, G.B., Losos, J.B., Singer, S.R. (2005). Biology. Tata McGraw Hill, Delhi.
5. Vanderpoorten, A. & Goffinet, B. (2009) Introduction to Bryophytes. Cambridge University Press.

II. SKILL ENHANCEMENT COURSE- SEC 2: MINOR FOREST PRODUCE

Marks: 75 (ESE: 3Hrs) = 75	Pass Marks: Th (ESE) = 30

(Credits: Theory-03) **45 Hours**

Course Objectives:

1. The purpose of this course is to familiarise with Minor Forest Products, management, collection, storage and post-harvest processing.

Course Learning Outcomes:

1. To acquaints with Minor Forest Products (NWFPs) and their scientific extraction, processing and disposal.
2. Livelihood of indigenous community based on minor forest produce.

Course Content:

Unit 1: Introduction **(2 lectures)**
Forest of Jharkhand and Minor Forest Produce.

Unit 2: Forest produce of Jharkhand **(17 lectures)**
Aromatic and Medicinal Plants: Neem, Karanj, Giloy, Munga, Pudina, Van Tulsi, Tulsi, Sweet flag, Kalmegh, Satavar, Lemon grass
Nutritional Plants: Mushroom, Mahua flower, Imli, Chironjee, Kathal
Oil Yielding Plants: Sal Seed, Mahua Seed, Neem Seed, Karanj Seed, Kusum, Castor
Fruit Trees: Kendu, Ber, Sahtoot, Mango, Jamun, Piyar**,** Karonda, Carombola
Leafy Vegetables: Chakor Sag, Beng Sag, Konar Sag

Unit 3: Source and Use of Minor Forest Products (MFPs) **(8 lectures)**
Gums and Resins, Katha, Dyes, Tannins, Oils. Technologies for extraction of Gums, Resins, Katha, Dyes, Tannins, Oils and other products.

Unit 4: Post Harvest Technology **(3 lectures)**
Cleaning, Packing, Storage and Processing.

Unit 5: Marketing of Minor Forest Produce **(3 lectures)**
Primary Agriculture Credit Society (PACS), Vyapaar Mandal Sahyog Samity (VMSS), Primary Minor Forest Produce Co-Operative Societies (PMFPCS), Women SHG or Repudiated NGO.

Unit 6: Forest Conservation. **(2 lectures)**

Unit 7: Strategy for Minor Forest Produce Management. **(2 lectures)**

Unit 8: Livelihood based on Minor Forest Produce of Jharkhand **(6 lectures)**
Bamboos, Canes and Grass.

Unit 9: Role of Minor Forest Produce in Sustainable development **(2 lectures)**

Reference Books:

1. Importance of Minor forest produces in tribal life- Manoshi Das (2018).
2. The Significance of Minor forest produce in the Indian tribal economy- K. Mohan Reddy (2018).
3. Tribal settlement and minor forest produce- D. Thakur (2009).
4. Procurement and Marketing of Minor Forest Produce in Tribal Areas- G. Parthasarathy and K. U. Shankar Patnaik (2003).

SEMESTER III

I. MAJOR COURSE- MJ 3:
PLANT ANATOMY AND EMBRYOLOGY

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

Course Objectives:

On completion of this course, the students will be able to understand:

1. To acquaint the students with internal basic structure and cellular composition of the plant body.
2. To correlate structure with important functions of different plant parts.
3. Study of various tissue systems and their development and functions in plants.

Course Learning Outcomes:

On successful completion of this course the student shall know:

1. Knowledge of various cells and tissues, meristem, epidermal and vascular tissue system in plants.
2. Various aspects of growth, development of the tissues and differentiation of various plant organs.
3. Knowledge of basic structure and organisation of plant parts in angiosperms.
4. Correlation of structure with morphology and functions.

Course Content:

Plant Anatomy

Unit 1: Introduction and scope of Plant Anatomy **(2 Lectures)**

Unit 2: Tissues and its types (Permanent and Meristematic). **(4 Lectures)**

Unit 3: Apical meristems Evolution of concept of organisation of shoot apex and root apex (Theories). **(6 Lectures)**

Unit 4: Vascular Cambium and Wood Structure, function and seasonal activity of cambium; Secondary growth and anomalous secondary growth in root and stem. Sapwood and heartwood; Ring and diffuse porous wood; Early and late wood, tyloses. Development and composition of periderm. **(12 Lectures)**

Unit 5: Morphological and Anatomical adaptations of xerophytes and hydrophytes. **(6 Lectures)**

Embryology

Unit 1: **Introduction-** Brief account of embryology and contributions of W. Hofmeister, E. Strasburger, S.G. Nawaschin, P. Maheshwari, B.M. Johri and scope**.** **(3 lectures**)

Unit 2: Anther and pollen biology **(5 lectures)**

Anther wall: Structure and functions, microsporogenesis and its significance. Microgametogenesis**.**

Unit 3: Ovule- Structure; Types; Special structures–endothelium, obturator, aril, caruncle and hypostase; Female gametophyte– megasporogenesis and megagametogenesis. **(6 lectures)**

Unit 4: Pollination and fertilisation- Brief account of Pollination and double fertilisation**.** **(3 lectures)**

Unit 5: Embryo, Endosperm and Seed- Structure and types; General pattern of development of dicot and monocot embryo, endosperm types and function, Seed structure (Monocot and Dicot). **(10 lectures)**

Unit 6: Polyembryony and apomixes- Introduction; Classification; Causes and applications. **(3 lectures)**

Reference Books:

1. Dickison, W.C. (2000). Integrative Plant Anatomy. Harcourt Academic Press, USA.
2. Fahn, A. (1974). Plant Anatomy. Pergmon Press, USA.
3. Mauseth, J.D. (1988). Plant Anatomy. The Benjammin/Cummings Publisher, USA.
4. Evert, R.F. (2006) Esau's Plant Anatomy: Meristems, Cells, and Tissues of the Plant Body: Their Structure, Function and Development. John Wiley and Sons, Inc
5. Bhojwani, S.S. and Bhatnagar, S.P. (2011). The Embryology of Angiosperms, Vikas Pub. House. Delhi. 5th edition.
6. Shivanna, K.R. (2003). Pollen Biology and Biotechnology. Oxford and IBH Pub. Co. Pvt. Ltd. Delhi.
7. Raghavan, V. (2000). Developmental Biology of Flowering plants, Springer, Netherlands.
8. Johri, B.M. l (1984). Embryology of Angiosperms, Springer-Verlag, Netherlands

II. MAJOR COURSE- MJ 4:
PRACTICAL-I

Marks: Pr (ESE: 6Hrs) =100	Pass Marks: Pr (ESE) = 40

(Credits: Practicals-04) **120 Hours**

Instruction to Question Setter for
End Semester Examination (ESE):
There will be one Practical Examination of 6Hrs duration. Evaluation of Practical Examination may be as per the following guidelines:
Experiment = 60 marks
Practical record notebook = 15 marks
Viva-voce = 25 marks

Practicals:
Unit I: Diversity & Economic Importance of Microbes
Microbiology

1. Electron micrographs/Models of viruses – T-Phage and TMV, Line drawings/ Photographs ofLytic and Lysogenic Cycle.
2. Types of Bacteria to be observed from temporary/permanent slides/photographs. Electronmicrographs of bacteria, binary fission, endospore, conjugation, root Nodule.
3. Gram staining.

Phycology

Study of vegetative and reproductive structures of *Nostoc, Volvox, Oedogonium, Chara* and *Vaucheria* through temporary slide preparations and permanent slides

Fungi

1. *Aspergillus*: study of asexual stage from temporary mounts. Study of Sexual stage from permanent slides/photographs.
2. *Peziza*: sectioning through ascocarp.
3. *Alternaria*: Specimens/photographs and temporary mounts.
4. *Puccinia*: Herbarium specimens of Black Stem Rust of Wheat and infected Barberry leaves; sections/ mounts of spores on wheat and permanent slides of both the hosts.
5. Phytopathology: Herbarium specimens of bacterial diseases; Citrus Canker; Viral diseases: TMV, Fungal diseases: Early blight of potato, Black stem rust of wheat.

Unit II: Non-Flowering Plants and Paleobotany

Lichens: Study of growth forms of lichens (crustose, foliose and fruticose) on different substrates. Study of thallus and reproductive structures (soredia and apothecium) through permanent slides. Mycorrhizae: ectomycorrhiza and endomycorrhiza (Photographs)

Archegoniate: *Riccia, Marchantia, Anthoceros, Sphagnum, Funaria, Selaginella, Equisetum, Pteris, Cycas, Pinus.*

Botanical excursion.

Unit III: Study of anatomical details through permanent slides/temporary stain mounts/ macerations/ museum specimens with the help of suitable examples.

1. Distribution and types of parenchyma, collenchyma and sclerenchyma.
2. Xylem: Tracheary elements-tracheids, vessel elements; thickenings; perforation plates; xylem fibres.
3. Phloem: Sieve tubes-sieve plates; companion cells; phloem fibers.
4. Epidermal system: cell types, stomata types.
5. Root: monocot, dicot, secondary growth.
6. Stem: monocot, dicot - primary and secondary growth.
7. Leaf anatomy: isobilateral, dorsiventral.
8. Adaptive Anatomy: xerophytes, hydrophytes.
9. Anther: Wall structure, MMC, spore tetrads.
10. Pollen germination.
11. Ovule: Types and embryo dissection.

Reference Books

1. Dubey, R.C. and Maheshwari, D.K. *A Textbook of Practical Microbiology*. S. Chand Publishing
2. Sharma, G.S. *Practical Phycology*. Rastogi Publications
3. Srivastava, K.P. *Practical Plant Pathology*. CBS Publishers and Distributors
4. Dutta, A.C. *A Manual of Practical Botany: Volume 2 (Bryophytes, Pteridophytes, Gymnosperms, Paleobotany)*. Oxford University Press.
5. Pandey, B.P. *Practical Plant Anatomy*. S. Chand Publishing.
6. Aneja, K.R. (2014). Laboratory manual of Microbiology and Biotechnology. Medtech, New Delhi.

III. SKILL ENHANCEMENT COURSE- SEC 3:
ELEMENTARY COMPUTER APPLICATION SOFTWARES

Marks: 75 (ESE: 3Hrs) = 75	Pass Marks: Th (ESE) = 30

A Common Syllabus for FYUGP (Credits: Theory-03) **45 Hours**

Instruction to Question Setter
*There will be **objective type test** consisting of **Seventy-five questions of 1 mark each**. Students are required to mark their answer on **OMR Sheet** provided by the University.*

Course Objectives:

The objective of the course is to generate qualified manpower in the area of Information Technology (IT) and Graphic designing which will enable such person to work seamlessly at any Offices.

1. Basic Concept of Computer: What is Computer, Applications of Computer, Types of computer, Components of Computer System, Central Processing Unit (CPU) **(3 Hours)**

2. Concepts of Hardware: Input Devices, Output Devices, Computer Memory, Types of Memory, processing Concept of Computer **(4 Hours)**

3. Operating system: Operating System, Functions of Operating System (Basic), Introduction to Windows 11, Working on Windows 11 environment, Installation of Application Software, My Computer, Control Panel, searching techniques in windows environment, Basic of setting **(6 Hours)**

4. Concept of Software: What is Software, Types of Software, Computer Software- Relationship between Hardware and Software, System Software, Application Software, some high level languages **(4 Hours)**

5. Internet & its uses: Basic of Computer networks; LAN, WAN, MAN, Concept of Internet, Applications of Internet; connecting to internet, what is ISP, World Wide Web, Web Browsing software's, Search Engines, URL, Domain name, IP Address, using e-governance website, Basics of electronic mail, getting an email account, Sending and receiving emails. **(6 Hours)**

6. Microsoft Word: Word processing concepts, Creation of Documents, Formatting of Documents, Formatting of Text, Different tabs of word 2016 environment, Formatting Page, Navigation of Page, Table handling, Header and footer, Page Numbering, Page Setup, Find and Replace, Printing the documents **(7 Hours)**

7. Microsoft Excel (Spreadsheet): Spreadsheet Concepts, Creating, Saving and Editing a Workbook, Inserting, Deleting Work Sheets, Formatting worksheet, Excel Formula, Concept of charts and Applications, Pivot table, goal seek, Data filter, data sorting and scenario manager, printing the spreadsheet **(6 Hours)**

8. Microsoft Power Point (Presentation Package): Concept and Uses of presentation package, Creating, Opening and Saving Presentations, working in different views in Power point, Animation, slide show, Master Slides, Creating photo album, Rehearse timing and record narration **(5 Hours)**

9. Digital Education: Introduction & Advantages of digital Education, Concept of e-learning, Technologies used in e learning **(4 Hours)**

Reference Books

1. Nishit Mathur, *Fundamentals of Computer*, APH publishing corporation (2010)
2. Neeraj Singh, *Computer Fundamentals (Basic Computer),* T Balaji, (2021)
3. Joan Preppernau, *Microsoft Power Point 2016 step by step*, Microsoft press (2015)
4. Douglas E Corner, *The Internet Book* 4th Edition, prentice –Hall (2009)
5. Wallace Wang, *Microsoft Office 2019*, Wiley (January 2018)
6. Noble Powell, *Windows 11 User Guide For Beginners and Seniors*, ASIN, (October 2021)

SEMESTER IV

I. MAJOR COURSE- MJ 5:
IKS, PLANT TAXONOMY & ECONOMIC BOTANY

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

Course Objectives:

After completion of the course, the learner shall be able to understand:

1. To explore traditional plant classification, ethnobotany, ayurveda and environmental practices.
2. To understand the holistic relationship between plants, health, environment and culture in Indian traditions.
3. To compare classical Indian botanical knowledge with modern scientific frameworks.
4. To promote conservation and sustainability use of plant resources inspired by indigenous practices.
5. To gain the knowledge on the taxonomy, phylogeny of plants.
6. To make the students familiar with economic importance of diverse plants that offer resources to human life.
7. It emphasizes the plants used as- food for man, fodder for cattle, feed for poultry, plants having medicinal value and also plant source of huge economic value etc.

Course Learning Outcomes:

On successful completion of this course the student should know the:

1. Explains the key concepts and sources of Indian Knowledge Systems related to Botany.
2. Identify important traditional classification systems and correlate them with modern taxonomy.
3. Will be able to document and analyse ethnobotanical practices among local communities.
4. Will be able to describe ayurvedic principles and recognise major medicinal plants and their uses.
5. Evaluate the relevance of IKS in sustainable agriculture and biodiversity conservation.
6. Apply traditional botanical knowledge in projects, fieldwork or herbal formulations.
7. Understanding of systematics its importance in bioresource utilisation and biodiversity management. Nomenclature pattern, Phylogeny, Classification systems of the plants.
8. After studying Economic Botany, students would have first-hand information of plants used as food, the various kinds of nutrients available in the plants. The dietary requirements of proteins, fats, amino-acids, vitamins etc. that can be met by plants.
9. The students will learn to perform the micro-chemical tests to demonstrate various components.
10. The students will learn about the use of fiber plants, beverages, fruits and vegetables that are integral to day to day life of plants.
11. Students will learn to explore the regional diversity in food crops and other plants and their ethno-botanical importance as well.

Course Content:

Indian Knowledge System

Unit 1: Indian Knowledge System in Botany and Traditional Plant Classification (10 Lectures)

1. Role of plants in Vedas, Upanishads and overview of *Vrikshayurveda*, *Charak Samhita*, *Sushruta Samhita.*
2. Contributions of ancient Indian Scholars in plant sciences: *Atreya*, *Agnivesa* and *Charaka*.
3. Principles of indigenous plant taxonomy.
4. *Dwivachana* Nomenclature.

Unit 2: Ethnobotany and Indigenous Knowledge (10 Lectures)

1. Plants in tribal customs, rituals and healthcare.
2. Sacred grove and traditional conservation ethics.
3. Indigenous plant knowledge systems: oral and documented; Digital documentation (AYUSH and TKDL).
4. Methodologies for ethnobotanical field studies.

Unit 3: Plants in Indian Spirituality and Rituals (4 Lectures)

1. Symbolism of plants in Hinduism, Buddhism and Jainism.
2. Ritual uses of sacred plants: Tulsi, Peepal, Banyan, Saal and Karam

Unit 4 Agriculture and Environmental Practices in IKS (6 Lectures)

1. Traditional farming systems and seasonal variations.
2. Pest management using botanicals (Neem, Tulsi, *Vitex*).
3. Indigenous soil fertility management (Panchagavya, Jeevamrut)

Plant Taxonomy & Economic Botany

Unit 1: Introduction to Plant Taxonomy (4 lectures)

1. Fundamental components of taxonomy (identification, nomenclature, classification, family, genus, species);

Categories and taxonomic hierarchy; Species concept.
2. Botanical Nomenclature- Principles and rules of ICN (ranks and names; principle of priority, binomial system; type method (Typification), author citation and valid-publication).
3. Taxonomic resources: Herbarium- functions & important herbaria, Botanical gardens, Flora.

Unit 2: Types of classification and Evidences (6 lectures)

1. Types of classification- Artificial, Natural (Bentham & Hooker's system of classification - merits and demerits) and Phylogenetic (Hutchinson classification - merits and demerits).
2. Taxonomic evidences from morphology, cytology and phytochemistry.

Unit 3: Plant Systematics (6 lectures)

Diagnostic characteristics, Systematic Phylogeny and economic importance of families: Ranunculaceae, Apocynaceae, Lamiaceae, Malvaceae, Poaceae, Cyperaceae.

Unit 4: Economic Botany (14 lectures)

Study of following economically important plants with special reference to Jharkhand: Cereals and Millets: Rice and Ragi – morphology and uses; Pulses & Vegetables: General account with special reference to Gram, soybean and Potato; Spices: General account with special reference to clove, black pepper, cinnamon, Ginger and Turmeric (Botanical name, family, part used, morphology and uses); Beverages Tea and Coffee (morphology, processing, uses); Oils and Sugar General description with special reference to groundnut and sugarcane; Timber and Fiber Yielding Plants General description of Sal, Teak, Cotton and Jute (Botanical name, family, parts used, morphology and uses)

Reference Books

1. Surapala's *Vrikshayurveda* (Translated editions)
2. *Charak Samhita, Sushruta Samhita*.
3. Jain, S. K. – Manual of Ethnobotany.
4. Ministry of AYUSH publications.
5. IKS Portal: https://iksindia.org
6. TKDL: https:www.tkdl.res.in
7. BSI & NMPB plant databases
8. Bhattacharya, A. K. – Indian Ethonobotany.
9. Murthy, K. R. K. – Traditional Knowledge and Modern Science.
10. Jain, S. K. – Plants and People in Indian Culture
11. Singh, (2012). Plant Systematics: Theory and Practice Oxford & IBH Pvt. Ltd., New Delhi.3rdedition.
12. Jeffrey, C. (1982). An Introduction to Plant Taxonomy. Cambridge University Press,Cambridge.
13. Judd, W.S., Campbell, C.S., Kellogg, E.A., Stevens, P.F. (2002). Plant Systematics-APhylogenetic Approach. Sinauer Associates Inc., U.S.A. 2nd edition.
14. Maheshwari, J.K. (1963). Flora of Delhi. CSIR, New Delhi.
15. Radford, A.E. (1986). Fundamentals of Plant Systematics. Harper and Row, New York.
16. Kochhar, S.L. (2012). Economic Botany in Tropics, MacMillan & Co. New Delhi, India.
17. Wickens, G.E. (2001). Economic Botany: Principles & Practices.Kluwer Academic Publishers, The Netherlands.

II. MAJOR COURSE- MJ 6:
ECOLOGY AND ENVIRONMENTAL STUDIES

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

Course Objectives:

1. This course aims to introduce the students to the concepts and principles of ecology, biological diversity, conservation, sustainable development, population, community and ecosystem structure and function, application of these concepts to solve environmental problems.
2. To make them understand complex community patterns, processes, and ecosystem functioning.

Course Learning Outcomes:

1. It will acquaint the students with complex interrelationship between organisms and environment; make them understand methods to studying vegetation, community patterns and processes, ecosystem functions, and principles of phytogeography. What are the limiting factors controlling distribution and growth of organisms?
2. What are the characteristics of organisms as population, community and ecosystems? What are the intra- and inter-specific interactions? What are the ecosystem functions? What are applications of ecological knowledge for the benefit of anthropogenic society?

Course Content:

Unit 1: Introduction: Basic concepts of ecology and environmental biology. **(2 lectures)**

Unit 2: Abiotic and Biotic components and their interactions **(4 lectures)**
Physical and Chemical factors: Climatic, edaphic and topographical. Trophic organisation, biomass, standing crop

Unit 3: Population ecology: Characteristics and Dynamics. Ecological Speciation **(4 lectures)**

Unit 4: Plant communities **(6 lectures)**
Concept of ecological amplitude; Habitat and niche; Characters: analytical and synthetic; Ecotone and edge effect; Dynamics: succession (Hydrosere and Xerosere).

Unit 5: Ecosystems Structure and function **(13 lectures)**
Food chains and Food webs; Autotrophy, heterotrophy; symbiosis, commensalism, parasitism; Pond ecosystem, grassland ecosystem and forest ecosystem, Biogeochemical cycles (Carbon, Nitrogen and Phosphorus cycle), Basic source of energy and Energy flow, productivity, Ecological pyramids.

Unit 6: Phytogeography: Phytogeographical regions of India; Local Vegetation and Endemism; hotspots. **(5 lectures)**

Unit 7: Pollution and Climate change **(14 lectures)**
Introduction to pollutants, pollution, causes, control and impact of air, water, soil, sound and radioactive. Role of Biotechnology in pollution control. Major global environmental issues: Climate change, ozone depletion, global warming, acid rain, carbon emission; Objectives of United Nations Framework Convention on Climate Change (UNFCC).

Unit 8: Biodiversity and Conservation **(12 lectures)**
Biodiversity: Definition, threats and importance, natural resources: renewable and non-renewable, conservation- in-situ and ex-situ methods. IUCN conservation category: Endangered, threatened, vulnerable, Biodiversity management committees, People's Biodiversity Register; Red Data Book, sustainable development goals: Biofuel and Green hydrogen. Convention on Biological Diversity, National Biodiversity Authority and Botanical Survey of India.

Reference Books:

1. Mukherjee, B. 2011: Fundamentals of Environmental Biology. Silverline Publications, Allahabad.
2. Gleeson, B. and Low, N. (eds.) 1999.Global Ethics and Environment, London, Routledge.
3. Grumbine, R. Edward, and Pandit, M.K. 2013. Threats from India's Himalaya dams. Science, 339: 36---37.
4. Odum, E.P., Odum, H.T. & Andrews, J. 1971.Fundamentals of Ecology. Philadelphia: Saunders.
5. Pepper, I.L., Gerba, C.P. & Brusseau, M.L. 2011. Environmental and Pollution Science. Academic Press.
6. Rao, M.N. & Datta, A.K. 1987. Waste Water Treatment. Oxford and IBH Publishing Co. Pvt. Ltd.
7. Rosencranz, A., Divan, S., & Noble, M. L. 2001. Environmental law and policy in India. Tripathi 1992.
8. Sengupta, R. 2003. Ecology and economics: An approach to sustainable development. OUP.
9. Singh, J.S., Singh, S.P. and Gupta, S.R. 2014. Ecology, Environmental Science and Conservation. S. Chand Publishing, New Delhi.
10. Sodhi, N.S., Gibson, L. & Raven, P.H. (eds). 2013. Conservation Biology: Voices from the Tropics. John Wiley & Sons.
11. Warren, C. E. 1971. Biology and Water Pollution Control. WB Saunders.
12. Odum, E.P. (2005). Fundamentals of ecology. Cengage Learning India Pvt. Ltd., New Delhi. 5th edition.
13. Sharma, P.D. (2010). Ecology and Environment. Rastogi Publications, Meerut, India. 8th edition.
14. Wilkinson, D.M. (2007). Fundamental Processes in Ecology: An Earth Systems Approach. Oxford University Press. U.S.A.
15. Das, M.C. Kormondy, E.J. (1996). Concepts of ecology. PHI Learning Pvt. Ltd., Delhi, India. 4th edition.

III. MAJOR COURSE- MJ 7:
PRACTICAL-II

Marks: Pr (ESE: 6Hrs) =100	Pass Marks: Pr (ESE) = 40

(Credits: Practicals-04) **120 Hours**

Instruction to Question Setter for

End Semester Examination (ESE):
There will be one Practical Examination of 6Hrs duration. Evaluation of Practical Examination may be as per the following guidelines:
Experiment = 60 marks
Practical record notebook = 15 marks
Viva-voce = 25 marks

Practicals:

Indian Knowledge System, Plant Taxonomy and Economic Botany

1. Systematic study of locally available plants belonging to the families prescribed in theory syllabus with reference to vegetative and floral characters of the following families (Description, V.S. flower, section of ovary, floral diagram/s, floral formula/e and systematic position according to Bentham & Hooker's system of classification)
2. Mounting of a properly dried and pressed specimen of any wild plant with herbarium label (to be submitted in the record book).
3. Study of economically important plants: Wheat, Rice, Gram, Soybean, Potato, Black pepper, Clove, Cinnamon, Ginger, Turmeric, Tea, Coffee, Cotton, Groundnut, Sugarcane, Mustard and Medicinal plants (Tulsi, Neem, Karanj, Haldi, Ghritkumari, Kalmegh) through specimens or sections.
4. Field visit to herbal gardens, sacred groves of tribal communities.
5. Ethnobotanical documentation and presentation

Ecology and Environmental Studies

1. Study of instruments used to measure microclimatic variables: Soil thermometer, anemometer, rain gauge, lux meter.
2. Determination of pH of various soil and water samples (pH meter and pH paper)
3. Comparison of water holding capacity, porosity and rate of infiltration of water in soils of three habitats.
4. Determination of minimal quadrat size for the study of herbaceous vegetation in the college campus, by species area curve method (species to be listed).
5. Quantitative analysis of herbaceous vegetation in the college campus for frequency and comparison with Raunkiaer's frequency distribution law.
6. Quantitative analysis of herbaceous vegetation for density and abundance in the college campus.
7. Field visit to familiarise students with ecology of different sites
8. Study of common plants, insects, birds and basic principles of identification. Study of simple ecosystems--pond, river etc.

Reference Books

1. Raziuddin, M., Mishra P.K. 2014, *A Handbook of Environmental Studies*, Akanaksha Publications, Ranchi.
2. Wickens, G.E. (2001). Economic Botany: Principles & Practices. Kluwer Academic Publishers, The Netherlands.
3. Rao, B. R. P. (2012). *Manual of Taxonomy of Angiosperms.* New Delhi: Scientific Publishers.
4. Jain, S. K., & Rao, R. R. (1977). *A Handbook of Field and Herbarium Methods.* New Delhi: Today and Tomorrow's Printers and Publishers.
5. Pandey, B. P. (2004). *Economic Botany: Practical Manual.* S. Chand Publishing.
6. Rao, R. R. (1986). *Ethnobotany: A Method Manual.* Lucknow: Scientific Publishers.
7. Misra, R. (1968). *Ecology Workbook.* New Delhi: Oxford & IBH Publishing Co.
8. Shukla, R. S., & Chandel, P. S. (2010). *A Textbook of Plant Ecology.* New Delhi: S. Chand Publishing.

SEMESTER V

I. MAJOR COURSE- MJ 8:
CELL BIOLOGY & BIOCHEMISTRY

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

Course Objectives:

After completion of the course, the learner shall be able to understand:

1. Cell biology study will provide inside into the organisation of cell, its features and regulation at different levels.
2. Through the study of cell organelles, they will be able to understand the various metabolic processes such as respiration, photosynthesis etc. which are important for life.
3. The objective of the present course content is to provide a foundation and background in cellular and acellular entities of plants, cell structure in relation to functions, eukaryotic genome structure (including nuclear and organellar), and regulatory mechanisms.

Course Learning Outcomes:

On successful completion of this course the student should know:

1. This course will be able to demonstrate foundational knowledge in understanding of cell.
2. Understanding of Cell metabolism, chemical composition, physiochemical and functional organisation of organelle
3. Contemporary approaches in modern cell and molecular biology.

Course Content:

Cell Biology

Unit1: The cell **(3 lectures)**

Cell as a unit of structure and function; Characteristics of prokaryotic and eukaryotic cells.

Unit 2: Cell wall and plasma membrane **(5 lectures)**

Chemistry, structure and function of Plant cell wall. Overview of membrane function; fluid mosaic model; Chemical composition of membranes. **Movement of molecules across plant cell membrane; Role of membrane proteins and transport processes in nutrient uptake, signaling.**

Unit 3: Cell organelles **(12 lectures)**

Nucleus: Structure-nuclear envelope, nuclear pore complex, nuclear lamina, molecular organisation of chromatin; nucleolus. **Chloroplast, mitochondria and peroxisomes:** Structural organisation; Function; Semiautonomous nature of mitochondria and chloroplast. **Endomembrane system:** Endoplasmic Reticulum – Structure, targeting and insertion of proteins in the ER, protein folding, processing; Smooth ER, export of proteins and lipids. **Golgi Apparatus** – organisation, protein glycosylation, protein sorting and export from Golgi Apparatus; Lysosomes.

Unit 4: Cell division **(7 lectures)**

Phases of eukaryotic cell cycle, mitosis and meiosis; Regulation of cell cycle- checkpoints.

Biochemistry:

Unit 1: Biomolecules **(23 lectures)**

Types and significance of chemical bonds; Structure and properties of water; pH and buffers.

Primary metabolites:

Carbohydrates: Nomenclature and classification; Monosaccharides; Disaccharides; Oligosaccharides and polysaccharides and its significance.

Proteins: Type and structure of amino acids; Levels of protein structure-primary, secondary, tertiary and quaternary and biological roles of proteins.

Lipids: Definition and major classes of storage and structural lipids; Fatty acids structure and functions; Essential fatty acids; Triacyl glycerols structure, functions and properties; Phosphoglycerides.

Nucleic acids: Structure of nitrogenous bases; Structure and function of nucleotides; Types of nucleic acids; Structure of A, B, Z types of DNA; Types of RNA; Structure of tRNA.

Secondary metabolites: types, chemical structure, basic pathway of biosynthesis and role of secondary metabolites.

Unit 2: Enzymes **(6 lectures)**

Structure of enzyme: holoenzyme, apoenzyme, cofactors, coenzymes and prosthetic group; Classification of enzymes; Features of active site, substrate specificity, mechanism of action (activation energy, lock and key hypothesis, induced - fit theory).

Unit 3: Vitamins **(4 lectures)**

General characteristics of vitamins. Nomenclature and classification of vitamins and its significance.

Reference Books:

1. Karp, G. (2010). Cell Biology, John Wiley & Sons, U.S.A. 6th edition.
2. Hardin, J., Becker, G., Skliensmith, L.J. (2012). Becker's World of the Cell, Pearson Education Inc. U.S.A. 8th edition.
3. Cooper, G.M. and Hausman, R.E. (2009) The Cell: A Molecular Approach. 5th edition. ASM Press &Sunderland, Washington, D.C.; Sinauer Associates, MA.
4. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009) The World of the Cell. 7th edition. Pearson Benjamin Cummings Publishing, San Francisco
5. Chrispeels, M.J. and Sadava, D.E. 1994 Plants, Genes and Agriculture. Jones & Bartlett Publishers)

II. MAJOR COURSE- MJ 9:
GENETICS

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

Course Objectives:

1. The paper will deal with heredity inheritance pattern among the organism.
2. Linkage and genetic recombination.
3. Gene mapping
4. Chromosomal structure.

Course Learning Outcomes:

1. The unit will enable the students to learn about the use of linkage and recombination frequencies to map genes.
2. The unit will provide an understanding of:
   - Morphology of chromosomes and its relevance in genetics.
   - Chromosomal and their role in genome evolution with special reference to crop plants.

Course Content:

Genetics

Unit 1: Mendelian genetics and its extension (10 lectures)

Mendelism: History; Principles of inheritance; Chromosome theory of inheritance; Autosomes and sex chromosomes; Probability and pedigree analysis; Incomplete dominance and codominance; Multiple alleles, Lethal alleles, Epistasis, Pleiotropy, Recessive and Dominant traits; Polygenic inheritance.

Unit 2: Extrachromosomal Inheritance (4 lectures)

Chloroplast mutation: Variegation in Four o'clock plant; Mitochondrial mutations in yeast; Maternal effects-shell coiling in snail; Infective heredity- Kappa particles in Paramecium.

Unit 3: Linkage, crossing over, genetic recombination and chromosome mapping (5 lectures)

Linkage and crossing over-Cytological basis of crossing over; two factor and three factor crosses; genetic recombination, Recombination frequency, Interference and coincidence; Numericals based on gene mapping; Sex Linkage.

Unit 4: Variation in chromosome number and structure (5 lectures)

Deletion, Duplication, Inversion, Translocation, Euploidy and Aneuploidy

Unit 5: Gene mutations (8 lectures)

Types of mutations; Molecular basis of Mutations; Mutagens – physical and chemical (Base analogs, deaminating, alkylating and intercalating agents); Detection of mutations: ClB method. Role of Transposons in mutation. DNA repair mechanisms.

Unit 6: Fine structure of gene (6 lectures)

Classical vs molecular concepts of gene; Cis-Trans complementation test for functional allelism; Structure of Phage T4, rII Locus.

Unit 7. Population and Evolutionary Genetics (5 lectures)

Allele frequencies, Genotype frequencies, Hardy-Weinberg Law, role of natural selection, mutation, genetic drift. Genetic variation and Speciation.

Plant Breeding and Crop improvement

Unit 1. Plant Breeding (10 lectures)

Introduction to plant breeding, steps in plant breeding, various technique of selfing and crossing, methods of plant breeding in self-pollinated, cross pollinated and asexual propagated plants; Parasexuality; sources of variation in plant breeding; mutation breeding; field trial techniques.

Unit 2. Crop improvement (8 lectures)

Methods of crop improvement for disease and pest resistance; Breeding and improvement in rice, wheat, maize, millets, sugarcane and potato. Biofortification.

Reference Books:

1. Karp, G. (2010). Cell Biology, John Wiley & Sons, U.S.A. 6th edition.
2. Hardin, J., Becker, G., Skliensmith, L.J. (2012). Becker's World of the Cell, Pearson Education Inc. U.S.A. 8th edition.
3. Cooper, G.M. and Hausman, R.E. (2009) The Cell: A Molecular Approach. 5th edition. ASM Press &Sunderland, Washington, D.C.; Sinauer Associates, MA.
4. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009) The World of the Cell. 7th edition. Pearson Benjamin Cummings Publishing, San Francisco
5. Chrispeels, M.J. and Sadava, D.E. 1994 Plants, Genes and Agriculture. Jones & Bartlett Publishers)
6. P K Gupta, Plant Breeding, Rastogi Publication.
7. B D Singh, Plant Breeding, Kalyani Publication.
8. Kumar and Sinha, A cytogenetics plant breeding and evolutionary biology.

III. MAJOR COURSE- MJ 10:
PLANT PHYSIOLOGY

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

Course Objectives:

1. The course aims at making students realise how plants function, namely the importance of water, minerals, hormones, and light in plant growth and development; understand transport mechanisms and translocation in the phloem, and appreciate the commercial applications of plant physiology.
2. Current understanding of regulation and integration of metabolic processes in plants with reference to crop productivity. To gain the knowledge of physiological and biochemical processes in the plant system

Course Learning Outcomes:

On successful completion of this course the student should be able to:

1. To understand water and nutrient uptake and movement in plants, role of mineral elements, translocation of sugars. Role of various plant growth regulator as, phytochrome cytochromes and phototropins, and flowering stimulus. Students will gain the knowledge on reproductive strategies in higher plants along with physiology of flowering, molecular and hormonal basis of flowering mechanism.

Course Content:

Unit 1: Plant-water relations (9 lectures)

Diffusion, Osmosis, Water Potential and its components, mechanism of water absorption: Active and Passive absorption, aquaporins, pathway of water movement, symplast, apoplast, transmembrane pathways, root pressure, guttation. Ascent of sap: cohesion-adhesion theory. Transpiration and its factors, antitranspirants, mechanism of stomatal movement.

Unit 2: Mineral nutrition (3 lectures)

Macro and micronutrients, essential and beneficial elements, mineral deficiency symptoms, roles of essential elements, chelating agents.

Unit 3: Phloem Translocation and Nutrient Uptake (8 lectures)

Soil as a nutrient reservoir, transport of ions across cell membrane, passive absorption, electrochemical gradient, facilitated diffusion, active absorption, role of ATP, carrier systems, proton ATPase pump and ion flux, uniport, co-transport, symport, antiport. Experimental evidence in support of phloem as the site of sugar translocation. Pressure–Flow Model; Phloem loading and unloading; Source–sink relationship.

Unit 4: Photosynthesis (12 lectures)

Photosynthesis as a chemical process, Chloroplast and its pigments – Light reaction; mechanism of absorption of light. The pigment system – PS I and PS II. Photophosphorylation – Electron Transport System and Photophosphorylation (Cyclic and Non-cyclic), Dark reaction; C3 Cycle (Calvin cycle), Hatch and Slack Pathway. CAM Cycle; Significance of C4 cycle and CAM. Photorespiration (C2 Cycle) and Glycolate metabolism. Factors affecting rate of photosynthesis. Significance of photosynthesis.

Unit 5: Respiration (7 lectures)

Types of respiration, mechanism (Glycolysis). Kreb's cycle: Electron Transport System, Oxidative phosphorylation, Pentose Phosphate Pathway (PPP), anaerobic respiration and fermentation. Factors affecting rate of respiration. Significance, Respiratory Quotient.

Unit 6: Plant growth regulators (7 lectures)

Discovery, chemical structure, biosynthesis, bioassay and physiological roles of Auxin, Gibberellins, Cytokinin, Abscisic acid, Ethylene.

Unit 7: Plant Movement (3 lectures)

Types of plant movement: tropic and nastic; role of phytohormones and phytochromes in movement.

Unit 8: Physiology of flowering (6 lectures)

Photoperiodism, flowering stimulus, florigen concept, vernalization. Phytochrome, cryptochromes and phototropins (Discovery, chemical nature and structure: role in photomorphogenesis)

Unit 9: Seed Germination and Dormancy (5 lectures)

Chemical composition of the seed, Factors affecting germination. Dormancy of seeds and its type, methods of breaking seed dormancy.

Reference Books:

1. Hopkins, W.G. and Huner, A. (2008). Introduction to Plant Physiology. John Wiley and Sons.
2. U.S.A. 4thedition.
3. Taiz, L., Zeiger, E., MØller, I.M. and Murphy, A (2015). Plant Physiology and Development. Sinauer Associates Inc. USA. 6th edition.
4. Bajracharya D. (1999). Experiments in Plant Physiology-A Laboratory Manual. Narosa Publishing House, New Delhi.
5. Campbell, MK (2012) Biochemistry, 7th ed., Published by Cengage Learning
6. Campbell, PN and Smith AD (2011) Biochemistry Illustrated, 4th ed., Published by Churchill Livingstone
7. Tymoczko JL, Berg JM and Stryer L (2012) Biochemistry: A short course, 2nd ed., W.H. Freeman
8. Berg JM, Tymoczko JL and Stryer L (2011) Biochemistry, W.H. Freeman and Company
9. Nelson DL and Cox MM (2008) Lehninger Principles of Biochemistry, 5th Edition., W.H. Freeman and Company

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IV. MAJOR COURSE- MJ 11:
PRACTICAL-III

Marks: Pr (ESE: 6Hrs) =100	Pass Marks: Pr (ESE) = 40

(Credits: Practicals-04) **120 Hours**

Instruction to Question Setter for

End Semester Examination (ESE):

There will be one Practical Examination of 6Hrs duration. Evaluation of Practical Examination may be as per the following guidelines:

Experiment = 60 marks
Practical record notebook = 15 marks
Viva-voce = 25 marks

Practicals:

Cell Biology & Biochemistry and Genetics

1. Study of cell and its organelles with the help of electron micrographs.
2. Stain preparation and different types of strains used in cytogenetics (Acetocarmine).
3. Study the phenomenon of plasmolysis and deplasmolysis.
4. Study the effect of organic solvent and temperature on membrane permeability.
5. Pollen viability test.
6. Preparation of temporary slides to study different stages of mitosis (Onion root tip/Provided material) and meiosis (Onion floral buds/Provided materials) using squash technique.
7. Mendel's laws through seed ratios. Laboratory exercises in probability and chi-square.
8. Chromosome mapping using point test cross data.
9. Incomplete dominance and gene interaction through seed ratios. (9:7, 9:6:1,13:3, 15:1, 12:3:1, 9:3:4).
10. Photographs/Permanent Slides showing stages of mitosis and meiosis, Translocation Ring, Laggards and Inversion Bridge.
11. Biochemical test of carbohydrate, lipid and protein.
12. Demonstration of hybridization techniques (Emasculation, Bagging and tagging)

Plant Physiology

1. Determination of osmotic potential of plant cell sap by plasmolytic method.
2. Determination of water potential of given tissue (potato tuber) by weight method.
3. Study of the effect of wind velocity and light on the rate of transpiration in excisedtwig/leaf.
4. Calculation of stomatal index and stomatal frequency from the two surfaces of leaves of a mesophyte and xerophyte.
5. To study the phenomenon of seed germination (effect of light).
6. To study the effect of different concentrations of IAA on *Avena* coleoptileelongation (IAA Bioassay).
7. To study the induction of amylase activity in germinating barley grains.
8. Perform rate of photosynthesis and oxygen evolution by Wilmott's bubbler. Perform Moll's experiment.

Demonstration experiments

1. To demonstrate suction due to transpiration.
2. Bolting experiment/Avena coleoptile bioassay (demonstration).
3. Study of plant cell structure with the help of epidermal peel mount ofOnion/*Rhoeo*/*Crinum*.
4. Demonstration of the phenomenon of protoplasmic streaming in *Hydrilla* leaf.
5. Measurement of cell size by the technique of micrometry.

Reference Books:

1. Karp, G. (2010). Cell Biology, John Wiley & Sons, U.S.A. 6th edition.
2. Hardin, J., Becker, G., Skliensmith, L.J. (2012). Becker's World of the Cell, Pearson Education Inc. U.S.A. 8th edition.
3. Cooper, G.M. and Hausman, R.E. (2009) The Cell: A Molecular Approach. 5th edition. ASM Press &Sunderland, Washington, D.C.; Sinauer Associates, MA.
4. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009) The World of the Cell. 7th edition. Pearson Benjamin Cummings Publishing, San Francisco
5. Chrispeels, M.J. and Sadava, D.E. 1994 Plants, Genes and Agriculture. Jones & Bartlett Publishers)
6. Plummer, D.T. (1996). An Introduction to Practical Biochemistry. Tata McGraw Hill Publishing Co. Ltd., New Delhi. 3rd Edition.

SEMESTER VI

I. MAJOR COURSE- MJ 12**:**
MOLECULAR BIOLOGY

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	**Pass Marks: Th (SIE + ESE) = 40**

(Credits: Theory-04) **60 Hours**

Course Objectives:

1. To gain the knowledge of structure and functions of DNA and RNA.

Course Learning Outcomes:

1. Understanding of nucleic acid, organisation of DNA in prokaryotes and Eukaryotes, DNA replication mechanism, genetic code and transcription process.
2. Processing and modification of RNA and translation process, function and regulation of expression. Application in biotechnology.

Course Content:

Unit 1: Nucleic acids (4 lectures)
Carriers of genetic information. Introduction, DNA as the carrier of genetic information (Griffith's, McLeod & McCarty experiment).

Unit 2. The Structures of DNA and RNA / Genetic Material (15 lectures)
DNA Structure: Watson and Crick model, Salient features of double helix, denaturation and renaturation, Organisation of DNA- Prokaryotes, Viruses, Eukaryotes. RNA Structure Organelle DNA -- mitochondria and chloroplast DNA. The Nucleosome Chromatin structure- Euchromatin, Heterochromatin- Constitutive and Facultative heterochromatin.

Unit 3: The replication of DNA (10 lectures)
Chemistry of DNA synthesis (Kornberg's discovery); General principles – bidirectional, semiconservative and semi discontinuous replication; Various models of DNA replication, including rolling circle, replication of linear ds-DNA, replication of the 5'end of linear chromosome; Enzymes involved in DNA replication.

Unit 4: Genetic code (2 lectures)
Genetic code (deciphering and salient features) and its significance

Unit 5: Transcription (8 lectures)
Concept of central dogma, Transcription in prokaryotes and eukaryotes. Principles of transcriptional regulation; Prokaryotes: Regulation of lactose metabolism and tryptophan synthesis in *E. coli*. Gene silencing.

Unit 6: Processing and modification of RNA (7 lectures)
Split genes-concept of introns and exons, removal of introns, spliceosome machinery, splicing pathways, group I and group II intron splicing, alternative splicing eukaryotic mRNA processing (5' cap, 3' polyA tail).

Unit 7: Translation (14 lectures)
Ribosome structure and assembly, mRNA; aminoacyl tRNA synthetases; Various steps in protein synthesis, proteins involved in initiation, elongation and termination of polypeptides; Fidelity of translation; Inhibitors of protein synthesis; Post-translational modifications of proteins.

Reference Books:

1. Watson J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M., Losick, R. (2007). Molecular Biology ofthe Gene, Pearson Benjamin Cummings, CSHL Press, New York, U.S.A. 6th edition.
2. Molecular Biology ofthe Gene, Pearson Benjamin Cummings, CSHL Press, New York, U.S.A. 6th edition.
3. Alberts, B et al. (2014). Molecular biology of the cell. Garland Science, 6th edition.
4. Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics. John Wiley and Sons Inc., U.S.A. 5th ed.
5. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. Benjamin Cummings. U.S.A. 9th edition.
6. Russell, P. J. (2010). i-Genetics- A Molecular Approach. Benjamin Cummings, U.S.A. 3rd edition.
7. Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., Doebley, J. (2010). Introduction to Genetic Analysis.
8. W. H. Freeman and Co., U.S.A. 10th edition.
9. Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles and Applications ofrecombinant DNA. ASM Press, Washington.

II. MAJOR COURSE- MJ 13:
PLANT BIOTECHNOLOGY

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

Course Objectives:

1. To give students new knowledge and widening of the knowledge acquired in other course by handling of classical and modern plant biotechnology processes, including tissue culture for healthy plants, plants with improved characteristics.
2. This course explores the use of biotechnology to both generate genetic variation in plants and to understand how factors at the cellular level contribute to the expression of genotypes and hence to phenotypic variation.
3. Understanding of biotechnological processes such as recombinant DNA technology.
4. This knowledge is central to our ability to modify plant responses and properties for global food security and commercial gains in biotechnology and agriculture. In the laboratory classes, students will perform some of the techniques currently used to generate information and detect genetic variation.

Course Learning Outcomes:

1. Learn the basic concepts, principles and processes in plant biotechnology. Have the ability of explanation of concepts, principles and usage of the acquired knowledge in biotechnological and agricultural applications.
2. Use basic biotechnological techniques to explore molecular biology of plants.
3. Understand, how biotechnology is used to for plant improvement and discuss the biosafety concern and ethical issue of that use.

Course Content:

Unit 1: Plant Tissue Culture (15 lectures)

Introduction, Requirements of Plant Tissue Culture Laboratory; Types and composition of nutrient media: Nutrient and hormone requirements (role of amino acids, vitamins and hormones); Totipotency; Organogenesis; Somatic embryogenesis and Somaclonal variation; Protoplast isolation, culture and somatic hybridisation; Tissue culture applications (micropropagation, virus elimination, secondary metabolite production, haploids and androgenesis, triploids and hybrids; Cryopreservation; Germplasm Conservation).

Unit 2: Recombinant DNA technology (10 lectures)

Restriction Endonucleases (History, Types I-IV, biological role and application); Restriction Mapping (Linear and Circular); Cloning Vectors: Prokaryotic (pUC 18 and pUC19, pBR322, Ti plasmid, BAC); Lambda phage, M13 phagemid, Cosmid, Shuttle vector; Eukaryotic Vectors (YAC).

Unit 3: Gene Cloning (10 lectures)

Recombinant DNA, Bacterial Transformation and selection of recombinant clones, PCR mediated gene cloning; Gene Construct; construction of genomic and cDNA libraries, screening DNA libraries to obtain gene of interest by genetic selection; complementation, colony hybridisation; PCR.

Unit 4: Methods of gene transfer (10 lectures)

Biological method (Indirect): *Agrobacterium*-mediated; Physical methods (Direct): Electroporation, Microinjection, Microprojectile bombardment; Selection of transgenics– selectable marker and reporter genes (Luciferase, GUS, GFP).

Unit 5: Applications of Biotechnology (15 lectures)

Pest resistant (Bt-cotton); herbicide resistant plants (RoundUp Ready soybean); Transgenic crops with improved quality traits (Flavr Savr tomato, Golden rice); Improved horticultural varieties (Moondust carnations); Role of transgenics in bioremediation (Superbug); edible vaccines; Industrial enzymes (Aspergillase, Protease, Lipase); Genetically Engineered Products–Human Growth Hormone; Humulin; Biosafety concerns.

Reference Books:

1. Watson J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M., Losick, R. (2007). Molecular Biology ofthe Gene, Pearson Benjamin Cummings, CSHL Press, New York, U.S.A. 6th edition.
2. Russell, P. J. (2010). i-Genetics- A Molecular Approach. Benjamin Cummings, U.S.A. 3rd edition.
3. Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., Doebley, J. (2010). Introduction to Genetic Analysis.
4. Bhojwani, S.S. and Razdan, M.K., (1996). Plant Tissue Culture: Theory and Practice. ElsevierScience Amsterdam. The Netherlands.
5. Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles and Applications ofrecombinant DNA. ASM Press, Washington.
6. Chawla, H.S. (2010). Introduction to plant biotechnology. Oxford & IBH Publishing Co. Pvt. Ltd. New Delhi.
7. Singh, B.D. (2018). Plant Biotechnology. Kalyani Publishers, New Delhi.
8. Dubey, R.C. (2017). Advanced Biotechnology. S. Chand Publication, New Delhi.
9. Steward, C.N. Jr. (2008). Plant biotechnology & Genetics: Principles, Techniques and Applications. John Wiley & Sons Inc. USA.

III. MAJOR COURSE- MJ 14:
BIOINFORMATICS & COMPUTATIONAL BIOLOGY

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

Course Objectives:

1. To familiarise the students with the fundamental principles of Bioinformatics and Computational biology.
2. Various potential application of Bioinformatics and Computational tools in biology.

Course Learning Outcomes:

1. Ability to carry out research /investigation independently in specialised area of Bioinformatics and Computational Biology.

Course Content:

Bioinformatics (30 lectures)

1. Bioinformatics: Introduction – genomics – transcriptome – proteome.
2. Biological databases: Generalised and specialised databases – DNA, protein and carbohydrate databases – nucleic acid sequence databases – premier institutes for databases – nucleic acid codes used in database formats; Collection and downloading of information from databases – literature search.
3. Sequence alignment and its evolutionary basis: Simple alignment and multiple sequence alignment - searching the database for sequence similarity – search programmes with special reference to FASTA, BLAST, CLUSTAL W. Application of bioinformatics in phylogenetic analysis.
4. Structural bioinformatics in drug discovery, Quantitative Structure Activity Relationship (QSAR) technique in drug discovery, Microbial genome application in crop improvement.

Computational Biology (30 lectures)

1. Diagrammatic, graphical and tabular representations of data; measures of central tendency, dispersion, skewness and kurtosis.
2. Basic concepts of hypothesis testing, two kinds of error, level of significance, p-value, student t-test for mean and difference between two means, partial t-test and Chi square test for goodness of fit.

Reference Books

1. Xiong, Essential Bioinformatics, Cambridge University Press.
2. Marketa J Zvelebil, Understanding Bioinformatics, Garland Sciences.
3. Shui Quing Ye, Bioinformatics: A practical approach.
4. Anna Tramantano, Introduction to Bioinformatics.
5. David W Mount, Bioinformatics. CBS.
6. Mani K and Vijayaraj N, Bioinformatics, Kalaikathir Achchagam.
7. Zar, J.H. (2012), Biostatistical analysis. Peers Publication, USA, 4th Edition.

IV. MAJOR COURSE- MJ 15:
PRACTICAL-IV

Marks: Pr (ESE: 6Hrs) =100	Pass Marks: Pr (ESE) = 40

(Credits: Practicals-04) **120 Hours**

Instruction to Question Setter for
End Semester Examination (ESE):
There will be one Practical Examination of 6Hrs duration. Evaluation of Practical Examination may be as per the following guidelines:

Experiment	*= 60 marks*
Practical record notebook	*= 15 marks*
Viva-voce	*= 25 marks*

Practicals:
MOLECULAR BIOLOGY & PLANT BIOTECHNOLOGY

1. Isolation of genomic DNA from *E.Coli.*
2. DNA isolation from plant leaves.
3. DNA estimation by diphenylamine reagent/UV Spectrophotometry.
4. Study of DNA replication mechanisms through photographs (Rolling circle, Theta replication and semi-discontinuous replication).
5. Study of structures of prokaryotic RNA polymerase and eukaryotic RNA polymerase II through photographs.
6. Photographs establishing nucleic acid as genetic material (Messelson and Stahl's, Avery et al, Griffith's, Hershey & Chase's and Fraenkel & Conrat's experiments)
7. Study of the following through photographs: Assembly of Spliceosome machinery;Splicing mechanism in group I & group II introns; Ribozyme and Alternative splicing
8. (a) Preparation of MS medium.
   (b) Demonstration of in vitro sterilisation and inoculation methods using leaf and nodal explants of tobacco, *Datura, Brassica* etc.
9. Study of anther, embryo and endosperm culture, micropropagation, somatic embryogenesis &artificial seeds through photographs.
10. Isolation of protoplasts.
11. Study of methods of gene transfer through photographs: Agrobacterium-mediated, direct gene transfer by electroporation, microinjection, microprojectile bombardment.
12. Study of steps of genetic engineering for production of Bt cotton, Golden rice,Flavr Savr tomato through photographs.
13. Gene identification by using Genbank (NCBI).
14. Sequence alignment and construction of phylogenetic tree by using tools (BLAST, MEGA, Bioedit).
15. Sequence homology and Gene annotation.

Reference Books

1. Watson J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M., Losick, R. (2007). Molecular Biology ofthe Gene, Pearson Benjamin Cummings, CSHL Press, New York, U.S.A. 6th edition.
2. Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics. John Wiley and Sons Inc., U.S.A. 5th ed.
3. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. Benjamin Cummings. U.S.A. 9th edition.
4. Russell, P. J. (2010). i-Genetics- A Molecular Approach. Benjamin Cummings, U.S.A. 3rd edition.
5. Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., Doebley, J. (2010). Introduction to Genetic Analysis.
6. W. H. Freeman and Co., U.S.A. 10th edition.
7. Bhojwani, S.S. and Razdan, M.K., (1996). Plant Tissue Culture: Theory and Practice. ElsevierScience Amsterdam. The Netherlands.
8. Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles and Applications ofrecombinant DNA. ASM Press, Washington.
9. Bhojwani, S.S. and Bhatnagar, S.P. (2011). The Embryology of Angiosperms. Vikas PublicationHouse Pvt. Ltd., New Delhi. 5th edition.
10. Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics. John Wiley and Sons, U.K. 5th edition.
11. Stewart, C.N. Jr. (2008). Plant Biotechnology & Genetics: Principles, Techniques andApplications. John Wiley & Sons Inc. U.S.A.
12. Ausubei, F., Brent, R., Kindsten, R.E., Moore, D.D., Seidman, J.G., Smith, J.A., Struhi, K. (1995). Short protocols in molecular biology. Jhon Willey & Sons. 3rd Edition.

SEMESTER VII

I. MAJOR COURSE- MJ 16:
RESEARCH METHODOLOGY

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	**Pass Marks: Th (SIE + ESE) = 40**

(Credits: Theory-04) **60 Hours**

Course Objectives:

1. Understand some basic concepts of research and its methodologies.
2. Identify appropriate research topics and, select and define appropriate research problem and parameters.

Course Learning Outcomes:

1. Demonstrate the ability to choose methods appropriate to research aims and objectives.
2. Understand the limitations of particular research methods.
3. Develop skills in qualitative and quantitative data analysis and presentation.
4. 4 Develop advanced critical thinking skills.

Course Content:

Unit 1: Basic concepts of research (10 lectures)
Research-definition and types of research (Descriptive vs analytical; applied vs fundamental; quantitative vs qualitative; conceptual vs empirical). Research methods vs methodology. Literature-review and its consolidation; Library research; field research; laboratory research.

Unit 2: General laboratory practices (12 lectures)
Common calculations in botany laboratories. Understanding the details on the label of reagent bottles. Molarity and normality of common acids and bases. Preparation of solutions. Dilutions. Percentage solutions. Molar, molal and normal solutions. Technique of handling micropipettes; Knowledge about common toxic chemicals and safety measures in their handling.

Unit 3: Data collection and documentation of observations (6 lectures)
Maintaining a laboratory record; Tabulation and generation of graphs. Imaging of tissue specimens and application of scale bars. The art of field photography.

Unit 4: Overview of Biological Problems (6 lectures)
History; Key biology research areas, Model organisms in biology (A Brief overview): Geneties, Physiology, Biochemistry, Molecular Biology, Cell Biology, Genomics, Proteomics Transcriptional regulatory network.

Unit 5: Methods to study plant cell/tissue structure (6 lectures)
Whole mounts, peel mounts, squash preparations, clearing, maceration and sectioning: Tissue preparation: living vs fixed, physical vs chemical fixation, coagulating fixatives, non-coagulant fixatives; tissue dehydration using graded solvent series; Paraffin and plastic infiltration; Preparation of thin and ultrathin sections.

Unit 6: Plant microtechniques (12 lectures)
Staining procedures, classification and chemistry of stains. Staining equipment. Reactive dyes and fluorochromes (including genetically engineered protein labeling with GFP and other tags). Cytogenetic techniques with squashed plant materials.

Unit 7: The art of scientific writing and its presentation (8 lectures)
Numbers, units, abbreviations and nomenclature used in scientific writing. Writing references. Powerpoint presentation. Poster presentation. Scientific writing and ethics, Introduction to copyright- academic misconduct/plagiarism.

Reference Books:

1. Dawson, C. (2002). Practical research methods. UBS Publishers, New Delhi.
2. Stapleton, P., Yondeowei, A., Mukanyange, J., Houten, H. (1995). Scientific writing for agricultural research scientists – a training reference manual. West Africa Rice Development Association, Hong Kong.
3. Ruzin, S.E. (1999). Plant micro technique and microscopy. Oxford University Press, New York, USA

II. MAJOR COURSE- MJ 17:
ADVANCED MOLECULAR BIOLOGY

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

Course Objectives:

1. To familiarise the students with the fundamental principles of molecular tools and techniques, and various potential application of molecular biology.

Course Learning Outcomes:

1. Use the techniques, skills, and modern tools necessary for imbalances in various life processes, design a molecular cell biology research project, collect and analyse data, and interpret results.

Course Content:

Unit 1: Introduction to Molecular Cloning (14 Lectures)

Vectors: Characteristics of cloning vectors, Plasmids (pBR322, pUC18/I9) and Ti plasmid. Shuttle vectors and Expression vectors: *E. coli lac* and T7 promoter-based vectors.

Enzymes used in Molecular Cloning: Restriction enzymes. Types I, II and III, nomenclature, use of Type II restriction enzymes in cloning. Reverse transcriptase.

Methods used in Molecular Cloning: Agarose gel electrophoresis of DNA, Southern, Northern and Western blotting. RFLP (Restriction Fragment Length Polymorphism).

Molecular probes: cDNA probes – RNA probes

Unit 2: PCR Techniques (9 lectures)

Principle of Polymerase Chain Reaction, RT-PCR, Real-Time PCR and their applications.

Unit 3: Gene Expression (16 lectures)

Regulation of gene expression in Prokaryotes: various models - operon - details of lac operon-negative and positive control lac operon. Regulation gene expression in eukaryotes: Regulation of transcription - regulation of RNA processing and translation. Microarray and gene expression analysis.

Unit 4: DNA Sequencing (7 lectures)

DNA sequencing: Maxam Gilbert chemical method - Sanger's enzymatic chain termination method – foot printing.

Unit 5: Gene Silencing and Genome Editing (6 lectures)

Introduction to gene silencing (RNAi)/ post-transcriptional gene silencing (PTGS) and its mechanism.

Introduction and Principle of genome editing.

Unit 6: Applied Cytogenetics and Molecular Biology (8 lectures)

Applied Plant Cytology: Advanced chromosome staining: G-banding, C-banding, NOR-banding; Fluorescent In Situ Hybridisation (FISH) and its applications; **DNA fingerprinting** and **barcoding** for plant variety protection; **Molecular and Cytogenetic Diagnostics in Plant Health:** Applications in seed certification, tissue culture fidelity, and conservation.

Reference Books:

1. Brown TA. (2010) Gene Cloning and DNA Analysis. 6th edition. Blackwell Publishing, Oxford, U.K.
2. Primrose SB and Twyman RM. (2006) Principles of Gene Manipulation and Genomics, 7th edition. Blackwell Publishing, Oxford, U.K.
3. Sambrook J and Russell D. (2001) Molecular Cloning-A Laboratory Manual. 3rd edition. Cold Spring Harbor Laboratory Press.
4. Walker J M and Gringold EB, Molecular Biology and Biotechnology. Panima.
5. Benjamin Lewin. Genes 1X. John Wiley.
6. Hartwell L H et al., Genetics: From Genes to Genome. Mc Graw Hill.
7. Watson J D et al., Molecular Biology of the Gene. The Benjamin / Cummings.
8. Lodish H et al., Molecular Cell Biology. Scientific American Books. W H Freeman.
9. David Freid felder, Molecular Biology. Narosa.
10. Adrin J Harwood, Methods in Molecular Biology, Vol.58, Basic DNA and RNA protocols. Humana Press.
11. Chris R Calladine et al., Understanding DNA. Elsevier.
12. Micklos D A et al., DNA Science. Cold Spring Harbour.
13. Cox et al, Molecular Biology, Principles and Practice, Freeman
14. Tropp, Molecular Biology, Genes to proteins, Jones and Bartlett
15. Allison, Fundamental Molecular Biology, Wiley.
16. Ernst L Winnacker, from genes to clones, Panim
17. Alberts B, Johnson A, Lewis J, et al. (2015) Molecular Biology of the Cell. 6th edition. Garland Science, New York, U.S.A.
18. Sharma AK, Sharma A. (2014) Plant Cytogenetics. 2nd edition. CRC Press, Boca Raton, FL, U.S.A.
19. Murray BG, Young A (eds.). (2021) Plant Cytogenetics: Methods and Protocols. 2nd edition. Humana Press, New York, U.S.A.

III. MAJOR COURSE- MJ 18:
PRACTICAL-V

Marks: Pr (ESE: 6Hrs) =100	Pass Marks: Pr (ESE) = 40

(Credits: Practicals-04) **120 Hours**

Instruction to Question Setter for

End Semester Examination (ESE):

There will be one Practical Examination of 6Hrs duration. Evaluation of Practical Examination may be as per the following guidelines:

Experiment = 60 marks
Practical record notebook = 15 marks
Viva-voce = 25 marks

Practicals:

ADVANCED MOLECULAR BIOLOGY AND RESEARCH METHODOLOGY

1. Isolation of plasmid/ plant genomic DNA.
2. Agarose Gel Electrophoresis of plasmid/ plant genomic DNA.
3. Digestion of plasmid DNA using restriction enzymes and analysis by agarose gel electrophoresis.
4. Practicals based on Research Methodology.

Reference Books

1. Brown TA. (2010) Gene Cloning and DNA Analysis. 6th edition. Blackwell Publishing, Oxford, U.K.
2. Primrose SB and Twyman RM. (2006) Principles of Gene Manipulation and Genomics, 7th edition. Blackwell Publishing, Oxford, U.K.
3. Sambrook J and Russell D. (2001) Molecular Cloning-A Laboratory Manual. 3rd edition. Cold Spring Harbor Laboratory Press.

IV. ADVANCED MAJOR COURSE- AMJ 1: BIOLOGICAL INSTRUMENTATION

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

(Only for Hons Degree)

Course Objective

1. Understand the Principles of microscopy.
2. Understand the structure and functioning of various biological instruments.
3. Get enlighten their knowledge in various biochemical methods

Course Learning Outcomes

4. Skill in operating laboratory equipment, their upkeep, and adept at various biological techniques. Ability to prepare molar, molal, normal solutions and solutions of different dilutions. Interpreting scientific results, and ability to present results in a scientific way through graphs, photographs, poster presentations and power point presentations.

Course Content:

Biological Instrumentation

Unit 1: Imaging and related techniques: (15 lectures)

Principles of microscopy; Light microscopy; Fluorescence microscopy; Electron Microscopy (a) Flow cytometry (b) Applications of fluorescence microscopy: Chromosome banding, FISH, chromosome painting; Transmission and Scanning electron microscopy – sample preparation for electron microscopy, cryofixation, negative staining, shadow casting, freeze fracture, freeze etching.

Unit 2: pH and Centrifugation: (10 lectures)

pH meter: Principles and instrumentation, Centrifugation: Principles, types of centrifuges, types of rotors, differential and density gradient centrifugation, application. Sonication, Freeze drying.

Unit 3: Spectrophotometry: (15 lectures)

Principle involved in Spectrophotometer; Spectrophotometric techniques, Instrumentation: ultraviolet and visible spectrophotometry (single and double beam, double wavelength spectrophotometers), Infrared spectrometers - Luminometry and densitometry – principles and their applications - Mass Spectroscopy-principles of analysis, application in Biology.

Unit 4: Chromatography: (10 lectures)

Chromatographic techniques: Principle and applications – Column - thin layer –paper, affinity and gas chromatography - Gel filtration - Ion exchange and High-performance liquid chromatography techniques– Examples of application for each chromatographic system - Basic principles of electrophoresis.

Unit 5: Preparation of molar, molal and normal solutions, buffers, the art of scientific writing: (10 lectures)

Understanding the details on the label of reagent bottles. Molarity and normality of common acids and bases. Preparation of solutions. Dilutions. Percentage solutions. Molar, molal and normal solutions. Technique of handling micropipettes; Knowledge about common toxic chemicals and safety measures in their handling. The art of scientific writing and presentation of scientific matter. Scientific writing and ethics. Writing references. PowerPoint presentation. Poster presentation. Introduction to copyright-academic misconduct/plagiarism in scientific writing.

Reference Books:

1. Dawson, C. (2002). Practical research methods. UBS Publishers, New Delhi.
2. Stapleton, P., Yondeowei, A., Mukanyange, J., Houten, H. (1995). Scientific writing for agricultural research scientists – a training reference manual. West Africa Rice Development Association, Hong Kong.
3. Ruzin, S.E. (1999). Plant micro technique and microscopy. Oxford University Press, New York, U.S.A.
4. Bajpai, P.K. 2006. Biological Instrumentation and methodology. S. Chand & Co. Ltd.
5. K. Wilson and J. Walker Eds. 2005. Biochemistry and Molecular Biology. Cambridge University Press.
6. K. Wilson andKHGoulding. 1986. Principles and techniques of Practical Biochemistry. (3 edn) Edward Arnold, London.
7. Stapleton, P., Yondeowei, A., Mukanyange, J., Houten, H. (1995). Scientific writing for agricultural research scientists – a training reference manual. West Africa Rice Development Association, Hong Kong.
8. Ruzin, S.E. (1999). Plant micro technique and microscopy. Oxford University Press, New York, U.S.A.

OR

RESEARCH COURSES- RC 1: (In lieu of AMJ 1)

RESEARCH PLANNING & TECHNIQUES

Marks: 25 (5 Attd. + 20 SIE: 1Hr) = 25	**Pass Marks: Th (SIE + ESE) = 10**

(Credits: Theory-03) **45 Hours**

(Only for Hons with Research Degree)

SIE 20+5=25 marks):

There will be Only One Semester Internal Assessment of 25 Marks in this paper. The Semester Internal Examination shall have two components. (a) One Semester Internal Assessment Test (SIA) of 20 Marks, (b) Class Attendance Score (CAS) of 5 marks.

Conversion of Attendance into score may be as follows:
Attendance Upto 45%, 1mark; 45<Attd.<55, 2 marks; 55<Attd.<65, 3 marks; 65<Attd.<75, 4 marks; 75<Attd, 5 marks.

Course Objective

1. To **introduce fundamental concepts of research**, including proposal development, experimental design, and scientific documentation.
2. To equip students with the **skills of scientific writing and communication**, such as synopsis writing, manuscript preparation, and data presentation.
3. To provide **hands-on knowledge of multidisciplinary research techniques** in various domains of plant sciences like biotechnology, microbiology, pathology, physiology, taxonomy, and cytogenetics.
4. To instill **ethical and responsible research practices** for integrity, authorship, safety, and societal benefit.
5. To familiarise students with **statistical methods and software tools** for data analysis and scientific interpretation.

Course Learning Outcomes

1. **Identify and define research problems** and draft a scientifically valid and methodologically sound **research proposal**.
2. **Review scientific literature** efficiently using academic databases and manage references using citation software.
3. Demonstrate skills in **maintaining laboratory records**, handling instruments, and presenting **data and images** with scientific accuracy (e.g., microscopy, imaging, photography).
4. Write effective **synopsis, abstracts, posters, and reports** following standard scientific formats and publication ethics.
5. Apply **core laboratory techniques** in algal biotechnology, microbiology, plant breeding, cytogenetics, molecular biology, and taxonomy in real research contexts.
6. Analyse experimental data using **statistical tools** (Excel, SPSS) and interpret results using hypothesis testing, ANOVA, regression, and data visualisations.
7. Follow ethical norms of **research conduct**, including intellectual property rights, biosafety, authorship ethics, and data reproducibility.
8. Demonstrate competence in **interdisciplinary research** and prepare for higher academic research, competitive exams, or professional R&D roles in plant sciences and biotechnology.

Course Content:

UNIT 1: Basic Concepts of Research **(8 lectures)**

1. **Meaning & Scope of Research**: Pure vs. applied, basic terminology, research cycle.
2. **Choosing a Research Problem**: Gap analysis, feasibility, objectives.
3. **Research Proposal Components**: Title, rationale, objectives, methodology, time-chart, budget.
4. **Experimental Design**: CRD, RBD, split-plot, factorial; replication & randomisation.
5. **Review of Literature**: Databases (Google Scholar, Scopus, PubMed etc.), reference managers (Zotero, Mendeley etc.).
6. **Laboratory Access & Safety**: Risk assessment, GLP, biosafety levels, waste disposal.
7. **Maintaining a Laboratory Notebook**: Formats, e-lab notebooks, data integrity & traceability.
8. **Scientific Imaging**: Light/fluorescence microscopy basics, camera settings, scale-bar calibration.
9. **Photography for Documentation**: Plant/field imaging, metadata, image ethics.
10. **Good Data Storage Practices**: File-naming, backups.

UNIT 2: Scientific Writing & Presentation **(8 lectures)**

1. **Structure of a Scientific Manuscript**: IMRaD, logical flow.
2. **Synopsis / Thesis Proposal Writing**: Purpose, length, common pitfalls.
3. **Abstracts & Keywords**: Concision, indexing.
4. **Referencing Styles & Citation Managers**: Harvard, Vancouver, BibTeX.
5. **Plagiarism & Similarity Checking**: Ethical issues, paraphrasing and Plagiarism Detection Softwares (Turnitin, Aboriginal etc.).
6. **Data Visualisation Principles**: Tables, graphs, image resolution.
7. **Oral & Poster Presentation Skills**: Slide design, storyboarding, delivery techniques.

8. **Role of Artificial Intelligence in scientific writing and Presentation**.

UNIT 3: Research Techniques (Multidisciplinary) (13 lectures)

1. **Algal Biotechnology**: Mass cultivation, lipid extraction, chlorophyll fluorescence, FTIR for biomass composition.
2. **Plant Pathology & Microbiology**: Isolation & culture of fungi/bacteria, Koch's postulates, enzyme production (cellulase, pectinase etc.) ELISA/PCR diagnostics, greenhouse inoculation assays.
3. **Cytogenetics, Plant Breeding & Molecular Biology**: Root-tip squash, karyotyping, FISH/GISH, PCR, qPCR, CRISPR/Cas delivery, marker-assisted selection (SSR, SNP).
4. **Plant Physiology & Molecular Biotechnology**: chromatography, chlorophyll fluorescence and rate of photosynthesis, proline & antioxidant assays, Western blotting, transcriptomics (RNA-seq)
5. **Taxonomy, Ethnobotany & Medicinal Plants**: Herbarium techniques, field ethnobotanical surveys, DNA barcoding (rbcL, matK), TLC/HPLC phytochemical profiling.
6. **Integrated Case Studies & Demonstrations**: Workflow from sample to publication; multidisciplinary project design.

UNIT 4: Scientific Conduct (7 lectures)

1. **Research Integrity & Misconduct**: Falsification, fabrication, plagiarism (FFP).
2. **Authorship & Publication Ethics**: ICMJE criteria, duplicate submission.
3. **Conflict of Interest & Peer Review**: Disclosure, reviewer responsibilities.
4. **Data Management Plans & Reproducibility**: Raw data sharing, pre-registration.
5. **Intellectual Property Rights**: Patents, plant breeder's rights, MTAs.
6. **Biosafety & Biosecurity**: GM regulations, nanotech risk assessment.
7. **Animal & Human Ethics (overview)**: IAEC, IEC protocols for botanical research involving extracts.
8. **Open Science & Citizen Science**: Preprints, open-access, community engagement.

UNIT 5: Statistical Application: Result Analysis & Interpretation (9 lectures)

1. **Data Types & Descriptive Statistics**: Mean, median, mode, SD, SE.
2. **Probability Distributions**: Normal, binomial, Poisson (theory & plots).
3. **Sampling Methods & Errors**: Random, stratified, cluster; confidence intervals.
4. **Hypothesis Testing**: Null vs. alternative, Type I/II errors, p-value concept.
5. **Student's t-Tests**: One-sample, paired, unpaired; effect size.
6. **One-way ANOVA**: Assumptions, F-ratio, post-hoc tests.
7. **Two-way ANOVA & Interaction Effects**.
8. **Correlation & Simple Linear Regression**: Pearson r, interpretation.
9. **Non-parametric Tests**: Chi-square.
10. **Multivariate Methods**: PCA, cluster analysis (conceptual).
11. **Statistical Software**: Excel data analysis tool-pak; SPSS: importing data, running t-test/ANOVA, graphical outputs.

Reference Books:

1. Kothari CR, Garg GK. (2019) *Research Methodology: Methods and Techniques.* 4th edition. New Age International, New Delhi, India.
2. Creswell JW. (2014) *Research Design: Qualitative, Quantitative and Mixed Methods Approaches.* 4th edition. Sage Publications, Los Angeles, U.S.A.
3. Day RA, Gastel B. (2016) *How to Write and Publish a Scientific Paper.* 8th edition. Cambridge University Press, Cambridge, U.K.
4. Alley M. (2018) *The Craft of Scientific Writing.* 4th edition. Springer, New York, U.S.A.
5. Richmond A, Hu Q (eds.). (2013) *Handbook of Microalgal Culture: Applied Phycology and Biotechnology.* 2nd edition. Wiley-Blackwell, Oxford, U.K.
6. Agrios GN. (2012) *Plant Pathology.* 5th edition. Elsevier Academic Press, San Diego, U.S.A.
7. Sambrook J, Russell DW. (2001) *Molecular Cloning: A Laboratory Manual.* 3rd edition. Cold Spring Harbor Laboratory Press, New York, U.S.A.
8. Resnik DB. (2020) *The Ethics of Science: An Introduction.* 3rd edition. Routledge, New York, U.S.A.
9. Shamoo AE, Resnik DB. (2015) *Responsible Conduct of Research.* 3rd edition. Oxford University Press, New York, U.S.A.
10. National Academies Press, Washington DC, U.S.A.
11. Zar JH. (2010) *Biostatistical Analysis.* 5th edition. Pearson, Upper Saddle River, NJ, U.S.A.
12. Field A. (2018) *Discovering Statistics Using IBM SPSS Statistics.* 5th edition. Sage Publications, London, U.K.

RESEARCH COURSE – RC 1:

PRACTICAL-RC 1

Marks: Pr (ESE: 6Hrs) = 75	Pass Marks: Pr (ESE) = 30

(Credits: Practicals-01) **30 Hours**

Instructions to Question Setter for

End Semester Examination (ESE):

There will be one Practical Examination of 6Hrs duration. Evaluation of Practical Examination may be as per the following guidelines:

Practical Examination = 50 marks
Viva-voce = 25 marks

Practicals:

1. Analysis of data for mean, mode, median, standard deviation and standard error using suitable plant material.
2. Determination of correlation and regression using suitable examples.
3. Chi square analysis, Analysis of Students 't' test using suitable example.
4. Group discussion
   i. Subject specific ethical issues
   ii. Conflicts of interest
   iii. Complaints and appeals: examples and fraud from India and abroad
5. Software tools-Use of plagiarism software like Turnitin, Aboriginal and other open source software tools.
6. Computer application - Exercise in MS word, MS excel, MS PowerPoint, Adobe photoshop; Introduction to SPSS, databases and their application

Reference Books

1. Danniel, W.W. 1987. Biostatistics. New York, NY: John Wiley Sons.
2. Campbell, R.C. 1974. Statistics for Biologists. Cambridge University Press.
3. Dawson, C. 2002. Practical research methods. New Delhi: UBS Publishers.
4. Freedman, P. 1949. The Principles of scientific research. Washington DC.: Macdonald And Company Limited.
5. Gurumani, N. 2006. Research Methodology for Biological sciences. Chennai, TN: MJP Publishers.
6. Stapleton, P., Yondeowei, A., Mukanyange, J., & Houten, H. 1995. Scientific writing for agricultural research scientists - a training resource manual. Hong Kong: West Africa Rice Development Association.
7. Sundar Rao, P. S. S., & Richards, J. 2012. An introduction to Biostatistics, and Research Methods, New Delhi: PHI learning Pvt. Ltd.
8. Parikh, M. N. and Nithya Gogtay, ABC of Research Methodology and Applied Biostatistics.
9. Chaudhary C.H. Research Methodology, RBSA Publication

SEMESTER VIII

I. MAJOR COURSE- MJ 19:
APPLIED BOTANY

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

Course Objective:

1. **To build an integrated, application-oriented understanding of modern botany** that links ecology, molecular biology, microbiology, taxonomy, cytology, phycology, and plant anatomy/embryology.
2. **To master hands-on and digital research competencies**—from CRISPR genome editing, diagnostics and chemotaxonomic profiling to GIS-based species-distribution modelling and remote-sensing analytics.
3. **To critically evaluate and deploy plant-based biotechnological solutions** for current challenges in food security, climate change mitigation, sustainable agriculture, bioremediation and the circular bio-economy.
4. **To design, execute and interpret multidisciplinary experiments** that combine laboratory, field and in-silico approaches while adhering to good laboratory practice, statistical rigour and biosafety/ethical guidelines.

Course Learning Outcome:

1. **Ability to explain** the conceptual framework of applied ecology in the Anthropocene and **evaluate** plant-based climate-smart solutions for urban and agro-ecosystems.
2. **Application of** remote sensing, GIS and species-distribution modelling to **predict** plant responses to environmental change and to guide ecological restoration projects.
3. **Ability to demonstrate** proficiency in advanced molecular techniques and **interpret** resulting data for plant improvement and diagnostics.
4. **Construction of** DNA-fingerprinting profiles and chemotaxonomic matrices to **differentiate** plant varieties, trace crop evolution and authenticate herbal raw materials.
5. **Analysis of** plant–microbe interactions, innate immunity pathways and endophyte functions, and **design** integrated disease- and pest-management protocols that emphasise biocontrol agents.
6. **Ability to perform** microscopic, histochemical and cytogenetic investigations to **assess** genetic stability, developmental stages and taxonomic relationships.
7. **Designing of** algal cultivation/harvesting workflows and **evaluate** their techno-economic and environmental feasibility for biofertilisers, biofuels, phycoremediation and carbon capture.

Course Content:

Unit 1: Applied Phycology (10 lectures)

1. **Algal Biotechnology:** Genetic engineering in microalgae and its applications in algal systems.
2. **Algae in Agriculture and Soil Health:** Algal biofertilizers (*Nostoc*, *Anabaena*, *Azolla-Anabaena* complex); Algal amendments for improving soil fertility and crop productivity.
3. **Algae in Wastewater Treatment and phycoremediation:** Phycoremediation of heavy metals, nitrates, phosphates; Algal biofilms and biosorption; Algae-based integrated waste management systems.
4. **Algae in Climate Change Mitigation:** Carbon sequestration by macro- and microalgae; algae-based carbon credits; Role in restoring degraded aquatic ecosystems.

Unit 2: Applied Microbiology and Pathology (10 lectures)

1. **Plant-Microbe Interactions and Molecular Basis of Plant Immunity:** Molecular signaling in symbiotic associations (e.g., nodulation genes); Endophytes and their role in stress tolerance; Effector triggered immunity (ETI); Pathogen triggered immunity (PTI): PAMP-triggered; Hypersensitive response (HR), systemic acquired resistance (SAR); Resistance genes (R genes) and their biotechnological applications.
2. **Soil and Rhizosphere Microbiology:** Microbes diversity in the rhizosphere; Plant growth promoting rhizobacteria; Application in organic farming and soil health restoration.
3. **Industrial Applications of Plant-Associated Microbes:** Microbes in bioproduct synthesis: biofertilizers, biopesticides, phytohormones; Fermentation technology in plant-based products (enzymes, antibiotics); Biotransformation and biodegradation by plant-associated microbes.
4. **Integrated Disease and Pest Management (IDM & IPM):** Concept and components of IDM/ IPM; Use of cultural, biological, mechanical, and chemical strategies; Biocontrol agents: *Trichoderma*, *Pseudomonas*, *Bacillus* spp.; Commercial formulations and their field applications.

Unit 3: Applied Morphology, Anatomy, Embryology and Forensic Botany (10 lectures)

1. **Morphology and Palynology:** General morphology; Morphological markers in plant breeding and varietal identification. Different types and methods of gathering data based on morphological markers.

2. **Plant Anatomy and Embryology:** Developmental embryogeny, general anatomy; Histochemical staining and micro technique tools and its applications in plant pathology, plant tissue culture, and systematics. Apomixis and its biotechnological applications; Experimental embryology.
3. **Forensic Botany:** Introduction and application of forensic botany.

Unit 4: Applied Taxonomy (10 lectures)

1. **Phytochemistry:** Phytochemistry of pharmacognostically important plants and identification of the major classes of the pharmaceutically important phytochemicals from *Withania sominifera*, *Tinospora cordifolia*, *Ocimum sanctum*, *Moringa oleifera*, *Curcuma longa* (phenolics, steroids, terpenoids glycosides and alkaloids).
2. **Chemotaxonomy:** History, general chemical and chemotaxonomic characters, types of data, methods of gathering data; Phytochemical databases.
3. **Numerical and Molecular taxonomy:** Introduction to numerical taxonomy and its application; Molecules and genomes in plant systematics, techniques used in molecular taxonomy, molecular systematics in crop evolution; Serology in relation to plant taxonomy- Methods, role of serology in taxonomy.

Unit 5: Applied Plant Physiology (10 lectures)

1. **Pharmaceutically important bioactive compounds of some medicinal plants through plant cell and tissue culture**
2. **Environmental signals in flowering:** Floral meristem identity genes; The ABC model of flower development.
3. **Molecular aspects of Plant Movement, Growth and Development:** Role and molecular aspects of phytohormones and phytochromes in plant movement, growth and development. Hydroponics and Aeroponics Techniques.

Unit 6: Applied Ecology and Environmental Biology (10 lectures)

1. **Fundamentals of Applied Ecology:** Conceptual framework of applied ecology in the Anthropocene; Role of botany in solving real-world ecological problems.
2. **Urban Ecology and Plant-Based Solutions:** Urban ecosystems: Characteristics and challenges; Role of green roofs, vertical gardens, urban forestry; Climate-resilient agriculture and ecological restoration.
3. **Ecological Modeling and Predictive Tools**: Basics of ecological modeling and simulation; Species distribution modeling (SDM) under climate change; Remote sensing and GIS in vegetation ecology.

Reference Book:

1. Birchler JA, Han F (eds.). (2018) Genome Engineering for Plant Improvement. Springer, Cham, Switzerland.
2. Odum EP, Barrett GW. (2005) Fundamentals of Ecology. 5th edition. Brooks/Cole, Belmont, CA, U.S.A.
3. Agrios GN. (2012) Plant Pathology. 5th edition. Elsevier Academic Press, San Diego, CA, U.S.A.
4. Rangaswami G, Bagyaraj DJ. (2005) Agricultural Microbiology. 2nd edition. Prentice Hall of India, New Delhi, India.
5. Gnanamanickam SS (ed.). (2006) Biological Control of Crop Diseases. CRC Press, Boca Raton, FL, U.S.A.
6. Simpson MG. (2019) Plant Systematics. 3rd edition. Academic Press, San Diego, CA, U.S.A.
7. Harborne JB. (1998) Phytochemical Methods: A Guide to Modern Techniques of Plant Analysis. 3rd edition. Chapman & Hall, London, U.K.
8. Colegate SM, Molyneux RJ (eds.). (2008) Bioactive Natural Products: Detection, Isolation, and Structural Determination. 2nd e dition. CRC Press, Boca Raton, FL, U.S.A.
9. Stace CA. (2010) Plant Taxonomy and Biosystematics. 3rd edition. Cambridge University Press, Cambridge, U.K.
10. Karp A, Isaac PG, Ingram DS (eds.). (1998) Molecular Tools for Screening Biodiversity: Plants and Animals. Chapman & Hall, London, U.K.
11. Fahn A. (1982) Plant Anatomy. 4th edition. Pergamon Press, Oxford, U.K.
12. Bhojwani SS, Bhatnagar SP. (2015) The Embryology of Angiosperms. 6th edition. Vikas Publishing House, New Delhi, India.
13. Ruzin SE. (1999) Plant Microtechnique and Microscopy. Oxford University Press, Oxford, U.K.
14. Erdtman G. (1969) Handbook of Palynology. Hafner Publishing, New York, U.S.A.
15. Richmond A, Hu Q (eds.). (2013) Handbook of Microalgal Culture: Applied Phycology and Biotechnology. 2nd edition. Wiley-Blackwell, Oxford, U.K.
16. Lee RE. (2018) Phycology. 6th edition. Cambridge University Press, Cambridge, U.K.
17. Kumar HD. (1999) Introductory Phycology. 2nd edition. Affiliated East-West Press, New Delhi, India.
18. Vashishta BR, Sinha AK. (2008) Botany for Degree Students: Algae. Revised edition. S. Chand & Company, New Delhi, India.
19. Sharma PD. (2020) Ecology and Environment. 12th edition. Rastogi Publications, Meerut, India.
20. Cooke BM, Jones DG, Kaye B (eds.). (2006) The Epidemiology of Plant Diseases. 2nd edition. Springer, Dordrecht, Netherlands.
21. Glick BR, Patten CL, Holguin G, Penrose DM. (1999) Biochemical and Genetic Mechanisms Used by Plant Growth Promoting Bacteria. Imperial College Press, London, U.K.
22. Mukhopadhyay AN, Kumar J, Rahman MM (eds.). (1998) Integrated Disease Management in Plantation Crops. Scientific Publi shers, Jodhpur, India.
23. Taiz, L., Zeiger, E., MØller, I.M. and Murphy, A (2015). Plant Physiology and Development. Sinauer Associates Inc. USA. 6th edition.
24. Bajracharya D. (1999). Experiments in Plant Physiology-A Laboratory Manual. Narosa Publishing House, New Delhi.
25. Campbell, MK (2012) Biochemistry, 7th ed., Published by Cengage Learning.
26. Nelson DL and Cox MM (2008) Lehninger Principles of Biochemistry, 5th Edition., W.H. Freeman and Company

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II. MAJOR COURSE- MJ 20:
PRACTICAL-VI

Marks: Pr (ESE: 6Hrs) =100	Pass Marks: Pr (ESE) = 40

(Credits: Practicals-04) **120 Hours**

Instruction to Question Setter for
End Semester Examination (ESE):
There will be one Practical Examination of 6Hrs duration. Evaluation of Practical Examination may be as per the following guidelines:

Experiment	*= 60 marks*
Practical record notebook	*= 15 marks*
Viva-voce	*= 25 marks*

List of Practical

1. **Mass cultivation of *Spirulina*/ *Chlorella*/ *Azolla*/ Aquatic ferns/ Algae/ Bryophyta/ Pteridophyta** in laboratory flasks
2. **Estimation of protein content** from *lower plants* using Lowry or Bradford assay
3. **Antibacterial or probiotic activity assay** using disc diffusion or turbidometric method
4. **Extraction of phytochemicals** from *Curcuma longa*, *Tinospora cordifolia* etc. or others using different solvents (ethanol/methanol)
5. **Qualitative tests** for phytochemicals (alkaloids, flavonoids, tannins, and phenols)
6. **Thin Layer Chromatography (TLC)** profiling of plant extracts/ paper chromatography of pigments/ amino acids and preparation of standard graph.
7. Herbarium preparation of different plants.
8. Pollen viability by histochemical test and palynology.
9. Plant extract preparation by various methods (Cold/ Hot).
10. Key preparation on the basis of morphological characters.
11. Identification of tissue by maceration technique.
12. Plant disease and protection; Identification and pest management.
13. Analysis of soil and water samples from polluted and non-polluted sites (Conventional and Modern techniques).
14. Tissue culture: MS media preparation and explant culture.
15. Artificial seed synthesis.
16. Effect of auxin and gibberellin on plant movement and growth using oat coleoptile or pea stem curvature bioassay.
17. Microbial media preparation and culture of bacteria/ fungus.

Reference Books

1. **Kochhar SL. (2016)** *Plant Physiology, Theory and Applications.* 2nd ed. New Age International Publishers, N. Delhi, India.
2. **Sadasivam S and Manickam A. (2008)** *Biochemical Methods.* 3rd edition. New Age International Publishers, New Delhi, India.
3. **Harborne JB. (1998)** *Phytochemical Methods: A Guide to Modern Techniques of Plant Analysis.* 3rd edition. Chapman & Hall, London, U.K.
4. **Karthikeyan S, Jain SK, Nayar MP. (2009)** *Herbaria and Herbarium Techniques.* 2nd edition. National Botanical Research Institute, Lucknow, India.
5. **Ruzin SE. (1999)** *Plant Microtechnique and Microscopy.* Oxford University Press, New York, U.S.A.
6. **Murashige T and Skoog F. (1962)** *A Revised Medium for Rapid Growth and Bioassays with Tobacco Tissue Cultures.*Physiologia Plantarum, 15(3): 473–497.
7. **George EF, Hall MA, De Klerk GJ. (2008)** *Plant Propagation by Tissue Culture.* 3rd edition. Springer, Dordrecht, Netherlands.
8. **Aneja KR. (2012)** *Experiments in Microbiology, Plant Pathology and Biotechnology.* 4th edition. New Age International Publishers, New Delhi, India.
9. **Wink M. (2009)** *An Introduction to Molecular Biotechnology: Molecular Fundamentals, Methods and Applications in Modern Biotechnology.* 2nd edition. Wiley-VCH Verlag, Weinheim, Germany.
10. **Jayaraman J. (1981)** *Laboratory Manual in Biochemistry.* New Age International Publishers, New Delhi, India.
11. **Sinha SK. (2004)** *Practical Botany, Vol. I & II.* Rastogi Publications, Meerut, India.
12. **Sharma OP. (2009)** *Plant Tissue Culture and Molecular Biology: A Practical Approach.* 1st edition. Narosa Publishing House, New Delhi, India.
13. **Chopra GL. (2004)** *Practical Botany, Vol. I & II.* Kalyani Publishers, New Delhi, India.
14. **Maiti P and Maiti G. (2011)** *Bioanalytical Techniques and Biostatistics.* 1st edition. IK International Publishing House, New Delhi, India.
15. **Mukherjee KL and Ghosh S. (2010)** *Medical Laboratory Technology, Vol. 1–3.* 2nd ed. Tata McGraw-Hill, N. Delhi, India.

III. ADVANCED MAJOR COURSE- AMJ 2: INTEGRATIVE BOTANY

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

(Only for Hons Degree)

Course Objective

1. To familiarise the students with the fundamental principles of Nanobiotechnology, various potential application of Nanobiotechnology.
2. To apply the cutting-edge computational and statistical tools to genomic, transcriptomic and proteomic datasets.
3. To analyse molecular, biochemical and physiological responses of photosynthetic organisms to environmental stresses to design sustainable, innovative solutions for agriculture, bio-products and ecosystem resilience.

Course Learning Outcomes

1. Ability to describe and differentiate major classes of nanomaterials used in agriculture and evaluate their regulatory and biosafety frameworks.
2. **Ability to select, operate and interpret data** from principal characterisation platforms for nanoparticle analysis.
3. **Execution of genomic, transcriptomic and proteomic workflows**—including genome annotation, RNA-seq analysis, homology modelling and molecular docking—using current bioinformatics software.
4. **Application of statistical reasoning** (probability distributions, hypothesis tests, t-tests, one- & two-way ANOVA) and use SPSS / Excel to analyse and visualise biological data sets.
5. **Ability to critically compare abiotic stress–response pathways** and relate omics-level changes to physiological adaptation.
6. **Designing of integrated biotechnological strategies**—such as nano-enabled agrichemicals or gene-edited, stress-tolerant crops—by synthesizing knowledge from all three units.

Course Content:

UNIT 1: NANO-BIOTECHNOLOGY (15 lectures)

1. Introduction of Nanobiotechnology and its applications. Various types of nanomaterial utilized in agriculture.
2. Synthesis of nanoparticle: Physical, Chemical and Biological.
3. Structural characterisation techniques: X-ray diffraction (XRD) technique; Electron Microscopy; Spectroscopic Techniques.
4. Application of plant-based nanoparticles as biofertilizer and drugs.
5. Regulatory and safety measures for nanotechnology-based agriculture products.

UNIT 2: ADVANCE BIOINFORMATICS AND BIOSTATISTICS (25 lectures)

1. **Genomics and Genome Annotation:** Structural and functional annotation; Gene prediction tools (GENSCAN); Genome browsers (Emsembl, NCBI).
2. **Transcriptomics and RNA-seq Analysis:** Introduction to transcriptomics, Microarray and RNA-seq workflow and differential gene expression; Use of tools: HISAT2 and DESeq2.
3. **Proteomics and Protein Structure Prediction:** Overview of proteomics; Protein structure databases (PDB, InterPro); Homology modeling.
4. **Probability Distributions and Sampling:** Normal, binomial, and Poisson distributions; Sampling techniques and sampling error
5. **Hypothesis Testing:** Null and alternative hypotheses; Type I and II errors; student t-test.
6. **Analysis of Variance:** One-way and two-way ANOVA; Assumptions and interpretations.
7. **Statistical Software:** Introduction to Excel and SPSS for biostatistics.

UNIT 3: STRESS BIOLOGY (20 lectures)

1. Distribution of extremophiles, cyanobacteria and plant across environmental gradients.
2. Biotic and abiotic stress tolerance: Bacterial, fungal, nematode, drought, salinity, light and temperature and its impact on physiological, biochemical and molecular level with reference to stress responsive gene/proteins in Rice, Wheat, *Arabidopsis*, Tomato and Soybean.
3. Concept of gene mining from plant model system for the development of stress tolerant crops.
4. Gene chemistry using photosynthetic organisms for production of biofuels and bioactive compounds.
5. Application of stress biology and its significance.

Reference Books:

1. Bhushan B (ed.). (2017) *Springer Handbook of Nanomaterials.* 2nd edition. Springer, Berlin, Germany.
2. Rai M, Ribeiro C (eds.). (2015) *Nanotechnology and Plant Sciences: Nanoparticles and Their Impact on Plants.* 1st edition. Springer, Cham, Switzerland.
3. Goldstein JI, Newbury DE, Michael JR, et al. (2018) *Scanning Electron Microscopy and X-ray*

Microanalysis. 4th edition. Springer, New York, U.S.A.
4. Pavia DL, Lampman GM, Kriz GS. (2014) *Introduction to Spectroscopy.* 5th edition. Cengage Learning, Boston, U.S.A.
5. Skoog DA, Holler FJ, Crouch SR. (2018) *Principles of Instrumental Analysis.* 7th edition. Cengage Learning, Boston, U.S.A.
6. Mount DW. (2020) *Bioinformatics: Sequence and Genome Analysis.* 3rd edition. Cold Spring Harbor Laboratory Press, New York, U.S.A.
7. Lesk AM. (2019) *Introduction to Bioinformatics.* 5th edition. Oxford University Press, Oxford, U.K.
8. Gentleman R, Carey V, Huber W, Irizarry R, Dudoit S (eds.). (2005) *Bioinformatics and Computational Biology Solutions Using R and Bioconductor.* 1st edition. Springer, New York, U.S.A.
9. Field A. (2018) *Discovering Statistics Using IBM SPSS Statistics.* 5th edition. Sage Publications, London, U.K.
10. Gill SS, Tuteja N (eds.). (2010) *Reactive Oxygen Species and Antioxidant Machinery in Abiotic Stress Tolerance in Crop Plants.* 1st edition. Springer, Berlin, Germany.
11. Hasegawa PM (ed.). (2013) *Plant Abiotic Stress.* 2nd edition. Wiley-Blackwell, Oxford, U.K.
12. Ahmad P, Rasool S (eds.). (2014) *Emerging Technologies and Management of Crop Stress Tolerance.* 1st edition. Academic Press, London, U.K.
13. Shanker AK, Shanker C (eds.). (2016) *Abiotic Stress in Plants: Mechanisms and Adaptations.* 1st edition. InTechOpen, London, U.K.
14. Castenholz RW (ed.). (2012) *Ecology of Cyanobacteria II: Their Diversity in Space and Time.* 2nd edition. Springer, Dordrecht, Netherlands.
15. Hall RD (ed.). (2015) *Plant Metabolomics.* 2nd edition. Springer, Dordrecht, Netherlands.
16. Henry RJ (ed.). (2013) *Plant Genomics.* 2nd edition. Wiley-Blackwell, Oxford, U.K
17. Barrangou R, van der Oost J (eds.). (2015) *CRISPR-Cas Systems: RNA-Mediated Adaptive Immunity in Bacteria and Archaea.* 1st edition. Springer, Berlin, Germany.

IV. ADVANCED MAJOR COURSE- AMJ 3: PRACTICAL-VII

Marks: Pr (ESE: 6Hrs) =100	Pass Marks: Pr (ESE) = 40

(Credits: Practicals-04) **120 Hours**

(Only for Hons Degree)

Instruction to Question Setter for

End Semester Examination (ESE):

There will be one Practical Examination of 6Hrs duration. Evaluation of Practical Examination may be as per the following guidelines:

Experiment = 60 marks
Practical record notebook = 15 marks
Viva-voce = 25 marks

Practicals:

1. **Demonstration on synthesis of nanoparticles by physical, chemical and biological methods.**
2. Demonstration on CYANOBASE, Phytozome, TAIR and retrieving of gene sequences for multiple sequence alignment for candidate gene for making phylogenetic tree using (MEGA, CLUSTAL X etc.).
3. Lipid assay from stressed and non-stressed photosynthetic organisms/microbes.
4. Study the effect of different biotic, abiotic factors, mutagens, heavy metals on cyanobacteria/ bacteria/ fungi/ angiospermic plant.
5. Determination of LC50 doses of selected abiotic stresses in plant.
6. Estimation of proline/signalling molecule content under different biotic and abiotic stress condition.
7. Analysis of Mean, median, mode, standard deviation, standard error, t-Test and ANOVA from the data collected/ provided.

Reference Books

1. Green MR, Sambrook J. (2012) *Molecular Cloning: A Laboratory Manual.* 4th edition. Cold Spring Harbor Laboratory Press, New York, U.S.A.
2. Niemeyer CM, Mirkin CA (eds.). (2004) *Nanobiotechnology: Concepts, Applications and Perspectives.* 1st edition. Wiley-VCH, Weinheim, Germany.
3. Bhushan B (ed.). (2017) *Springer Handbook of Nanomaterials.* 2nd edition. Springer, Berlin, Germany.
4. Egerton RF. (2016) *Physical Principles of Electron Microscopy.* 2nd edition. Springer, Cham, Switzerland.
5. Skoog DA, Holler FJ, Crouch SR. (2018) *Principles of Instrumental Analysis.* 7th edition. Cengage Learning, Boston, U.S.A.
6. Sadasivam S, Manickam A. (2008) *Biochemical Methods.* 3rd edition. New Age International Publishers, New Delhi, India.
7. Wenk MR (ed.). (2010) *The Handbook of Lipidomics.* 1st edition. CRC Press, Boca Raton, FL, U.S.A.
8. Pessarakli M (ed.). (2014) *Handbook of Plant and Crop Stress.* 3rd edition. CRC Press, Boca Raton, FL, U.S.A.
9. Gupta US. (1993) *Methods for Environmental Stress Tolerance Screening in Crop Plants.* 1st edition. CRC Press, Boca Raton, FL, U.S.A.
10. Zar JH. (2010) *Biostatistical Analysis.* 5th edition. Pearson, Upper Saddle River, NJ, U.S.A.
11. Field A. (2018) *Discovering Statistics Using IBM SPSS Statistics.* 5th edition. Sage Publications, London, U.K.
12. Hall BG. (2011) *Phylogenetic Trees Made Easy: A How-To Manual.* 4th edition. Sinauer Associates, Sunderland, MA, U.S.A.
13. Glick BR, Patten CL, Holguin G, Penrose DM. (1999) *Biochemical and Genetic Mechanisms Used by Plant Growth-Promoting Bacteria.* 1st edition. Imperial College Press, London, U.K.
14. Hall RD (ed.). (2015) *Plant Metabolomics: Methods and Applications.* 2nd edition. Springer, Dordrecht, Netherlands.
15. Greenfield PJ. (2019) *Nanoparticle Characterisation: Instruments and Methods.* 1st edition. CRC Press, Boca Raton, FL, U.S.A.

OR RESEARCH COURSES- RC 2: (In lieu of AMJ 2 & AMJ 3)

RESEARCH/ PROJECT DISSERTATION/ RESEARCH INTERNSHIP/ FIELD WORK

Marks: 50 (SIE: 25 Synopsis + 25 Viva on Synopsis: 1Hr) + 100 (ESE Pr: 6Hrs) + 50 (Viva) = 200	**Pass Marks = 80**

(Only for Hons with Research Degree)

Guidelines to Examiners for Semester Internal Examination (SIE):

Evaluation of project dissertation work may be as per the following guidelines:

Project Synopsis = 25 marks

Project Synopsis presentation and viva-voce = 25 marks

Guidelines to Examiners for End Semester Examination (ESE):

Evaluation of project dissertation work may be as per the following guidelines:

Project model (if any) and the Project record notebook = 70 marks

Project presentation and viva-voce = 30 marks

The overall project dissertation may be evaluated under the following heads:

- *Motivation for the choice of topic*
- *Project dissertation design*
- *Methodology and Content depth*
- *Results and Discussion*
- *Future Scope & References*
- *Participation in an Internship programme with a reputed organisation*
- *Application of the Research technique in Data collection*
- *Report Presentation*
- *Presentation style*
- *Viva-voce*

Research Project

Research project under a Supervisor of the Department/Institution may be allocated to the eligible and qualifying candidate.

Project Dissertation/ Research Internship/ Field Work

The students of Graduation must work Thirty-Six (36) days as Interns under Any Organisation having an MoU with the Ranchi University, which may include Government Organisations/judiciary/ Health Care Sectors/ Educational Institutions/ NGOs etc.

- The nature and the place of working must be informed in writing, seeking permission from the head of the department or the institution before undertaking the Project dissertation.

Submission of the Project Work

Each student has to submit two copies of the dissertation work duly forwarded by the HOD of the Department concerned. The forwarded copies will be submitted to the Department/Institution for evaluation at least seven days before the seminar.

The Project Report will consist of:

a. Field work/Lab work related to the project.
b. Preparation of the dissertation based on the work undertaken.
c. Presentation of project work in the seminar on the assigned topic & open viva there on.
d. At least one Research paper must be presented at a conference or may be published in a reputed journal.

Topics

Project work related to the Industrial/socially relevant topics may be given.

NB: Students will select topics for the project work in consultation with a teacher of the department.

The seminar will be held in the respective University Department at Ranchi University, Ranchi.

COURSES OF STUDY FOR FYUGP IN **"BOTANY" MINOR**

ASSOCIATED CORE COURSE- MN A **Either may be opted in Sem-I or Sem-II**

I. ASSOCIATED CORE COURSE- MN A: INTRODUCTORY BOTANY

Marks: 15 (15 SIE: 1Hr) + 60 (ESE: 3Hrs) = 75	**Pass Marks: Th (SIE + ESE) + Pr (ESE) = 40**

(Credits: Theory-03) **45 Hours**

Course Objectives:

1. Objective of this paper is to make students aware about the diversity of plant life and their role in economical, ecological and biotechnological aspects with focus on restoration of ecosystems and sustainable development.

Course Learning Outcomes:

1. Students will be able to learn the diversity of plant kingdom and scientific nomenclature of plants. Acquaintance of students with micro to macro flora of different groups along with their utilisation for human welfare.
2. They will also come to know about various plant pathogens and their integrated control methods helpful in enhancing the yield of crops and implementation of modern tools and techniques in agriculture.
3. Students will acquire knowledge about various pollutants, their ill effects on environmental health and human well-being at the same time with emphasis on control measures required for restoration of our ecosystems and sustainable development.
4. Acquaintance with ethnobotanical practices prevalent in Jharkhand and their application in keeping the environment clean and healthy as well as meeting the needs of malnutritional and anaemic population.

Course Content:

Basic Concept of Botany

1. Elementary idea of classification of plant kingdom, Taxonomic hierarchy upto species, Botanical Nomenclature of plants, herbarium - types and use. Family description- Solanaceae and Poaceae. **(3 lectures)**

2. A concise introduction to branches and scope of botany. **(2 lectures)**

3. Diversity of Plants: General identifying features, structures, life cycle and economic importance of the following groups: **(8 lectures)**
   a) Bacteria
   b) Virus
   c) Algae
   d) Fungi
   e) Lichens
   f) Bryophyta
   g) Pteridophyta
   h) Gymnosperms
   i) Angiosperms: Morphology of flowering plants (Monocots and Dicots)

4. Plant pathology- Name of causal organisms, symptoms and control of the following diseases: **(2 lectures)**
   a. Wilt of tomato
   b. Citrus canker
   c. Yellow vein mosaic of bhindi
   d. Leaf curl of papaya
   e. Black stem rust of wheat
   f. Loose smut of wheat

5. Brief notes on ethnobotanical uses of the following plants with particular reference to Jharkhand: **(3 lectures)**
   a. Kalmegh
   b. Palash
   c. Karanj
   d. Neem
   e. Bamboo
   f. Sal

6. Cell - Ultra structure of a typical prokaryotic and eukaryotic cell and cell division **(4 lectures)**
   a. Plant cell and its organelles - structure and function
   b. Cell cycle

c. Mitosis
d. Meiosis

7. Genetics: Structure and Function of DNA, Mendel's Law. **(2 lectures)**

8. Application of Biotechnology in Agriculture and environment. **(1 lectures)**

9. Introductory knowledge of pollination, Fertilisation and seed development in Angiosperms, Monocot and Dicot seeds; Germination of seeds. **(2 lectures)**

10. Physiology of Plants: Ascent of Sap, Transpiration, Photosynthesis and Respiration. Fermentation- Role of microbes in food production and preservation. Biological Nitrogen Fixation. **(5 lectures)**

11. Ecology and Environment: Pond Ecosystem, Forest Ecosystem; Biogeochemical cycle –Carbon and Nitrogen. Pollution: Causes and control of air, water, soil and noise pollution; conservation of natural resources, biodiversity: definition, threats, loss and importance. Indigenous eco-friendly practices. An introduction to major global environmental issues and sustainable development. Disaster management. Peoples Biodiversity Register (PBR). **(8 lectures)**

12. An introduction to organic farming. **(2 lectures)**

13. Economic Botany: Food, fodder, fibre, timber, oil and pulses. **(2 lectures)**

14. Botanical Survey of India – Objectives and achievements. **(1 lectures)**

Reference Books:

1. Botany for degree students; A.C. Dutta
2. College Botany; Vol I, Ganguly, Das and Dutta
3. College Botany; Vol. II, Ganguly, Kar and Santra
4. Study of Botany; Mitra, Mitra and Guha
5. A text book of Botany; K. S. Bilgrami
6. A text book of Botany; Vol. I & II, Hait, Bhattacharya and Ghosh
7. Practical botany: Bendre and Kumar, and S. P. Lal

II. ASSOCIATED CORE COURSE- MN A PR: BOTANY MINOR-A PRACTICAL

Marks: Pr (ESE: 6Hrs) = 25	Pass Marks: Pr (ESE) = 10

(Credits: Practicals-01) **30 Hours**

Instruction to Question Setter for

End Semester Examination (ESE):

There will be one Practical Examination of 6Hrs duration. Evaluation of Practical Examination may be as per the following guidelines:

Experiment = 15 marks
Practical record notebook = 05 marks
Viva-voce = 05 marks

Practicals:

1. Family descriptions of given plant.
2. Anatomical features of: monocot (root and stem) and dicot (root and stem).
3. Morphology of bacteria with the help of photographs.
4. Gram's staining technique.
5. Botanical name, common name, family and uses of cereal, pulses, oil yielding.
6. Osmosis.
7. Plasmolysis.
8. Acquaintance with the instruments.
9. Identifying features and name of the given materials/permanent slides (algae, fungi, bryophytes, pteridophytes and gymnosperms).
10. Mitosis and Meiosis: Study of materials/permanent slides.

Reference Books:

1. Kumar, H.D. (1999). Introductory Phycology. Affiliated East-West. Press Pvt. Ltd. Delhi. 2nd edition.
2. Tortora, G.J., Funke, B.R., Case, C.L. (2010). Microbiology: An Introduction, Pearson BenjaminCummings, U.S.A. 10th edition.
3. Sethi, I.K. and Walia, S.K. (2011). Text book of Fungi & Their Allies, MacMillan Pub. Pvt. Ltd., Delhi.
4. Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996). Introductory Mycology, John Wiley and Sons(Asia), Singapore. 4th edition.
5. Raven, P.H., Johnson, G.B., Losos, J.B., Singer, S.R., (2005). Biology. Tata McGraw Hill, Delhi, India.
6. Vashishta, P.C., Sinha, A.K., Kumar, A., (2010). Pteridophyta, S. Chand. Delhi, India.
7. Bhatnagar, S.P. and Moitra, A. (1996). Gymnosperms. New Age International (P) Ltd Publishers, New Delhi, India.
8. Parihar, N.S. (1991). An introduction to Embryophyta. Vol. I. Bryophyta. Central Book Depot, Allahabad.

MINOR COURSE-B

I. MINOR COURSE- MN B:
BIODIVERSITY

Marks: 15 (15 SIE: 1Hr) + 60 (ESE: 3Hrs) = 75	**Pass Marks: Th (SIE + ESE) + Pr (ESE) = 40**

(Credits: Theory-03) **45 Hours**

Course Objectives:

1. To introduce the students with diversity of plants such as microbes, algae, fungi, archegoniates.

Course Learning Outcomes:

1. It acquaints the students with diversity of plants like microbes, algae, fungi, archegoniates and, complex interrelationship between organisms and environment; community patterns and processes, ecosystem functions, and principles of phytogeography.

Course Content:

Unit 1: Microbes **(6 lectures)**

General characteristic and economic importance of microorganism. Viruses –Lytic and lysogenic cycle, RNA virus (TMV); Bacteria – cell structure; Reproduction – vegetative, asexual and recombination (conjugation, transformation and transduction).

Unit 2: Algae **(7 lectures)**

Classification of algae, General characteristics; Range of thallus organisation and life cycle pattern; Life cycle of Nostoc, Chlamydomonas and Batrachospermum. Economic importance of algae.

Unit 3: Fungi **(10 lectures)**

Classification of fungi, General characteristics; Range of thallus organisation and life cycle pattern; True Fungi- life cycle of Albugo, Puccinia, Alternaria, Agaricus; economic importance of fungi.

Symbiotic Associations-Lichens: General account, reproduction and significance; Mycorrhiza and their significance

Unit 4: Introduction to Archegoniate **(2 lectures)**

Unifying features of archegoniates, Transition to land habit, Alternation of generations.

Unit 5: Bryophytes **(6 lectures)**

General characteristics, adaptations to land habit, Classification. Life cycle of Marchantia and Sphagnum. Economic importance of Bryophytes.

Unit 6: Pteridophytes **(8 lectures)**

General characteristics, classification. Life cycle of Lycopodium, Selaginella and Pteris. heterospory and Seed habit. Types of stele.

Unit 7: Gymnosperms **(6 lectures)**

General characteristics; Classification. Life cycle of Cycas and Pinus. Economic importance.

Reference Books:

1. Botany for degree students; A.C. Dutta
2. College Botany; Vol I, Ganguly, Das and Dutta
3. College Botany; Vol. II, Ganguly, Kar and Santra
4. Study of Botany; Mitra, Mitra and Guha
5. A text book of Botany; K. S. Bilgrami
6. A text book of Botany; Vol. I & II, Hait, Bhattacharya and Ghosh
7. Practical botany: Bendre and Kumar, and S. P. Lal

II. MINOR COURSE- MN B PR:
BOTANY MINOR-B PRACTICAL

Marks: Pr (ESE: 6Hrs) = 25	**Pass Marks: Pr (ESE) = 10**

(Credits: Practicals-01) **30 Hours**

Instruction to Question Setter for

End Semester Examination (ESE):

There will be one Practical Examination of 6Hrs duration. Evaluation of Practical Examination may be as per the following guidelines:

Experiment = 15 marks
Practical record notebook = 05 marks
Viva-voce = 05 marks

Practicals:

1. EMs/Models of viruses – T-Phage and TMV, Line drawing/Photograph of Lytic and Lysogenic Cycle.
2. Types of Bacteria from temporary/permanent slides/photographs; EM bacterium; Binary Fission; Conjugation; Structure of root nodule.
3. Gram staining
4. Study of vegetative and reproductive structures of Nostoc, Chlamydomonas (electron micrographs), through temporary preparations and permanent slides.
5. *Alternaria*: Specimens/photographs and tease mounts.
6. *Puccinia*: Herbarium specimens of Black Stem Rust of Wheat and infected Barberryleaves; section/tease mounts of spores on Wheat and permanent slides of both the hosts.
7. *Agaricus*: Specimens of button stage and full grown mushroom; Sectioning of gills of Agaricus.
8. Lichens: Study of growth forms of lichens (crustose, foliose and fruticose)
9. *Marchantia*- morphology of thallus, w.m. rhizoids and scales, v.s. thallus throughgemma cup, w.m. gemmae (all temporary slides), v.s. antheridiophore, archegoniophore, l.s. sporophyte (all permanent slides).
10. *Sphagnum*- morphology, w.m. leaf, rhizoids, operculum, peristome, annulus, spores (temporary slides); permanent slides showing antheridial and archegonial heads, l.s. capsule and protonema.
11. *Selaginella*- morphology, w.m. leaf with ligule, t.s. stem, w.m. strobilus, w.m.microsporophyll and megasporophyll (temporary slides), l.s. strobilus (permanent slide).
12. *Equisetum*- morphology, t.s. internode, l.s. strobilus, t.s. strobilus, w.m. sporangiophore,w.m. spores (wet and dry)(temporary slides); t.s rhizome (permanent slide).
13. *Pteris*- morphology, t.s. rachis, v.s. sporophyll, w.m. sporangium, w.m. spores (temporary slides), t.s. rhizome, w.m. prothallus with sex organs and young sporophyte (permanent slide).
14. *Cycas*- morphology (coralloid roots, bulbil, leaf), t.s. coralloid root, t.s. rachis, v.s. leaflet,v.s. microsporophyll, w.m. spores (temporary slides), l.s. ovule, t.s. root (permanent slide).
15. *Pinus*- morphology (long and dwarf shoots, w.m. dwarf shoot, male and female), w.m.dwarf shoot, t.s. needle, t.s. stem, , l.s./t.s. male cone, w.m. microsporophyll, w.m. microspores (temporary slides), l.s. female cone, t.l.s. & r.l.s. stem (permanent slide).

Reference Books:

1. Kumar, H.D. (1999). Introductory Phycology. Affiliated East-West. Press Pvt. Ltd. Delhi. 2nd edition.
2. Tortora, G.J., Funke, B.R., Case, C.L. (2010). Microbiology: An Introduction, Pearson BenjaminCummings, U.S.A. 10th edition.
3. Sethi, I.K. and Walia, S.K. (2011). Text book of Fungi & Their Allies, MacMillan Pub. Pvt. Ltd., Delhi.
4. Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996). Introductory Mycology, John Wiley and Sons(Asia), Singapore. 4th edition.
5. Raven, P.H., Johnson, G.B., Losos, J.B., Singer, S.R., (2005). Biology. Tata McGraw Hill, Delhi, India.
6. Vashishta, P.C., Sinha, A.K., Kumar, A., (2010). Pteridophyta, S. Chand. Delhi, India.
7. Bhatnagar, S.P. and Moitra, A. (1996). Gymnosperms. New Age International (P) Ltd Publishers, New Delhi, India.
8. Parihar, N.S. (1991). An introduction to Embryophyta. Vol. I. Bryophyta. Central Book Depot, Allahabad.

MINOR COURSE-C

I. MINOR COURSE- MN C:

PLANT ECOLOGY AND TAXONOMY

Marks: 15 (15 SIE: 1Hr) + 60 (ESE: 3Hrs) = 75	**Pass Marks: Th (SIE + ESE) + Pr (ESE) = 40**

Course Objectives:

1. To make them understand complex community patterns and processes, and ecosystem functioning.
2. environmental factors affecting the plants, the basic principles of ecology and phytogeography.
3. Objective of this paper is to make students aware about the diversity of plant life and their role in economical, ecological and biotechnological aspects with focus on restoration of ecosystems and sustainable development.

Course Learning Outcomes:

1. This knowledge is critical in evolving strategies for sustainable natural resource management and biodiversity conservation.
2. Students will be able to learn the diversity of plant kingdom and scientific nomenclature of plants. Acquaintance of students with micro to macro flora of different groups along with their utilisation for human welfare.

Course Content:

Unit 1: Introduction **(2 lectures)**

Unit 2: Ecological factors **(9 lectures)**

Soil: Origin, formation, composition, soil profile. Water: States of water in the environment, precipitation types. Light and temperature: Variation Optimal and limiting factors; Shelford law of tolerance. Adaptation of hydrophytes and xerophytes.

Unit 3: Plant communities **(5 lectures)**

Succession: Hydrosere and Xerosere.

Unit 4: Ecosystem **(16 lectures)**

Structure and function of ecosystem; energy flow trophic organisation; Food chains and food webs, Ecological pyramids; Biogeochemical cycling; Cycling of carbon, nitrogen and phosphorous.

Unit 5: Phytogeography **(7 lectures)**

Phytogeographical regions of India.

Unit 6 Introduction to plant taxonomy **(3 lectures)**

Classification (Bentham and Hooker), Identification, Nomenclature). Functions of Herbarium, important herbaria and botanical gardens of India. Principle of ICN. Ranks, categories and taxonomic groups.

Unit 7 Taxonomic evidences **(3 lectures)**

Taxonomic evidences from morphology and anatomy.

Reference Books:

1. Odum, E.P., Odum, H.T. & Andrews, J. 1971.*Fundamentals of Ecology*. Philadelphia: Saunders.
2. Rao, M.N. & Datta, A.K. 1987. *Waste Water Treatment*. Oxford and IBH Publishing Co. Pvt. Ltd.
3. Sengupta, R. 2003. *Ecology and economics*: An approach to sustainable development. OUP.
4. Singh, J.S., Singh, S.P. and Gupta, S.R. 2014. *Ecology, Environmental Science and Conservation*.
5. Kormondy, E.J. (1996). Concepts of Ecology. Prentice Hall, U.S.A. 4th edition.
6. Sharma, P.D. (2010) Ecology and Environment. Rastogi Publications, Meerut, India. 8th edition
7. Singh, (2012). Plant Systematics: Theory and Practice Oxford & IBH Pvt. Ltd., New Delhi. 3rdedition.
8. Jeffrey, C. (1982). An Introduction to Plant Taxonomy. Cambridge University Press, Cambridge.
9. Sharma, O.P. Plant Taxonomy. Mc Graw Hill

II. MINOR COURSE- MN C PR:
BOTANY MINOR-C PRACTICAL

Marks: Pr (ESE: 6Hrs) = 25	Pass Marks: Pr (ESE) = 10

(Credits: Practicals-01) **30 Hours**

Instructions to Question Setter for
End Semester Examination (ESE):
There will be one Practical Examination of 6Hrs duration. Evaluation of Practical Examination may be as per the following guidelines:

Experiment	*= 15 marks*
Practical record notebook	*= 05 marks*
Viva-voce	*= 05 marks*

Practicals:

1. Study of instruments used to measure microclimatic variables: Soil thermometer, anemometer, rain gauge and lux meter.
2. Determination of pH of soil sample.
3. Comparison of water holding capacity in soil of three habitats.
4. Study of morphological adaptations of hydrophytes and xerophytes (four each).
5. Determination of minimal quadrat size for the study of herbaceous vegetation in the college campus by species area curve method. (species to be listed)
6. Quantitative analysis of herbaceous vegetation in the college campus for frequency and comparison with Raunkiaer's frequency distribution law
7. Study of vegetative and floral characters of the following families (Description, V.S. flower, sectionof ovary, floral diagram/s, floral formula/e and systematic position according to Bentham & Hooker's system of classification): Local available flora.
8. Mounting of a properly dried and pressed specimen of any wild plant with herbarium label (to be submitted in the record book).

Reference Books

1. Kormondy, E.J. (1996). Concepts of Ecology. Prentice Hall, U.S.A. 4th edition.
2. Sharma, P.D. (2010) Ecology and Environment. Rastogi Publications, Meerut, India. 8th edition.
3. Simpson, M.G. (2006). Plant Systematics. Elsevier Academic Press, San Diego, CA, U.S.A. Singh, G. (2012).
4. Plant Systematics: Theory and Practice. Oxford & IBH Pvt. Ltd., New Delhi. 3rd edition.

MINOR COURSE-D

I. MINOR COURSE- MN D:

PLANT ANATOMY & EMBRYOLOGY

Marks: 15 (15 SIE: 1Hr) + 60 (ESE: 3Hrs) = 75	**Pass Marks: Th (SIE + ESE) + Pr (ESE) = 40**

(Credits: Theory-03) **45 Hours**

Course Objectives:

1. The Objective of this paper is to provide basic knowledge of plant internal architecture, cellularcomposition and reproduction.
2. This help them to understand how different plant tissue structure evolve and modify their functions with respect to their environment. Also, to make them awareabout identification, nomenclature and classification.

Course Learning Outcomes:

1. Knowledge regarding anatomy equipped the students to identify different types of tissues andmake them able to correlate their physiology in a better away.
2. This will also help them to understand how different plant tissue evolve and modify their structure and functions with respect to their environment.
3. Knowledge regarding embryology make them understand how reproduction play significant role in defining population structure and natural diversity.
4. Also, after successful completion of the course the student shall have adequate knowledge about thebasic principle and nomenclature of plant classification, herbarium preparation.

Course Content:

Unit 1: Meristematic and permanent tissues **(8 lectures)**

Root and shoot apical meristems; Simple and complex tissues

Unit 2: Organs **(4 lectures)**

Structure of dicot and monocot root stem and leaf.

Unit 3: Secondary Growth **(7 lectures)**

Vascular cambium – structure and function, seasonal activity. Secondary growth in root and stem,Wood (heartwood and sapwood)

Unit 4: Adaptive and protective systems **(6 lectures)**

Epidermis, cuticle, stomata; General account of adaptations in xerophytes and hydrophytes.

Unit 5: Structural organisation of flower **(7 lectures)**

Structure of anther and pollen; Structure and types of ovules; Types of embryo sacs, organisation andultrastructure of mature embryo sac.

Unit 6: Pollination and fertilisation **(7 lectures)**

Pollination mechanisms and adaptations; Double fertilisation; Seed-structure appendages and dispersalmechanisms.

Unit 7: Embryo and endosperm **(4 lectures)**

Endosperm types, structure and functions; Dicot and monocot embryo; Embryo endosperm relationship

Unit 8: Apomixis and polyembryony **(2 lectures)**

Definition, types and Practical applications

Reference Books:

1. Bhojwani, S.S. & Bhatnagar, S.P. (2011). Embryology of Angiosperms. Vikas Publication House Pvt. Ltd New Delhi. 5th edition.
2. Mauseth, J.D. (1988). Plant Anatomy. The Benjamin/Cummings Publisher, USA.

II. MINOR COURSE- MN D PR:
BOTANY MINOR-D PRACTICAL

Marks: Pr (ESE: 6Hrs) = 25	Pass Marks: Pr (ESE) = 10

(Credits: Practicals-01) **30 Hours**

Instructions to Question Setter for

End Semester Examination (ESE):

There will be one Practical Examination of 6Hrs duration. Evaluation of Practical Examination may be as per the following guidelines:

Experiment = 15 marks
Practical record notebook = 05 marks
Viva-voce = 05 marks

Practicals:

1. Study of meristems through permanent slides and photographs.
2. Tissues (parenchyma, collenchyma and sclerenchyma); Macerated xylary elements, Phloem(Permanent slides, photographs)
3. Stem: Monocot: *Zea mays*; Dicot: Helianthus; Secondary: Helianthus (only Permanent slides).
4. Root: Monocot: *Zea mays*; Dicot: Helianthus; Secondary: Helianthus (only Permanent slides).
5. Leaf: Dicot and Monocot leaf (only Permanent slides).
6. Adaptive anatomy: Xerophyte (Nerium leaf); Hydrophyte (Hydrilla stem).
7. Structure of anther (young and mature), tapetum (amoeboid and secretory) (Permanent slides).
8. Types of ovules: anatropous, orthotropous, circinotropous, amphitropous/ campylotropous.
9. Female gametophyte: Polygonum (monosporic) type of Embryo sac Development (Permanent slides/photographs).
10. Ultrastructure of mature egg apparatus cells through electron micrographs.
11. Pollination types and seed dispersal mechanisms (including appendages, aril, caruncle)(Photographs and specimens).
12. Dissection of embryo/endosperm from developing seeds.
13. Calculation of percentage of germinated pollen in a given medium.

Reference Books:

1. Bhojwani, S.S. & Bhatnagar, S.P. (2011). Embryology of Angiosperms. Vikas Publication House Pvt. Ltd. New Delhi. 5th edition.
2. Mauseth, J.D. (1988). Plant Anatomy. The Benjamin/Cummings Publisher, USA.

MINOR COURSE-E

I. MINOR COURSE- MN E:

PLANT PHYSIOLOGY & METABOLISM

Marks: 15 (15 SIE: 1Hr) + 60 (ESE: 3Hrs) = 75	**Pass Marks: Th (SIE + ESE) + Pr (ESE) = 40**

(Credits: Theory-03) **45 Hours**

Course Objectives:

1. The course aims to make students realise how plants function, namely the importance of water, minerals, hormones, and light in plant growth and development.
2. Transport mechanisms and translocation in the phloem, and appreciate the commercial applications of plant physiology.
3. Also, students acquired knowledge about handling of classical and modern plant biotechnology processes, including tissue culture for healthy plants, plants with improved characteristics.

Course Learning Outcomes:

1. The students are able to correlate morphology, anatomy, cell structure and biochemistry with plant functioning.
2. The link between theory and practical syllabus is established, and the employability of youth would be enhanced.
3. The youth can also begin small-scale enterprises.
4. Have the ability of explanation of concepts, principles and usage of the acquired knowledge in biotechnological, pharmaceutical, medical, ecological and agricultural applications.

Course Content:

Unit 1: Plant-water relations **(3 lectures)**

Importance of water, water potential and its components; Transpiration types and its mechanism, significance; Factors affecting transpiration; Root pressure and guttation.

Unit 2: Mineral nutrition **(4 lectures)**

Essential elements, macro and micronutrients; Criteria of essentiality of elements; Role of essential elements; Transport of ions across cell membrane, active and passive transport.

Unit 3: Translocation in phloem **(4 lectures)**

Composition of phloem sap, girdling experiment; Pressure flow model; Mechanism of translocation of Organic solutes.

Unit 4: Photosynthesis **(8 lectures)**

Photosynthetic Pigments (Chla, Chlb, xanthophylls, carotene); Photosystem I and II, reaction center, antenna molecules; Photophosphorylation; C3, C4 and CAM pathways of carbon fixation; Photorespiration.

Unit 5: Respiration **(8 lectures)**

Glycolysis, anaerobic respiration, TCA cycle; Oxidative phosphorylation, Glyoxylate, Oxidative Pentose Phosphate Pathway.

Unit 6: Enzymes **(3 lectures)**

Structure and properties; Mechanism and mode of enzyme action, factors.

Unit 7: Nitrogen metabolism **(4 lectures)**

Biological nitrogen fixation; Nitrate and ammonia assimilation.

Unit 8: Plant growth regulators **(6 lectures)**

Discovery and physiological roles of Auxins, Gibberellins, Cytokinins, ABA, Ethylene.

Unit 9: Plant response to light and temperature **(5 lectures)**

Photoperiodism (SDP, LDP, Day neutral plants); Phytochrome (discovery and structure), red and far red-light responses on photomorphogenesis; Vernalization.

Reference Books:

1. Taiz, L., Zeiger, E., (2010). Plant Physiology. Sinauer Associates Inc., U.S.A. 5th Edition.
2. Hopkins, W.G., Huner, N.P., (2009). Introduction to Plant Physiology. John Wiley & Sons, U.S.A. 4th ed.
3. Bajracharya, D., (1999). Experiments in Plant Physiology- A Laboratory Manual. Narosa Publishing House, New Delhi.
4. Bhojwani, S.S. and Razdan, M.K., (1996). Plant Tissue Culture: Theory and Practice. Elsevier Science Amsterdam. The Netherlands.
5. Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington.

II. MINOR COURSE- MN E PR:
BOTANY MINOR-E PRACTICAL

Marks: Pr (ESE: 6Hrs) = 25	Pass Marks: Pr (ESE) = 10

(Credits: Practicals-01) **30 Hours**

Instructions to Question Setter for
End Semester Examination (ESE):
There will be one Practical Examination of 6Hrs duration. Evaluation of Practical Examination may be as per the following guidelines:
Experiment = 15 marks
Practical record notebook = 05 marks
Viva-voce = 05 marks

Practicals:

1. Determination of osmotic potential of plant cell sap by plasmolytic method.
2. Measurement of rate of transpiration; Farmers photometer/Ganogs photometer.
3. Calculation of stomatal index and stomatal frequency of a mesophyte and a xerophyte.
4. Demonstration of Hill reaction.
5. To study the effect of light intensity and bicarbonate concentration on O_2 evolution inphotosynthesis.
6. Separation of amino acids / pigments by paper chromatography.
7. To determine the absorption of water by Oily and starchy seed.

Demonstration experiments

1. Effect of auxins on rooting.
2. Suction due to transpiration.
3. R.Q.
4. Respiration in roots.

Reference Books:

1. Taiz, L., Zeiger, E., MØller, I.M. and Murphy, A (2015). Plant Physiology and Development. SinauerAssociates Inc. USA. 6th edition.
2. Hopkins, W.G., Huner, N.P., (2009). Introduction to Plant Physiology. John Wiley & Sons, U.S.A. 4thEdition.
3. Bajracharya, D., (1999). Experiments in Plant Physiology- A Laboratory Manual. Narosa PublishingHouse, New Delhi..

MINOR COURSE-F

I. MINOR COURSE- MN F:
CYTOGENETICS AND MOLECULAR BIOLOGY

Marks: 15 (15 SIE: 1Hr) + 60 (ESE: 3Hrs) = 75	Pass Marks: Th (SIE + ESE) + Pr (ESE) = 40

(Credits: Theory-03) **45 Hours**

Course Objectives:

1. To understand the principles and applications of cytogenetics and molecular biology in plant systems.
2. To analyse chromosomal behavior, genetic inheritance, and gene expression mechanisms.
3. To develop technical skills in cytological and molecular lab techniques.

Course Learning Outcomes:

1. Explain the structure, function, and behaviour of chromosomes.
2. Understand molecular processes such as replication, transcription, and translation.
3. Interpret gene regulation and genome organisation.
4. Perform basic cytological and molecular biology experiments.
5. Analyse and interpret experimental results using appropriate tools.

Course Content:

Unit I: Chromosome Biology and Cytogenetics (12 lectures)

Structure and types of chromosomes; Chromosome banding, karyotyping, idiogram construction; Chromosomal aberrations: structural (deletions, duplications, inversions, translocations) and numerical (aneuploidy, polyploidy); Sex determination mechanisms in plants and animals; Techniques: Microscopy, squash techniques, C-mitosis, colchicine-induced polyploidy.

Unit II: Molecular Structure of Genes and Genomes (10 lectures)

DNA structure and properties: A, B, Z forms; DNA replication in prokaryotes and eukaryotes; RNA types and functions; Structure of eukaryotic genes, operon model (lac, trp); Transposable elements in prokaryotes and plants.

Unit III: Gene Expression and Regulation (12 lectures)

Transcription and post-transcriptional modifications; Translation and post-translational processing; Regulation of gene expression in prokaryotes and eukaryotes; Small RNAs: siRNA, miRNA, RNAi; Epigenetics: DNA methylation and histone modification

Unit IV: Tools and Applications in Molecular Biology (11 lectures)

DNA fingerprinting and barcoding; PCR and its types (RT-PCR, qPCR); Gel electrophoresis (agarose and PAGE); Vectors and cloning methods (plasmid, cosmids, BACs, YACs); Overview of CRISPR/Cas gene editing; Genomics and transcriptomics (basic concepts)

Reference Books

1. Ram J. Singh – Plant Cytogenetics (CRC Press)
2. C.L. Darlington – Recent Advances in Cytology
3. Sharma & Sharma – Plant Chromosomes: Analysis, Manipulation and Engineering
4. David Freifelder – Molecular Biology
5. Alberts et al. – Molecular Biology of the Cell (Garland Science)
6. Watson et al. – Molecular Biology of the Gene (Pearson)
7. Glick & Pasternak – Molecular Biotechnology

II. MINOR COURSE- MN F PR:
BOTANY MINOR-F PRACTICAL

Marks: Pr (ESE: 6Hrs) = 25	Pass Marks: Pr (ESE) = 10

(Credits: Practicals-01) **30 Hours**

Instruction to Question Setter for
End Semester Examination (ESE):
There will be one Practical Examination of 6Hrs duration. Evaluation of the Practical Examination may be as per the following guidelines:

Experiment	*= 15 marks*
Practical record notebook	*= 05 marks*
Viva-voce	*= 05 marks*

Practicals:

1. Preparation of mitotic and meiotic chromosomes (onion root tip, grasshopper testis)
2. Karyotype analysis and chromosome counting
3. Colchicine treatment and polyploidy observation
4. DNA extraction from plant tissues
5. RNA extraction from leaves or seedlings
6. Agarose gel electrophoresis of DNA
7. PCR amplification using gene-specific primers
8. Restriction digestion and fragment analysis
9. Observation of chromosomal aberrations in slides (prepared/permanent)
10. Quantification of nucleic acids using spectrophotometry

Reference Books:

1. Sambrook & Russell – *Molecular Cloning: A Laboratory Manual*
2. K. Wilson & J. Walker – *Principles and Techniques of Biochemistry and Molecular Biology*

MINOR COURSE-G

I. MINOR COURSE- MN G:
PLANT BIOTECHNOLOGY

Marks: 15 (15 SIE: 1Hr) + 60 (ESE: 3Hrs) = 75	Pass Marks: Th (SIE + ESE) + Pr (ESE) = 40

(Credits: Theory-03) **45 Hours**

Course Objectives:

1. To provide an in-depth understanding of plant biotechnology tools and their application in crop improvement.
2. To equip students with practical skills in plant tissue culture, genetic engineering, and molecular diagnostics.
3. To build capacity for innovation in agriculture, bioresource conservation, and sustainable development.

Course Learning Outcomes:

1. Explain the principles and techniques of plant tissue culture and genetic transformation.
2. Apply biotechnological tools for crop improvement and trait enhancement.
3. Perform standard experiments in plant biotechnology laboratories.
4. Evaluate ethical, regulatory, and biosafety issues related to GM crops and biotechnology products.

Course Content:

Unit I: Plant Tissue Culture and Micropropagation (12 lectures)

Historical perspective and scope; Totipotency and cellular differentiation; MS media composition and modifications; Callus induction, organogenesis, and somatic embryogenesis; Micropropagation stages and commercial applications; Somaclonal variation and synthetic seed technology

Unit II: Genetic Engineering and Gene Transfer (11 lectures)

Gene cloning: Vectors (plasmid, Ti, binary vectors); Gene transfer techniques: *Agrobacterium*-mediated, particle bombardment, electroporation, PEG; Selection markers and reporter genes; Confirmation of transformants (PCR, GUS assay); Promoters and gene constructs for plant expression

Unit III: Molecular Tools and Crop Improvement (11 lectures)

DNA markers: RFLP, RAPD, SSR, SNP; Marker-assisted selection (MAS); Transgenic crops: Bt cotton, Golden Rice, virus-resistant papaya; Gene pyramiding for stress tolerance; Genome editing: CRISPR/Cas, TALEN, ZFN (introductory concepts)

Unit IV: Applications, Biosafety and IPR (11 lectures)

Plant biotechnology in pharmaceuticals and nutraceuticals; Biotic/abiotic stress resistance via biotechnology; GMOs: Risks, benefits, and regulatory framework (India & global); Biosafety levels and risk assessment; Intellectual Property Rights (IPR), patents, and bioethics

Reference Books

1. Bhojwani, S.S. & Razdan, M.K. – *Plant Tissue Culture: Theory and Practice*
2. Slater, A., Scott, N., & Fowler, M. – *Plant Biotechnology: The Genetic Manipulation of Plants*
3. Chawla, H.S. – *Introduction to Plant Biotechnology*
4. Glick, B.R., & Pasternak, J.J. – *Molecular Biotechnology: Principles and Applications of Recombinant DNA*
5. Singh, B.D. – *Biotechnology: Expanding Horizons*
6. Gamborg & Phillips – *Plant Cell, Tissue and Organ Culture*
7. Sambrook & Russell – *Molecular Cloning: A Laboratory Manual*
8. Chrispeels & Sadava – *Plants, Genes, and Crop Biotechnology*
9. FAO/Biosafety documents on GMO regulation.

II. MINOR COURSE- MN G PR:
BOTANY MINOR-G PRACTICAL

Marks: Pr (ESE: 6Hrs) = 25	Pass Marks: Pr (ESE) = 10

(Credits: Practicals-01) **30 Hours**

Instruction to Question Setter for

End Semester Examination (ESE):

There will be one Practical Examination of 6Hrs duration. Evaluation of Practical Examination may be as per the following guidelines:

Experiment = 15 marks
Practical record notebook = 05 marks
Viva-voce = 05 marks

Practicals:

1. Preparation of MS medium and media sterilization
2. Explant sterilization and inoculation (leaf/shoot/root)
3. Callus induction and sub-culturing
4. Shoot and root regeneration
5. Somatic embryogenesis and synthetic seed preparation
6. Agrobacterium-mediated transformation (demonstration)
7. DNA isolation and quantification (spectrophotometric and gel-based)
8. PCR amplification of plant DNA
9. GUS or GFP reporter assay (demo or virtual)
10. RAPD/SSR marker analysis (optional/demo)
11. Field visit to biotech lab/industry or gene bank facility

Reference Books:

1. **Brown, T. A.** - *Gene Cloning and DNA Analysis: An Introduction*
2. **Razdan, M. K.** - *Introduction to Plant Tissue Culture*
3. **Gupta, P. K.** - *Elements of Biotechnology*
4. **Pattnaik, S., & Mandal, B. B.** - *Laboratory Manual of Plant Biotechnology*
5. Practical Protocols from NPTEL / DBT / ICAR Manuals
