ST. JOSEPH'S COLLEGE (AUTONOMOUS), DEVAGIRI

B.Sc. BOTANY HONOURS (MAJOR, MINOR AND GENERAL FOUNDATION COURSES)

SYLLABUS & MODEL QUESTION PAPERS
w.e.f. 2024 admission onwards

(FYUGP Regulations 2024)

B.Sc. BOTANY HONOURS
(MAJOR, MINOR AND GENERAL FOUNDATION COURSES)

SYLLABUS

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PREFACE

The educational landscape in Kerala is undergoing a significant transformation with the introduction of the Four-Year Undergraduate Programme (FYUGP). This initiative is aligned with global educational standards and aims to provide students with an extensive and in-depth learning experience.

In conjunction with the introduction of the FYUGP, the syllabus for the Botany program is being meticulously restructured. This restructuring aims to align the curriculum with contemporary scientific advancements and societal needs. The revised syllabus is designed to provide a deep understanding of plant sciences, combining traditional knowledge with modern research and technology.

The curriculum begins with fundamental concepts and advances to complex topics. Students will explore various plant groups; explore their evolutionary significance, structural complexities, and ecological roles. Incorporating modern scientific advancements, the syllabus introduces Artificial intelligence in Plant Science, genomics, transcriptomics, proteomics, and metabolomics, equipping students to integrate multi-omics datasets, enhancing their understanding of plant biology and preparing them for research in applied Plant Science.

Critical aspects of applied Botany are covered, including plant breeding techniques, intellectual property rights in crop improvement, and integrated pest management strategies. Ecological and environmental implications of plant science are explored, including geobotanical principles, remote sensing, GIS technology, and sustainability challenges. Practical skills are emphasized through laboratory exercises on all topics, reinforcing theoretical knowledge, developing critical thinking and problem-solving skills to meet industrial needs.

In conclusion the syllabus aims to cultivate a thorough understanding of plant biology, integrating conventional knowledge with contemporary scientific advancements. These updates are expected to enhance academic standards and equip students with the skills needed to excel in their future endeavours, whether as professionals or entrepreneurs, contributing positively to the scientific community and society at large.

SYLLABUS INDEX

CORE COURSES IN MAJOR

ELECTIVE COURSES IN MAJOR

MINOR COURSES

VOCATIONAL MINOR COURSES

GENERAL FOUNDATION COURSES

PROGRAMME OUTCOMES (POs)

At the end of the graduate programme at Calicut University, a student would:

PO1	**Knowledge Acquisition:** Demonstrate a profound understanding of knowledge trends and their impact on the chosen discipline of study.
PO2	**Communication, Collaboration, Inclusiveness, and Leadership:** Become a team player who drives positive change through effective communication, collaborative acumen, transformative leadership, and a dedication to inclusivity.
PO3	**Professional Skills:** Demonstrate professional skills to navigate diverse career paths with confidence and adaptability.
PO4	**Digital Intelligence:** Demonstrate proficiency in varied digital and technological tools to understand and interact with the digital world, thus effectively processing complex information.
PO5	**Scientific Awareness and Critical Thinking:** Emerge as an innovative problem-solver and impactful mediator, applying scientific understanding and critical thinking to address challenges and advance sustainable solutions.
PO6	**Human Values, Professional Ethics, and Societal and Environmental Responsibility:** Become a responsible leader, characterized by an unwavering commitment to human values, ethical conduct, and a fervent dedication to the well-being of society and the environment.
PO7	**Research, Innovation, and Entrepreneurship:** Emerge as a researcher and entrepreneurial leader, forging collaborative partnerships with industry, academia, and communities to contribute enduring solutions for local, regional, and global development.

PROGRAMME SPECIFIC OUTCOMES (PSOs)

At the end of the B. Sc. Botany Honours programme at Calicut University, a student would

PSO1	Understand and articulate fundamental concepts in botany, the role of plants in aesthetics, the range of plant diversity, biosafety, and intellectual property rights, thereby establishing a foundational knowledge of plant science conducive to subsequent study and research.
PSO2	Appreciate nature, and become socially responsible citizens by using the acquired knowledge to help conserve environment
PSO3	Critically Analyse and Apply botanical knowledge to address real-world issues, employing practical skills in Plant Sciences for personal, professional, environmental, and societal benefits, while developing a research-oriented mindset in related fields.
PSO4	Evaluate the validity and reliability of scientific evidence in botany, critically assessing research methods and conclusions in plant science studies, and effectively communicate botany-related concepts, research findings, and scientific information.
PSO5	Design, Conduct, and Analyse experiments using appropriate techniques and tools in the field of botany, while integrating information from various disciplines within and related to botany, such as bioinformatics, nanoscience, biotechnology, forensic botany, and artificial intelligence.
PSO6	Develop innovative solutions for conservation and sustainable plant resource management, bioprospecting, and sustainable agriculture using principles of plant science, while demonstrating creativity and entrepreneurial skills through project design and implementation.

MINIMUM CREDIT REQUIREMENTS OF THE DIFFERENT PATHWAYS
IN THE THREE-YEAR PROGRAMME IN CUFYUGP

<table>
<tr><th rowspan="3">Sl. No</th><th rowspan="3">Academic Pathway</th><th>Major</th><th>Minor/ Other Disciplines</th><th rowspan="2">Foundation Courses
AEC: 4
MDC: 3
SEC: 3
VAC: 3</th><th rowspan="3">Intern-ship</th><th rowspan="3">Total Credits</th><th rowspan="3">Example</th></tr>
<tr><td colspan="2" rowspan="2">Each course has 4 credits</td></tr>
<tr><td>Each course has 3 credits</td></tr>
<tr><td>1</td><td>Single Major (A)</td><td>68 (17 courses)</td><td>24 (6 courses)</td><td>39 (13 courses)</td><td>2</td><td>133</td><td>Major: Botany + six courses in different disciplines in different combinations</td></tr>
<tr><td>2</td><td>Major (A) with Multiple Disciplines (B, C)</td><td>68 (17 courses)</td><td>12 + 12 (3 + 3 = 6 courses)</td><td>39 (13 courses)</td><td>2</td><td>133</td><td>Major: Botany + Chemistry and Zoology</td></tr>
<tr><td>3</td><td>Major (A) with Minor (B)</td><td>68 (17 courses)</td><td>24 (6 courses)</td><td>39 (13 courses)</td><td>2</td><td>133</td><td>Major: Botany
Minor: Chemistry</td></tr>
<tr><td>4</td><td>Major (A) with Vocational Minor (B)</td><td>68 (17 courses)</td><td>24 (6 courses)</td><td>39 (13 courses)</td><td>2</td><td>133</td><td>Major: Botany
Minor: Computational Biology</td></tr>
<tr><td rowspan="2">5</td><td rowspan="2">Double Major (A, B)</td><td rowspan="2">A: 48 (12 courses)

B: 44 (11 courses)</td><td>-</td><td>12 + 18 + 9</td><td>2</td><td rowspan="2">133</td><td rowspan="2">Botany and Zoology double major</td></tr>
<tr><td colspan="3">The 24 credits in the Minor stream are distributed between the two Majors.
2 MDC, 2 SEC, 2 VAC and the Internship should be in Major A. Total credits in Major A should be 48 + 20 = 68 (50% of 133)
1 MDC, 1 SEC and 1 VAC should be in Major B. Total credits in Major B should be 44 + 9 = 53 (40% of 133)</td></tr>
<tr><td colspan="8">Exit with UG Degree / Proceed to Fourth Year with 133 Credits</td></tr>
</table>

B.Sc. BOTANY HONOURS PROGRAMME

COURSE STRUCTURE FOR PATHWAYS 1 – 4

1. Single Major
2. Major with Multiple Disciplines
3. Major with Minor
4. Major with Vocational Minor

Semester	Course Code	Course Title	Total Hours	Hours/ Week	Credits	Marks		
						Internal	External	Total
1	BOT1CJ 101/ BOT1MN100	Core Course 1 in Major **Aesthetic Botany**	75	5	4	30	70	100
		Minor Course 1	60/ 75	4/ 5	4	30	70	100
		Minor Course 2	60/ 75	4/ 5	4	30	70	100
	ENG1FA 101(2)	Ability Enhancement Course 1 English	60	4	3	25	50	75
		Ability Enhancement Course 2 Additional Language	45	3	3	25	50	75
		Multi-Disciplinary Course 1 Other than Major	45	3	3	25	50	75
		Total		**23/ 25**	**21**			**525**
2	BOT2CJ 101/ BOT2MN100	Core Course 2 in Major **Microbial Diversity & Phyto -Pathology**	75	5	4	30	70	100
		Minor Course 3	60/ 75	4/ 5	4	30	70	100
		Minor Course 4	60/ 75	4/ 5	4	30	70	100
	ENG2FA 103(2)	Ability Enhancement Course 3 English	60	4	3	25	50	75
		Ability Enhancement Course 4 Additional Language	45	3	3	25	50	75
		Multi-Disciplinary Course 2 Other than Major	45	3	3	25	50	75
		Total		**23/ 25**	**21**			**525**
3	BOT3CJ 201	Core Course 3 in Major **Plant Embryology, Palynology & Evolution**	60	4	4	30	70	100
	BOT3CJ 202/ BOT3MN200	Core Course 4 in Major **Plant Anatomy & Analytical techniques**	75	5	4	30	70	100
		Minor Course 5	60/ 75	4/ 5	4	30	70	100

		Minor Course 6	60/ 75	4/ 5	4	30	70	100
		Multi-Disciplinary Course 3 Kerala Knowledge System	45	3	3	25	50	75
	ENG3FV 108(2)	Value-Added Course 1 English	45	3	3	25	50	75
		Total		**23/ 25**	**22**			**550**
4	BOT4CJ 203	Core Course 5 in Major **Plant Diversity I**	75	5	4	30	70	100
	BOT4CJ 204	Core Course 6 in Major **Phytochemistry & Pharmacognosy**	75	5	4	30	70	100
	BOT4CJ 205	Core Course 7 in Major **Cell & Molecular Biology**	75	5	4	30	70	100
	ENG4FV 109(2)	Value - Added Course 2 English	45	3	3	25	50	75
		Value-Added Course 3 Additional Language	45	3	3	25	50	75
	ENG4FS 111(2)	Skill Enhancement Course 1 English	60	4	3	25	50	75
		Total		**25**	**21**			**525**
5	BOT5CJ 301	Core Course 8 in Major **Plant Diversity II**	75	5	4	30	70	100
	BOT5CJ 302	Core Course 9 in Major **Angiosperm Morphology, Systematics & Plant Resources**	75	5	4	30	70	100
	BOT5CJ 303	Core Course 10 in Major **Genetics, Plant Breeding & Palaeobotany**	60	4	4	30	70	100
		Elective Course 1 in Major	60	4	4	30	70	100
		Elective Course 2 in Major	60	4	4	30	70	100
		Skill Enhancement Course 2	45	3	3	25	50	75
		Total		**25**	**23**			**575**
6	BOT6CJ 304/ BOT8M N304	Core Course 11 in Major **Plant Physiology & Metabolism**	75	5	4	30	70	100
	BOT6CJ 305/ BOT8M N305	Core Course 12 in Major **Plant Biotechnology, Nanotechnology & Bioinformatics**	75	5	4	30	70	100

	BOT6CJ 306/ BOT8M N306	Core Course 13 in Major **Environmental Science & Phytogeography**		60	4	4	30	70	100
		Elective Course 3 in Major		60	4	4	30	70	100
		Elective Course 4 in Major		60	4	4	30	70	100
	BOT6FS 113 (1)	Skill Enhancement Course 3 - **Phytochemical Techniques**	Any one	45	3	3	25	50	75
	BOT6FS 113 (2)	**Essential Oils & Perfumery**							
	BOT6FS 113 (3)	**Seaweed Farming**							
	BOT6CJ 349	Internship in Major (Credit for internship to be awarded only at the end of Semester 6)		60		2	50	-	50
		Total			**25**	**25**			**625**
Total Credits for Three Years						**133**			**3325**
7	BOT7CJ 401	Core Course 14 in Major **Advances in Microbiology & Thallophytes**		75	5	4	30	70	100
	BOT7CJ 402	Core Course 15 in Major **Advances in Archegoniates**		75	5	4	30	70	100
	BOT7CJ 403	Core Course 16 in Major **Advanced Plant Systematics**		75	5	4	30	70	100
	BOT7CJ 404	Core Course 17 in Major **Advanced Cell & Molecular Biology**		75	5	4	30	70	100
	BOT7CJ 405	Core Course 18 in Major **Multi-omics Approach in Biology**		75	5	4	30	70	100
		Total			**25**	**20**			**500**
8	BOT8CJ 406 / BOT8M N406	Core Course 19 in Major **Geobotanical Mapping & Sustainable Development**		75	5	4	30	70	100
	BOT8CJ 407 / BOT8M N407/	Core Course 20 in Major- **Crop Improvement & Plant Pathology**		60	4	4	30	70	100

	BOT8CJ 408 / BOT8MN408/ BOT8VN302	Core Course 21 in Major- **Smart Farming**	60	4	4	30	70	100
	OR (instead of Core Courses 19-21 in Major)							
	BOT8CJ 449	Project (in Honours programme)	360	13	12	90	210	300
	BOT8CJ 499	Project (in Honours with Research programme)	360	13	12	90	210	300
		Elective Course 5 in Major / Minor Course 7	60	4	4	30	70	100
		Elective Course 6 in Major / Minor Course 8	60	4	4	30	70	100
		Elective Course 7 in Major / Minor Course 9 / Major Course in any Other Discipline	60	4	4	30	70	100
	OR (instead of Elective Course 7 in Major, in the case of Honours with Research Programme)							
	BOT8CJ 489	**Research Methodology in Botany**	60	4	4	30	70	100
		Total		**25**	**24**			**600**
Total Credits for Four Years					**177**			**4425**

The teacher should have 13hrs/week of engagement (the hours corresponding to the three core courses) in the guidance of the Project(s) in Honours programme and Honours with Research programme, while each student should have 24 hrs/week of engagement in the Project work. Total hours are given based on the student‘s engagement.

CREDIT DISTRIBUTION FOR PATHWAYS 1 – 4

1. Single Major
2. Major with Multiple Disciplines
3. Major with Minor
4. Major with Vocational Minor

Semester	Major Courses	Minor Courses	General Foundation Courses	Internship/ Project	Total
1	4	4 + 4	3 + 3 + 3	-	21
2	4	4 + 4	3 + 3 + 3	-	21
3	4 + 4	4 + 4	3 + 3	-	22
4	4 + 4 + 4	-	3 + 3 + 3	-	21
5	4 + 4 + 4 + 4 + 4	-	3	-	23
6	4 + 4 + 4 + 4 + 4	-	3	2	25
Total for Three Years	**68**	**24**	**39**	**2**	**133**
7	4 + 4 + 4 + 4 + 4	-	-	-	20
8	4 + 4 + 4	4 + 4 + 4	-	12*	24
*Instead of three Major courses					
Total for Four Years	**88 + 12 = 100**	**36**	**39**	**2**	**177**

DISTRIBUTION OF MAJOR COURSES IN BOTANY FOR PATHWAYS 1 – 4

1. Single Major
2. Major with Multiple Disciplines
3. Major with Minor
4. Major with Vocational Minor

Semester	Course Code	Course Title	Hours/ Week	Credits
1	BOT1CJ101 / BOT1MN100	Core Course 1 in Major - **Aesthetic Botany**	5	4
2	BOT2CJ101 / BOT2MN100	Core Course 2 in Major - **Microbial Diversity & Phyto Pathology**	5	4
3	BOT3CJ201	Core Course 3 in Major - **Plant Embryology, Palynology & Evolution**	4	4
	BOT3CJ202 /	Core Course 4 in Major -	5	4

	BOT3MN200	**Plant Anatomy & Analytical Techniques**		
4	BOT4CJ203	Core Course 5 in Major – **Plant Diversity I**	5	4
	BOT4CJ204	Core Course 6 in Major - **Phytochemistry & Pharmacognosy**	5	4
	BOT4CJ205	Core Course 7 in Major - **Cell & Molecular Biology**	5	4
5	BOT5CJ301	Core Course 8 in Major - **Plant Diversity II**	5	4
	BOT5CJ302	Core Course 9 in Major - **Angiosperm Morphology, Systematics & Plant Resources**	5	4
	BOT5CJ303	Core Course 10 in Major - **Genetics, Plant Breeding & Palaeobotany**	4	4
		Elective Course 1 in Major	4	4
		Elective Course 2 in Major	4	4
6	BOT6CJ304 / BOT8MN304	Core Course 11 in Major - **Plant Physiology & Metabolism**	5	4
	BOT6CJ305 / BOT8MN305	Core Course 12 in Major - **Plant Biotechnology, Nanotechnology & Bioinformatics**	5	4
	BOT6CJ306 / BOT8MN306	Core Course 13 in Major- **Environmental Science & Phytogeography**	4	4
		Elective Course 3 in Major	4	4
		Elective Course 4 in Major	4	4
	BOT6CJ349	Internship in Major	-	2
Total for the Three Years				**70**
7	BOT7CJ401	Core Course 14 in Major- **Advances in Microbiology & Thallophytes**	5	4
	BOT7CJ402	Core Course 15 in Major- **Advances in Archegoniates**	5	4
	BOT7CJ403	Core Course 16 in Major- **Advanced Plant Systematics**	5	4
	BOT7CJ404	Core Course 17 in Major-	5	4

		Advanced Cell & Molecular Biology		
	BOT7CJ405	Core Course 18 in Major- **Multi-omics Approach in Biology**	5	4
8	BOT8CJ406 / BOT8MN406	Core Course 19 in Major- **Geobotanical Mapping & Sustainable Development**	5	4
	BOT8CJ407 / BOT8MN407	Core Course 20 in Major- **Crop Improvement & Plant Pathology**	4	4
	BOT8CJ408 / BOT8MN408/ BOT8VN302/	Core Course 21 in Major- **Smart Farming**	4	4
	OR (instead of Core Courses 19-21 in Major)			
	BOT8CJ449	Project (Honours programme)	13	12
	BOT8CJ499	Project (Honours with Research programme)	13	12
		Elective Course 5 in Major	4	4
		Elective Course 6 in Major	4	4
		Elective Course 7 in Major	4	4
	OR (instead of Elective course 7 in Major, in Honours with Research programme)			
	BOT8CJ489	**Research Methodology in Botany**	4	4
Total for the Four Years				**114**

ELECTIVE COURSES IN BOTANY WITH SPECIALISATION

Group No.	Sl. No.	Course Code	Title	Semester	Total Hrs	Hrs/ Week	Credits	Marks		
								Internal	External	Total
1		**CONSERVATION BIOLOGY**								
	1	BOT5EJ301(1)	**Conservation Biology**	5	60	4	4	30	70	100
	2	BOT5EJ302(1)	**Environmental Monitoring & Disaster Management**	5	60	4	4	30	70	100
	3	BOT6EJ301(1)	**Climate Change & Ecosystem Management**	6	60	4	4	30	70	100
	4	BOT6EJ302(1)	**Invasive Plant Ecology**	6	60	4	4	30	70	100
2		**PLANT RESOURCE UTILISATION**								
	1	BOT5EJ303(2)	**Plant Resource Utilisation & Bioprospecting**	5	60	4	4	30	70	100
	2	BOT5EJ304(2)	**Indigenous Plant Science & Forestry**	5	60	4	4	30	70	100
	3	BOT6EJ303(2)	**Plant Nanotechnology**	6	60	4	4	30	70	100
	4	BOT6EJ304(2)	**Botanical Entrepreneurship**	6	60	4	4	30	70	100

ELECTIVE COURSES IN BOTANY WITH NO SPECIALISATION

Sl. No.	Course Code	Title	Semester	Total Hrs	Hrs/ Week	Credits	Marks		
							Internal	External	Total
1	BOT5EJ305	**Plantation Science & Wood Technology**	5	60	4	4	30	70	100
2	BOT6EJ305	**Forensic Botany**	6	60	4	4	30	70	100
3	BOT8EJ401/ BOT8VN301	**Artificial Intelligence in Plant Science**	8	60	4	4	30	70	100
4	BOT8EJ402	**Computational Biology & Data Analysis**	8	60	4	4	30	70	100
5	BOT8EJ403	**Industrial Biotechnology & Plant Genetic Engineering**	8	60	4	4	30	70	100
6	BOT8EJ404	**Angiosperm Anatomy, Developmental Botany & Palynology**	8	60	4	4	30	70	100
7	BOT8EJ405	**Advanced Plant Physiology & Metabolism**	8	60	4	4	30	70	100
8	BOT8EJ406	**Genetics & Cancer Biology**	8	60	4	4	30	70	100
9	BOT8EJ407	**Instrumentation Biology**	8	60	4	4	30	70	100
10	BOT8EJ408	**Biosafety, IPR & Patenting**	8	60	4	4	30	70	100

GROUPING OF MINOR COURSES IN BOTANY

(Title of the Minor: **GENERAL BOTANY)**

The minor courses listed below are not to be offered for Botany Major students, they are intended for students in other major disciplines only

Group No.	Sl. No	Course Code	Title	Semester	Total Hrs	Hrs/ Week	Credits	Marks		
								Internal	External	Total
1	**BOTANICAL DIVERSITY**									
	1	BOT1MN101	**Plant Ecology, Conservation & Plant Interactions**	1	75	5	4	30	70	100
	2	BOT2MN101	**Plant Morphology, Physiology & Plant Resources**	2	75	5	4	30	70	100
	3	BOT3MN201	**Plant Diversity & Angiosperm Taxonomy**	3	75	5	4	30	70	100
2	**INDUSTRIAL BOTANY**									
	1	BOT1MN102	**Phytochemistry**	1	75	5	4	30	70	100
	2	BOT2MN102	**Secondary Metabolites & Biofuels**	2	75	5	4	30	70	100
	3	BOT3MN202	**Essential oils of Aromatic Plants**	3	75	5	4	30	70	100
3	**PLANTS IN HUMAN WELLNESS**									
	1	BOT1MN103	**Economic Botany**	1	75	5	4	30	70	100
	2	BOT2MN103	**Plant Nutraceuticals**	2	75	5	4	30	70	100
	3	BOT3MN203	**Ethnobotany**	3	75	5	4	30	70	100
4	**AESTHETIC BOTANY** (This group can be offered to students who choose a Major with a Minor in Botany pathway, especially in colleges where there is insufficient workload for a second minor.)									
	1	BOT1CJ101/ BOT1MN100	**Aesthetic Botany**	1	75	5	4	30	70	100
	2	BOT2CJ101 / BOT2MN100	**Microbial Diversity & Phyto-Pathology**	2	75	5	4	30	70	100
	3	BOT3CJ202 / BOT3MN200	**Plant Anatomy & Analytical Techniques**	3	75	5	4	30	70	100

GROUPING OF VOCATIONAL MINOR COURSES IN BOTANY

(Title of the Vocational Minor: **VOCATIONAL BOTANY)**

Group No.	Sl. No.	Course Code	Title	Semester	Total Hrs	Hrs/ Week	Credits	Marks		
								Internal	External	Total
1		**COMPUTATIONAL BOTANY**								
	1	BOT1VN101	**Computational Botany**	1	75	5	4	30	70	100
	2	BOT2VN101	**Biostatistics**	2	75	5	4	30	70	100
	3	BOT3VN201	**Bioinformatics**	3	75	5	4	30	70	100
	4	BOT8VN301/ BOT8EJ401	**Artificial Intelligence in Plant Science**	8	60	4	4	30	70	100
2		**HORTICULTURE TECHNIQUES**								
	1	BOT1VN102	**Horticulture & Nursery Management**	1	75	5	4	30	70	100
	2	BOT2VN102	**Plant Propagation Techniques**	2	75	5	4	30	70	100
	3	BOT3VN202	**Biofertilizer Technology**	3	75	5	4	30	70	100
	4	BOT8VN302 /BOT8CJ408	**Smart Farming**	8	60	4	4	30	70	100

(i) Students in Single Major pathway can choose course/courses from any of the Minor/ Vocational Minor groups offered by a discipline other than their Major discipline.

(ii) Students in Major with Multiple Disciplines pathway can choose all the three courses from any one of the Minor/ Vocational Minor groups offered by any discipline, other than his Major discipline as one of the multiple disciplines.

(iii) Students in Major with Minor pathway can choose all the courses from any two Minor groups offered by any discipline.

(iv) Students in Major with Vocational Minor pathway can choose all the courses from any two Vocational Minor groups offered by any discipline. The title of the Vocational Minor will be **Vocational Botany**

DISTRIBUTION OF GENERAL FOUNDATION COURSES IN BOTANY

Semester	Course Code	Course Title		Total Hours	Hours/ Week	Credits	Marks		
							Internal	External	Total
1	BOT1FM105 (1)	Multi-Disciplinary Course 1 - **Incredible Plant Kingdom**	Any one	45	3	3	25	50	75
	BOT1FM105 (2)	**Plant Propagation**							
2	BOT2FM106 (1)	Multi-Disciplinary Course 2 - **Ecosystem Diversity in India**	Any one	45	3	3	25	50	75
	BOT2FM106 (2)	**Plants in Everyday Life**							
3	BOT3FV108	Value-Added Course 1 -**Biodiversity & Conservation**		45	3	3	25	50	75
4	BOT4FV110	Value-Added Course 2 - **Environment & Climate Change**		45	3	3	25	50	75
5	BOT5FS112 (1)	Skill Enhancement Course 2 -**Herbal Technology**	Any one	45	3	3	25	50	75
	BOT5FS112 (2)	**Landscaping and Gardening**							
6	BOT6FS113 (1)	Skill Enhancement Course 3 - **Phytochemical Techniques**	Any one	45	3	3	25	50	75
	BOT6FS113 (2)	**Essential Oils & Perfumery**							
	BOT6FS113 (3)	**Seaweed Farming**							

COURSE STRUCTURE FOR BATCH A1 (B2)

IN PATHWAY 5: DOUBLE MAJOR

A1: 68 credits in Botany (Major A) ***B1: 68 credits in Major B***

A2: 53 credits in Botany (Major A) ***B2: 53 credits in Major B***

The combinations available to the students: (A1 & B2), (B1 & A2)

Note: Unless the batch is specified, the course is for all the students of the class

Semester	Course Code	Course Title		Total Hours	Hours/ Week	Credits	Marks		
							Internal	External	Total
1	BOT1CJ101 / BOT1MN100	Core Course 1 in Major Botany- **Aesthetic Botany**		75	5	4	30	70	100
	BBB1CJ101	Core Course 1 in Major B -		60/ 75	4/ 5	4	30	70	100
	BOT1CJ102 / BOT4CJ203*	Core Course 2 in Major Botany - **Plant Diversity I**		75	5	4	30	70	100
	ENG1FA101(2)	Ability Enhancement Course 1 - English		60	4	3	25	50	75
		Ability Enhancement Course 2 -Additional Language		45	3	3	25	50	75
	BOT1FM105 (1)	Multi-Disciplinary Course 1 –**Incredible Plant Kingdom**	Any one	45	3	3	25	50	75
	BOT1FM105 (2)	**Plant Propagation**							
		Total			**24/ 25**	**21**			**525**
2	BOT2CJ101 / BOT2MN100	Core Course 3 in Major Botany - **Microbial Diversity & Phyto Pathology**		75	5	4	30	70	100
	BBB2CJ101	Core Course 2 in Major B		60/ 75	4/ 5	4	30	70	100
	BBB2CJ102 / BBB1CJ102	Core Course 3 in Major B (for batch B2 only)		60/ 75	4/ 5	4	30	70	100

	ENG2FA103(2)	Ability Enhancement Course 3 - English		60	4	3	25	50	75
		Ability Enhancement Course 4 - Additional Language		45	3	3	25	50	75
	BOT2FM106 (1)	Multi-Disciplinary Course 2 - **Ecosystem Diversity in India**	Any one	45	3	3	25	50	75
	BOT2FM106 (2)	**Plants in Everyday Life**							
		Total			**23 – 25**	**21**			**525**
3	BOT3CJ201	Core Course 4 in Major Botany - **Plant Embryology, Palynology & Evolution**		60	4	4	30	70	100
	BOT3CJ202 / BOT3MN200	Core Course 5 in Major Botany - **Plant Anatomy & Analytical Techniques**		75	5	4	30	70	100
	BBB3CJ201	Core Course 4 in Major B		60/ 75	4/ 5	4	30	70	100
	BBB3CJ202	Core Course 5 in Major B		60/ 75	4/ 5	4	30	70	100
	BBB3FM106 / BBB2FM106	Multi-Disciplinary Course 1 in B		45	3	3	25	50	75
	BOT3FV108	Value-Added Course 1 in Botany - **Biodiversity & Conservation** (for batch A1 only)		45	3	3	25	50	75
		Total			**23 – 25**	**22**			**550**
4	BOT4CJ203/ BOT5CJ301*	Core Course 6 in Major Botany - **Plant Diversity II**		75	5	4	30	70	100
		Core Course 6 in Major B		60/ 75	4/ 5	4	30	70	100
	BOT4CJ205	Core Course 7 in Major Botany - **Cell & Molecular Biology**		75	5	4	30	70	100
	BOT4FV110	Value Added Course 2 in Botany - **Environment & Climate change**		45	3	3	25	50	75

	BBB4FV110	Value-Added Course 1 in B		45	3	3	25	50	75
	BOT4FS112(1)	Skill Enhancement Course 1 in Botany - **Herbal Technology**	Any one	45	3	3	25	50	75
	BOT4FS112(2)	**Landscaping & Gardening**							
		Total			**23/ 24**	**21**			**525**
5	BOT5CJ302	Core Course 8 in Major Botany - **Angiosperm Morphology, Systematics & Plant Resources**		75	5	4	30	70	100
		Core Course 7 in Major B		60/ 75	4/ 5	4	30	70	100
	BOT5CJ303	Core Course 9 in Major Botany - **Genetics, Plant Breeding & Palaeobotany** (for batch A1 only)		60	4	4	30	70	100
		Elective Course 1 in Major Botany		60	4	4	30	70	100
		Elective Course 1 in Major B		60	4	4	30	70	100
	BBB5FS112 / BBB4FS112	Skill Enhancement Course 1 in B		45	3	3	25	50	75
		Total			**24/ 25**	**23**			**575**
6	BOT6CJ304/ BOT8MN305	Core Course 10 in Major Botany - **Plant Physiology & Metabolism**		75	5	4	30	70	100
		Core Course 8 in Major B		60/ 75	4/ 5	4	30	70	100
	BBB6CJ305	Core Course 9 in Major B (for batch B2 only)		60	4	4	30	70	100
		Elective Course 2 in Major Botany		60	4	4	30	70	100
		Elective Course 2 in Major B		60	4	4	30	70	100
	BOT6FS113 (1)	Skill Enhancement Course 2 in Botany- **Phytochemical Techniques**	Any one	45	3	3	25	50	75

	BOT6FS 113 (2)	**Essential Oils & Perfumery**						
	BOT6FS 113 (3)	**Seaweed Farming**						
	BOT6CJ349	Internship in Major Botany (Credit for internship to be awarded only at the end of Semester 6)	60	-	2	50	-	50
		Total		**24/ 25**	**25**			**625**
Total Credits for Three Years					**133**			**3325**
For batch A1(B2), the course structure in semesters 7 and 8 is the same as for pathways 1 – 4, except that the number of the core and elective courses is in continuation of the number of courses in the two categories completed at the end of semester 6.								

* The course code of the same course as used for the pathways 1 – 4

CREDIT DISTRIBUTION FOR BATCH A1(B2)
IN PATHWAY 5: DOUBLE MAJOR

Semester	Major Courses in Botany	General Foundation Courses in Botany	Internship/ Project in Botany	Major Courses in B	General Foundation Courses in B	AEC	Total
1	4 + 4	3	-	4	-	3 + 3	21
2	4	3	-	4 + 4	-	3 + 3	21
3	4 + 4	3	-	4 + 4	3	-	22
4	4 + 4	3 + 3	-	4	3	-	21
5	4 + 4 + 4	-	-	4 + 4	3	-	23
6	4 + 4	3	2	4 + 4 + 4	-	-	25
Total for Three Years	**48**	**18**	**2**	**44**	**9**	**12**	**133**
	68			**53**		**12**	**133**
	Major Courses in Botany	Minor Courses					
7	4 + 4 + 4 + 4 + 4	-			-	-	20
8	4 + 4 + 4	4 + 4 + 4	12*		-	-	24
*Instead of three Major courses							
Total for Four Years	**88 + 12 = 100**	**12**					**177**

COURSE STRUCTURE FOR BATCH B1 (A2)
IN PATHWAY 5: DOUBLE MAJOR

A1: 68 credits in Botany (Major A) ***B1: 68 credits in Major B***

A2: 53 credits in Botany (Major A) ***B2: 53 credits in Major B***

The combinations available to the students: (A1 & B2), (B1 & A2)

Note: Unless the batch is specified, the course is for all the students of the class

Semester	Course Code	Course Title	Total Hours	Hours/ Week	Credits	Marks		
						Internal	External	Total
1	BOT1CJ102/ BOT4CJ203*	Core Course 1 in Major Botany- **Plant Diversity I**	75	5	4	30	70	100
	BBB1CJ101	Core Course 1 in Major B	60/ 75	4/ 5	4	30	70	100
	BBB1CJ102 / BBB2CJ102	Core Course 2 in Major B – (for batch B1 only)	60/ 75	4/ 5	4	30	70	100
	ENG1FA101(2)	Ability Enhancement Course 1 – English	60	4	3	25	50	75
		Ability Enhancement Course 2 – Additional Language	45	3	3	25	50	75
	BBB1FM105	Multi-Disciplinary Course 1 in B – (for batch B1 only)	45	3	3	25	50	75
		Total		**23 – 25**	**21**			**525**
2	BOT2CJ101 / BOT2MN100	Core Course 2 in Major Botany- **Microbial Diversity & Phyto Pathology**	75	5	4	30	70	100
	BBB2CJ101	Core Course 3 in Major B	60/ 75	4/ 5	4	30	70	100
	BOT2CJ102/	Core Course 3 in Major Botany-	75	5	4	30	70	100

	BOT4CJ203#/ BOT5CJ301*	(for batch A2 only) **Plant Diversity II**							
	ENG2FA103(2)	Ability Enhancement Course 3 – English		60	4	3	25	50	75
		Ability Enhancement Course 4 – Additional Language		45	3	3	25	50	75
	BOT2FM106 (1)	Multi-Disciplinary Course 1 in Botany - **Ecosystem Diversity in India**	Any one	45	3	3	25	50	75
	BOT2FM106 (2)	**Plants in Everyday Life**							
		Total			**24/ 25**	**21**			**525**
3	BOT3CJ201	Core Course 4 in Major Botany- **Plant Embryology, Palynology & Evolution**		60	4	4	30	70	100
	BOT3CJ202	Core Course 5 in Major Botany- **Plant Anatomy & Analytical Techniques**		75	5	4	30	70	100
	BBB3CJ201	Core Course 4 in Major B		60/ 75	4/ 5	4	30	70	100
	BBB3CJ202	Core Course 5 in Major B		60/ 75	4/ 5	4	30	70	100
	BBB3FM106 / BBB2FM106	Multi-Disciplinary Course 2 in B -		45	3	3	25	50	75
	BBB3FV108	Value-Added Course 1 in B – (for batch B1 only)		45	3	3	25	50	75
		Total			**23 – 25**	**22**			**550**
4	BOT4CJ205	Core Course 6 in Major Botany -**Cell & Molecular Biology**		75	5	4	30	70	100

		Core Course 6 in Major B		60/ 75	4/ 5	4	30	70	100
		Core Course 7 in Major B – (for batch B1 only)		60/ 75	4/ 5	4	30	70	100
	BOT4FV110	Value-Added Course 1 in Botany – **Environment & Climate change**		45	3	3	25	50	75
	BBB4FV110	Value-Added Course 2 in B –		45	3	3	25	50	75
	BOT4FS112 (1) BOT5FS112 (1)*	Skill Enhancement Course 1 in Botany – **Herbal Technology**	Any one	45	3	3	25	50	75
	BOT4FS112 (2) BOT5FS112 (2)*	**Landscaping & Gardening**							
		Total			**22 – 24**	**21**			**525**
5	BOT5CJ302	Core Course 7 in Major Botany-**Angiosperm Morphology, Systematics & Plant Resources**		75	5	4	30	70	100
		Core Course 8 in Major B		60/ 75	4/ 5	4	30	70	100
		Core Course 9 in Major B (for batch B1 only)		60	4	4	30	70	100
		Elective Course 1 in Major Botany		60	4	4	30	70	100
		Elective Course 1 in Major B		60	4	4	30	70	100
	BBB5FS112 / BBB4FS112	Skill Enhancement Course 1 in B		45	3	3	25	50	75
		Total			**24/ 25**	**23**			**575**
6	BOT6CJ304/	Core Course 8 in Major Botany- **Plant**		75	5	4	30	70	100

	BOT8MN304	**Physiology and Metabolism**						
		Core Course 10 in Major B	60/ 75	4/ 5	4	30	70	100
	BOT6CJ307/ BOT5CJ303*	Core Course 9 in Major Botany- **Genetics, Plant Breeding & Palaeobotany** (for batch A2 only)	60	4	4	30	70	100
		Elective Course 2 in Major Botany	60	4	4	30	70	100
		Elective Course 2 in Major B	60	4	4	30	70	100
	BBB6FS113	Skill Enhancement Course 2 in B – (for batch B1 only)	45	3	3	25	50	75
	BBB6CJ349	Internship in Major B (Credit for internship to be awarded only at the end of Semester 6)	60		2	50	-	50
		Total		**24/ 25**	**25**			**625**
Total Credits for Three Years					**133**			**3325**
To continue to study Botany in semesters 7 and 8, batch B1(A2) needs to earn additional 15 credits in Botany to make the total credits of 68. Suppose this condition is achieved, and the student of batch B1(A2) proceeds to the next semesters to study Botany. The course structure in semesters 7 and 8 is the same as for pathways 1 – 4, except that the number of the core and elective courses is in continuation of the number of courses in the two categories completed at the end of semester 6, taking into account the number of courses in Botany taken online to earn the additional 15 credits.								

* The course code of the same course as used for the pathways 1 – 4 #The course code as in for Batch A1(B2) in pathway 5: Double Major

CREDIT DISTRIBUTION FOR BATCH B1(A2)
IN PATHWAY 5: DOUBLE MAJOR

Semester	Major Courses in B	General Foundation Courses in B	Internship/ Project in B	Major Courses in Botany	General Foundation Courses in Botany	AEC	Total
1	4 + 4	3	-	4	-	3 + 3	21
2	4	-	-	4 + 4	3	3 + 3	21
3	4 + 4	3 + 3	-	4 + 4	-	-	22
4	4 + 4	3	-	4	3 + 3	-	21
5	4 + 4 + 4	3	-	4 + 4	-	-	23
6	4 + 4	3	2	4 + 4 + 4	-	-	25
Total for Three Years	**48**	**18**	**2**	**44**	**9**	**12**	**133**
	68			**53**		**12**	**133**
	Major Courses in B	Minor Courses					
7	4 + 4 + 4 + 4 + 4	-			-	-	20
8	4 + 4 + 4	4 + 4 + 4	12*		-	-	24
* Instead of three Major courses							
Total for Four Years	**88 + 12 = 100**	**12**					**177**

EVALUATION SCHEME

1. The evaluation scheme for each course contains two parts: internal evaluation (about 30%) and external evaluation (about 70%). Each of the Major and Minor courses is of 4-credits. It is evaluated for 100 marks, out of which 30 marks is from internal evaluation and 70 marks, from external evaluation. Each of the General Foundation course is of 3-credits. It is evaluated for 75 marks, out of which 25 marks is from internal evaluation and 50 marks, from external evaluation.
2. The 4-credit courses (Major and Minor courses) are of two types: (i) courses with only theory and (ii) courses with 3-credit theory and 1-credit practical.
    - In 4-credit courses with only theory component, out of the total 5 modules of the syllabus, one open-ended module with 20% content is designed by the faculty member teaching that course, and it is internally evaluated for 10 marks. The internal evaluation of the remaining 4 theory modules is for 20 marks.
    - In 4-credit courses with 3-credit theory and 1-credit practical components, out of the total 5 modules of the syllabus, 4 modules are for theory and the fifth module is for practical. The practical component is internally evaluated for 20 marks. The internal evaluation of the 4 theory modules is for 10 marks.
3. All the 3-credit courses (General Foundational Courses) in Botany are with only theory component. Out of the total 5 modules of the syllabus, one open-ended module with 20% content is designed by the faculty member teaching that course, and it is internally evaluated for 5 marks. The internal evaluation of the remaining 4 theory modules is for 20 marks.

<table>
<tr><th rowspan="2">Sl. No.</th><th rowspan="2" colspan="2">Nature of the Course</th><th colspan="2">Internal Evaluation in Marks (about 30% of the total)</th><th rowspan="2">External Exam on 4 modules (Marks)</th><th rowspan="2">Total Marks</th></tr>
<tr><th>Open-ended module / Practical</th><th>On the other 4 modules</th></tr>
<tr><td>1</td><td>4-credit course</td><td>only theory (5 modules)</td><td>10</td><td>20</td><td>70</td><td>100</td></tr>
<tr><td>2</td><td>4-credit course</td><td>Theory (4 modules) + Practical</td><td>20</td><td>10</td><td>70</td><td>100</td></tr>
<tr><td>3</td><td>3-credit course</td><td>only theory (5 modules)</td><td>5</td><td>20</td><td>50</td><td>75</td></tr>
</table>

1. MAJOR AND MINOR COURSES

INTERNAL EVALUATION OF THEORY COMPONENT

<table>
<tr><th rowspan="3">Sl. No.</th><th rowspan="3">Components of Internal Evaluation of Theory Part of a Major / Minor Course</th><th colspan="4">Internal Marks for the Theory Part of a Major / Minor Course of 4-credits</th></tr>
<tr><th colspan="2">Theory Only</th><th colspan="2">Theory + Practical</th></tr>
<tr><th>4 Theory Modules</th><th>Open-ended Module</th><th>4 Theory Modules</th><th>Practical</th></tr>
<tr><td>1</td><td>Test paper/
Mid-semester Exam</td><td>10</td><td>4</td><td>5</td><td>-</td></tr>
<tr><td>2</td><td>Seminar/ Viva/ Quiz</td><td>6</td><td>4</td><td>3</td><td>-</td></tr>
<tr><td>3</td><td>Assignment</td><td>4</td><td>2</td><td>2</td><td>-</td></tr>
<tr><td colspan="2" rowspan="2">Total</td><td>20</td><td>10</td><td>10</td><td>20*</td></tr>
<tr><td colspan="2">30</td><td colspan="2">30</td></tr>
</table>

* Refer the table in section 1.2 for the evaluation of practical component

EVALUATION OF PRACTICAL COMPONENT

The evaluation of practical component in Major and Minor courses is completely by internal evaluation.

- Continuous evaluation of practical by the teacher-in-charge shall carry a weightage of 50%.
- Lab activities are to be regularly recorded in the Practical Book/Journal. The students are required to present a duly certified Practical Book/Journal, field reports and submissions wherever applicable, for appearing at the practical examination, failing which they will not be allowed to appear for the examination.
- The end-semester practical examination and viva-voce, and the evaluation of practical records shall be conducted by the teacher in-charge and an internal examiner appointed by the Department Council.
- Practical exam may include components designed to test a range of skills. These may involve demonstrating scientific experiments, innovations, identifying specimens on the spot, solving relevant problems etc.
- The process of continuous evaluation of practical courses shall be completed before 10 days from the commencement of the end-semester examination.
- Those who passed in continuous evaluation alone will be permitted to appear for the end-semester examination and viva-voce.

The scheme of continuous evaluation and the end-semester examination and viva-voce of practical component shall be as given below:

Sl. No.	Evaluation of Practical Component of Credit-1 in a Major / Minor Course	Marks for Practical	Weightage
1	Continuous evaluation of practical/ exercise performed in practical classes by the students (Performance in Lab - 7 marks; Attendance in the Lab - 3 marks)	10	50%
2	End-semester examination and viva-voce to be conducted by teacher-in-charge along with an additional examiner arranged internally by the Department Council	7	35%
3	Evaluation of the Practical records submitted for the end semester viva–voce examination by the teacher-in-charge and additional examiner	3	15%
	Total Marks	20	

EXTERNAL EVALUATION OF THEORY COMPONENT

External evaluation carries 70% marks. Examinations will be conducted at the end of each semester. Individual questions are evaluated in marks and the total marks are converted into grades by the University based on 10-point grading system (refer section 5).

PATTERN OF QUESTION PAPER FOR MAJOR AND MINOR COURSES

Duration	Type	Total No. of Questions	No. of Questions to be Answered	Marks for Each Question	Ceiling of Marks
2 Hours	Short Answer	10	8 – 10	3	24
	Paragraph/ Problem	8	6 – 8	6	36
	Essay	2	1	10	10
Total Marks					70

2. INTERNSHIP

- All students should undergo Internship of 2-credits during the first six semesters in a firm, industry or organization, or training in labs with faculty and researchers of their own institution or other Higher Educational Institutions (HEIs) or research institutions.
- Internship can be for enhancing the employability of the student or for developing the research aptitude.
- Internship can involve short term work experience, experiential learning, hands-on training on a particular skill/ equipment/techniques. It can be a short project on a specific problem or area. Attending seminars or workshops related to an area of learning or skill can be a component of Internship.
- A faculty member/ scientist/ instructor of the respective institution, where the student does the Internship, should be the supervisor of the Internship.

GUIDELINES FOR INTERNSHIP

- Internship can be in Botany or allied disciplines.
- There should be minimum 60 hrs. of engagement from the student in the Internship.
- Summer vacations and other holidays can be used for completing the Internship.
- The students should make regular and detailed entries in to a personal log book through the period of Internship. The log book will be a record of the progress of the Internship and the time spent on the work, and it will be useful in writing the final report. It may contain details of data collection, experimental conditions and results, ideas, rough work and calculation, etc. All entries should be dated. The Internship supervisor should periodically examine and countersign the log book.
- The log book and the typed report must be submitted at the end of the Internship.
- The institution at which the Internship will be carried out should be prior-approved by the Department Council of the college where the student has enrolled for the UG Honours programme.

FORMAT OF THE INTERNSHIP REPORT

1. Title page
2. Statement of attendance forwarded by the external supervisor
3. Internship Certificate, from where the internship is done which contains Name of internship centre, the area of internship, duration, performance evaluation, and date, should be included and signed by the internship supervisor and head of the internship institution
4. Introduction - Details and Profile of the institute
5. Report of the work done.
6. Summary

EVALUATION OF INTERNSHIP

- The evaluation of Internship shall be done internally through continuous assessment mode by a committee internally constituted by the Department Council of the college where the student has enrolled for the UG Honours programme.
- The credits and marks for the Internship will be awarded only at the end of semester 6.
- The scheme of continuous evaluation and the end-semester viva-voce examination based on the submitted report shall be as given below:

<table>
<tr><th>Sl. No.</th><th colspan="2">Components of Evaluation of Internship</th><th>Marks for Internship
2 Credits</th><th>Weightage</th></tr>
<tr><td>1</td><td rowspan="3">Continuous evaluation of internship through interim presentations and reports by the committee internally constituted by the Department Council</td><td>Acquisition of skill set</td><td>10</td><td rowspan="3">40%</td></tr>
<tr><td>2</td><td>Interim Presentation and Viva-voce</td><td>5</td></tr>
<tr><td>3</td><td>Punctuality and Log Book</td><td>5</td></tr>
</table>

<table>
<tr><td>4</td><td rowspan="3">End-semester viva-voce examination to be conducted by the committee internally constituted by the Department Council</td><td>Quality of the work</td><td>8</td><td rowspan="3">40%</td></tr>
<tr><td>5</td><td>Presentation of the work</td><td>6</td></tr>
<tr><td>6</td><td>Viva-voce</td><td>6</td></tr>
<tr><td>7</td><td colspan="2">Evaluation of the day-to-day records, the report of internship supervisor, and final report submitted for the end semester viva–voce examination before the committee internally constituted by the Department Council</td><td>10</td><td>20%</td></tr>
<tr><td></td><td colspan="2">Total Marks</td><td>50</td><td></td></tr>
</table>

3. PROJECT

PROJECT IN HONOURS PROGRAMME

- In Honours programme, the student has the option to do a Project of 12-credits instead of three Core Courses in Major in semester 8.
- The Project can be done in the same institution or any other higher educational institution (HEI)/ research centre/training centre
- The Project in Honours programme can be a short research work or an extended internship or a skill-based training programme.
- A faculty member of the respective institution, where the student does the Project, should be the supervisor of the Project.

PROJECT IN HONOURS WITH RESEARCH PROGRAMME

- Students who secure 75% marks and above (equivalently, CGPA 7.5 and above) cumulatively in the first six semesters are eligible to get selected to Honours with Research stream in the fourth year.
- A relaxation of 5% in marks (equivalently, a relaxation of 0.5 grade in CGPA) is allowed for those belonging to SC/ ST/ OBC (non-creamy layer)/ Differently-Abled/ Economically Weaker Section (EWS)/ other categories of candidates as per the decision of the UGC from time to time.
- In Honours with Research programme, the student has to do a mandatory Research Project of 12-credits instead of three Core Courses in Major in semester 8.
- The approved research centres of University of Calicut or any other university/ HEI can offer the Honours with Research programme. The departments in the affiliated colleges under University of Calicut, which are not the approved research centres of the University, should get prior approval from the University to offer the Honours with Research programme. Such departments should have minimum two faculty members with Ph.D., and they should also have the necessary infrastructure to offer Honours with Research programme.
- A faculty member of the University/ College with a Ph.D. degree can supervise the research project of the students who have enrolled for Honours with Research. One such faculty member can supervise maximum five students in Honours with Research stream.

- The maximum intake of the department for Honours with Research programme is fixed by the department based on the number of faculty members eligible for project supervision, and other academic, research, and infrastructural facilities available.
- If a greater number of eligible students are opting for the Honours with Research programme than the number of available seats, then the allotment shall be based on the existing rules of reservations and merits.

GUIDELINES FOR THE PROJECT IN HONOURS PROGRAMMEAND HONOURS WITH RESEARCH PROGRAMME

- Project can be in Botany or allied disciplines.
- Project should be done individually.
- Project work can be of experimental/ theoretical/ exploration in nature.
- There should be minimum 360 hrs. of engagement from the student in the Project work in Honours programme as well as in Honours with Research programme.
- There should be minimum 13 hrs./week of engagement (the hours corresponding to the three core courses in Major in semester 8) from the teacher in the guidance of the Project(s) in Honours programme and Honours with Research programme.
- The various steps in project works are the following:
    1. Wide review of a topic.
    2. Investigation on a problem in systematic way using appropriate techniques.
    3. Systematic recording of the work.
    4. Reporting the results with interpretation/statistical analysis in a standard documented form.
    5. Presenting the results before the examiners.
- During the Project the students should make regular and detailed entries in to a personal log book through the period of investigation. The log book will be a record of the progress of the Project and the time spent on the work, and it will be useful in writing the final report. It may contain experimental conditions and results, ideas, methodologies, rough work and calculation, etc. All entries should be dated. The Project supervisor should periodically examine and countersign the log book.
- The log book and the typed report must be submitted at the end of the Project. A copy of the report should be kept for reference at the department. A soft copy of the report too should be submitted, to be sent to the external examiner in advance.
- It is desirable, but not mandatory, to publish the results of the Project in a peer reviewed journal.
- The project report shall have an undertaking from the student and a certificate from the research supervisor for originality of the work, stating that there is no plagiarism, and that the work has not been submitted for the award of any other degree/ diploma in the same institution or any other institution.
- The project proposal, institution at which the project is being carried out, and the project supervisor should be prior-approved by the Department Council of the college where the student has enrolled for the UG Honours programme.

EVALUATION OF PROJECT

- The evaluation of Project will be conducted at the end of the eighth semester by both internal and external modes.

- The Project in Honours programme as well as that in Honours with Research programme will be evaluated for 300 marks. Out of this, 90 marks is from internal evaluation and 210 marks, from external evaluation.
- The internal evaluation of the Project work shall be done through continuous assessment mode by a committee internally constituted by the Department Council of the college where the student has enrolled for the UG Honours programme. 30% of the weightage shall be given through this mode.
- The remaining 70% shall be awarded by the external examiner appointed by the University.
- The scheme of continuous evaluation and the end-semester viva-voce of the Project shall be as given below:

Components of Evaluation of Project	Marks for the Project (Honours/ Honours with Research)	Weightage
Continuous evaluation of project work through interim presentations and reports by the committee internally constituted by the Department Council	90	30%
End-semester viva-voce examination to be conducted by the external examiner appointed by the university	150	50%
Evaluation of the day-to-day records and project report submitted for the end-semester viva–voce examination conducted by the external examiner	60	20%
Total Marks	300	

INTERNAL EVALUATION OF PROJECT

Sl. No	Components of Evaluation of Project	Marks for the Project (Honours/ Honours with Research)
1	Skill in doing project work	30
2	Interim Presentation and Viva-Voce	20
3	Punctuality and Log book	20
4	Scheme/ Organization of Project Report	20
	Total Marks	90

EXTERNAL EVALUATION OF PROJECT

Sl. No	Components of Evaluation of Project	Marks for the Project (Honours/ Honours with Research) 12 credits
1	Content and relevance of the Project, Methodology, Quality of analysis, and Innovations of Research	50

2	Presentation of the Project	50
3	Project Report (typed copy), Log Book and References	60
4	Viva-Voce	50
	Total Marks	210

4. GENERAL FOUNDATION COURSES

All the General Foundation Courses (3-credits) in Botany are with only theory component.

INTERNAL EVALUATION

Sl. No.	Components of Internal Evaluation of a General Foundation Course in Botany	Internal Marks of a General Foundation Course of 3-credits in Botany	
		4 Theory Modules	Open-ended Module
1	Test paper/ Mid-semester Exam	10	2
2	Seminar/ Viva/ Quiz	6	2
3	Assignment	4	1
	Total	20	5
		25	

EXTERNAL EVALUATION

External evaluation carries about 70% marks. Examinations will be conducted at the end of each semester. Individual questions are evaluated in marks and the total marks are converted into grades by the University based on 10-point grading system (refer section 5).

PATTERN OF QUESTION PAPER FOR GENERAL FOUNDATION COURSES

Duration	Type	Total No. of Questions	No. of Questions to be Answered	Marks for Each Question	Ceiling of Marks
1.5 Hours	Short Answer	10	8 – 10	2	16
	Paragraph/ Problem	5	4 – 5	6	24
	Essay	2	1	10	10
				Total Marks	50

5. LETTER GRADES AND GRADE POINTS

- Mark system is followed for evaluating each question.
- For each course in the semester letter grade and grade point are introduced in 10-point indirect grading system as per guidelines given below.
- The Semester Grade Point Average (SGPA) is computed from the grades as a measure of the student‘s performance in a given semester.

- The Cumulative GPA (CGPA) is based on the grades in all courses taken after joining the programme of study.
- Only the weighted grade point based on marks obtained shall be displayed on the grade card issued to the students.

LETTER GRADES AND GRADE POINTS

Sl. No.	Percentage of Marks (Internal & External Put Together)	Description	Letter Grade	Grade Point	Range of Grade Points	Class
1	95% and above	Outstanding	O	10	9.50 – 10	First Class with Distinction
2	Above 85% and below 95%	Excellent	A+	9	8.50 – 9. 49	
3	75% to below 85%	Very Good	A	8	7.50 – 8.49	
4	65% to below 75%	Good	B+	7	6.50 – 7.49	First Class
5	55% to below 65%	Above Average	B	6	5.50 – 6.49	
6	45% to below 55%	Average	C	5	4.50 – 5.49	Second Class
7	35% to below 45% aggregate (internal and external put together) with a minimum of 30% in external valuation	Pass	P	4	3.50 – 4.49	Third Class
8	Below an aggregate of 35% or below 30% in external evaluation	Fail	F	0	0 – 3.49	Fail
9	Not attending the examination	Absent	Ab	0	0	Fail

- When students take audit courses, they will be given Pass (P) or Fail (F) grade without any credits.
- The successful completion of all the courses and capstone components prescribed for the three-year or four-year programme with 'P' grade shall be the minimum requirement for the award of UG Degree or UG Degree Honours or UG Degree Honours with Research, as the case may be.

COMPUTATION OF SGPA AND CGPA

- The following method shall be used to compute the Semester Grade Point Average (SGPA):

  The SGPA equals the product of the number of credits (Ci) with the grade points (Gi) scored by a student in each course in a semester, summed over all the courses taken by a student in the semester, and then divided by the total number of credits of all the courses taken by the student in the semester,

i.e. SGPA (Si) = Σi (Ci x Gi) / Σi (Ci)

where Ci is the number of credits of the i^{th} course and Gi is the grade point scored by the student in the i^{th} course in the given semester. Credit Point of a course is the value obtained by multiplying the credit (Ci) of the course by the grade point (Gi) of the course.

$$\text{SGPA} = \frac{\text{Sum of the credit points of all the courses in a semester}}{\text{Total credits in that semester}}$$

ILLUSTRATION – COMPUTATION OF SGPA

Semester	**Course**	**Credit**	**Letter Grade**	**Grade point**	**Credit Point** (Credit x Grade)
I	Course 1	3	A	8	3 x 8 = 24
I	Course 2	4	B+	7	4 x 7 = 28
I	Course 3	3	B	6	3 x 6 = 18
I	Course 4	3	O	10	3 x 10 = 30
I	Course 5	3	C	5	3 x 5 = 15
I	Course 6	4	B	6	4 x 6 = 24
	Total	20			139
	SGPA				139/20 = 6.950

- The Cumulative Grade Point Average (CGPA) of the student shall be calculated at the end of a programme. The CGPA of a student determines the overall academic level of the student in a programme and is the criterion for ranking the students.

  CGPA for the three-year programme in CUFYUGP shall be calculated by the following formula.

$$\text{CGPA} = \frac{\text{Sum of the credit points of all the courses in six semesters}}{\text{Total credits in six semesters (133)}}$$

  CGPA for the four-year programme in CUFYUGP shall be calculated by the following formula.

$$\text{CGPA} = \frac{\text{Sum of the credit points of all the courses in eight semesters}}{\text{Total credits in eight semesters (177)}}$$

- The SGPA and CGPA shall be rounded off to three decimal points and reported in the transcripts.
- Based on the above letter grades, grade points, SGPA and CGPA, the University shall issue the transcript for each semester and a consolidated transcript indicating the performance in all semesters.

MAJOR COURSES

<table>
<tr><td>Programme</td><td colspan="5">B. Sc. BOTANY</td></tr>
<tr><td>Course Title</td><td colspan="5">Aesthetic Botany</td></tr>
<tr><td>Type of Course</td><td colspan="5">Major</td></tr>
<tr><td>Semester</td><td colspan="5">I</td></tr>
<tr><td>Academic Level</td><td colspan="5">100 - 199</td></tr>
<tr><td rowspan="2">Course Details</td><td>Credit</td><td>Lecture per week</td><td>Tutorial per week</td><td>Practical per week</td><td>Total Hours</td></tr>
<tr><td>4</td><td>3</td><td>-</td><td>2</td><td>75</td></tr>
<tr><td>Pre-requisites</td><td colspan="5">Higher secondary level biology course</td></tr>
<tr><td>Course Summary</td><td colspan="5">This course offers basic idea in gardening, horticulture, photography, illustration, and craft making using botanicals.</td></tr>
</table>

Course Outcomes (CO): After completing the Course, the student should be able to:-

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Demonstrate basic principles of gardening to successfully grow and maintain plants	U	C	Practical Assignment/ Quiz
CO2	Demonstrate fundamental knowledge in plant propagation and care	U	C	Observation of Practical Skills/ Quiz
CO3	Identify the importance of floriculture and its market	U	C	Seminar Presentation
CO4	Translate the passion for plants into captivating botanical imagery	Ap	P	Home Assignments
CO5	Implement techniques to plan, plant, and nurture both indoor and outdoor gardens	Ap	P	Home Assignments
CO6	Design art pieces using plant parts	C	P	Observation of Practical Skills

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)

- Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)
I	**Introduction to Aesthetic Botany**		**15**
	1	Aesthetic characteristics of plants - Shape and outline, Structure and branching pattern, Symmetry of flowers, Geometric arrangements of leaves, Size and scale, Surface texture, Pattern and veining, Colour- flower hues, foliage variations, seasonal shifts.	2
	2	Landscaping - Goals, Types, Planning and layout, Style of gardens (Formal, Informal); Types of gardens (English, Mughal and Japanese)	2
	3	Gardening - definition; Principles of garden design, site selection, Features of a garden (Trees, shrubs and shrubberies, climbers and creepers, Lawn, Garden wall, Fences and gates, Paths and walkways, Borders, Hedge, Edging, Rockery, Flower beds, Pergola, Gazebo, Garden furniture, Solar-electric lights, Sculptures, Water garden)	3
	4	Propagating structures - green house, poly house, mist chamber, net frame	1
	5	Indoor gardening - selection of indoor plants, care and maintenance of indoor plants; Vertical gardens Some Famous gardens of India	3
	6	Bonsai - principle, types, methods & tools	2
	7	Aquascaping & Terrarium - Methods	2
II	**Horticultural techniques**		**15**
	8	Soil - components of soil, types of soil Fertilizers - chemical, organic, biofertilizer, composting systems Pots and Potting - Earthen, fibre, polythene bags Potting mixture, potting, repotting, top dressing. Irrigation - Surface, sprinkle, drip	4
	9	Garden tools and implements	1
	10	Seed propagation - Seed quality, seed treatment, essential conditions for successful propagation, raising of seed beds, transplanting techniques	2
	11	Vegetative propagation: a) Cutting (stem, roots, leaves) b) Grafting (approach, side, tongue) c) Budding (T-budding, patch)	3

		d) Layering (simple, trench, air)	
	12	Protection of horticultural plants - Precautions to avoid pests and diseases, biopesticides	1
	13	Hydroponics - Principle and method	1
	14	Floriculture - Industrial importance of ornamental plants Floriculture in India Cut flower market - Scope and prospects	2
	15	Flower shows and exhibitions - Importance	1
III		**Botanical documentation**	**8**
	16	Digital documentation - Basics	2
	17	Photography - Basics of Botanical Photography, Composition, Lighting and capturing, Editing and Presentation	2
	18	Micro and Macro photography	2
	19	Botanical illustrations - Botanical illustration techniques, Sketching, Water colour, Pen and Ink. Colour theory and Mixing; Significance	2
IV		**Botanical Art and Craft**	**7**
	20	Floral arrangements - Ikebana: Types of arrangements. Contemporary floral design styles.	3
	21	Resin embedding of flowers - techniques, methods and applications.	2
	22	Botanical printing - process and techniques	2
V		**Practical (Mandatory list)**	**30**
		1. Vegetative propagation-cutting, budding, grafting, layering 2. Familiarizing gardening tools and implements 3. Fresh and dry flower arrangements 4. Preparation of potting mixture and Polybag filling 5. Visit to public/institutional/ botanical gardens/nurseries/horticulture station (A brief report may be recorded)	
		Practical (Open ended/Suggestive list)	
		1. Preparation of bottle gardens 2. Terrarium making 3. Botanical Photographs 4. Bonsai preparation 5. Visit to flower shows and exhibitions	

Suggested Readings

- Andiance and Brison. 1971. Propagation Horticultural Plants.
- Chanda, K.L. and Choudhury, B. Ornamental Horticulture in India.
- George Acquaah. 2005. Horticulture: Principles and Practices. Pearson Education, Delhi.
- Hudson, T. Hartmann, Dale K. Kester, Fred T. Davies, Robert L. Geneve, Plant Propagation, Principles and Practices.
- Kolay, A.K. Basic Concepts of Soil Science. New Age International Publishers, Delhi.
- Nishi Sinha: Gardening in India, Abhinav Publications, New Delhi.
- Prasad, S., and U. Kumar. Green house Management for Horticultural Crops, Agrobios, Jodhpur.
- Sudhir P. 2018. Landscape gardening. Scientific Publishers India.
- Gavino M. 2018. Floriculture and landscaping. Scitus Academics LLC.
- Percy L. 2004. Gardening in India. Oxford & IBH publishers.
- Laeeq F. 2008. Gardens. National book trust India Publishers.
- Ekta Chaudhary 2022. Garden Up. Penguin Random House India publishers.
- Prathap Rao M. 2020. Landscape Design. Standard Publishers and Distributors Pvt.
- Percy L. 2008. Gardening in India. 2nd Edition, Oxford & IBH publishers.

Online Sources

- https://www.georgeweil.com/blog/botanical-printing-an-overview/
- https://www.lostincolours.com/eco-printing-for-beginners/
- https://www.instructables.com/Techniques-to-Embed-Flowers-in-Resin/
- https://www.researchgate.net/publication/341831968_Epoxy_resin_encapsulation_technique

Mapping of COs with PSOs and POs:

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	-	-	-	-	-	3	-	1	-	1	-	-
CO2	3	-	-	-	-	-	3	-	1	-	1	-	-
CO3	3	-	-	-	-	1	3	-	1	-	-	-	-
CO4	3	-	-	-	-		3	-	3	2	-	-	-
CO5	3	-	1	-	-	-	3	-	3	-	2	-	-
CO6	3	-	-	-	-	-	3	-	3	-	-	1	1

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly/Low
2	Moderate/ Medium
3	Substantial/ High

Assessment Rubrics:

- Quiz / Assignment/ Discussion / Seminar
- Midterm Exam
- Project/Practical
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		
CO 5		✓		✓
CO 6		✓	✓	

ST. JOSEPH'S COLLEGE (AUTONOMOUS), DEVAGIRI

Programme	B. Sc. BOTANY				
Course Title	**Microbial Diversity and Phytopathology**				
Type of Course	**Major**				
Semester	**II**				
Academic Level	100-199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Higher secondary level biology course				
Course Summary	This course aims to provide students with a comprehensive understanding of the microbiome and its significance in our surroundings. Students will explore the diversity of microflora and critically analyse their impact, both beneficial and harmful, on various aspects of human life and the biosphere.				

Course Outcomes: After completing the Course, the student should be able to:-

COs	Statement	Cognitive level*	Knowledge Category#	Evaluation Tools used
CO1	Explain characteristic features of microbial life and their economic importance	U	F	Instructor-created exams / Quiz
CO2	Identify plant diseases and derive control measures	Ap	C & P	Seminar Presentation/Practical
CO3	Develop general awareness on the diversity of microorganisms	U	F	Instructor-created exams / Quiz
CO4	Examine the impact of microbes on the biosphere	An	C & P	Seminar presentation
CO5	Evaluate the significance of plant diseases with respect to crop production is concerned	E	P	In-class discussions

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)

- Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (45 + 30)
I	**Introduction to Microbiology and Virology**		**8**
	1	History, diversity of microbial world	1
	2	Whittaker's five kingdom system of classification. Evolutionary significance	1
	3	General characters of Viruses with emphasis on occurrence, architecture and multiplication	3
	4	Structure of Bacteriophages (T4), Virions, Prions, Mycoplasma	2
	5	General account on viral epidemics and pandemics and its pathogens - Covid, H1N1	1
II	**Bacteriology**		**15**
	6	General outline on Eubacteria and Archaebacteria, Thermophiles, Psychrophiles, and Halophiles	1
	7	Bacterial morphology and ultrastructure	3
	8	Cell Wall - Composition and detailed structure of Gram-positive and Gram-negative cell walls Gram and acid fast staining	2
	9	Effect of antibiotics and enzymes on the bacterial cell wall (brief account only).	1
	10	Cell membrane - Structure, function and chemical composition of bacterial cell membranes, mesosomes.	2
	11	Phases of growth (S-curve), Asexual methods of reproduction	1
	12	Gene transfer mechanism in bacteria - Conjugation, Transduction, and Transformation	3
	13	Pure culture isolation - Streaking, Serial dilution and Plating methods	1
	14	Cultivation, maintenance and preservation/stocking of pure cultures	1
III	**Applied Microbiology**		**12**
	15	Microbiology in agriculture - biofertilizer, bioinsecticides, nitrogen fixation, biofuels, Plant Growth Promoting Bacteria, Soil microbes and plant health	3
	16	Microbiology in medicine - Antibiotics, Antimicrobial resistance, Probiotics and Microbial therapeutics - microbiome.	2

	17	Viruses as Tools in Genetic Engineering	2
	18	Biotechnological Applications of extremophiles Bacteria in Industrial Fermentation Bioaugmentation and Biostimulation	5
IV		**Phytopathology**	**10**
	19	Importance, Definition and concepts of diseases, Types of plant pathogens, Symptoms associated with microbial plant diseases.	1
	20	Koch's postulates, Host-parasite interaction Defense strategies in plants to pathogens- Phenolics, phytoalexin, elicitors, enzymes, toxins.	3
	21	Disease management strategies - Cultural, Botanical, Chemical, Biological and Integrated Disease Management. Environmental concern over chemical management - Residues and health hazards, fungicidal resistance in plant pathogens and its managements.	3
	22	Study of some important plant diseases giving emphasis on its etiology, symptoms, epidemiology and management i) Fungal diseases - Grey leaf spot disease of coconut, Quick wilt of pepper ii) Bacterial diseases - Citrus canker, Blast of paddy iii) Viral diseases - Tapioca mosaic disease, Bunchy top of Banana	3
V		**Practical (Mandatory list)**	**30**
	1. Gram staining - Curd, root-nodules 2. Culture and isolation of bacteria using nutrient agar medium (demonstration only) 3. Case study on microbial diseases 4. Identification of the disease, pathogen, symptoms and control measures of the plant diseases mentioned in the syllabus		
		Practical (Open ended/Suggestive list)	
	5. Microbiology lab visit 6. Collections and dry preservation of diseased specimens of important crops. 7. Plant pathology lab and field visit 8. Preparation of an assignment of 10 significant plant or human pathogens with the symptoms, epidemiology, life cycle and control measures (Photographs or sketch of stages of infection)		

Suggested Readings

- Agrios, G.N. 1997. Plant Pathology (4th ed) Academic Press.
- Bilgrami K.H. & H.C. Dube. 1976. A text book of Modern Plant Pathology. International

- Book Distributing Co. Lucknow.
- Mehrotra, R.S. 1980. Plant Pathology – TMH, New Delhi.
- Pandey, B.P. 1999. Plant Pathology. Pathogen and Plant diseases. Chand & Co., New Delhi.
- Rangaswami, G. 1999. Disease of Crop plants of India Prentice Hall of India Pvt. Ltd.
- Sharma P.D. 2004. Plant Pathology Rastogi Publishers.
- Gerard, J. T., Berdell, R. F., Christine, L. C. 2019. Microbiology: An Introduction. Pearson India, Noida, Uttar Pradesh.
- Joanne, W., Linda, S., Christopher, J. W. 2018. Prescott's Microbiology. McGraw Hill Education, Noida, Uttar Pradesh
- Trivedi, P.C. 2017. Introduction to Microbiology. S. Chand Publishing, Ram Nagar, New Delhi.
- Dubey, R. C. 2019. Microbiology: Principles and Applications. S. Chand Publishing, Ram Nagar, New Delhi.
- Jacquelyn, G. B., Laura, J. B. 2018. Microbiology: Principles and Explorations. John Wiley & Sons India Pvt. Ltd., Gurgaon, Haryana.
- Baveja, C.P. 2019. Microbiology: A Laboratory Manual. Arya Publications, 4221/1, Ansari Road, Daryaganj, New Delhi.

Mapping of COs with PSOs and POs:

	.PSO1	PSO2	PSO3	.PSO4	PSO5	.PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	-	-	-	-	-	3	-		-	-	-	-
CO2	1	-	-	-	-	2	-	-	2	-	-	-	-
CO3	1	-	-	-	-	1	3	-		-	-	-	-
CO4	1	-	-	-	1	1	-	-	2	-	-	-	-
CO5	-	-	-	-	-	2	-	-		-	-	-	1
CO6	- .	-	-	- .	-	2	-	-	2	-	2	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Discussion / Seminar
- Midterm Exam
- Project/Practical
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Practical/Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓	✓	✓	✓
CO 3	✓	✓		✓
CO 4				✓
CO 5	✓	✓		✓

Programme	B. Sc. BOTANY				
Course Title	**Plant Embryology, Palynology & Evolution**				
Type of Course	**Major**				
Semester	**III**				
Academic Level	200-299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-		60
Pre-requisites	Higher secondary level biology course				
Course Summary	This course aims to provide students with a deep understanding of plant development, reproduction, and evolution, integrating knowledge from embryology, palynology, and evolutionary biology				

Course Outcomes (CO): After completing the Course, the student should be able to:-

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools
CO1	Explain embryo development, pollen structure, and evolutionary processes in plants	U	F	Instructor-created exams / Quiz
CO2	Apply knowledge of plant reproductive biology to explain the mechanisms of pollination, fertilization, and seed formation in various species.	Ap	C	Instructor-created exams / Quiz
CO3	Analyse and interpret the role of embryology, palynology, and evolution in shaping plant diversity and adaptation to different environments.	An	C	Seminar presentation
CO4	Appreciate the process of organic evolution	E	C	Oral presentations
CO5	Critically evaluate and understand the concept of speciation, evolution and animal extinction	E	C & P	In-class discussions

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)

\# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (48 + 12)
I		**Plant Embryology**	**24**
	1	Introduction to angiosperm embryology with special reference to contributions of Indian embryologists	2
	2	Microsporogenesis - structure and function of wall layers, development of male gametophyte, dehiscence of anther	3
	3	Megasporogenesis - Development of female gametophyte - Embryo sac - Development and types - Monosporic – *Polygonum* type, Bisporic - *Allium* type, Tetrasporic – *Adoxa* type	3
	4	Pollination - types of pollination, Significance of Pollen - pistil interaction	2
	5	Fertilization - Germination of pollen - Role of synergids and filiform apparatus - double fertilization	2
	6	Types of ovules - Anatropous, Orthotropous, Circinotropous, Amphitropous/ Campylotropous	2
	7	Seed - Structure (Dicot and Monocot) appendages and dispersal mechanisms (Autochory, Anemochory, Hydrochory, Zoochory with one example each) Adaptations (aril, caruncle)	2
	8	Structure of Embryo - Dicot (*Capsella*), Monocot (*Sagittaria*)	2
	9	Endosperm - Classification and types	2
	10	A general account on Polyembryony, Apomixis and Parthenocarpy	2
II		**Palynology**	**12**
	11	Spore - pollen morphology: units, polarity, symmetry, shape, size, aperture; NPC system for numerical expression of apertural details	2
	12	Pollen wall and extraexinous wall materials - Sporoderm stratification and sculptures; LO - analysis; sporopollenin; pollen wall development; Ubisch body; pollen connecting threads, perine, pollen-kit.	3
	13	Pollen grains adaptation: Pollen grains adaptation in different habitats and pollination types; pollen wall adaptation and significance; Hermomegathic mechanism	2
	14	Spore/Pollen Viability and Storage - Estimation; variations	1
	15	Branches of palynology & application - palynology in taxonomic & phylogenetic deductions	2
	16	Palynology in academic & applied aspects - melissopalynology, medical palynology, forensic palynology, entomopalynology & copropalynology	2
III		**Evolution**	**10**
	17	Origin of life. Condensation and Polymerization; Protenoids and Prions - Oparin‘s concept; Miller‘s experiment	2
	18	Evolution of prokaryotic and eukaryotic cells, archaebacteria, early fossilized cells	2
	19	Evidences of organic evolution from Morphology, Anatomy, Embryology, Palynology, Genetics and Molecular Biology	3

	20	Theories on origin and evolution of species - Darwinism; Neo-Darwinism and its objection; Arguments and support for Darwinism, Modern concept of evolution	3
IV	**Speciation &Isolating mechanism**		**4**
	21	Genetic Constancy and Creation of Variability - Cell divisions and genetic constancy; Genetic variability by recombination, Chromosomal variations, Gene mutations, Selection and genetic Drift	2
	22	Speciation - Isolating mechanism, Modes of speciation: sympatric and allopatric	2
V	**Practical/Theory (Open ended, Suggestive list)**		**10**
	1. Datura anther T.S. (mature). 2. Types of ovules: Orthotropous, Anatropous and Campylotropous (Slides) 3. Viability test for pollen 4. Study of pollen morphology of different flowers with respect to shape, colour, pores etc. 5. Pollen germination of different pollen grains and calculate percentage of germination		

Suggested Readings:

- Agarwal S. B. 1984. Embryology of Angiosperms- a fundamental approach, Sahithya Bhavan, Hospital Road, Agra.
- Bhojwani S. S., Bhatnagar S. P. & Dantu P. K. 2015. The Embryology of Angiosperms. 6th edition, Vikas Publishing House (P) Ltd.
- Erdtman G. 1952. Pollen Morphology and Plant Taxonomy Part I. Almquist & Wiksell Stockholm
- Erdtman G. 1969. Hand Book of Palynology. National Botanical Gardens Publication, Lucknow.
- Johri B. D. 1984 (ed.) Embryology of Angiosperms Springer-Verlag, Berlin.
- Maheswari P. 1985. Introduction to Embryology of Angiosperms - McGraw Hill, New York.
- Nair P. K. K. 1970. Pollen Morphology of Angiosperms. Vikas Publishing House, Delhi.
- Shivanna K. R. & Johri B. M. 1985. The Angiosperm Pollen, Structure and Function. John Wiley & Sons Pte Ltd.
- Shivanna K. R. & Johri B. M. 1985. Pollen Biology: A Laboratory Manual, Springer Verlag, New Yrok.
- Singh V., Pande P. C. & Jain D. K. 2001. Embryology of Angiosperms- Rastogi Publications, Gangothri, Sivaji Road, Meerut.
- Dott R.H., Batten R. L. 1981. Evolution of the earth 3rd edn. McGraw Hill New York.
- Fox S.W. & Dose K. 1972. Molecular evolution and the origin of life. W.H. Freeman & Co., San Francisco.
- Jardine N., Mc Kenzie D. 1972. Continental drift and the dispersal and evolution of organisms. Nature, 234. 20-24.

Mapping of COs with PSOs and POs:

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	1	-	3	-	-	-	3	-	-	-	-	-	-
CO2	1	-	3	-	-	-	1	-	2	-	-	-	-
CO3	-	-	3	-	-	-	3	-	-	-	-	-	-
CO4	-	-	3	-	-	-	3	-	-	-	-	-	-
CO5	-	-	3	-	-	1	1	-	2	-	-	-	1

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Discussion / Seminar
- Midterm Exam
- Project/Practical
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Practical/Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓	✓		✓
CO 4		✓		
CO 5		✓		✓

Prog	B. Sc. BOTANY				
Cour	**Plant Anatomy & Analytical Techniques**				
Type of Course	**Major**				
Semester	**III**				
Academic Level	200-299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Higher Secondary level Biology course				
Course Summary	This course explores the intricate structures and functions of plant anatomy and the organization of tissues within plants and its diversity. The course also deals with a variety of analytical techniques crucial for studying various branches in biological sciences.				

Course Outcomes (CO): After completing the Course, the student should be able to:-

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools
CO1	Explain the anatomical features and its ecological diversity in plants	U	F & P	Instructor-created exams / Observation of practical skills
CO2	Assess the principle and working procedure of various analytical techniques used in biology	U	F & P	Viva voce/ Practical Assignment
CO3	Apply the analytical skills for various lab practices	Ap	P	Observation of practical skills
CO4	Analyse and compare the normal and abnormal behaviour of cambium	An	C	Instructor-created exams
CO5	Evaluate the role of plant anatomy and analytical techniques in various fields of science.	E	C	Home assignments

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)

\# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)
I		**Plant Anatomy -Basics, Scope and Applications**	**9**
	1	Introduction & Applications of plant anatomy in various fields	2
	2	Tissue systems - Simple & Complex, sclereids & fibres, Stomatal diversity	2
	3	Non-living inclusions of the cell & its applications	3
	4	Anatomical complexity in organization of shoot & root apex	2
II		**Special features in Plant Anatomy**	**12**
	5	Secondary thickening in dicot stem & root	2
	6	Anomalous secondary thickening - abnormal position and behaviour of cambium	2
	7	Anatomical diversity in major ecological groups of plants	3
	8	Wood anatomy - characteristics of wood & Types of wood	3
	9	Identification of various wood & defects in wood (shakes, knots, cross grain and stress defects)	2
III		**Analytical techniques**	**12**
	10	Solutions: representing concentrations: Molarity, Normality, Percentage and ppm	1
	11	Acids and bases, buffers and pH, measurement of pH	1
	12	Preparation and use of buffers in biological studies	1
	13	Microscopy – Introduction & Applications of Light microscopy	1
	14	Electron microscopy (SEM & TEM) - Principle, working & applications	2
	15	UV - Visible spectroscopy - Working and Applications	2
	16	IR spectroscopy - Applications	2
	17	Fluorescent spectroscopy - Principle & Applications	2
IV		**Separation techniques**	**12**
	18	Centrifugation - Basics, Principles behind various types & applications	2
	19	Differential, density gradient and Ultracentrifugation	2
	20	Chromatography - Introduction & Types	3
	21	Thin Layer Chromatography, Gas Chromatography & Liquid Chromatography - Principle and applications	3
	22	Mass spectroscopy - Basic principle and applications in plant science	2

V	Practical (Mandatory experiments)	30
	1. Normal secondary thickening in dicot stem and dicot root (any suitable material) *2.* Anomalous secondary thickening of *Boerhaavia* and *Bignonia* 3. Special anatomical features of major ecological groups - any two plants depending on local availability (Hydrophytes, Xerophytes, Parasites) 4. Detection of different structures of plants - identification of starch grains, cystolith, raphides, any two types of sclereids and fibres 5. Stomatal types - identification	
	Practical (Open ended - Suggestive list)	
	6. Anatomical identification of commercial timber like (any two from the list - Teak, Rosewood, Artocarpus, Mahogany - Original specimen/ photographs and salient features) 7. Identification of types of wood and defects 8. Demonstration of the working of different kinds of centrifuges 9. Visit to a nearby analytical lab which facilitates the use of instruments mentioned in the syllabus and submission of report.	

Suggested Readings

- Esau, K. 1977. Anatomy of Seed Plants. John Wiley & Sons.
- Metcalfe, C. R., & Chalk, L. 1979. Anatomy of the Dicotyledons: Leaves, Stem, and Wood in Relation to Taxonomy with Notes on Economic Uses (Vol. 1). Oxford University Press.
- Raven, P. H., Evert, R. F., & Eichhorn, S. E. 2005. Biology of Plants (7th ed.). W.H. Freeman and Company.
- Mauseth, J. D. 2003. Botany: An Introduction to Plant Biology. Jones and Bartlett Publishers.
- Spectroscopic Techniques: Nakanishi, K., & Solomon, T. D. 1997. Infrared and Raman Spectra of Inorganic and Coordination Compounds. Wiley.
- Mass Spectrometry in Botany: Gross, J. H. 2011. Mass Spectrometry: A Textbook. Springer.
- Coutler E. G.1969. Plant Anatomy - Part I Cells and Tissues – Edward Arnold, London.
- Dickison, W.C. (2000). Integrative Plant Anatomy, Harcourt Academic Press, USA
- Eames A. J. Morphology of Angiosperms - Mc Graw Hill, New York.
- Evert, R.F. 2006. Esau‘s Plant Anatomy: Meristem, Cells, and Tissues of the Plant Body: Their Structure, Function and Development. John Wiley and Sons, Inc
- Fahn, A. 1992. Plant Anatomy, Pergamon Press, USA
- Ruzin S.E. 1999. Plant Microtechnique and Microscopy, Oxford University Press, New York. U.S.A.
- Webster J. G. 2004. Bioinstrumentation, John Wiley & Sons Inc.
- Narayanan P. 2000. Essentials of Biophysics, New Age Int. Pub. New Delhi.
- Hames G. G. 2005. Spectroscopy for the Biological Sciences, John Wiley & Sons Inc.

Mapping of COs with PSOs and POs:

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	2	3	-	-	-	-	3	-	-	-	-	-	-
CO2	2	-	-	-	3	-	3	-	-	-	-	-	1
CO3	-	-	-	-	3	-	-	-	2	-	-	-	-
CO4	-	3	-	-	-	-	-	-	2	-	-	-	-
CO5	-	3	-	-	-	-	-	-	2	-	1	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Discussion / Seminar
- Midterm Exam
- Project/Practical
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Practical/Project Evaluation	End Semester Examinations
CO 1	✓		✓	✓
CO 2	✓		✓	✓
CO 3			✓	✓
CO 4	✓			✓
CO 5		✓		

Programme	B. Sc. BOTANY				
Course	**Plant Diversity I**				
Type of Course	**Major**				
Semester	**IV**				
Academic Level	200-299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Higher Secondary level Biology course				
Course Summary	This course covers the study of fungi and algae, exploring their diversity, biology, ecology, and importance in various ecosystems.				

Course Outcomes

COs	Statement	Cognitive level*	Knowledge category#	Evaluation Tools
CO1	Recall the different types of life forms present in the environment and their importance	R	F	Quiz/ Discussions
CO2	Apply practical skills in identifying different plant forms	Ap	C & P	Practical Assignment
CO3	Distinguish the systematics, morphology and structure of fungi, algae and lichens	An	P	Observation of practical skills /Exam
CO4	Assess the beneficial and harmful roles of different plant forms	An	C	Report writing

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)

- Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus

Module	Unit	Content	Hrs (45+30)
I		**Mycology**	**18**
	1	General characteristics; Thallus organization; Cell wall composition; Nutrition, Reproduction	2
	2	Overview of fungi classification (Alexopoulos et al.,1996), Brief outline on recent trends in fungal systematics	2
	3	Allied fungi: General characteristics; Status of Slime molds, Classification; Occurrence; Types of plasmodia; Types of fruiting bodies.	2
	4	General characteristics, Ecology, Life cycle of - Oomycota: *Phytophthora* Chytridiomycota: *Synchytrium* Zygomycota: *Rhizopus* Ascomycota: *Xylaria* Basidiomycota: *Puccinia*	8
	5	Symbiotic associations: Lichen – Occurrence; General characteristics; Growth forms and range of thallus organization; Nature of associations of algal and fungal partners; Reproduction with reference to *Usnea*; Mycorrhiza-Ectomycorrhiza, Endomycorrhiza and their significance.	4
II		**Applied Mycology**	**7**
	6	Application of fungi in food industry (Fermentation, Baking, Organic acids, Enzymes, Mycoproteins);	1
	7	Agriculture (Biofertilizers); Biological control (Mycofungicides, Mycoherbicides, Mycoinsecticides, Myconematicides)	1
	8	Medical mycology and human health -mycosis, mycotoxin, mycetism.	1
	9	Secondary metabolites production by fungi: Antibiotics, Enzymes, growth regulators, vitamins.	1
	10	Mushroom Cultivation - Spawn production and cultivation strategies with reference to oyster mushroom	2
	11	Economic importance of Lichens - medicine, dyes, perfumes Ecological importance of Lichens- Pioneers, ecological indicators, microhabitat formation, soil stability, Bioluminescence	1
III		**Phycology**	**15**
	12	General characteristics; Thallus organization, Range of thallus structure, cell structure - pigments, reserve food materials, cell wall, flagella and reproduction	3
	13	Classification of Algae proposed by FE Fritsch (1935). Recent trends in Algal classification .	2

	14	General characteristics, Cell structure and Life cycle of - Cyanophyceae: *Nostoc* Xanthophyceae: *Vaucheria* Chlorophyceae: *Oedogonium* Phaeophyceae: *Sargassum* Rhodophyceae: *Polysiphonia*	10
IV		**Applied Phycology**	**5**
	15	Algal cultivation methods, Algal bioprospecting	2
	16	Algae in soil fertility, Commercial products of Algae, Algae in space research	2
	17	Causes and ecological impacts of Water blooms, Eutrophication, Neurotoxins	1
V		**Practical (Mandatory list)**	**30**
	1. Identification of the vegetative and reproductive structures of the types mentioned in the syllabus using preserved or original specimen/slide preparation 2. Preparation of culture media 3. Morphological and reproductive features of Usnea 4. Field visit, identification and documentation of common fungi, algae and lichen of the campus		
	Practical (Open ended/suggestive list)		
	5. Isolation of fungi from soil by dilution-plate method. 6. Familiarization of the technique of making algal herbarium. 7. Observation of algal diversity in ponds (both free and attached forms)		

Suggested Readings:

- Alexopoulos C.J., Mims, C.W. and Blackwell, M. (1996) Introductory Mycology, 4th Edn. John Wiley and Sons, New York.
- Jim Deacon (2007) Fungal Biology, 4th edition, Blackwell publishing, Ane Books Pvt Ltd
- Sethi, I.K. and Walia, S.K. (2011) Text book of Fungi and their Allies, Macmillan Publishers India Ltd.
- Money N. P. 2016. Fungi: A Very Short Introduction. Oxford University Press.
- Dinabandhu S. and Joseph, S. (2016) The Algae world: Cellular Origin, Life in Extreme Habitats and Astrobiology, Springer Dordrecht Heidelberg, New York, London
- Prescott, G. W.1969. The Algae. A Review. Thomas Nelson and Sons Ltd.
- Round, F. E. 1975. The Biology of Algae. Edward Arnold
- van den Hoek, C, Mann, D.G., Jahns, H.M. 1995. Algae. An Introduction to Phycology. Cambridge University Press
- Lee, R.E. 2008. Phycology. Cambridge University Press, Cambridge. 4th edition.
- Fritsch, F. E. 1961. The Structure and Reproduction of Algae. Vol. 2. Cambridge University Press.
- Nash, T. H. 2008. Lichen Biology 2 nd edition. Cambridge University Press.
- Gilbert, O. 2004. Lichen Hunters. The Book Guild Ltd. England
- Kershaw, K.A. 1985. Physiological Ecology of Lichen. Cambridge University Press.

Mapping of COs with PSOs and POs:

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	1	-	1	-	-	-	2	-	-	-	-	-	-
CO2	2	-	1	-	-	-	2	-	-	-	-	-	-
CO3	1	-	1	-	-	-	-	-	1	-	-	-	-
CO4	1	-	1	-	-	-	-	-	1	-	-	-	-
CO5	2	-	1	-	-	1	-	-	1	-	-	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Discussion / Seminar
- Exam
- Project/Practical
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Practical Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓		✓	✓
CO 3	✓		✓	✓
CO 4		✓		✓

Program	B. Sc. BOTANY				
Course Title	**Phytochemistry & Pharmacognosy**				
Type of Course	**Major**				
Semester	**IV**				
Academic Level	200-299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Higher secondary level Biology				
Course Summary	This course explores the intricate world of plant chemistry and medicinal properties and it gives prime importance to phytochemical analysis, natural product isolation, and pharmacological applications				

Course Outcomes (CO): After completing the Course, the student should be able to:-

CO	CO Statement	Cognitive level*	Knowledge Category#	Evaluation Tools
CO1	Explain the various primary and secondary metabolites present in plant sources	U	F	Quiz/Test
CO2	Identify the use of various medicinal plants against various ailments	U	C	Assignment/ Presentations
CO3	Apply the concepts of phytochemistry and pharmacognosy in various life situations	Ap	C & P	Assignment
CO4	Evaluate the quality of natural drugs and standardise their use	E	C & P	Practical Assignment/ Report writing

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
\# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (45 + 30)
I	**Phytochemistry - Introduction & Primary Metabolites**		**18**
	1	Introduction to Phytochemistry, Primary and secondary metabolites - Overview	1
	2	Carbohydrates - Classification, Structure & functions of monosaccharides, disaccharides & plant polysaccharides.	3
	3	Amino acids & Proteins - Amino acids: structure & classification. Proteins - Primary, secondary, tertiary and quaternary structure	3
	4	Lipids - basic information. Fatty acids - saturated and unsaturated. Classification - storage and structural lipids; lipids in membranes	3
	5	Enzymes - classification & nomenclature. Mechanism of enzyme action and enzyme kinetics. Regulation of enzyme actions.	3
	6	Isoenzymes, ribozymes & abzymes, synzymes, co-enzymes and co factors. Application of enzymes in various fields	2
	7	Nucleotides - structure, functions of nucleotides and nucleotide derivatives.	3
II	**Secondary Metabolites**		**8**
	8	Extraction methods - Hot & Cold extraction, Maceration, Enfleurage, Soxhlet extraction, Distillation	3
	9	Solvents used in extraction of secondary metabolites - Polarity of solvents	1
	10	Major classes of secondary metabolites - alkaloids, flavonoids, terpenoids, phenolics, and glycosides. Therapeutical and ecological significance of secondary metabolites.	4
III	**Pharmacognosy**		**12**
	11	Definition, history, scope and development of Pharmacognosy	1
	12	Role of Pharmacognosy in various systems of medicine	1
	13	Sources of Drugs - Plants, Animals, Marine & Tissue culture	2
	14	Organized drugs and unorganized drugs. (dried latex, dried juices, dried extracts, gums and mucilage, oleoresins and oleo-gum - resins)	2
	15	Alphabetical, Morphological, Taxonomical, Chemical, Pharmacological, Chemo and Sero taxonomical Classification of Drugs	2
	16	Utilization of Aromatic Plants and Products - Importance of aromatic plants in various industries (perfumery, cosmetics, food, pharmaceuticals).	2
	17	Overview of the medicinal and aromatic plant (MAP) industry in India, Government policies and regulations governing MAP, Opportunities for enterprise development	2

IV		**Quality Control in Pharmacognosy**	**7**
	19	Quality control of natural drugs - Adulteration of drugs of natural origin	1
	20	Evaluation by organoleptic, microscopic, physical, chemical and biological methods and properties	3
	21	Standardization - guidelines of WHO	1
	22	Determination of foreign matter, ash value, extractive values, crude fibre	2
V		**Practical (Mandatory list)**	**30**
		1. Qualitative tests for carbohydrates, proteins and lipids. 2. Preliminary analysis of secondary metabolites from medicinal plants - test for alkaloids, phenols, saponins, glycosides, Phytosterols, tannins, flavonoids, coumarins 3. Quantitative estimation of DNA and RNA by colorimetric/ spectrophotometric method 4. Estimation of proteins from plant sources - Biuret method/Lowry‘s method 5. Demonstration of assay of any one enzyme - Papain/Invertase/Pectinase/Catecholase 6. Estimation of proline by ninhydrin method from plant sources 7. Leaf constants in pharmacognosy - stomatal number, stomatal index, palisade ratio, vein-islet number, vein termination number - comparison of any two medicinal plants available in the centre.	
		Practical (Open ended/Suggestive list)	
		8. Visit to any pharmacognosy laboratory - submit the report for evaluation 9. Organoleptic, chemical, physical and biological evaluation of crude plant powders (any two plants of medicinal importance) 10. Quantitative microscopic evaluation of crude powders using Lycopodium spore method 11. Familiarisation of plant extraction methods	

Suggested Readings:

- Kokate C. K., Purohit A. P. & Gokhale S.B. 2017. - Textbook of Pharmacognosy. Nirali Prakashan (India)
- Biren Shah. 2019. Pharmacognosy and Phytochemistry. Elsevier (India),1st Edition.
- Kirtikar K. R. & Basu B. D. 2018. Natural Products: Chemistry and Pharmacology, CBS Publishers & Distributors (India),1st Edition
- Biren Shah 2017. Textbook of Pharmacognosy, CBS Publishers & Distributors (India)
- Vinod D. Rangari 2018. Textbook of Pharmacognosy and Phytochemistry, Career Publications (India), 1st Edition
- Trease G. E. & Evans W.C. 2013. Introduction to Pharmacognosy. Elsevier (UK)
- Handa S. S &. Khanuja S. P. S. 2013. Textbook of Pharmacognosy. Vallabh Prakashan 5th Edition
- David L. Nelson & Michael M. Cox. 2017. Lehninger Principles of Biochemistry, W. H. Freeman (USA) 7th Edition
- Satyanarayana U & Chakrapani U. 2017. Biochemistry, Elsevier (India)
- Donald V, Judith G. V., & Charlotte W. Pratt. 2016. Principles of Biochemistry, Wiley (USA)

- Vasudevan D. M., Sreekumari S. & Kannan V. 2018. Biochemistry, Jaypee Brothers Medical Publishers (India) 8th Edition
- K. R. Khandelwal. 2015. Practical Pharmacognosy, Nirali Prakashan 22nd Edition
- Kokate C. K. 2017. Practical Pharmacognosy, Nirali Prakashan 26th Edition
- Pangtey Y. P. S. & Singh A. K. 2019. Medicinal and Aromatic Plants: Agricultural, Commercial, Ecological, Legal, Pharmacological and Social Aspects" Daya Publishing House (India)
- Gupta A. K. 2016. Medicinal Plants of India: An Encyclopedia, Daya Publishing House (India)
- Sharma P.V. 2016. Medicinal Plants of India: A Guide to Ayurvedic and Ethnomedicinal Himalayan Books (India)

Online Sources

- Chromeextension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.phytojournal.com/archives/2019/vol8issue3/PartX/8-1-577-767.pdf

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	-	3	1	1	2	-	3	1	-	-	2	-	1
CO2	3	-	3	1	3	1	1	-	1	-	1	1	1
CO3	1	3	3	1	3	-	-	-	2	-	3	3	2
CO4	-	-	2	3	1	1	-	-	2	1	-	1	1

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Discussion / Seminar
- Midterm Exam
- Project/Practical
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Practical/Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓	✓		✓
CO 3		✓		✓
CO 4		✓	✓	

Programme	B. Sc. BOTANY				
Course Title	**Cell and Molecular Biology**				
Type of Course	**Major**				
Semester	**IV**				
Academic Level	**200-299**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Higher Secondary level Biology course				
Course Summary	In this course, students will explore the fundamental principles governing the structure and function of cells at the molecular level. Topics covered include cell structure and organelles, cellular processes such as cell division, molecular genetics, gene expression, and regulation.				

Course Outcomes (CO): After completing the Course, the student should be able to:-

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Explain the functions of each cell organelle	U	F	Quiz
CO2	Summarise the fundamental principles and processes that govern the structure and function of cells at the molecular level	U	F	Assignment/Presentations
CO3	Demonstrate the concepts of cell biology and the techniques employed in molecular biology	U	C	Assignment
CO4	Analyse and interpret the experimental data, related to molecular biology.	An	P	Practical Assignment
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 + 30)
I		**Cell Biology**	**10**
	1	Architecture of cells. Prokaryotic and Eukaryotic cells.	1
	2	Structure and function of the following - Cell membrane (fluid mosaic model), Endoplasmic reticulum, Golgi complex, Mitochondria, Chloroplast, Ribosomes	4
	3	Structure and function - Lysosomes, Glyoxisomes, Cytoskeleton, Cytosol, Vacuole	2
	4	Nucleus - Nuclear membrane; Nuclear pore complex; NPC in transport, Organization of interphase Nucleus.	2
	5	Nucleolus - Structure and function	1
II		**Chromosomes**	**15**
	6	Chromosomes - Morphology, classification, Euchromatin and heterochromatin; Primary and Secondary constriction, SAT-bodies, Chemical composition - histones & non histones - Solenoid model. Supercoiled and relaxed DNA. Functions of chromosomes	4
	7	Special types of chromosomes - Polytene chromosomes, lampbrush chromosomes	1
	8	Cell division - cell cycle-mitosis and meiosis, Synaptonemal complex, Significance	4
	9	Chromosomal changes - structural aberrations: deletion, duplication, inversion, translocation - their meiotic consequences and significance	3
	10	Numerical aberration - Definition - Basic chromosome number (Genomic Number) Aneuploidy, Haploidy and Polyploidy - their meiotic behaviour and significance	3
III		**Basic Concepts of genome and its organisation**	**8**
	11	Nucleic acids - DNA; the discovery of DNA as the genetic material; Hershey and Chase experiment, Repetitive DNA, C - value paradox	2
	12	Structure of DNA, Watson & Crick‘s Model, Types of DNA-(A,B,Z); denaturation and renaturation of DNA, melting temperature (Tm), hyperchromic effect	2
	13	RNA - structure, types and properties	2
	14	Replication - semi conservative replication - Meselson and Stahl‘s experiment; Molecular mechanism of Replication	2

<table>
<tr><td rowspan="9">IV</td><td colspan="2">Gene expression and regulation</td><td>12</td></tr>
<tr><td>15</td><td>Genetic code - Properties, Genetic code in mitochondria</td><td>2</td></tr>
<tr><td>16</td><td>Central dogma protein synthesis; Transcription, post-transcriptional modification of RNA, Translation; Teminism.</td><td>2</td></tr>
<tr><td>17</td><td>Gene action - One gene - one enzyme hypothesis, one cistron one polypeptide hypothesis; concept of collinearity</td><td>1</td></tr>
<tr><td>18</td><td>Modern concept of gene - cistrons, recons and mutons</td><td>1</td></tr>
<tr><td>19</td><td>Gene regulation in prokaryotes - operon concept, (Lac operon, trp operon). Gene regulation in eukaryotes (brief account)</td><td>3</td></tr>
<tr><td>20</td><td>Mutation - spontaneous and induced; causes and consequences</td><td>1</td></tr>
<tr><td>21</td><td>Types of mutagens and their effects.</td><td>1</td></tr>
<tr><td>22</td><td>Point mutations - molecular mechanism of mutation - Transition, Transversion and substitution</td><td>1</td></tr>
<tr><td rowspan="3">V</td><td colspan="2">Practical (Mandatory experiments)</td><td>30</td></tr>
<tr><td colspan="3">8. Mitosis - Acetocarmine squash preparation of Onion root tip.
9. Calculation of mitotic index
10. Demonstration of meiosis in Rhoeo/ Chlorophytum/ Maize and identification of different stages of Meiosis.
11. Molecular biology lab visit and submission of report</td></tr>
<tr><td colspan="3">Practical (Open ended)</td></tr>
<tr><td colspan="4">Suggested Readings
• Alberts B. et al. 2008. 5th Edition, Molecular Biology of the Cell, Garland
• De Robertis, E. D. P. & De Robertis E.M.F. 2006. Cell and Molecular Biology. 8th edition. Lipincott Williams and Wilkins, Philadelphia.
• Cooper, G. M. and Hausman, R. E. 2009. The Cell: A Molecular Approach. 5th Edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA
• Surzycki S. 2000. Basic techniques in molecular biology. Springer.
• P.S. Verma, V.K. Agarwal. Cell Biology, Genetics, Molecular biology, Evolution and Ecology.
• Gerald Karp, Cell and Molecular Biology: Concepts and Experiments. John Wiley and Sons Inc.
• Lodish. H. et. al. 2000. Molecular Cell Biology, Freeman & Company.
• Powar C. B. 1988. Essentials of Cytology, Himalaya Publishing House.
• Rastogi S. G. Cell Biology. Tata Mc Graw Hill Publishing Company New Delhi
• Rastogi. V. B. 2008. Fundamentals of Molecular Biology, Ane Books India</td></tr>
</table>

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	2	-	-	-	1	-	2	-	-	-	2	-	-
CO 2	3	-	-	1	-	-	3	-	-	-	1	-	-
CO 3	1	-	3	1	2	-	1	-	2	1	2	-	1
CO 4	-	-	3	1	1	1	-	-	1	2	2	-	1

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Discussion / Seminar
- Midterm Exam
- Project/Practical
- Final Exam

Mapping of COs to Assessment Rubrics

	Internal Exam	Assignment	Practical/Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓	✓		✓
CO 3		✓		✓
CO 4		✓	✓	

Programme	B. Sc. BOTANY				
Course Title	**Plant Diversity II**				
Type of Course	**Major**				
Semester	**V**				
Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Higher Secondary level Biology course				
Course Summary	The course aims to provide an overview on the diversity, morphology, anatomy, reproduction, ecological and economic importance of Bryophytes, Pteridophytes and Gymnosperms				

Course Outcomes (CO): After completing the Course, the student should be able to:-

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools
CO1	Identify the origin, evolution and diversity of Bryophytes, Pteridophytes and Gymnosperms	U	C	Quiz/Test
CO2	Describe the morphological, anatomical and reproductive features of Bryophytes, Pteridophytes and Gymnosperms	U	F	Practical Assignment
CO3	Explain the economic and ecological importance of Bryophytes, Pteridophytes and Gymnosperms	U	F	Seminar presentations
CO4	Evaluate the threats and conservation approaches of Pteridophytes in Western Ghats	E	P	In-class discussion/ case study report
CO5	Evaluate the biodiversity of Bryophytes, Pteridophytes and Gymnosperms of Western Ghats	E	C & P	Report on field trip/Presentation

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)

- Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (45+30)
I		**Introduction**	**4**
	1	Origin, evolution and diversity of Embryophytes	2
	2	General characters of different groups of flowerless embryophytes	2
II		**Diversity of Bryophytes**	**15**
	3	Origin and evolution of Bryophytes Modern trends in the classification of Bryophytes (Brief account only)	2
	4	General characters of Anthocerotophyta, Marchantiophyta and Bryophyta	3
	5	General morphology, reproduction, life cycle of *Anthoceros, Riccia* and *Funaria*	6
	6	Economic and ecological importance of Bryophytes	2
	7	Diversity of Bryophytes in Kerala	2
III		**Diversity of Pteridophytes**	**16**
	8	Origin and evolution of Pteridophytes	2
	9	Classification of Pteridophytes (PPG I, 2016-brief account only)	1
	10	General characters and diversity of Polypodiopsida and Lycopodiopsida	2
	11	Morphology, anatomy and reproductive biology of *Selaginella* and *Pteris*	4
	12	Diversity, threats and conservation of Pteridophytes in Western Ghats	3
	13	Systematic relationships among Lycophytes and Euphyllophytes	2
	14	Ecological and economic importance of Pteridophytes	2
IV		**Diversity of Gymnosperms**	**10**
	15	Origin, evolution, diversity and classification of gymnosperms (Yang *et al.*, 2022-brief account only)	2
	16	Morphology, anatomy and reproductive biology of *Cycas, Pinus* and *Gnetum*	7
	27	Economic and ecological importance of Gymnosperms	1
V		**Practical (Mandatory list)**	**30**
	1. *Riccia* - Habit, Anatomy of thallus Slides of -V.S. of thallus through		

	antheridium, archegonium and sporophyte. 2. *Anthoceros*- Habit, Anatomical slides of thallus. V.S. of sporophyte. 3. Record the morphological characters of any moss in the campus or study the structure of *Funaria* - Habit, Slides of antheridial cluster, archegonial cluster, L.S. of sporophyte 4. *Selaginella* - Habit, T.S. of stem, T.S. of rhizophore, strobilus Slide of L.S. of strobilus 5. *Pteris* - Habit, T.S. of stipe/petiole, C.S. of sporophyll 6. *Cycas* - Habit, coralloid root, male cone, microsporophyll, megasporophyll, leaflet T. S., Slides of T.S. of coralloid root, T. S. of microsporophyll, L.S. of ovule 7. *Pinus* - branch of unlimited growth, spur shoot, male cone and female cone, T.S. of needle. Slides of T.S. of stem, L.S. of male cone and female cone 8. *Gnetum* - Habit, male and female cones, seed. Slides of stem T.S., leaf T.S., L.S. of ovule 9. Field trip to Western Ghats region to appreciate the diversity of Bryophytes, Pteridophytes and Gymnosperms

Practical (Open ended)

Suggested Readings:

- Simpson, M.G. 2010. Plant Systematics. Academic Press
- Shaw, A. J. & Goffinet, B. (eds.). 2009. Bryophyte Biology, Cambridge University Press.
- Vanderpoorten A. & Goffinet, B. (eds.). 2009. Introduction to Bryophytes, Cambridge University Press.
- Pteridophyte Phylogeny Group. 2016. A Community-derived classification for extant Lycophytes and Ferns. Journal of Systematics and Evolution, Vol.54 (6) 563–603. doi: 10.1111/jse.12229.
- Chandra, S. 2000. The Ferns of India. International Book Distributors, Dehradun.
- Chandra, S. et al. 2008. A Summary of the Status of Threatened Pteridophytes of India. Taiwania, 53(2): 170-209
- Fraser-Jenkins, C.R. 2012. Rare And Threatened Pteridophytes Of Asia 2. Endangered Species Of India—The Higher IUCN Categories. Bull. Natl. Mus. Nat. Sci., Ser. B, 38: 153–181.
- Madhusoodanan, P.V. 2015. Hand book on ferns and fern allies of Kerala, Malabar Botanical Garden and Institute for Plant Sciences. Calicut, Kerala.
- Manickam, V.S. and Irudayaraj, V.1992. Pteridophyte Flora of the Western Ghats-South India. B I Publications, New Delhi
- Ranker, T.A. Haufler C. H. (eds) Biology and evolution of ferns and lycophytes 2008.Cambridge University Press
- Schneider, H et al.2004. Ferns diversified in the shadow of angiosperms. Nature, 428(6982). pp. 553–557. 10.1038/nature02361
- Yang, Y; Ferguson, D.K; Liu B.*et al*.2022. Recent advances on phylogenomics of gymnosperms and an updated classification, Plant Diversity
- Tokareva, T. G. 2020. The use of gymnosperms in urban landscaping of the dry steppe

zone. In IOP Conference Series: Earth and Environmental Science (Vol. 421, No. 2, p. 022037). IOP Publishing.

- Biswas, C. and Johri B.M. 1997. The Gymnosperms. Springer-Verlag Berlin
- Glime, J. M. Bryophyte Ecology. e-book. https://digitalcommons.mtu.edu/bryophyte-ecology1

Mapping of COs with PSOs and POs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	2	-	1	-	-	3	-	-	-	1	-	-
CO 2	3	2	-	1	-	-	3	-	-	-	1	-	-
CO 3	3	2	-	1	-	-	3	-	-	-	1	1	-
CO 4	-	1	2	1	-	2	-	-	-	-	1	2	-
CO 5	-	1	2	1	-	2	-	-	-	-	1	2	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Discussion / Seminar
- Midterm Exam
- Project/Practical
- Final Exam

Mapping of COs to Assessment Rubrics

	Internal Exam	Assignment	Practical/Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓		✓	✓
CO 3	✓	✓		✓
CO 4		✓	✓	✓
CO 5	✓	✓		✓

Programme	B. Sc. BOTANY				
Course Title	**Angiosperm Morphology, Systematics & Plant Resources**				
Type of Course	**Major**				
Semester	**V**				
Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Higher secondary level Biology course				
Course Summary	This course deals with the physical characteristics and classification of plants. Students will explore the diversity of plant resources available for human use, such as food, medicine, and materials.				

Course Outcomes (CO): After completing the Course, the student should be able to:-

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools
CO1	Identify and explain the morphological characteristics of Angiosperms	U	C	Written Test
CO2	Analyse the morphology of the common Angiosperms and recognize their families	An	P	Practical Assignment
CO3	Acquaint with the basic technique in the preparation of herbarium and identify the relevance of digital documentation	Ap	P	Observation of practical skills
CO4	Explain the diagnostic characters of some common Angiosperm taxa	U	C	Field work/Practical assignment
CO5	Demonstrate the conventional and computer assisted keys to identify Angiosperm taxa	Ap	P	Practical Assignment

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
\# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (45 + 30)
I		**Morphology**	**7**
	1	Introduction to Plant Morphology, Morphology of Root, Stem and Leaf, their modifications for various functions	1
	2	Inflorescence - racemose, cymose and specialised (cyathium, hypanthodium, coenanthium, verticillaster, thyrsus, fascicle)	2
	3	Flower - Flower as a modified shoot, detailed structure of flower, floral parts, their arrangement, relative position, cohesion and adhesion, placentation, symmetry, sexuality; Floral diagram and floral formula.	2
	4	Fruits - simple, aggregate and multiple with examples; Dispersal of fruits and seeds - types and adaptations.	2
II		**Systematics - Tools**	**10**
	5	Introduction - History, objectives, scope and relevance of Taxonomy, Botanical survey of India.	1
	6	Systems of classification - Artificial, Natural and Phylogenetic; brief account of Linnaeus', Bentham & Hooker's, and APG System (IV - 2016), a brief history.	2
	7	Merits and demerits of classifications	1
	8	Taxonomic literatures - Floras, Monographs, Revisions, Journals, Manuals, Periodicals, *Hortus Malabaricus*, Digital resources, E-Flora	2
	9	Botanical gardens - Major botanical garden of world and India, (RBG, IGB, JNTBGRI, MBGIPS).	1
	10	Herbarium Preparation, Virtual herbarium; Digital documentation and its relevance	1
	11	Herbaria - Important herbaria of the world and India; (K, MH, CAL, CALI)	1
III		**Systematics - Families and Code**	**18**
	12	Taxonomic Hierarchy - Concept of taxa (family, genus, species); Categories and taxonomic hierarchy; Species concepts (biological, morphological, evolutionary).	2
	13	ICBN: brief history, ICN: A brief account, principles and rules, latest code. Typification, Author citation, effective and valid publication, rejection of names, principle of priority and its limitations; Names of hybrids; ICNCP, naming of cultivated plants, relationships with the ICN.	2
	14	Taxonomic keys - intended (yoked) and bracketed keys. Recent trends - Computer assisted keys.	1
	15	Taxonomic study with distribution, floral morphology, interrelationships and economic importance of following families/subfamilies/tribes as per APG IV. a. Annonaceae b. Orchidaceae (subfamily Orchioideae only)	13

		c. Liliaceae (Lilioidea) d. Poaceae (subfamily Pooideae only) e. Fabaceae (subfamilies Caesalpinoideae, [includes former Caesalpinioideae and Mimosoideae] and Papilionoideae only) f. Euphorbiaceae (subfamily Euphorbioideae only) g. Malvaceae (subfamily Malvoideae only) h. Sapotaceae i. Rubiaceae (subfamilies Ixoroideae and Rubioideae) j. Apocynaceae (subfamily Apocynoideae only) k. Lamiaceae l. Asteraceae (Subfamily Asteroideae)	
IV		**Plant Resources**	**10**
	16	Introduction to Plant Resources - Classification of economic plants based on their uses.	1
	17	Binomial, Family, Processing, Morphology of useful part, products and uses - Food (Rice & Green gram), Sugar (Sugar cane), fibres (Cotton & Coir), medicine (Rauwolfia &Vinca), timber (Teak & Rose wood), Fats & oils (Coconut, Gingelly), gums & resins (Dammar, Gum Arabic) Latex (Rubber), Beverages (Tea, Coffee, Cocoa)	4
	18	Petro-crops - Calotropis, Jatropha	1
	19	Ethno-botany - Introduction, concept, scope and objectives; Ethnobotany as an interdisciplinary science. The relevance of ethnobotany in the present context	1
	20	Tribal Communities in Kerala - Anthropology and Ethnobotany; Brief overview with special reference to Kurichiya, Adiyan, Paniya, Cholanaikan, Kadar, Kurumba, Kuruman, Kani, Mannan, Ulladan; Exploration of their customs, beliefs, and unique Ethnobotanical practices. Plants used by ethnic groups (Brief account)	3
V		**Practical (Mandatory list)**	**30**
	1. Students are expected to work out at least two members of each taxonomic rank mentioned in the syllabus and make suitable diagrams (including floral parts, flower LS, floral diagram, floral formula etc.). Describe them in technical terms and identify up to species using the Flora. Family Orchidaceae and Poaceae may be excluded from practical examination scheme. 2. Students may prepare and record an artificial key to segregate any five given plants included in the syllabus. 3. Students may prepare 5 properly dried and mounted specimens (rare, endangered or endemic plants should not be collected for the purpose) from the families mentioned in the syllabus (with proper herbarium label and tags and field book). 4. It is compulsory that every student has to undertake field study trips of 3-5 days to study vegetation of ecologically different areas, under the guidance of teachers. Visits to standard Herbaria, Organizations/ Institutions involved in exploring and conservation of plant resources, Botanical		

	museums etc. may be conducted as part of study tour. Submit a field visit report countersigned by the Head of the department during the practical examination.
	Practical (Open ended) (Two experiments other than the above to be introduced by the teacher)

Suggested Readings:

- Gangulee, H.C., J.S. Das & C. Dutta. 1982. College Botany (5th Ed.) New Central Book Agency, Kolkata.
- George, H.M. Lawrence. 1951. Introduction to Plant Taxonomy. Mac Millan comp. Ltd., New York.
- Simpson, M. G. 2006. Plant Systematics. Elsevier Academic Press, London Sporne, K.R. (1974) Morphology of Angiosperms. Hutchinson University Press, London.
- Harris, J. G., Harris, M. W. 2001. Plant Identification Terminology: An Illustrated Glossary. Spring Lake, Utah: Spring Lake Pub. Spring Lake, Utah.
- Radford, A. E. 1974. Vascular plant systematics. Harper & Row Publishers, New York,
  London.
- Judd, W.S., Campbell, L.S., Kellogg, E.A., Stevens, P.F., Donoghue, M.J. 2016. Plant Systematics: A Phylogenetic Approach. 4th edition. Sunderland, MA: Sinauer Associates
- Bharati Bhattacharyya 2009. Systematic Botany, Narosa Publishing House Pvt. Ltd., New Delhi.
- Burkill, I.H. 1965. Chapters on the History of Botany in India, Delhi.
- Clive A. Stace 1991. Plant Taxonomy and Biosystematics, Cambridge University Press.
- Davis, P.H. & V.H. Heywood. 1963. Principles of Angiosperm Taxonomy. Oliver & Boyd Ltd., London.
- Gurucharan Singh 2012. Plant Systematics - Theory and Practice. Oxford & IBH, New

Online Sources

- https://courseware.cutm.ac.in/wp-content/uploads/2020/05/APG-SYSTEM-Note.pdf

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	2	-	-	1	1	-	3	-	1	-	1	-	-
CO 2	3	-	1	2	-	1	2	-	1	-	1	-	-
CO 3	1	-	1	2	1	-	1	-	2	3	1	-	1
CO 4	1	-	1	1	-	-	1	-	-	1	1	-	1
CO 5	1	-	1	2	-	1	1	-	1	3	2	-	1

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Discussion / Seminar
- Midterm Exam
- Project/Practical
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Practical/Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓		✓	✓
CO 3	✓	✓	✓	✓
CO 4			✓	✓
CO 5			✓	✓

Programme	B. Sc. BOTANY
Course Title	**ics, Plant Breeding & Palaeobotany**
Type of Course	
Semester	
Academic Level	300-399

Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-		60

Pre-requisites	Higher secondary level biology course
Course Summary	The course on Genetics, Plant Breeding, and Palaeobotany covers topics related to the principles of genetics, techniques in plant breeding, and the study of ancient plant life.

Course Outcomes (CO): After completing the Course, the student should be able to:-

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools
CO1	Analyse the basic principles of inheritance and predict the pattern of inheritance	An	C	Written Test/Quiz
CO2	Employ various plant breeding techniques to develop improved crops	Ap	P	Practical Assignment
CO3	Explain the facts behind heredity and variations	U	F	Quiz/Discussion
CO4	Apply genetic principles to solve classical genetic problems	Ap	P	In-class exercise/Exam
CO5	Identify career opportunities in the fields of crop improvement and fossil studies	An	P	Presentation

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (48+12)
I	**Classical Genetics, Extensions and modification of basic principles**		**15**
	1	Classical Genetics – Introduction: Mendel's life history (brief), Mendelian experiments	2
	2	Allelic Interaction - Incomplete dominance, Modified Dihybrid	4

		ratios by incomplete dominance of one pair of gene (3:6:3:1:2:1) and both pairs (1:2:1:2:4:2:1:2:1). Co dominance - Coat colour in cattle, Lethal genes - Sickle cell anaemia in human beings	
	3	Interaction of genes - Complementary Gene interaction - Flower colour in Lathyrus (9:7), Epistasis - Dominant: Fruit colour in summer squashes (12:3) and Recessive: Coat colour in Mice (9:3:4), Non Epistatic Interaction: Comb pattern in Fowls (9:3:3:1)	5
	4	Multiple alleles - Self sterility in Nicotiana. ABO blood group in man, Quantitative Characters - General characters, Polygenic Inheritance - Skin colour in Man, Ear size in Maize	2
	5	Extra nuclear inheritance - general account, maternal influence - plastid inheritance in Mirabilis, Shell coiling in Snails	2
II		**Linkage, Crossing over, Chromosomal changes**	**13**
	6	Linkage - Complete and Incomplete linkage	2
	7	Crossing Over General account, Cytological basis of crossing over, Two point and three point test cross, chromosome mapping, Interference and Coincidence	3
	8	Structural changes in chromosome - Deletion, Duplication, Translocation and Inversion. Numerical changes in chromosome - Euploidy-Monoploidy , Diploidy, Polyploidy. Aneuploidy - Monosomy, nullisomy, trisomy, tetrasomy	3
	9	Mutation - spontaneous and induced; causes and consequences. Types of mutagens and their effects. Significance & Practical applications of Mutation	3
	10	Population genetics; Hardy - Weinberg law, Factors affecting	2
IV		**Plant breeding**	**10**
	11	Definition and objectives of Plant breeding - Organization of ICAR and its role in plant	1
	12	Plant Genetic Resources - Components of Plant Genetic Resources	1
	13	Plant introduction - Procedure, quarantine regulations, acclimatization - agencies of plant introduction in India, major achievements	1
	14	Selection - mass selection, pureline selection and clonal selection; genetic basis of selection, significance and achievements	2
	15	Hybridization - procedure; intergeneric, interspecific and intervarietal hybridization with examples	2
	16	Heterosis breeding - genetics of heterosis and inbreeding depression	1
	17	Mutation breeding and Polyploidy breeding - methods, achievements	2
III		**Palaeobotany**	**10**
	18	Introduction and objectives, Fossil formation and types of fossils	2
	19	Geological time scale - sequence of plants in geological time	2

	20	Fossil Pteridophytes - *Rhynia*, *Lepidodendron* and *Calamites* Fossil gymnosperms - *Williamsonia*	3
	21	Applied aspects of Palaeobotany - exploration of fossil fuels	2
	22	Indian Paleobotanical Institutes, Indian Palaeobotanists	1
V		**Practical/Theory (Open ended, Suggestive list)**	**12**
		1. Students are expected to work out problems related to Mendelian and modified gene interactions 2. Chromosome mapping, Calculation of Coincidence and interference 3. Demonstration of emasculation, bagging, artificial pollination techniques for hybridization. 4. Identification of Fossil Pteridophytes & Gymnosperms	

Suggested Readings:

- Gupta, P.K. 2018 -19. Genetics. Revised edition. Rastogi Publications, Meerut
- John Ringo 2004. Fundamental Genetics Cambridge University Press.
- Klug, W.S., Cummings, M.R., Spencer, C.A. 2009. Concepts of Genetics. Benjamin Cummings. U.S.A. 9th edition.
- Lewin B. 2000. Genes VII Oxford University Press.
- Rastogi V. B. 2008. Fundamentals of Molecular Biology, Ane Books, India.
- Sinnot, W. L. C. Dunn & Dobzhansky J. 1996. Principles of Genetics. Tata McGraw Hill Publishing Company Ltd., New Delhi
- Verma P.S. & Agarwal V. K. Cell Biology, Genetics, Molecular biology, Evolution and Ecology.
- Singh B. D. Genetics. Kalyani Publishers, New Delhi
- Lewin Benjamin. 2017. Gene XII. Jones and Bartlett Publishers Inc
- Allard. R.W. 1960. Principles of Plant breeding, John Wiley & Sons, Inc, New York.
- Chaudhari. H. K. Elementary Principles of Plant breeding, Oxford & IBH Publishers.
- Singh B.D. 2005. Plant Breeding: Principles & methods, Kalyani Publishers, New Delhi.
- Sinha U. & Sunitha Sinha 2000. Cytogenetics, Plant breeding & Evolution, Vikas Publishing House.
- Swaminathan, Gupta & Sinha 1983. Cytogenetics of Crop plants Macmillan India Ltd.
- Andrews H.N. 1961. Studies in Paleobotany. John Wiley and Sons Inc., New York.
- Arnold C. A. 1947. Introduction to Paleobotany, Tata McGraw Hill, New Delhi.
- Shukla, A. C. & Misra S. P. 1975. Essential of Palaeobotany, Vikas Publishing House, Pvt. Ltd., Delhi.
- Sreevastava H. N. 1998. Palaeootany, Pradeep Publishing Company, Jalandhar
- Taylor, T.N. Paleobotany. An Introduction to Fossil Plant Biology. Mc Graw Hill, New York.
- Steward A.C. 1935. Fossil Plants Vol. I to IV. Watson J. An introduction to study of fossil plants. Adams and Charles Black Ltd. London.

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	1	-	1	1	1	-	1	-	-	-	2	1	-
CO 2	1	2	3	1	1	2	-	1	2	-	2	3	3
CO 3	3	-	-	-	-	-	3	-	-	-	1	-	-
CO 4	1	-	2	2	2	-	1	-	1	-	3	-	1
CO 5	-	1	1	1	-	3	-	2	3	-	1	2	3

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Discussion / Seminar
- Midterm Exam
- Project/Practical
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Practical/Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓	✓	✓	✓
CO 3	✓	✓		✓
CO 4				✓
CO 5		✓		

Programme	B. Sc. BOTANY				
Course Title	nt Physiology & Metabolism				
Type of Course	jor				
Semester					
Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	A basic knowledge about the Plant physiology and metabolism in Higher Secondary level				
Course Summary	The course aims to provide a deep understanding of the various physiological and metabolic processes in plants				

Course Outcomes (CO): After completing the Course, the student should be able to:-

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools
CO1	Explain plant cell as an osmotic system and the concept of water potential	U	F	Quiz/Test
CO2	Analyse the process of transpiration and ascent of sap in plants	An	C	Test
CO3	Assess the physiological processes like seed germination, photosynthesis and mineral nutrient absorption	U	C	Practical Assignment
CO4	Identify the physiological roles of phytohormones	U	F	Quiz
CO5	Evaluate the metabolic pathways involved in energy production and biomolecule synthesis	E	C & P	Written Test

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)

- Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (45+30)
I		**Water relations and Mineral Nutrition in plants**	**16**
	1	Plant cell and Water - Water as a solvent, cohesion, adhesion. plant cell as an osmotic system and entry of water to plant cells, water potential and its components	3
	2	Transpiration - Types, process. Mechanism of guard cell movement. Role of ABA and K^+ ions in stomatal movement. Antitranspirants	2
	3	Absorption of water by transpiration pull and cohesion of water molecules. Radial movement of water through root; SPAC	2
	4	The ascent of sap; Transpiration pull and cohesion of water molecules. Merits and demerits of cohesion-tension theory.	2
	5	Mineral nutrition in plants - Macro and Micro nutrients. Uptake of mineral elements. Difference between passive uptake and active uptake.	2
	6	Mineral nutrition in plants - Simple and facilitated diffusion. Active uptake. Carrier concept. Evidences. Deficiency symptoms of N, P, K, Mg, Fe, Zn, Mn	2
	7	Biological nitrogen fixation, symbiotic nitrogen fixation in leguminous plants; Biochemistry of Nitrogen fixation, Ammonia assimilation, assimilation of nitrate; Biosynthesis of amino acids	3
II		**Photosynthesis and translocation of Photo-assimilates**	**11**
	8	Photosynthetic apparatus and pigments (Chlorophylls, Carotenoids); Electromagnetic radiation.	1
	9	Absorption of light (absorption spectra and action spectra); Fluorescence and phosphorescence; Organization of light harvesting units.	2
	10	Photochemical and chemical phases of photosynthesis; Red drop and Emerson enhancement effect;Two pigment systems, components.	2
	11	Photosynthetic electron transport and photophosphorylation. Assimilatory powers - ATP and NADPH	1
	12	Photosynthetic carbon reduction cycle (PCR), RUBISCO, C3, C4, C3-C4 intermediates (mention only) and CAM pathways. Ecological significance of C4, and CAM metabolism. Photorespiration - process, significance	3
	13	Translocation and distribution of photo assimilates. Mechanism of phloem transport. Phloem loading and unloading; pressure flow hypothesis	2
III		**Plant growth and Development**	**8**
	14	Plant growth regulators - Auxins, gibberellins, cytokinins, abscisic acid and ethylene, brassinosteroid - their physiological	3

		roles and commercial significance	
	15	Plant movements - phototropism, gravitropism, nyctinastic and seismonastic movements	2
	16	Photoperiodism and Vernalization. Phytochrome - chemistry and physiological effects. role in photoperiodism	2
	17	Seed dormancy and germination	1
IV		**Metabolism**	**10**
	18	Catabolism of hexoses - Glycolysis pathway, energy yield, Fate of pyruvate under aerobic and anaerobic conditions.	2
	19	TCA cycle, Anapleurotic reactions and Amphibolic nature of TCA cycle.	2
	20	Amino Acid Metabolism **-** transamination**,** deamination, transulfuration, decarboxylation	1
	21	Oxidation of fatty acids; β oxidation of saturated fatty acids in plants	1
	22	Oxidative phosphorylation - Electron transport reactions in mitochondrion. Electron carriers, redox potential, electron carriers functioning as multienzyme complexes, ATP synthesis, Chemiosmotic hypothesis, cyanide-resistant respiration.	4
V		**Practical (Mandatory list)**	**30**
		1. Determination of water potential by tissue weight change method 2. Absorbotranspirometer 3. Ganong's Potometer 4. Ganong's light-screen 5. Separation of leaf pigments by paper chromatography/ column chromatography /TLC. 6. Mohl's half-leaf experiment 7. Effects of light intensity on photosynthesis by Wilmot's bubbler 8. Ganong's respirometer 9. Kuhne's fermentation vessel 10. Demonstration of gravitropism using Klinostat.	
		Practical (Open ended)	

Suggested Readings:

- William G. Hopkins and Norman P. A. Huner. 2009 Introduction to Plant Physiology. John Wiley & Sons, Inc.
- Taiz L., Zeiger, E., Moller, I.M. and Murphy, A. 2015. Plant Physiology and Development. Sinauer Associates Inc. USA. 6th edition.
- Frank B. Salisbury and Cleon W. Ross 2002. Plant Physiology 3rd edition. CBSpublishers and distributers.
- Noggle G. R. and Fritz G. J. 1983. Introductory Plant Physiology Prentice Hall. Bidwell, R.G.S. Plant Physiology. Macmillan Publishing Corporation.
- Buchanan B. B., Gruissem, W. and Johns R. L. Biochemistry and Molecular Biology

of Plants. American Society of Plant Biologists.

- Devlin R. M. and Withan, F.H. Plant Physiology. CBS Publishers & Distributers.
- Moore T. C. Research Experience in Plant Physiology- A Laboratory Manual. Springer Verlag.
- Steward F.C. Plant Physiology- A Treatise. Vol. I to X. Academic Press.
- Stumpf P.K. and Conn, E.E. The Biochemistry of Plants: A comprehensive Treatise. Academic Press
- Anderson, J.W. and Boardall J. Molecular Activation of Plant Cells - An Introduction to Plant Biochemistry. Blackwell Scientific Publishers.
- Beck C.B. An Introduction to Plant Structure and Development. Cambridge University Press.
- Bajracharya, D. Experiments in Plant Physiology: A Laboratory Manual. Narosa Publishing House, New Delhi.
- Wilkins M. B. Advances in Plant Physiology. Longman Scientific & Technical.
- Lehnìnger. Principles of Biochemistry, Macmillan, U.K.
- Zubay, G. Biochemistry. Macmillan Publishing Company, New York.
- Voet D. and Voet, J.G. Biochemistry. Wiley

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	-	-	-	2	-	2	-	-	-	1	-	-
CO 2	3	2	1	-	1	-	1	-	-	-	1	-	-
CO 3	2	1	-	-	1	-	1	-	-	-	1	-	-
CO 4	2	-	1	-	-	-	1	-	-	-	1	-	-
CO 5	3	1	1	1	1	-	2	-	-	-	2	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Discussion / Seminar
- Midterm Exam
- Practical
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Practical/Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3		✓	✓	✓
CO 4	✓			✓
CO 5	✓			✓

Programme	B. Sc. BOTANY				
Course Title	**t Biotechnology, Nanotechnology & Bioinformatics**				
Type of Course	**or**				
Semester					
Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Higher secondary level Biology course				
Course Summary	The course aims to provide a thorough understanding of basic and applied aspects of plant tissue culture, recombinant DNA technology, nanotechnology and bioinformatics.				

Course Outcomes (CO): After completing the Course, the student should be able to:-

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools
CO1	Explain the principles of Plant tissue culture and Nanotechnology	U	F	Written Test/Quiz
CO2	Analyse the importance of rDNA technology and its applications in daily life	An	C	In-class discussions
CO3	Apply the techniques of Plant Tissue Culture for the mass production of plants	Ap	C & P	Observation of Practical skill
CO4	Discuss the concept of biogenic methods for nanoparticle synthesis & its applications	U	C	Test/Assignment
CO5	Identify and use various biological software to analyse biomolecules	Ap	C & P	Practical Assignment

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)

\# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus

Module	Unit	Content	Hrs (45+30)
I		**Plant Tissue Culture**	**13**
	1	Historical background of plant tissue culture - Haberlandt's contribution; Totipotency of plant cells - understanding differentiation, dedifferentiation, and redifferentiation	2
	2	Facilities for tissue culture - Requirements for establishing a plant tissue culture laboratory and basic design of a plant tissue culture laboratory Sequence in tissue culture - explant selection, sterilization, inoculation, induction of callus, organogenesis and hardening	2
	3	Tissue culture media - Types of media, general account of media with respect to their contents like inorganic chemicals, organic constituents, vitamins, amino acids, hormones etc. MS Media composition, preparation, sterilization and storage	4
	4	Application of Plant Tissue culture - micropropagation, somatic embryogenesis & synthetic seeds, protoplast fusion, embryo rescue, anther & pollen culture, production of pathogen free plants by shoot apical meristem culture, somaclonal variation and cryopreservation	5
II		**Recombinant DNA Technology**	**15**
	5	Introduction to rDNA technology/genetic engineering. Steps of rDNA technology	1
	6	Enzymes used in genetic engineering - Restriction endonucleases, DNA polymerase, Reverse transcriptase, DNA ligase, Taq DNA polymerase, Polynucleotide kinase, Exonucleases, S1 nuclease, Terminal deoxynucleotidyl transferase and Alkaline phosphatase. Construction of rDNA using the enzymes - sticky and blunt end ligations	2
	7	Vectors - General characteristics of cloning vectors, Shuttle and expression vectors, account of commonly used cloning vectors - Prokaryotic (pBR322, Ti plasmid & BAC); Lambda phage, M13 phagemid, Cosmid, Eukaryotic Vectors (YAC)	3
	8	Gene transfer methods in plants - Cloning Vector that Works with Plant Cells. Direct gene transfer - Biolistics, Lipofection, Electroporation, Microinjection - Advantages and disadvantages	4
	9	Vector mediated gene transfer - Agrobacterium mediated gene transfer -T DNA, Ti plasmid and Ri plasmid derived vector systems; Process of Agrobacterium mediated transfer	2
	10	Analysis of Transgene expression - Southern, Northern and Western blotting, dot and slot blots	1
	11	Need for Genetically Modified (GM) crops - Pest resistant (Bt-cotton); Transgenic crops with improved quality traits (Flavr Savr tomato, Golden rice); Edible vaccines	2

III	**Nanotechnology**		**5**
	12	Introduction - Nano-definition, The fundamental Science behind nanotechnology Strategies for Nano architecture (top down and bottom up approaches)	1
	13	Synthesis of nanoparticle - Physical, Chemical and Biological. Characterisation of nanoparticles - SEM analysis and atomic force microscope	1
	14	Nanomaterials in use - Various types of nanomaterial utilized in agriculture - Biopesticides, Biofertilizers and Biosensors.	2
	15	Regulation - Regulatory and safety measures for nanotechnology-based agriculture products	1
IV	**Bioinformatics**		**12**
	16	Introduction to Bioinformatics - WetLab vs WebLab.	1
	17	Biological Databases - Nucleic acid and protein sequence databases, GenBank/EMBL Protein sequence databases, RCSB PDB, UniProtKB/SwissProt, structural databases, NDB, derived databases Prosite, Database search engines, Entrez, SRS	3
	18	Overview/concepts in sequence analysis - Pairwise sequence alignment algorithms, Database Similarity Searches - BLAST, FASTA, Multiple sequence alignment, CLUSTAL W.	3
	19	Genomics and Proteomics - DNA sequencing, Sangers procedure, automation of DNA sequencing, brief account of NGS, genome sequence assembly. Brief account of functional, structural and comparative genomics	2
	20	Genome projects - Major findings and relevance of the following genome projects - Human and *Arabidopsis thaliana*. Proteomics - Protein sequencing (brief account), protein structure prediction - homology modelling	2
	21	Bioinformatics Software and Tools- A brief account on Molecular phylogeny and phylogenetic trees-MEGA; Molecular visualization - use of Rasmol	1
V	**Practical (Mandatory list)**		**30**
	1. Demonstration of various sterilization techniques used in laboratory 2. The preparation of MS Medium using stock solutions and ready-made medium. 3. Study of micropropagation, somatic embryogenesis & artificial seeds through photographs 4. Understand the facilities and techniques by visiting to a leading Biotechnology/Plant tissue culture lab - submission of report. 5. Study different cloning vectors and its parts using photographs. 6. Familiarizing with the different data bases mentioned in the syllabus. 7. Retrieving sequence data from Entrez (nucleotide and protein sequences) 8. Pair wise alignment of sequence data using FASTA		

	9. BLAST search of nucleotide sequences and analysis of BLAST results 10. Multiple sequence alignment and creation of phylogenetic trees using MEGA. 11. Molecular visualization using Rasmol.
	Practical (Open ended, Suggestive list)
	12. Demonstration and operation of gel documentation system. 13. Study of methods of gene transfer through photographs - Agrobacterium-mediated, direct gene transfer by electroporation, microinjection, microprojectile bombardment. 14. Isolation of genomic DNA from living cell and analysis of DNA by agarose gel electrophoresis and Spectrophotometer. 15. Familiarise PCR machine and do a PCR programme by setting denaturation, annealing and extension. 16. Study of steps of genetic engineering for production of Bt cotton, Golden rice, Flavr Savr tomato through photographs Green synthesis of nanoparticles and investigate its development using UV-Vis spectroscopy.

Suggested Readings

- Singh, B.D. 2006. Plant Biotechnology. Kalyani publications.
- Bhojwani, S.S. and Razdan, M.K., 1996. Plant Tissue Culture: Theory and Practice. Elsevier Science Amsterdam. The Netherlands.
- Glick, B.R., Pasternak, J.J. 2003. Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington.
- Snustad, D.P. and Simmons, M.J. 2010. Principles of Genetics. John Wiley and Sons, U.K. 5th edition.
- Stewart, C.N. Jr. 2008. Plant Biotechnology & Genetics: Principles, Techniques and Applications. John Wiley & Sons Inc. U.S.A.
- The 2018-2023 World Outlook for Nanobiotechnology Paperback – December 18, 2017, Icon group international.
- Arunava Goswami and Samrat Roy Choudhury, Nanobiotechnology, Basic and Applied Aspects.
- Clive Jarvis, Nanobiotechnology: An Introduction.
- H B Singh, S Mishra, L F Fraceto, R D D Lima; Emerging Trends in Agri-Nanotechnology.
- Bharath Bhushan, 2004 Handbook of nanotechnology. Springer -verlag, Berlin
- Attwood TK & Parry, Smith DJ. 2003. Introduction to Bioinformatics. Pearson Education
- Jeremy W. Dale and Malcolm Von Schantz 2003, From Genes to Genomes. John Wiley & Sons, Ltd. New York.
- Jin XIong, 2009, Essential Bioinformatics, Cambridge
- Lesk, A. 2019. Introduction to bioinformatics. Oxford university press.
- Rastogi SC, Mendiratta M and Rastogi P. 2004. Bioinformatics: concepts, Skills and Application CBS. David W Mount, Bioinformatics. CBS.

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	-	-	-	2	-	2	-	-	-	1	-	-
CO 2	3	1	3	1	3	3	3	-	3	-	3	1	3
CO 3	3	3	3	-	3	3	2	-	3	-	3	1	2
CO 4	2	-	-	-	3	-	3	-	-	-	1	-	-
CO 5	3	-	3	-	3	-	2	-	1	3	2	-	1

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Discussion / Seminar
- Midterm Exam
- Practical
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Practical/Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3			✓	
CO 4	✓	✓		✓
CO 5			✓	

ST. JOSEPH'S COLLEGE (AUTONOMOUS), DEVAGIRI

Programme	B. Sc. BOTANY				
Course Title	**Environmental Science & Phytogeography**				
Type of Course					
Semester					
Academic Level	9				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-		60
Pre-requisites	Higher secondary level Biology course				
Course Summary	In this course, students will explore the interactions between plants and their environment, focusing on the distribution of plant species in different ecosystems. Students will also learn about the role of plants in environmental processes, such as carbon sequestration and ecosystem services.				

Course Outcomes (CO): After completing the Course, the student should be able to:-

CO	CO Statement	Cognitive Level*	Knowledge Category	Evaluation Tools
CO1	Explain the factors influencing plant communities in different ecosystems.	U	F	Written exam/Quiz/Field report
CO2	Develop environmental concern in all actions	Ap	C	Reflection papers/Group discussions
CO3	Develop conservation strategies to protect plant diversity and promote sustainable land management practices	An	C & P	Case studies
CO4	Apply phytogeographic concepts to predict plant species distribution patterns in various habitats	Ap	P	Practical Assignments
CO5	Evaluate the role of plants in ecosystem functioning and their contribution to environmental sustainability	E	C	Presentations/Literature Reviews

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (48+12)
I		**Introduction to Plant Ecology & Ecosystem**	**16**
	1	Definition of Ecology, Ecological Factors, Inter-relationships between the living world and the environment.	1
	2	Plant Communities - Habitat and niche, Characters - Analytical and synthetic, Ecotone and edge effects	2
	3	Ecological Succession - Definition & types; Processes and types (autogenic, allogenic, autotrophic, heterotrophic, primary & secondary), Hydrosere and Xerosere.	3
	4	Ecological Adaptations (Morphological and Physiological) - Hydrophytes, Xerophytes, Halophytes, Epiphytes and Parasites.	2
	5	Ecosystem - Structure; Processes; Trophic organisation	1
	6	Types of ecosystems - Sea; Estuarine ecosystem; Lentic ecosystem - lake, Pond; Lotic ecosystem - river; Desert; Forest; Grass land.	3
	7	Techniques in plant community studies - Quadrat and transect methods - species area curve - density, frequency, abundance, dominance of populations - importance value index - construction of phytographs.	4
II		**Biodiversity and Conservation**	**14**
	8	Biodiversity Definition - genetic, species, and ecosystem diversity. Value of biodiversity - social, ethical, aesthetic; hotspots of Biodiversity	2
	9	Biodiversity Crisis - Loss of Species and Genetic Diversity - Introduction, Factors causing loss: Founder Effects, Genetic Drift, Inbreeding depression, invasion, habitat destruction, expanding agriculture, increasing human consumption.	3
	10	Endemic and endangered species of plants in India. IUCN Categories (RET Plants)	1
	11	Conservation of Biodiversity - In-situ Conservation: International efforts and Indian initiatives, protected areas in India, concept of Wildlife sanctuaries, Biosphere Reserves, National Parks, Biodiversity Park, Sacred grooves (definition, objectives, features, advantages and disadvantages).	3
	12	Ex-situ Conservation - Germplasm collections, Botanical Gardens, Seed bank, Gene bank, Pollen bank and DNA bank	2
	13	Agencies playing role in conservation (BSI, NBPGR, ICAR, CSIR, DBT, Ministry of Environment and Forest, Biodiversity Board, World Wide Fund for Nature, Greenpeace)	2
	14	Ecotourism - Environmental impact	1

III		**Environmental audit & Sustainability**	**12**
	15	Pollution monitoring systems for air, water and soil	3
	16	Concept of environmental audit; Scheme of labelling of environment friendly products (Ecomark); Concept of energy and green audit.	2
	17	Carbon credit - concept, exchange of carbon credits. Carbon sequestration - importance, meaning and ways.	2
	18	Environmental Impact Assessment - Objectives, significance; National and International Environmental conventions - Kyoto protocol, Montreal protocol, Earth summit, Paris agreement. Recent trends in Global concern on Environment	3
	19	Role of GIS - Geographical Information Systems: definitions and components; spatial and non-spatial data; Applications	2
IV		**Phytogeography**	**6**
	20	Concept & definition, species distribution - continental drift, continuous and discontinuous distribution.	1
	21	Vegetation in India – Forests: tropical, temperate, sholas, sub alpine, alpine, mangroves & grass lands.	2
	22	Phytogeographical regions of India - Western and Eastern Himalayas, Desert, Western Ghats, Deccan Peninsula, Gangetic Plain, North East India, Coasts & Islands	3
V		**Open ended (Suggestive list)**	**12**
		1. Project Tiger as a case study in conservation. 2. Applications and case studies of remote sensing and GIS in land use planning, forest resources & agriculture studies. 3. Guidelines of environmental audit; Methodologies adopted along with some industrial case studies 4. Field visit to familiarize students with ecology of different sites. 5. Visit a local polluted site and report major pollutants. 6. Visit a mangrove vegetation and report diversity 7. Study of ecological modifications of Xerophytes, Hydrophytes, Halophytes, Epiphytes and Parasites. 8. Observation and study of different ecosystems mentioned in the syllabus. 9. Phytogeographical regions of India - Photos/Diagrams	

Suggested Readings:

- Beeby A. & Brennan A. M. 2004. First Ecology. Ecological Principles and Environmental Issues. Oxford University Press.
- Cunninghan W. P. and M. A. Cunningham 2003. Principles of Environmental Science: Inquiry and Applications. Tata McGraw Hill Pub. N.D.
- Dash M.C. 1993. Fundamentals of Ecology. Tata McGraw Hill Publishing Company Ltd. New Delhi.
- Dix J. H. 1989. Environmental Pollution. Atmosphere, Land, Water and Noise. Wiley Chichester.
- Khitoliya R. K. 2007. Environmental Pollution – Management and Control for Sustainable development S. Chand and Company Ltd., New Delhi.
- Mishra D.D. 2008. Fundamental Concepts in Environmental Studies. S. Chand & Co., New Delhi.

- Mishra S.P. & Pandey S.N. 2008. Essential Environmental Studies. Ane Books Pvt. Ltd. Thiruvananthapuram.
- Odum E.P. 1983. Basics of Ecology. Saunders International UN Edition.
- Shukla R.S. & P.S. Chandel (2005). A Text Book of Plant Ecology S. Chand & Co. Ltd. New Delhi.
- Krebs C. J. 1985. Ecology 3rd edn. Harper & Row New York.
- Sharma, P.D. 2008-2009. Ecology and Environment. Rastogi Publication.
- Wilkinson, D. M. (2007). Fundamental Processes in Ecology: An Earth Systems Approach. Oxford University Press. U.S.A.
- Barrow C. J. 2005. Environmental Management: Principles & Practices,
- Khitaliya R. K. 2008 Environmental Management and Conservation
- Ronald Good 1947. The Geography of Flowering Plants. Longmans, Green and Co, New York
- Armen Takhtajan 1986. Floristic Regions of the World. (translated by T. J. Crovello & A. Cronquist). University of California Press, Berkeley.

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	3	1	-	-	1	3	-	-	-	1	1	-
CO 2	1	3	3	-	-	-	3	-	-	-	2	3	-
CO 3	1	3	3	-	-	-	3	-	-	-	2	3	-
CO 4	1	3	3	-	-	-	3	-	-	-	2	3	-
CO 5	1	3	3	-	-	-	3	-	-	-	2	3	-

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion /
- Assignment/ Seminar
- Practical
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Discussion	Practical/Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2		✓		
CO 3		✓		✓
CO 4			✓	✓
CO 5		✓	✓	

Programme	B. Sc. BOTANY				
Course Title	**Advances in Microbiology & Thallophytes**				
Type of Course	**Major**				
Semester	**V**				
Academic Level	400				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisite	Basic knowledge on Microbiology, Phycology and Mycology				
Course Summary	This course provides an in-depth exploration of microbiology, mycology, and phycology, covering the diversity, physiology, ecological roles, and applications of microorganisms, fungi, and algae. It integrates theoretical knowledge with practical laboratory skills to equip students with a complete understanding of these fields.				

Course Outcomes (CO): After completing the Course, the student should be able to:-

COs	Statement	Cognitive level *	Knowledge Category #	Evaluation Tools
CO1	Recognize the diversity of microbial life and their ecological role	U	F	Written exam/Quiz
CO2	Analyse the nutrition, reproduction, growth patterns and interactions of microbes	An	C	Test
CO3	Assess the ecological & economic roles of fungi	E	C	Presentations
CO4	Develop the skills in culturing, isolation and identification of microbes, fungi and algae	Ap	C & P	Practical Assignments
CO5	Develop a systematic model to identify and classify the organisms using various criteria	C	C & P	Group discussion

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hours 45+30
I	**Microbiology**		**12**
	1	Bacteria - Bergey‘s manual of bacterial classification, Bacterial recombination (Brief account), Homologous recombination;	2

		integrons	
	2	Viruses - morphology and host range, Baltimore classification; Algal and fungal viruses	2
	3	Bacteriophage - clinical aspects	2
	4	Virophages - Diversity, interactions, genetic material, pathogenic aspects	2
	5	Actinomycetes - morphology, cell wall composition and metabolism; Identification (morphological features, biochemical tests, molecular techniques); Ecological role; Industrial applications	2
	6	Mycoplasma - morphology, genome, pleiomorphism; Pathogenicity, detection and preventive methods	1
	7	Microbial ecology - Nitrogen and phosphate synthesis; Phylloplane and Rhizosphere	1
II		**Applied Microbiology**	**9**
	8	Environmental microbiology - Bioaugmentation, sewage treatment, bioremediation, microbes for bioenergy, microbes as biosensors, microbes in biomonitoring of climate change	2
	9	Food microbiology - Production of enzymes; food spoilage and preservation methods; Microbiology of fermented food - dairy products, bread and other fermented plant products; Microorganisms as source of food- single cell protein	2
	10	Agricultural microbiology - bio stimulants; Microbiome management, Microbes in IPM	2
	11	Industrial microbiology - Production of secondary metabolites, production of bioplastics, alcohol, vinegar, vitamins, organic acids, amino acids; Metabolic engineering for desirable traits	2
	12	Medicinal microbiology - antibiotics, Lantibiotics, Glycopeptide antibiotics, steroids, vaccines	1
III		**Mycology**	**12**
	11	General characters of Fungi - ultra structure, hyphal growth, cell wall composition, nutrition, reproduction; Heterothallism & parasexuality	2
	12	Phylogeny of fungi; Updated phylum-level classification of true fungi; current taxonomic concepts regarding straminipilan fungi and protistan fungi	3
	13	Mycotechnology - scope and techniques, Fungal Enzymes and Metabolites, Fungi in the production of antibiotics, organic acids, vitamins, single cell protein, alcohols	3
	14	Environmental mycology - bioremediation, biodeterioration of food and leather, biodegradation of buildings and cloth, role in degradation of pesticides, role in mineral recycling	2

	15	Fungi in agriculture - Mycorrhiza - ectotrophic, orchidaceous and Ericoid mycorrhiza, Vesicular Arbuscular Mycorrhiza - their distribution and significance, Endophytic fungi	2
	16	Lichenology - General account and systematics of lichens, key mechanisms involved in desiccation tolerance, Ecosystem services	1
IV		**Phycology**	**12**
	17	Classification of Algae - Criteria for algal classification; Phylogenetic considerations	2
	18	Algal cytology - Electron microscopic studies of algal cell, cell wall, flagella, chloroplast, pyrenoid, eyespot- their importance in classification	2
	19	Algal biotechnology - Resource potential of algae; commercial utility of algae. Algae as a source of food and feed; Algae as a source of pigments, fine chemicals, fuel and bio-fertilizers, nutraceutical and pharmaceutical industry	3
	20	Liquid seaweed fertilizer: Method of preparation and application. Biodiesel from algae: algae producing biodiesel; Advantages over other sources of biodiesel; Cultivation and extraction methods. Phycoremediation.	4
	21	Role of algae in nanobiotechnology	1
V		**Practical (Mandatory list)**	**30**
		1. Test for the presence of coliform bacteria in contaminated water. 2. Isolation of Eubacteria and Cyanobacteria from soil by dilution plate method. 3. Isolation of pure bacterial culture by streak plate method. 4. Staining of bacteria (negative staining, Gram staining and spore staining). 5. Demonstration of bacterial motility by hanging drop method. 6. Collection, preparation and submission of algal herbarium (5 numbers). 7. Collection and study of the types mentioned below and their identification up to generic level using algal monographs: Chlorophyta: *Pediastrum, Scenidesmus, Hydrodyctyon, Ulva, Cladophora, Pithophora, Bulbochaeta, Cephaleuros, Draparnaldiopsis, Bryopsis, Codium, Caulerpa, Halimeda, Desmids (Closterium, Cosmarium), Nitella*. Xanthophyta: *Botrydium.* Bacillariophyta: *Biddulphia, Coscinodiscus, Cymbella*. Phaeophyta: *Ectocarpus, Dictyota, Padina, Turbinaria*. Rhodophyta: *Batrachospermum, Gracilaria, Champia.* 8. Critical study of the following types with the help of fresh/preserved materials by making suitable micro preparations giving emphasis on systematic position, details of vegetative and reproductive structures: *Stemonitis, Saprolegnia, Phytophthora, Albugo, Mucor, Pilobolus, Saccharomyces, Xylaria, Chaetomium, Peziza, Puccinia, Auricularia, Polyporus, Ganoderma, Lycoperdon, Dictyophora, Geastrum, Cyathus, Aspergillus, Curvularia, Alternaria, Fusarium, ColIetotrichum, Parmelia, Usnea.*	
		Practical (Open ended)	

Suggested Readings

- Agrios, G.N. (1997) Plant Pathology (4th ed) Academic Press.
- Brock, T. D., Madigan, M. T., Martinko, J. M., & Parker, J. (2003). Brock biology of microorganisms. Upper Saddle River (NJ): Prentice-Hall, 2003.
- Bilgrami K.H. & H.C. Dube. (1976) A text book of Modern Plant Pathology. International
- Book Distributing Co. Lucknow.
- Mehrotra, R.S. (1980) Plant Pathology – TMH, New Delhi.
- Pandey, B.P. (1999) Plant Pathology. Pathogen and Plant diseases. Chand & Co., New Delhi.
- Rangaswami, G. (1999) Disease of Crop plants of India Prentice Hall of India Pvt. Ltd.
- Sharma P.D. (2004) Plant Pathology Rastogi Publishers.
- Microbiology: An Introduction by Gerard J. Tortora, Berdell R. Funke, Christine L. Case 2015
- French, E., Kaplan, I., Iyer-Pascuzzi, A., Nakatsu, C. H., & Enders, L. (2021). Emerging strategies for precision microbiome management in diverse agroecosystems. Nature plants, 7(3), 256-267.

Web resources

- https://www.clinicalmicrobiologyandinfection.com/article/S1198-743X(23)00059-9/fulltext
- https://microbiomejournal.biomedcentral.com/articles/10.1186/s40168-019-0768-5
- https://www.sciencedirect.com/topics/pharmacology-toxicology-and-pharmaceutical-science/lantibiotic
- https://www.sciencedirect.com/science/article/abs/pii/B0122270703018559

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	1	3	-	-	-	3	-	-	-	1	1	-
CO 2	2	2	1	-	1	-	2	-	-	-	3	1	-
CO 3	3	2	1	-	-	-	2	-	1	-	1	1	-
CO 4	1	1	2	3	3	3	1	-	3	-	3	1	3
CO 5	-	1	1	2	3	-	2	-	-	-	3	-	1

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Written test
- Assignment/ Seminar
- Internal Theory/Practical
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Discussion	Practical/Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓	✓		✓
CO 4			✓	✓
CO 5		✓		

ST. JOSEPH'S COLLEGE (AUTONOMOUS), DEVAGIRI

Programme	B. Sc. BOTANY				
Course Title	**Advances in Archegoniates**				
Type of Course	**Major**				
Semester	**VII**				
Academic Level	400-4				
Course Details		Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Basic knowledge on Bryophytes, Pteridophytes and Gymnosperms				
Course Summary	The course aims to provide capstone expertise on Bryophytes, Pteridophytes and Gymnosperms				

Course Outcomes (CO): After completing the Course, the student should be able to:-

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools
CO1	Explain the evolution of stele, sorus and sporangia in Pteridophytes	U	C	Written Test/Quiz
CO2	Assess the recent trends in Pteridology research	U	C	Literature Review/Group discussion/presentation
CO3	Analyse the importance of fossil gymnosperms in plant evolution	An	C	Assignment
CO4	Demonstrate the methods of spore germination and gametophyte development in Pteridophytes	Ap	F, C & P	Practical Assignment

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (45+30)
I		**Bryophytes**	**10**
	1	General account of the morphology, anatomy, reproduction and life history of Marchantiales, Porellales, Sphagnales, Polytrichales	7
	2	Methods of collection and sampling techniques of Bryophytes	2

	3	Diversity of Bryophytes in Western Ghats based on macrohabitat and microhabitat	1
II		**Pteridophytes**	**16**
	4	Structure and evolution of stele in Pteridophytes	2
	5	Cytology of Pteridophytes - chromosome number and polyploidy in Pteridophytes	2
	6	Soral and sporangial characters, evolution of sorus and sporangium. Heterospory and seed habit;	3
	7	Gametophyte - Patterns of spore germination; patterns of gametophyte development in homosporous and heterosporous pteridophytes.	2
	8	Apogamy, apospory and apomixis	1
	9	Brief account on the diversity, distribution, habitat, morphology and reproduction - Lycopodiales, Equisetales, Psilotales, Marattiales, Gleicheniales, Salviniales and Polypodiales	6
III		**Gymnosperms**	**14**
	10	General account on the fossil gymnosperms - Pteridospermales, Glossopteridales, Caytoniales, Cycadaeoidales, Pentoxylales, Cordaitales	6
	11	Geological horizons, Distribution, morphology, anatomy, reproduction - Cycadales (Study of families and types not required)	2
	12	Geological horizons. Distribution, morphology, anatomy, reproduction- Ginkgoales, Araucariales and Cupressales, Ephedrales and Welwitschiales (Study of families and types not required).	6
IV		**Applied Aspects**	**5**
	13	Bioprospecting of Bryophytes	2
	14	Recent trends in Pteridology research (Cytology, DNA barcoding)	2
	15	Products of commercial importance from Gymnosperms	1
V		**Practical (Mandatory list)**	**30**
	1. Morphological and structural study of the following genera: *Cyathodium, Marchantia, Asterella, Targionia, Porella, Sphagnum, Pogonatum* *2.* Study of morphology and anatomy of vegetative and reproductive organs of the following genera: *Lycopodiella*, *Equisetum*, *Psilotum*, *Angiopteris*, *Dicranopteris*, *Marsilea*,*Adiantum* 3. Spore germination and gametophyte development of *Ceratopteris* using Knop‘s agar medium 4. ldentification of petrifications, compressions, impressions: *Lyginopteris*, *Heterangium*, *Medullosa*, *Trignocarpus*, *Glossopteris*, *Caytonia*, *Pentaxylon* and *Cordaites*. *5.* Study of vegetative and reproductive structures of *Zamia*, *Ginkgo*, *Araucaria*, *Agathis*, *Podocarpus*, *Cryptomeria*, *Cupressus*, *Cephalotaxus and Ephedra*		

	Practical (Open ended) To be introduced by the supervising teacher

Suggested Readings:

- Shaw, A. J. & Goffinet, B. (eds.). 2009. Bryophyte Biology, Cambridge University Press.
- Vanderpoorten A. & Goffinet, B. (eds.). 2009. Introduction to Bryophytes, Cambridge University Press.
- Glime, J. M. Bryophyte Ecology. e-book. https://digitalcommons.mtu.edu/bryophyte-ecology1
- Nair, M. C., Rajesh, K. P. & Madhusoodanan P. V. 2005. Bryophytes of Wayanad in Western Ghats. Malabar Natural History Society.
- Schofield, W. B. 2001. Introduction to Bryology. The Blackburn Press.
- Smith, A. J. E. (ed.). 1982. Bryophyte Ecology. Chapman & Hall.
- Parihar N.S. An introduction of Embryophyta: Bryophyta. General Book House, Allahabad. (Reprint -Surjeet publications, Delhi,2018).
- Pteridophyte Phylogeny Group. 2016.A Community-derived classification for extant Lycophytes and Ferns. Journal of Systematics and Evolution, Vol.54(6) 563–603. doi: 10.1111/jse.12229.
- Chandra, S. 2000. The Ferns of India. International Book Distributors, Dehradun.
- Chandra, S. *et al*. 2008. A Summary of the Status of Threatened Pteridophytes of India. Taiwania, 53(2): 170-209
- Chandra S. & Srivastava M. (Eds.). 2003. *Pteridology in the New Millennium*. NBRI Golden Jubilee Volume, india
- Fraser-Jenkins, C.R. 2012. Rare And Threatened Pteridophytes of Asia 2. Endangered Species of India—The Higher IUCN Categories. Bull. Natl. Mus. Nat. Sci., Ser. B, 38: 153–181.
- Madhusoodanan, P.V. 2015. Hand book on ferns and fern allies of Kerala, Malabar Botanical Garden and Institute for Plant Sciences. Calicut, Kerala.
- Manickam, V.S. and Irudayaraj, V. 1992. Pteridophyte Flora of the Western Ghats-South India. B I Publications, New Delhi
- Ranker, T.A. Haufler C.H. (eds) Biology and evolution of ferns and lycophytes 2008.Cambridge University Press
- Baker, J.G. 1887. Handbook to the ferns of British India. Reprint (1995). Bishan Singh Mahendra Pal Singh, Dehradun
- Beddome, R.H. 1865-1870. The ferns of British India. Vol 1 & 2. Reprint (1976). Oxford and IBH, New Delhi.
- Beddome, R.H. 1863-1865. Ferns of South India. Reprint (1970). Today & Tommorrow‘s Publ., New Delhi
- Nitta, J.H. and Ebihara, A. 2019.Virtual issue: Ecology and evolution of pteridophytes in the era of molecular genetics. Journal of Plant Research 132:719–721. https://doi.org/10.1007/s10265-019-01139-1
- Yang, Y; Ferguson, D.K; Liu B. *et al*. 2022. Recent advances on phylogenomics of gymnosperms and an updated classification, Plant Diversity, https://doi.org/10.1016/j.pld.2022.05.003

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	1	-	-	-	-	3	-	-	-	1	-	-
CO 2	3	1	-	-	-	-	3	-	-	-	1	-	-
CO 3	3	1	-	-	-	-	3	-	-	-	1	-	-
CO 4	3	1	-	-	-	-	3	-	-	-	1	-	-

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Written test
- Assignment/ Seminar
- Internal Theory/Practical
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Discussion	Practical Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2		✓		✓
CO 3	✓	✓		✓
CO 4			✓	✓

ST. JOSEPH'S COLLEGE (AUTONOMOUS), DEVAGIRI

<table>
<tr><td>Programme</td><td colspan="5">B. Sc. BOTANY</td></tr>
<tr><td>Course Title</td><td colspan="5">Advanced Plant Systematics</td></tr>
<tr><td>Type of Course</td><td colspan="5">Major</td></tr>
<tr><td>Semester</td><td colspan="5">VII</td></tr>
<tr><td>Academic Level</td><td colspan="5">400-499</td></tr>
<tr><td rowspan="2">Course Details</td><td>Credit</td><td>per week</td><td>Tutorial per week</td><td>Practical per week</td><td>Total Hours</td></tr>
<tr><td>4</td><td>3</td><td>-</td><td>2</td><td>75</td></tr>
<tr><td>Pre-requisites</td><td colspan="5">Basic knowledge on Plant Systematics</td></tr>
<tr><td>Course Summary</td><td colspan="5">This course deals with advanced Plant Systematics and molecular Phylogeny</td></tr>
</table>

Course Outcomes (CO): After completing the Course, the student should be able to:-

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools
CO1	Develop clear understanding about phylogeny and phylogenetic systematics	Understand	Conceptual	Written Exams/ Quizzes
CO2	Acquire skills required to effectively identify order, family, genus and species	Understand	Factual	Observing Practical skill
CO3	Develop knowledge about plant nomenclature	Apply	Factual	Quiz
CO4	Construct phylogenetic trees based on several molecular markers	Create	Factual & Procedural	Assignment

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (45+30)
I		**Morphology**	**12**
	1	A critical study of the current ideas on the origin of Angiosperms with special reference to their ancestral stock, time and place of origin.	3
	2	The concept of primitive angiosperm flower. Origin and evolution of flower, co-evolution of flowers vis-a-vis pollinators; Methods of illustrating evolutionary relationship	3
	3	Origin and evolution of structure and morphology of stamens,	4

		nectarines and nectar. Origin and evolution of carpels: different types- concept of foliar origin of carpels; types of ovary; evolution of placentation types- inferior ovary- foliar and axial concepts.	
	4	Role of floral anatomy in interpreting the origin and evolution of flower and floral parts	2
		Plant Systematics	**10**
	5	Plant Systematics and Taxonomy; Principles and procedures of plant systematics; Plant speciation: Allopatric, abrupt, sympatric, hybrid, apomictic speciation, Isolating mechanisms; Biosystematics: Steps in biosystematics, categories, Importance of Biosystematics.	3
	6	Sources of data for systematics: Morphology, Anatomy, Embryology, Palynology, Biochemistry, Micromorphology, Cytology, protein and DNA sequences	3
	7	Systems of classification: Major contributions of Theophrastus, Linnaeus, Adanson, de Candolle, Bessey, Hutchinson, Engler and Prantles, Takhtajan and Cronquist (brief)	1
II	8	Types of classification: Artificial, natural and phylogenetic (brief); Angiosperm Phylogeny Group (APG I, II, III) classification. Salient features and inter-relationships of major clades of APG IV.	2
	9	Conceptual basis of classification- essentialism, nominalism, empiricism	1
III		**Phylogeny and Speciation**	**11**
	10	Systems of Angiosperm Classification: Phenetic versus phylogenetic systems. Principles of taximetrics. Cladistics in taxonomy - Phylogenetic terms; primitive and advanced, plesiomorphic and apomorphic characters; homology and analogy; parallelism and convergence; monophyly, paraphyly, polyphyly; phylogenetic diagram; phylogenetic data analysis.	4
	11	Origin of angiosperms; age of angiosperm; molecular dating. Monophyletic and polyphyletic origin of angiosperms; possible ancestor and theories; origin of monocot, basal living angiosperms	3
	12	Origin of intra-population variation, population and environment General biological Principle, Transference of Function,	2
	13	Adaptive radiations. Allopathic / Abrupt / Sympatric / Hybrid / Apomictic speciation, Isolating mechanisms.	2
IV	**Molecular Phylogeny**		**12**
	14	Introduction to phylogenetics and tree building, Theory and Practice of Molecular Phylogenetics. Phylogenomics – concepts and principles	2
	15	Molecular markers, homology and homoplasy	2
	16	Plant Molecular Systematics: DNA sequence data, Types of sequence data, Sequence alignment, Phylogenetic analysis (parsimony, Maximum Likelihood, Bayesian approaches, Neighbor-Joining), DNA barcoding and its practical implications. Molecular taxonomy and barcoding in plants.	4

	17	Next-generation sequencing for ecological and evolutionary research, DNA Sequencing and Analysis.	2
	18	Genetic variation in populations, gene trees	1
	19	Molecular Evolution: Understanding genetic variation, mutation and Molecular Clocks. Application of Molecular Phylogeny.	1
V		**Practical (Mandatory list)**	**30**
		1. It is compulsory that every student has to undertake regular field trips to study vegetation of ecologically different areas, under the guidance of teachers. Submit field visit report countersigned by the Head of the department during the practical examination. 2. Students may prepare 15 properly dried and mounted specimens (rare, endangered or endemic plants should not be collected for the purpose) from the families mentioned below (with proper herbarium label, tags and field book). 3. Students are expected to work out and identify the plant specimens using floras and identification keys, up to species, from the families mentioned below. Record them with suitable scientific diagrams (including floral parts, flower LS, floral diagram, floral formula etc.) and describe in technical terms. Monocotyledonous families may be excluded from practical examination scheme. 4. Students may prepare and record an artificial key to segregate any eight given plants included in the syllabus. 5. Study of the following families with special reference to morphology of modified parts, economic importance, interrelationships and evolutionary trends, by using live plants/preserved specimens (classification based on APG IV): 6. Family Nymphaeaceae, Magnoliaceae, Araceae, Amaryllidaceae, Commelinaceae, Zingiberaceae, Cyperaceae, Menispermaceae, Ranunculaceae, Cucurbitaceae, Vitaceae, Polygalaceae, Rosaceae, Urticaceae, Clusiaceae, Oxalidaceae, Malvaceae (subfamily Sterculioideae only), Myrtaceae, Melastomaceae, Sapindaceae, Meliaceae, Caryophyllaceae, Aizoaceae, Balsaminaceae, Gentianaceae, Boraginaceae, Convolvulaceae, Scrophulariaceae, Pedaliaceae, Acanthaceae, Lentibularaceae, Apiaceae 7. Construction of dendrograms using appropriate software. Use of molecular markers to determine genetic relatedness between species	

Suggested Readings:

- Christenhusz, M. J., Fay, M. F., & Chase, M. W. (2020). Plants of the world: an illustrated encyclopedia of vascular plants. University of Chicago Press.
- Jones, Jr. S.B. and Luchsinger, A.E. 1987: Plant Systematics and Evolution, McGraw-Hill International Editions, New Delhi.
- Gurucharan Singh, 2014: Plant Systematics – Theory and Practice, 3rd Edition, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, India
- Manilal, K.S. and Kumar, M.S.M, 1998: A Handbook on Taxonomy Training, Department of Sciences and Technology, Govt. of India, New Delhi.
- APG III, 2009. An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG III. Botanical Journal of the Linnean Society 161: 105 –121.
- Benson, L.D. 1962. Plant Taxonomy: Methods and Principles. Ronald Press, New

York.

- Cronquist, A. 1981. An Integrated System of Classification of Flowering Plants. Columbia University Press, New York.
- Sivarajan, V.V. 1991 (2nd ed.). Introduction to the Principles of Plant Taxonomy (Ed. N S K Robson). Oxford and IBH publishing Co. Pvt. Ltd.
- Stuessy, Tod F., 2009. Plant taxonomy: the systematic evaluation of comparative data (2nd ed.). New York Columbia University Press.
- Arun K. Pandey, Shruti Kasana., 2021. Plant Systematics. CRC Press: Oxon.
- Heywood, VH and Moore, DM. 1984. Current Concepts in Plant Taxonomy. Academic Press, London.
- Davis, PH and Heywood, VH. 1973. Principles of Angiosperms Taxonomy. Robert E. Krieger Publishing Co., New York.
- Grant, WF. 1984. Plant Biosystematics. Academic Press, London.
- Crawford, D.J. (2003). Plant Molecular Systematics. Cambridge University Press, Cambridge, UK.
- Hollingsworth, P.M., Bateman, R.M. and Gornall, R.J. (1999). Molecular Systematics and Plant Evolution. Taylor and Francis, London.

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	-	-	-	-	-	3	-	-	-	1	-	-
CO 2	2	-	1	-	1	-	2	-	1	-	1	-	-
CO 3	2	-	1	-	-	-	3	-	-	-	1	-	-
CO 4	2	-	2	2	1	1	2	-	1	1	1	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Viva
- Assignment/ Seminar
- Internal Theory/Practical
- Final Exam

Mapping of COs to Assessment Rubrics :

	Quiz / Viva	Assignment/ Seminar	Internal Theory/Practical	Final Exam
CO 1	✓	✓	✓	✓
CO 2	✓		✓	✓
CO 3	✓		✓	✓
CO 4			✓	✓

Programme	B. Sc. BOTANY				
Course Title	**Advanced Cell and Molecular Biology**				
Type of Course	**Major**				
Semester	**VII**				
Academic Level	400-499				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Basic knowledge on cell and molecular biology				
Course Summary	This course deals with advanced cell biology concepts, molecular biology techniques, and the relationship between cellular structure and function.				

Course Outcomes (CO): After completing the Course, the student should be able to:-

CO	CO Statement	Cognitive Level*	Knowledge level#	Evaluation Tools
CO1	Demonstrate the process of cellular reproduction & the factors affecting the same	U	C	Practical Assignment/written test
CO2	Construct the Idiogram of an organism from a karyotype data	C	P	Assignment/Test
CO3	Evaluate the cell cycle regulation factors and identify various pathological conditions	E	P	Literature Review/Quiz
CO4	Apply the concepts in molecular biology to work out the related problems	Ap	P	Problem Sets/Exams

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
\# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (45+30)
I	**Cell Biology**		**28**
	1	Organization of eukaryotic chromosome - Nucleosome organisation, scaffold, Solenoid model; Heterochromatin - constitutive, facultative and condensed; Euchromatin; organization of centromere and telomere; Supercoiled and relaxed	3

		DNA	
	2	Karyotype analysis, Idiogram and Chromosome banding - Types and Applications	2
	3	Cell reproduction - Cell cycle, Specific events G_1, S, G_2 and M phases, Significance of G_0; Cell cycle control, Significance; Gene expression during cell cycle; Mitotic Inducers	4
	4	Meiosis - types, significance of meiosis; Genetic control and consequences of meiosis; Ultra-structure of Synaptonemal complex; Restriction points and check points; Meiotic defects and human diseases	4
	5	Regulation of Cell cycle progression - Maturation promoting factors (MPF), Cyclins and Cyclin dependent kinases, growth factors and growth inhibitory factors	4
	6	Components of cell cycle control system - Intracellular and Extra-cellular control of cell division, Programmed cell death (Apoptosis), intrinsic & extrinsic pathways of cell death, Apoptosis in relation with Cancer, Viral disease (AIDS) & Organ transplant	4
	7	Cellular differentiation and specialization - General characteristics, intrinsic interactions - Nucleo-cytoplasmic; Extrinsic interactions; Molecular mechanisms of cellular differentiations; Introduction to stem cells	3
	8	Cell signalling, signalling molecules and cell surface, receptors; intracellular signal transduction; G protein coupled receptors; plant growth factors and hormones, quorum sensing and intercellular signalling, Signal peptides, biofilm formation; Jasmonic Acid Signalling pathway in Plants	4
II		**Molecular Biology**	**12**
	9	Three-dimensional structure of DNA, unusual DNA structures, DNA interactions	2
	10	Replication of DNA - Enzymology of replication. Replication in prokaryotes and eukaryotes, Primosomes and replisomes, Telomerase and its function.	3
	11	Protein synthesis: Transcription, post-transcriptional events. Introns and their significance. Translation. Post-translational events. Role of chaperons; Inhibitors and Modifiers of protein synthesis	4
	12	DNA damages and repair Mechanisms – Reversible & non-reversible DNA damages; Direct reversal, Single and Double stranded breakage repair, Translesion synthesis	3
III		**Prokaryotic gene regulation**	**7**
	13	Control of Gene in Prokaryotes - Constitutive, Inducible and Repressible control; Positive and Negative control of gene expression; Operon concept - Arabinose operon model	3
	14	Transcription level control - Promoter gene, Pribnow box and	2

		other regulatory DNA sequences, Feedback Inhibition	
	15	Translation level control in Prokaryotes - Ribosome binding sites, mRNA stability, regulatory proteins and riboswitches	2
IV	**Eukaryotic Gene regulation**		**8**
	16	Control of Gene Expression at transcription and translation level in Eukaryotes - Eukaryotic genome organization, Proteins involved in the control of transcription, Protein-protein interactions.	2
	17	Regulatory strategies in Eukaryotes - Gene alteration (Gene loss, Gene amplification, Gene rearrangement: the joining of coding sequences in the immune system)	2
	18	Transcriptional Control by hormones, Gene expression regulation by methylation, acetylation and phosphorylation, Regulation of mRNA processing, RNA editing	2
	19	Translational control - Regulation of gene expression in plant cells by light. TATA box, CAAT box and other regulatory DNA sequences; post-translational regulatory mechanisms	2
V	**Practical (Mandatory list)**		**30**
	1. Study of meiosis in Rheo/ Chlorophytum/ Maize and identification of different stages of Meiosis. 2. Karyotype analysis and preparation of Idiogram 3. Work out the problems in molecular biology 4. Isolation of plant DNA and its quantification by spectrophotometric/ calorimetric method. 5. Study of induced aberrations in onion root tips employing chemicals and plant extracts.		
Practical (Open ended)			

Suggested Readings

- B. Alberts et. al. 2008. 5th Edition, Molecular Biology of the Cell, Garland
- De Robertis E. D. P and De Robertis E. M. F. 2006. Cell and Molecular Biology. 8th edition. Lipincott Williams and Wilkins, Philadelphia.
- Cooper G. M. and Hausman R. E. 2009. The Cell: A Molecular Approach. 5th Edition. ASM Press & Sunderland, Washington D. C.; Sinauer Associates, MA
- Surzycki S. 2000. Basic techniques in molecular biology. Springer.
- Verma P.S. & Agarwal V. K. Cell Biology, Genetics, Molecular biology, Evolution and Ecology.
- Gerald Karp, Cell and Molecular Biology: Concepts and Experiments. John Wiley and Sons Inc.
- Lodish. H. et. al., 2000. Molecular Cell Biology, Freeman & Company.
- Powar C.B. 1988. Essentials of Cytology, Himalaya Publishing House.
- Rastogi S.G. Cell Biology. Tata Mc Graw Hill Publishing Company New Delhi
- Rastogi. V.B. 2008. Fundamentals of Molecular Biology, Ane Books India

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	-	1	1	1	-	3	-	-	-	2	-	-
CO 2	3	-	1	1	1	-	3	-	1	1	3	-	-
CO 3	3	-	3	1	1	-	3	-	1	-	2	-	-
CO 4	3	-	-	1	1	-	3	-	-	-	1	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Viva
- Assignment/ Seminar
- Internal Theory/Practical
- Final Exam

Mapping of COs to Assessment Rubrics :

	Quiz / Viva	Assignment/ Seminar	Internal Theory/Practical	Final Exam
CO 1	✓	✓	✓	✓
CO 2	✓	✓	✓	✓
CO 3	✓		✓	✓
CO 4			✓	✓

Programme	B. Sc. BOTANY				
Course Title	**Multi - omics Approach in Biology**				
Type of Course	**Major**				
Semester	**VII**				
Academic Level	400-499				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	[illegible]	3	-	2	75
Pre-requisites	Knowled[illegible]ious semesters courses with similar topics				
Course Summary	This course introduces genomics, transcriptomics, proteomics, metabolomics, and their integration, omics approaches to address research questions in various fields, from medicine to ecology				

Course Outcomes (CO): After completing the Course, the student should be able to:-

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools
CO1	Recall fundamental concepts in genomics, transcriptomics, proteomics, and metabolomics	U	F & C	Written Exam/Quiz
CO2	Apply knowledge of omics technologies to design and conduct experiments in various biological contexts, such as gene expression analysis and protein identification.	Ap	C & P	Home Assignments
CO3	Construct comprehensive models of biological systems integrating multi-omics datasets	C	C & P	Presentations
CO4	Formulate research questions, design experiments, and conduct investigations using multi-omics approaches	C	C & P	Practical Assignment

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (45 + 30)
I		**Introduction**	**5**
	1	Introduction to Multi-Omics - Overview of omics technologies, Evolution and emergence of multi-omics approach, Importance and applications in biology	1
	2	Basics of Genomics - Introduction to the structure and function of genomes, Genome organization - genes, non-coding regions, repetitive elements, Concepts of genome size, complexity, and variation	2
	3	Next-Generation Sequencing (NGS) Technologies- Overview of NGS platforms; Sequencing workflows: library preparation, sequencing, data analysis, Applications of NGS in genomics research and clinical diagnostics	3
II		**Genomics & Transcriptomics**	**14**
	4	Genome Assembly and Annotation- Genome assembly methods: de novo assembly, reference-guided assembly, Challenges in genome assembly: repeat regions, heterozygosity, sequencing errors, Genome annotation: gene prediction, functional annotation, comparative genomics	4
	5	Principles of Transcriptomics - Overview of gene expression regulation, Transcriptional machinery: RNA polymerase, transcription factors, enhancers, promoters, Post - transcriptional regulation: RNA processing, splicing, stability, localization	3
	6	RNA Sequencing (RNA-Seq) Technologies - Principles of RNA-Seq: library preparation, sequencing, data analysis, RNA-Seq applications: gene expression profiling, alternative splicing analysis, isoform quantification,	5
	7	Single-cell RNA-Seq (scRNA-Seq) and its significance in transcriptomics research	2
III		**Proteomics & Metabolomics**	**16**
	8	Fundamentals of Proteomics-Introduction to the proteome and its complexity, Protein structure and function: primary, secondary, tertiary, quaternary structure, Protein post-translational modifications (PTMs) and their roles in cellular processes	2
	9	Proteomics workflows: sample preparation, protein digestion, peptide separation, MS analysis	2
	10	Protein Identification and Quantification-Database searching algorithms for peptide and protein identification, Quantitative proteomics methods: label-free quantification, stable isotope labelling (SILAC), Data analysis and interpretation: protein abundance estimation, differential expression analysis	3
	11	Introduction to Metabolomics - Overview of metabolites and their roles in cellular metabolism; Metabolite classes: carbohydrates, lipids, amino acids, nucleotides, secondary metabolites	3

	12	Importance of metabolomics in systems biology and personalized medicine	1
	13	Metabolic Pathway Analysis - Metabolic pathway databases and resources: KEGG, MetaCyc, HMDB, Pathway enrichment analysis methods for interpreting metabolomics data, Integration of metabolomics with other omics data for systems-level analysis	3
	14	Epigenomics - Epigenetic modifications and their role, Epigenomic profiling techniques, Epigenetic regulation of gene expression	2
IV		**Applications**	**10**
	15	Multi-Omics - Role of multi-omics in disease diagnosis and prognosis, Biomarker discovery using multi-omics data, Precision medicine and personalized treatment strategies	2
	16	Multi - Omics in Microbiome Studies-Overview of microbiome research, Integration of multi-omics data in microbiome studies	2
	17	Multi-Omics in Evolutionary Biology - Phylogenomics and comparative genomics, Studying adaptation and speciation using multi-omics, Environmental Applications of Multi-Omics-Monitoring environmental changes & management using multi-omics	3
	18	Ethical Considerations in Multi-Omics Research - Data sharing and privacy concerns, Guidelines and regulations. Future Directions in Multi-Omics- Emerging trends and technologies, Challenges and opportunities in multi-omics research	3
V		**PRACTICAL**	**30**
		1. Literature Review and Presentation- Assign students to research recent articles or reviews on multi-omics technologies, applications, and emerging trends. They present summaries and critical analyses in class. 2. Genome Annotation Exercise- Provide a sample genome sequence and guide students through the process of genome annotation using online tools such as NCBI's Genome Workbench or Apollo. 3. NGS Data Analysis Workshop- Introduce students to NGS datasets (e.g., FASTQ files) and guide them through basic analysis steps using bioinformatics tools such as Galaxy or command-line tools. 4. RNA Isolation and RT-qPCR- Hands-on experience in isolating RNA from samples, synthesizing cDNA, and performing real-time quantitative PCR (RT-qPCR) to quantify gene expression. 5. Protein Structure Prediction- Utilize online tools or software like SWISS-MODEL to predict protein structures and discuss the relationship between structure and function. 6. Label-Free Quantification Exercise- Analyse label-free proteomics data using software such as MaxQuant or Skyline, and interpret protein abundance and differential expression results. 7. Visit to nearby omics lab and submit a report of one day workshop/training/class/practical gained from that lab covering any two specific area of the syllabus	

Suggested Readings

- Mass Spectrometry-Based Proteomics. Kris Gevaert 2023. Springer. Kris Gevaert
- Pevsner. Bioinformatics and Functional Genomics, (3rd edition)
- Haddock and Dunn. Practical Computing for Biologists
- Primrose S. B. and Twyman R. M. 2006. Principles of gene manipulation and genomics. Blackwell Publishing
- Simpson R. 2002. Proteins and proteomics: A laboratory manual. Cold Spring Harbor Laboratory Press.
- Pevzner P. A. 2000. Computational Molecular Biology. MIT Press,
- Cantor and Smith 1999. Genomics. John Wiley & Sons.
- Arthur M Lesk 2007. Introduction to Genomics - Oxford University Press.
- Twyman R. M. 2004. Principles of Proteomics, BIOS Scientific Publishers.
- Michael P. Conn 2003. Handbook of Proteomic Method. Humana Press, Totowa, New Jersay, USA
- Devarajan Thangadurai & Saher Islam. Omics Biology in Life Sciences., Apple Academy press

Mapping of COs with PSOs and POs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	-	-	-	1	-	2	-	-	1	1	-	1
CO 2	3	-	3	3	3	-	2	-	1	-	1	-	2
CO 3	2	-	1	1	3	-	2	-	1	1	1	1	1
CO 4	1	2	2	-	3	1	1	-	2	2	2	1	2

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Viva
- Assignment/ Seminar
- Internal Theory/Practical
- Final Exam

Mapping of COs to Assessment Rubrics :

	Quiz / Viva	Assignment/ Seminar	Internal Theory/Practical	Final Exam
CO 1	✓		✓	✓
CO 2		✓	✓	✓
CO 3	✓		✓	✓
CO 4			✓	✓

Programme	B. Sc. BOTANY				
Course Title	**Geobotanical Mapping and Sustainable Development**				
Type of Course	**Major/Minor**				
Semester	**VII**				
Academic Level	400-499				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4		-	2	75
Pre-requisites	Basics of Ecc				
Course Summary	This course c mplete exploration of the relationship between plant distribution, environmental factors and sustainable development. Students will learn how to use geobotanical mapping techniques to assess vegetation patterns and biodiversity. The course covers topics such as remote sensing, GIS technology and field work methods to analyse and interpret geobotanical data effectively				

Course Outcomes (CO): After completing the Course, the student should be able to:-

CO	CO Statement	Cognitive Level*	Knowledge level#	Evaluation Tools
CO1	Demonstrate geobotanical principles and their implications for sustainable development	U	C	Written Test/Presentations
CO2	Analyse and interpret geobotanical data using advanced techniques such as remote sensing and GIS technology, showcasing their ability to evaluate vegetation patterns and biodiversity	An	C & P	Data Analysis Exercises
CO3	Develop the skills to assess and address local, regional, and global sustainability challenges	C	C & P	Case study report/Group Project

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)

- Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (45+30)
I		**Geobotanical mapping**	**15**
	1	Geobotanical mapping - introduction, significance; Basics of Cartography - Map types, scales, projections; Natural vegetation of India and its classification	3
	2	Chorological Mapping - General Characteristics and Current Trends, Types of Chorological Maps - Quantified Chorological Maps, Location Maps, Grid Maps	3
	3	Vegetation mapping - General characters, Types (Physiognomic maps, Phytosociological maps, Phytoecological maps, Synchorological maps, Phyto geographical maps)	3
	4	Applied Geobotanical Mapping - Inventory mapping, Mapping habitats, Mapping for landscape planning	2
	5	Forest mapping and monitoring - Geographical distribution, types, extent and status of vegetation (World and Asia-Pacific region). Global forest resource assessment (FRA), Forest cover classification scheme (IGBP), Mapping for afforestation and social forestry sites	4
II		**Remote Sensing and GIS**	**16**
	6	Fundamentals of Remote Sensing (RS) - Principle, Hyperspectral RS, Microwave RS and Thermal RS (Brief account)	3
	7	Geographical Information system (GIS) – Introduction, Key components of GIS	2
	8	Global positioning system (GPS) - Concept of Global positioning system (GPS) and its architecture, Working procedure of GPS, Different types of Errors in GPS, Kinds of GPS	2
	9	Application of remote sensing in vegetation mapping; Spectral properties of vegetation and other features, Visual interpretation from satellite imagery, Subjectivity and Positional Errors in Vegetation Mapping	2
	10	Bio diversity studies using RS and GIS , Wildlife habitat analysis, Biological invasion and monitoring of invasive species through RS and GIS	2
	11	Environmental Planning & Resource Management - Using GIS for land-use planning, Zoning and land suitability analysis; Urban and regional planning, Water resource management, Agriculture and natural resource management; Applications of remote sensing in ecosystem monitoring and conservation	3
	12	Global, national and state mapping agencies and their	2

		authorized reference maps - general & thematic	
III	**Sustainable Development**		**6**
	13	Depletion of resources and environmental degradation. Sustainable Development: Strategies and Policies. Sustainable human development index, Sustainability pillars	3
	14	Sustainable Development, Sustainable Consumption, Sustainable Production - key issues; Sustainable development goals and achievements, UN Guidelines	3
IV	**Education for Environment and Sustainable Development**		**8**
	15	Global Conservation initiatives, Conservation in South and Southeast Asia, National Conservation Action Plan; Landscape-level Conservation	2
	16	Restoration biology, Environmental History and Conservation Movements, People and Nature: Ecosystem services.	2
	17	Human-wildlife Conflict, Legal aspects of conservation in India. Biopiracy - causes and effects. Sustainable Management of biological resources of Kerala	2
	18	Environmental education - Education for Sustainable Development, Education for sustainable consumption	2
V	**Practical (Mandatory)**		**30**
	1. Study of Vegetation types using Google earth images and identification of dense vegetation, degraded vegetation etc. 2. Study of vegetation of a local area and preparation of a local Vegetation map 3. Prepare a report on natural resources of a particular area and its long-term sustainable consumption plan. 4. Identify and label the forest fragmentation from the google earth image/satellite image/ aerial photograph. 5. Conduct Environmental Impact Assessment of a small area and furnish it as submission for evaluation.		
	Practical (Open ended)		

Suggested Readings

- Anji Reddy, M. 2004: Geoinformatics for Environmental Management.B.S. Publications
- Franklin S.E. 2001. Remote Sensing for Sustainable Forest Management. Lewis Publication
- Rampal K.K. 1999: Hand book of Aerial Photography and Interpretation. Concept Publication
- Lillesand, T.M., and Kieffer, R.M., 1987: Remote Sensing and Image Interpretation, John Wiley.
- Franco Pedrotti.2013. Geobotany Studies, Springer.
- Blackburn R.W. 2007. The sustainability Handbook. Earthscan, UK.
- Dalal-Clayton Barry Bass Stephen 2002. Sustainable Development Strategies – A Resource Book, Earth Scan, London.

- Dayanandan R. 2005. Sustainable development opportunities and challenges, Serials Publications, New Delhi.
- Cauter, I.M. 1981. Environmental Impact Analysis. Mc Graw Book Co. New York.
- Glasson, J., Therivel, R and Chadwick, A. 1994. Introduction to Environmental Impact Assessment. UCI Press Ltd. London
- Lohani, B.N, Envas, J.W, Evertt, R.R, Ludwig, H, Carpenter R.A, Shih Liang Ta. 1997. Environmental Impact Assesment for Developing Countries in Asia. Vol 1 & Vol 2. Asian Developmental Bank.
- Morris, P and Therivel, R. 1995. Methods of Environmental Impact Assessment, Press ltd, London.

Online sources

- https://www.ceom.ou.edu/static/docs/IGBP.pdf
- https://sustainabledevelopment.un.org/?menu=1300
- https://sustainabledevelopment.un.org/partnership/?p=1545 https://www.coe.int/en/web/good-governance/12-principles-and-eloge
- https://www.un.org/sustainabledevelopment/news/communications-material

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	2	2	2	-	-	3	1	-	-	-	-	3	-
CO 2	2	1	1	2	-	3	1	-	1	2	1	1	1
CO 3	-	3	2	-	-	-	-	-	-	-	2	2	-

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Viva
- Case study
- Internal Theory/Practical
- Final Exam

Mapping of COs to Assessment Rubrics :

	Quiz / Viva	Assignment/ Seminar	Internal Theory/Practical	Final Exam
CO 1	✓	✓	✓	✓
CO 2			✓	
CO 3			✓	✓
CO 4			✓	✓

Programme	B. Sc. BOTANY				
Course Title	**Crop Improvement & Plant Pathology**				
Type of Course	**Major/Minor**				
Semester	**VII**				
Academic Level	400 - 499				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4		-		60
Pre-requisites	Basic knowledg breeding and Pathology				
Course Summary	The course w topics such as plant breeding, genetic improvement techniques, molecular breeding, and the principles of developing crops with desirable traits like higher yield and disease resistance. Students will also learn about common plant diseases, their causes, symptoms, and methods of control and management				

Course Outcomes (CO): After completing the Course, the student should be able to:-

COs	Statement	Cognitive level *	Knowledge Category #	Evaluation Tools
CO1	Identify common plant diseases, their causes, symptoms, control measures and management.	U	F	Quiz/Written Exam/Practical Assignments
CO2	Apply the principles of plant breeding techniques to develop crops with desirable traits	Ap	P	Home Assignments/ Presentations
CO3	Identify IPR guidelines related to crop improvement	U	C	Written Test
CO4	Develop practical skills in conducting field surveys, disease diagnosis, and implementing integrated pest management strategies to protect crops from diseases.	Ap	C & P	Field survey report/Field Practical

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (48+12)
I		**Crop Improvement**	**6**
	1	Crop genetic resources - Centres of origin of cultivated plants - primary and secondary centres of diversity	2
	2	Crop genetic resource activities - Exploration, Conservation, Evaluation, Documentation and Utilization. Agencies involved in crop genetic resource activities- IPGRI and NBPGR	2
	3	Detailed account of crop research institutes under CGIAR, ICAR and Commodity Boards	2
II		**Breeding Techniques**	**24**
	4	Conventional methods of plant breeding (Brief account)	3
	5	Resistance breeding- breeding for biotic and abiotic stress resistance. Release and multiplication of varieties - Procedure of variety release - Production of improved seeds	3
	6	Modern methods of plant breeding - mutation breeding, polyploidy breeding, distant hybridization	3
	7	Molecular plant breeding - Concept of markers - Marker assisted breeding, Types of markers - Morphological markers, Enzyme based markers (Protein markers) & DNA based markers	5
	8	Haploids in crop improvement - Anther, pollen and ovary culture for production of haploid plants and homozygous lines	2
	9	Crop Genetics - General account of origin, genetic variability, breeding techniques and achievements in the area of (a) Rice, (b) Coconut, (c) Rubber (d) Pepper (e) Cashew	5
	10	IPR in relation to crop improvement - PPVFR, Farmer‘s Right Act - 2001, ICAR guidelines on IPR management. Plant variety protection - purpose of plant variety protection - UPOV: functions, Organisation and features.	3
III		**Plant Pathology**	**8**
	12	Principles of Plant Pathology - Causal agents of plant diseases - Biotic (fungi, bacteria, virus, mycoplasma, nematodes, angiosperm parasites).	2
	13	Symptoms - Details of different symptoms of plant diseases. Dispersal of plant pathogens, Plant disease epidemiology, plant disease forecasting	2
	14	Process of infection - Entry and establishment of pathogens in the host tissues. Mechanical, physiological and biochemical means of the infection process.	2

	15	Host - parasite interaction - Enzymes and toxins in pathogenesis.	1
	16	Defence mechanisms in plants (structural, physiological and biochemical)	1
IV	**Plant disease management**		**10**
	17	Exclusion, eradication and protection; Pesticides and fungicides - chemistry, mode of application and mode of action.	2
	18	Biocides in plant protection. Microbial biocontrol agents and their applications	1
	19	Integrated pest and disease management strategies for sustainable agriculture	1
	20	Fungal diseases - Blister blight of tea, Coffee rust, Bacterial blight of paddy, Bud rot of coconut, Rhizome rot of ginger and turmeric, Tikka disease of ground nut	3
	21	Bacterial diseases - Wilt and brown rot of potato	1
	22	Viral diseases - Yellow vein mosaic of Bhindi Angiospermic parasites - Viscum, Dendrophthoe	2
V	**Open ended (Practical/Theory)**		**12**
	1. Study of floral morphology and flower structure in crop plants (a) Rice, (b) Coconut (c) Rubber (d) Pepper (e) Cashew 2. Practice of hybridization technique. 3. Study of symptoms of important diseases of vegetable and spice crops 4. Microscopic study of important pathogens. 5. Isolation of organisms associated with the diseases. 6. Demonstration of Koch's Postulates 7. Preparation of botanicals used for the management of the diseases		

Suggested Readings

- Agrios, G.N. 1997. Plant Pathology (4th ed) Academic Press.
- Bilgrami K.H. & H.C. Dube. 1976. A text book of Modern Plant Pathology. International Book Distributing Co. Lucknow.
- Mehrotra, R. S. 1980. Plant Pathology, TMH, New Delhi.
- Pandey, B. P. 1999. Plant Pathology. Pathogen and Plant diseases. Chand & Co., New Delhi.
- Rangaswami, G. 1999. Disease of Crop plants of India, Prentice Hall of India Pvt. Ltd.
- Sharma P. D. 2004. Plant Pathology, Rastogi Publishers.
- Gerard J. Tortora, Berdell R. Funke, Christine L. Case. 2015. Microbiology: An Introduction
- Joanne Willey, Linda Sherwood, Christopher J. Woolverton 2011. Prescott's Microbiology
- Heitefuss R & Williams PH. 1976. Physiological Plant Pathology. Springer Verlag, Berlin, New York.
- Mehrotra R. S. & Aggarwal A. 2003. Plant Pathology. 2nd Ed. Oxford & IBH, New

Delhi.
- Singh R. S. 2002. Introduction to Principles of Plant Pathology. Oxford & IBH, New Delhi.
- Singh D. P. & Singh A. 2007. Disease and Insect Resistance in Plants. Oxford & IBH, New Delhi.
- Upadhyay R. K. & Mukherjee K. G. 1997. Toxins in Plant Disease Development and Evolving Biotechnology. Oxford & IBH, New Delhi.

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	-	1	-	-	1	2	-	1	-	1	1	-
CO 2	1	1	2	2	-	-	3	1	3	-	3	-	1
CO 3	3	-	1	-	1	1	3	-	1	-	2	1	2
CO 4	3	1	3	1	1	1	2	-	3	-	3	1	1

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Viva
- Assignment/Seminar
- Internal Theory/Practical
- Final Exam

Mapping of COs to Assessment Rubrics :

	Quiz / Viva	Assignment/ Seminar	Internal Theory/Practical	Final Exam
CO 1	✓	✓	✓	✓
CO 2			✓	
CO 3	✓			✓
CO 4			✓	✓

Programme	B. Sc. BOTANY				
Course Title	**Smart Farming**				
Type of Course	**Major/Minor**				
Semester	**VIII**				
Academic Level	**400-499**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	[illegible]	-	-	60
Pre-requisites	-				
Course Summary	This course h[illegible] students to understand the concept and techniques of smart farming. The course also includes Precision farming and Integrated agriculture practices.				

Course Outcomes (CO): After completing the Course, the student should be able to:-

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools
CO1	Appreciate the role of smart farming for human welfare	U	C	Discussions/ Presentations
CO2	Apply smart farming techniques in real world situations	Ap	C, P	Assignments
CO3	Analyse the importance of precision farming and integrated agriculture practices	An	C	Case Studies/Written Exams
CO4	Develop the ability to make data-driven decisions to improve crop yield, reduce cost and increase efficiency	C	C, P	Practical Assignments

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C), # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (48+12)
I		**Smart Farming**	**12**
	1	Introduction, Evolution of farming - from traditional to smart farming, benefits - increased productivity, sustainability, cost savings, improved crop quality, better decision making	3

	2	Challenges to adopt smart farming - cost, data management, data security and privacy, training, infrastructure	2
	3	Conservation farming - Principles, tillage practices, cover cropping, Crop rotation strategies, water management. Constraints and benefits of conservation farming	3
	4	Precision farming - objectives, importance, Steps in precision farming - Identification and assessment of variability, management variability, evaluation.	2
	5	Scope of precision farming in India, Advantages and disadvantages of precision farming.	2
II	**Smart Farming Techniques**		**18**
	6	GIS in smart farming - Techniques and applications	2
	7	Remote sensing - Types, components, applications	2
	8	Global Positioning System - components and its functions, Crop modelling, types, steps in crop modelling - uses and limitations of models.	2
	9	Site Specific Nutrient Management (SSNM) - importance, Plant analysis based on SSNM, yield monitoring and soil mapping.	2
	10	Unmanned Aerial Vehicle - Types, Applications	2
	11	Soil Test Crop Response (STCR) - Introduction, objectives, Methods, STCR Approach for Precision Agriculture, Integrated pest management system basic concepts, Plant health monitoring.	2
	12	Variable Rate Technology	2
	13	Brief account on various smart farming technologies - IoT in smart farming, Smart green house, Robotics and automation in agricultural tasks, SaaS based cloud software, Automated Irrigation Systems	4
III	**Nanotechnology in Smart Farming**		**8**
	14	Use of Nano-technology in Agriculture - Nanotechnology in tillage, in Seed Science, water use , use of fertilizers, plant protection	2
	15	Nano pesticides and Nano fertilizers - Definition, formulation, advantages.	4
	16	Nano biosensors - Introduction, features, types and their role in agriculture	2
IV	**Climate Smart Farming**		**10**
	17	Climate change scenarios in agriculture - Trends of agricultural production and productivity under the changing climatic scenarios including extreme events such as drought, flood, pest and disease outbreak	2
	18	Climate Resilient Agriculture (CRA) - concept, scope and importance.	2

	19	Climate smart technologies for enhancing crop productivity and sustainability - weather smart (weather forecasts, crop diversification), water smart (rain water harvesting, SRI, aquifer recharge), carbon smart (organic agriculture, conservative agriculture	2
	20	Energy smart (biomass recycling, use of solar energy) and knowledge smart (ICTs, Smart phone Apps, crop simulation models).	2
	21	Climate Smart Crop Development - Introduction to climate smart crops and their development, Strategies being adopted to develop climate smart crops, selection and evaluation of climate smart crop varieties. Concept of climate smart village	2
	Open Ended (Practical/Theory)		**12**
	1. Field visits to precision farming sites and research facilities 2. Group projects and case studies 3. Guest lectures from industry experts and researchers		

Suggested Readings

- Aqeel-ur-Rehman. Smart Agriculture: An Approach towards Better Agriculture Management, OMICS Group
- Singh Brahma and Balraj Singh. 2014. Advances in protected cultivation, New India Publishing Company.
- Sharma P. 2007. Precision Farming. Daya Publishing House New Delhi.
- Elangovan K. GIS: Fundamentals, Applications & Implementations, New India publishing Agency, New Delhi.
- Tasneem Abbasi & S.A. Abbasi Remote sensing, GIS and wet land management

Online Sources

- https://www.dhyeyaias.com/current-affairs/daily-current-affairs/smart-farming-the-future-of-agriculture
- https://eos.com/blog/precision-agriculture/
- https://www.sciencedirect.com/topics/earth-and-planetary-sciences/precision-agriculture
- https://www.agrivi.com/blog/precision-farming/
- https://www.researchgate.net/publication/355181889_Precision_Farming_Technologies_to_Increase_Soil_and_Crop_Productivity
- https://bisresearch.com/news/applications-of-variable-rate-technology-in-precision-agriculture-at-different-stages-of-farming
- https://iiss.icar.gov.in/eMagazine/v1i1/10.pdf
- https://www.fao.org/4/y4690e/y4690e0a.htm
- https://www.researchgate.net/publication/360777347_GIS_Applications_in_Agriculture
- https://juniperpublishers.com/ijesnr/IJESNR.MS.ID.556009.php

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	1	1	3	2	1	1	1	-	1	1	1	1	-
CO 2	2	-	3	2	1	1	1	-	2	2	2	3	1
CO 3	2	-	3	2	1	1	1	-	2	2	2	3	1
CO 4	1	-	2	2	3	2	1	1	2	1	2	1	1

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Viva
- Assignment/ Seminar
- Internal Theory/Practical
- Final Exam

Mapping of COs to Assessment Rubrics :

	Quiz / Viva	Assignment/ Seminar	Internal Theory/Practical	Final Exam
CO 1		✓		✓
CO 2		✓	✓	✓
CO 3	✓	✓	✓	✓
CO 4		✓	✓	✓

MAJOR ELECTIVES

Programme	B. Sc. BOTANY					
Course Title	**Conservation Biology**					
Type of Course	**Major Elective**					
Semester	**V**					
Academic Level	300-399					
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours	
	4	4	-		60	
Pre-requisites	-					
Course Summary	Conservation biology [illegible]ltidisciplinary field that focuses on understanding and pre[illegible]odiversity and the natural world. The course covers topics suc[illegible]uses of biodiversity loss, the importance of biodiversity for ecos[illegible]ctioning and human well-being, and the strategies and tools used in conservation efforts.					

Course Outcomes (CO): After completing the Course, the student should be able to:-

Cos	Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools
CO1	Recall key concepts and principles of conservation biology, such as biodiversity, ecosystem services, and threats to biodiversity.	R	F & C	Quiz/Written exams/Class discussions
CO2	Explain the significance of biodiversity conservation for ecosystem health and human well-being	U	C	Oral presentations /Case studies / Group projects/Reflection papers
CO3	Apply conservation principles to assess the genetic diversity of endangered species population	Ap	C, P	Fieldwork Assignment
CO4	Critically evaluate the ethical implications of conservation interventions, such as habitat restoration projects or species reintroduction programs	E	C	Case Studies/ Comparative Analysis
CO5	Develop innovative solutions to emerging conservation challenges	C	C, P	Group Project/ Discussion
* - Remember ©, Understand (U), Apply (Ap), Analyse (An), Evaluate ©, Create © # - Factual Knowledge(F) Conceptual Knowledge © Procedural Knowledge (P) Metacognitive Knowledge (M)				

Module	Unit	Content	Hrs (48 + 12)
1		**Introduction to Conservation Biology**	**8**
	1	Definition, scope, importance, History and Evolution of Conservation Biology	1
	2	Milestones and key figures.	2
	3	Biodiversity – services, extinction, Red Data Book, RET category	3
	4	Threats to Biodiversity – Habitat loss, climate change, pollution, overexploitation, invasive species.	2
II		**Biodiversity Conservation**	**10**
	5	Patterns of Biodiversity – Species richness, endemism, hotspots.	3
	6	Conservation Genetics – Genetic diversity, inbreeding, genetic drift.	3
	7	Protected Areas and their Management – National parks, wildlife sanctuaries, marine reserves.	2
	8	Ex Situ Conservation – Botanical gardens, seed banks, captive breeding programs.	2
III		**Conservation Strategies and Tools**	**10**
	9	Habitat Restoration and Management – Ecological restoration techniques.	2
	10	Sustainable Land Use Practices – Agroforestry, sustainable agriculture, urban planning.	3
	11	Conservation Policies and Legislation, International conventions, national laws, and regulations.	2
	12	Community based Conservation- Indigenous knowledge, community participation, co-management.	3
IV		**Applied Conservation Biology**	**20**
	13	Conservation of Endangered Species – Species recovery programs, reintroduction.	2
	14	Conservation of Ecosystems – Coral reefs, forests, wetlands, grasslands	2
	15	Conservation and Human Well-being – Ecosystem services, cultural values, eco-tourism.	2
	16	Emerging Challenges in Conservation – Climate change adaptation, emerging diseases, biotechnology.	2
	17	Conservation Education and Outreach – Environmental awareness, public engagement, citizen science.	2
	18	Conservation Economics – Valuation of natural resources, ecotourism revenue, cost-benefit analysis.	2
	19	Invasive Species Management- Prevention, eradication, control measures.	2
	20	Biogeography and Conservation Planning – Conservation prioritization, reserve design, connectivity.	2

	21	Conservation of Pollinators – Importance, threats, conservation strategies.	2
	22	Ethical Issues in Conservation – Animal rights, indigenous rights, environmental justice.	2
V	**Open ended (Suggestive list)**		**12**
	1. The Role of Indigenous Knowledge in Conservation 2. Field Techniques in Biodiversity Assessment – Conduct hands-on activities such as species identification, habitat mapping, and biodiversity surveys in local ecosystems. 3. Habitat Restoration Projects – Organize field trips or volunteer opportunities for students to participate in habitat restoration projects, such as tree planting, invasive species removal, or wetland restoration. 4. Community Engagement Activities – Invite guest speakers from local conservation organizations to discuss their work and involve students in community-based conservation initiatives, such as citizen science projects or environmental education programs.		

Suggested Readings

- Michael E. Soulé, Bruce A. Wilcox, and Gary Kohlmann. 2005. Conservation Biology: Foundations, Concepts, Applications, Sinauer Associates.
- Martha J. Groom, Gary K. Meffe, and C. Ronald Carroll. 2005. Principles of Conservation Biology, Sinauer Associates.
- Scott P. Carroll and Charles W. Fox. 2008. Conservation Biology: Evolution in Action, Oxford University Press.
- Fred Van Dyke 2008. Conservation Biology: Concepts and Applications Springer.
- Navjot S. Sodhi and Paul R. Ehrlich. 2010. Conservation Biology for All, Oxford University Press.
- Richard Frankham, Jonathan D. Ballou, and David A. Briscoe. 2009. Introduction to Conservation Genetics, Cambridge University Press.
- Peter Kareiva, Michelle Marvier, and Brian Silliman. 2011. Conservation Science: Balancing the Needs of People and Nature, Roberts and Company Publishers.
- Navjot S. Sodhi and Luke Gibson. 2018. Conservation Biology: Voices from the Tropics, John Wiley & Sons

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	3	-	-	-	3	-	-	-	1	2	-
CO2	3	3	3	-	-	-	3	-	-	-	1	2	-
CO3	3	3	3	-	-	-	3	-	-	-	1	2	-
CO4	1	3	3	3	1	1	1	-	-	-	1	3	-
CO5	-	3	3	1	1	3	-	-	3	1	3	3	3

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Discussion / Seminar
- Exam
- Project/Practical
- Final Exam

Mapping of Cos to Assessment Rubrics :

	Internal Exam	Assignment	Project/Practical Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓		✓	✓
CO 3		✓	✓	✓
CO 4		✓		
CO 5		✓	✓	✓

Programme	B. Sc. BOTANY				
Course Title	**Environmental Monitoring & Disaster Management**				
Type of Course	**Major Elective**				
Semester	**V**				
Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-		60
Pre-requisites	Basic knowledge about Environmental issues and major disasters				
Course Summary	This course integrates mental monitoring and disaster management, covering tec r assessing air, water, and soil quality, alongside disaster types, i l mitigation strategies.				

Course Outcomes (CO): After completing the Course, the student should be able to:-

COs	Statement	Cognitive level*	Knowledge Category#	Evaluation Tools
CO1	Define key concepts related to environmental monitoring and disaster management	U	F & C	Written exams/ Quiz
CO2	Interpret data obtained from environmental monitoring activities and describe the interconnections between environmental factors and disasters	E	C & P	Case studies/ Practical Assignments
CO3	Apply monitoring techniques to assess environmental health and utilize GIS for spatial analysis in disaster management	Ap	C & P	Practical Assignments/ Fieldwork reports
CO4	Analyse the impact of human activities on environmental sustainability	An	C & P	Research paper presentations/ Debates
CO5	Integrate data from multiple sources to create a holistic view of environmental conditions and propose innovative solutions for sustainable environmental management	C	C & P	Group Projects

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
\# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus

Module	Unit	Content	Hrs (48 +12)
1		**Introduction to Environmental Monitoring**	**10**
	1	Basics of Environmental Monitoring; Applications of Environmental Monitoring	1
	2	Importance of monitoring environmental parameters Types of environmental monitoring (air, water, soil)	2
	3	Data Collection and Analysis - Sampling techniques in environmental monitoring, Basic data analysis and interpretation , Automated Weather Stations and SCADA	3
	4	Emerging challenges - Urbanization, industrialization, and population growth; monitoring and impact assessment	2
	5	Laws regarding Environmental monitoring in India; UN interventions in Environment quality monitoring; Public Awareness and Education.	2
II		**Air, Water & Soil quality monitoring**	**14**
	6	Air Quality - air pollutants and their sources, Air quality standards and regulations, Health implications of poor air quality	3
	7	Air Quality Monitoring Techniques - Sampling and analysis of air pollutants, Remote sensing in air quality monitoring, Real-time monitoring technologies	3
	8	Water Quality Parameters and Monitoring - common water quality parameters, Water sampling techniques, Analytical methods for water quality assessment - pH, DO, BOD, TCC	3
	9	Soil Quality Assessment - Soil pollutants and their sources, Soil quality indicators and standards	3
	10	Environmental Impact Assessment (EIA) - Introduction to EIA, Role of monitoring in EIA	2
III		**Introduction to Disaster Management**	**10**
	11	Fundamentals of Disaster Management, Definition and Types of Disasters, Natural Disasters and Man-made Disasters, Importance of Disaster Management	2
	12	Social and Economic Impacts of disasters, Role of Government and NGOs, Disaster Risk Reduction (DRR), Understanding Vulnerability and Resilience, Mitigation Strategies	2
	13	Disaster Preparedness and Planning - Early Warning Systems, Community Involvement, Evacuation Planning, Shelter Management, Transportation and Logistics	3
	14	Emergency Response Teams and Protocols, Roles and Responsibilities	1

	15	Recovery and Rehabilitation - Post-Disaster Assessment, Damage and Needs Assessment, Rehabilitation Strategies, Psychosocial Support, Sustainable Development Goals (SDGs) in Disaster Recovery	2
IV	**Risk Assessment and Mitigation**		**14**
	16	Risk Assessment, Hazard Identification, Risk Mapping and Analysis, Vulnerability Assessment	2
	17	Effective Communication Strategies - Geographic Information Systems, Remote Sensing Applications in Risk Assessment	2
	18	Mitigation Strategies - Structural Mitigation, Building Codes and Standard, Infrastructure Development.	1
	19	Non - Structural Mitigation, Land Use Planning, Environmental Conservation, Climate Change Adaptation, Impact on Disaster Risks, Sustainable Practices	2
	20	International Cooperation in Disaster Management: Global Frameworks and Agreements	3
	21	Sendai Framework for Disaster Risk Reduction, International Humanitarian Response Mechanisms, Role of Non-Governmental Organizations	2
	22	Case Studies of Major Disasters - Historical Disasters and Lessons Learned; Tsunami in the Indian Ocean, 2004; Kerala flood 2018; Landslides in Kerala – 2018-2021; Covid-19 pandemic	2
V	**Open ended (Suggestive list)**		**12**
	1. Case Studies and Practical Applications: Case studies on air quality issues - Delhi Air quality crisis 2. Case studies in water quality monitoring - Ganges River basin monitoring, Vembanad lake water quality monitoring. 3. Case studies from Kerala - Palakkad Agricultural Lands Soil Health Assessment, Cochin International Airport Area Soil Quality Assessment. 4. Case studies on EIA and monitoring - Kuttanad wetland ecosystem, Impact of tourism in Alappuzha district. 5. Field Visit and Practical Application - Field Visit to Disaster-Prone Area and preparation of report		

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	2	-	-	-	3	-	-	-	1	1	-
CO2	1	3	3	1	-	-	-	-	-	-	1	2	-
CO3	-	3	3	1	1	2	-	-	1	3	2	2	-
CO4	-	3	3	3	1	1	-	-	-	1	2	3	-
CO5	-	3	3	3	3	3	-	1	1	-	1	3	3

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz/Written Test
- Assignment/Presentation
- Project/Practical
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project/Practical Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓	✓	✓	✓
CO 3	✓			✓
CO 4	✓	✓	✓	✓
CO 5			✓	

Programme	B. Sc. BOTANY				
Course Title	**Plant Resource Utilization & Bioprospecting**				
Type of Course	**Major Elective**				
Semester	**V**				
Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-		60
Pre-requisites	Higher secondary level Biology				
Course Summary	The course explore the diverse ways in which plants are utilized for various purposes, such a dicine, fuel, etc., and the process of bioprospecting, which ne discovery and development of new products from natu				

Course Outcomes (CO): After completing the Course, the student should be able to:-

COs	Statement	Cognitive level*	Knowledge Category#	Evaluation Tools
CO1	Recall key concepts related to plant resource utilization and bioprospecting	R	F	Written exams/ Quiz
CO2	Appreciate the role of plant resources towards mankind	An	C	Reflective essays/ Presentations/Discussions
CO3	Evaluate the effectiveness of different strategies and techniques used in bioprospecting	E	C & P	Case studies/Research reviews
CO4	Develop improvements and innovations in the field of bioprospecting	C	P	Group Project
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48 +12)
1	**Introduction to Plant resources and utilization**		**12**
	1	Introduction - Concept, Plants as natural resources; Utilization: Bioenergy, food, fodder, fibre, medicine and essences.	1
	2	Botanical identification - Macroscopic examination, Microscopic examination, Profiling: Introduction and scope	2
	3	Forest as potential resource - Introduction and scope, Major forest product and their uses - Timber, fuel, paper (Two examples of each, Botanical source, part, uses)	3
	4	Non wood forest produce and their uses - Gum, resin, tannin, dyes and pigments (Two examples of each, Botanical source, part, uses)	2
	5	Processed plant resource: Rubber: Introduction, chemical composition of rubber, plantation and production of rubber in the world and India, processing. Uses of rubber and synthetic rubber. Unprocessed plant resource: (Two examples with source, uses)	4
II	**Conservation of Plant resources**		**10**
	6	Objectives of plant resource conservation, Conservation of plant biodiversity, Principles of conservation	3
	7	Environmental status of plant based on International Union for Conservation of Nature (IUCN)	2
	8	Adulteration in plant products: Introduction, detection of adulteration in oils, spices and condiments:	3
	9	Adulteration in medicinal plants: reasons, substitutes	2
III	**Commercial aspects of plant resources**		**10**
	10	Biocontrol - Introduction, sources and advantages. Important commercial products: Source, preparation and uses of Pyrethrins, Azadiractin, Trichoderma; Biocontrol as an agri-business.	4
	11	Biofertlizers for sustainable crop management and its production	2
	12	Phytoremediation - Introduction, concept and principles. Plant population for phytoremediation processes.	3
	13	Phytoremediation strategies - Applications	1
IV	**Bioprospecting**		**16**
	14	Bioprospecting - Introduction, concept and scope, Phases of Bioprospecting	1
	15	Bioprospecting for new drugs of plant origin - Traditional	2

		assays (Eg Antioxidant assay), High Throughput screening (HTS -fluorescence or luminescence assays), CADD; Principle and applications	
	16	Drugs from plants - Morphin, Artemisinin, Taxol; Drugs from microbes - Pencillin, Gentamycin, Streptomycin (Source and uses)	2
	17	Marine Bioprospecting - Sources of marine planktons and their Bioprospecting, Isolation and cultivation of Marine bioresources, Bioactive chemicals from Seaweeds and their applications.	4
	18	Microbial Bioprospecting - Isolation of Microbial metabolites and their bio-activity. Endophytic microbial products as Antibiotics. Bioprospecting novel antifoulants and anti-biofilm agents from microbes	4
	19	Bioprospecting and sustainable development, Key issues and challenges: exploitation, biopiracy, benefit sharing	3
V	**Open ended (Suggestive list)**		**12**
	1. Commercial products and their applications in biocontrol: Pyrethrin, Azadiractin and Trichoderma. 2. Identification of plants used in phytoremediation: Eichornia, Azolla, Pistia, Lemna, Algal blooms 3. Identification of plant resources and products: Penicillium - Penicillin, Spirulina - Spirulina tablets, 4. Algal products - agar, liquid biofertilizer, Bamboo - paper, Teak - timber, Acacia arabica - gum, Asafoetida - resin, Acacia catechu - kath. 5. Bioactivity study of medicinal plants		

Suggested Readings:

- Arora, R.K. and Nayar, E.R. 1984. Wild relatives of crop plants in India, NBPGR Science Monograph.
- Baker, H.G. 1978. Plants and civilization. Ill Ed. (A. Wadsworth, Belmount).
- Bole, P.V. and Vaghani, Y. 1986. Field guide to common Indian trees, Oxford University Press, Mumbai.
- Thakur, R.S., Puri, H.S. and Husain, A. 1969) Major medicinal plants of India, Central Institute of medicinal and aromatic plants, Lucknow.
- Swaminathan, M.S. and Kocchar, S.L. (Es.) 1989. Plants and Society, MacMillan Publication Ltd.
- Sharma, O. P. 1996. Hills Economic Botany, Tata McGraw Hill Co., Ltd., New Delhi.
- Kocchar, S. L. 1998. Economic Botany of the tropics, II Edn. MacMillan India Ltd.
- CSIR 1986. The useful plants of India Publication and Information directorate, CSIR New Delhi.
- Samba Murty and Subrahmanyam 2011. Text Book of Modern Economic Botany, CBS Publishers and Distributors, New Delhi.
- Wickens, G. E. 2001. Economic Botany: Principles & Practices. Kluwer Academic Publishers, The Netherlands.

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	1	1	2	-	-	-	1	-	-	-	-	2	-
CO 2	2	3	3	-	-	-	2	-	1	-	1	2	-
CO 3	1	3	2	-	-	-	1	-	1	-	1	1	1
CO 4	-	2	2	1	3	3	-	-	2	-	2	3	3

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz/Written Test
- Assignment/Presentation
- Project/Practical
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project/Practical Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2		✓		✓
CO 3	✓	✓		✓
CO 4			✓	

ST. JOSEPH'S COLLEGE (AUTONOMOUS), DEVAGIRI

Programme	B. Sc. BOTANY				
Course Title	**Indigenous Plant Science & Forestry**				
Type of Course	**Major Elective**				
Semester	**V**				
Academic Level	300 - 399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	-				
Course Summary	This course is designed to provide students with a comprehensive understanding of the interplay between human societies and plant life within forest ecosystems the traditional knowledge of plant use, the ecological and aspects of forests, and sustainable practices in silviculture and forestry				

Course Outcomes (CO): After completing the Course, the candidate should be able to:-

COs	Statement	Cognitive Level*	Knowledge Category#
CO 1	Define ethnobotany and its relevance in understanding human-plant interactions	U	C
CO 2	Analyse the contributions of significant centers in ethnobotanical studies	An	P
CO 3	Apply the traditional knowledge of plants for the welfare of human beings	Ap	P
CO 4	Evaluate the sustainability and conservation practices related to indigenous plant species & forestry management	E	C & P

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
\# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (48 +30)
I		**Introduction to Ethnobotany**	**12**
	1	Introduction; significance & scope in biodiversity conservation and sustainable development.	2
	2	Centers of Ethnobotanical Studies - The International Center for Ethnobotanical Education, Research, and Service (ICEERS) in India - AICRPE (All India Coordinated Research Project on Ethnobiology), FRLHT (Foundation for the Revitalisation of Local Health Traditions), Contributions of ICEERS, AICRPE and FRLHT	2
	3	Traditional Knowledge of Plant Use in Different Cultures - Tribal Communities in Kerala: Anthropology and Ethnobotany; Brief overview of tribal communities (Kurichiya, Adiyan, Paniya, Cholanaikan, Kadar, Kurumba, Kuruman, Kani, Mannan, Ulladan); Exploration of their customs, beliefs, and unique Ethnobotanical practices	4
	4	Ethnomedicine - Role of Ethnomedicine in contemporary healthcare	1
	5	Medicinal plants exploration and Documentation - Methods and Techniques in Ethnobotany: Field-level activities for data collection; Documentation methods (Audio, Video recording, Photographs, Interviews, Questionnaire), Authentication of plant species using floras and herbariums	3
II		**Ethnopharmacology**	**10**
	6	Definition and Scope of Ethnopharmacology, Historical Perspective and Contributions to Modern Pharmacology	2
	7	Crude Drug: Classification and sources of crude drugs, Quality, Safety, and Efficacy of Herbal Medicines. Ensuring standards in herbal medicines/nutraceuticals	2
	8	Role of Ethnopharmacology in ensuring quality and safety. Importance of ethnopharmacological studies in drug discovery	3
	9	Ethnopharmacologic contribution to Bioprospecting natural products; emerging opportunities in ethnopharmacology	3
III		**Silviculture and Forest Management**	**12**
	10	Evolution of silviculture and its historical context, Characteristics of major tropical forest formations, Ecosystem Structure	2
	11	Forest types - Champion & Seth,1968.	2
	12	Forest products - Major and minor forest products. Forest products of Kerala.	2
	13	Forest services, Sustainable utilization of bioresources	2

	14	Forests on Environment - Consequences of deforestation, anthropogenic activities and industrialization on forest ecosystems.	2
	15	Importance of forest ecosystem with special reference to conservation of natural resources	2
IV		**Agroforestry**	**14**
	16	Land Use system - Overview of land use systems related to agroforestry, Principles and criteria for selecting tree species in agroforestry	2
	17	Soil Productivity and dynamics - Role of Trees in Soil Productivity and Conservation, impact of trees on soil dynamics, Strategies for sustainable soil productivity in agroforestry.	2
	18	Economics of Agroforestry - Economic considerations in agroforestry practices, Role of agroforestry in mitigating climate change and carbon sequestration	2
	19	Socioeconomics of Agroforestry - Role of agroforestry- Fulfillment of food, fodder, fuelwood and shelter-based needs- income generation vs. subsistence production.	2
	20	Marketing of Agroforest products - Marketing of tree products – Marketing strategies for NTFPs: Cooperative Societies.	2
	21	Value Addition - Exploring market expansion through value addition by improved post-harvest processing. Feasibility, profitability, and acceptability of Agroforestry adoption.	2
	22	Agroforestry adoption - Major factors involved in Agroforestry adoption (land, labor, income, inputs, experience, social capital, training and membership in farmer cooperatives).	2
V		**Open Ended**	**12**
	1. Visit to a tribal settlement and documentation of traditional knowledge		

Suggested Readings

- Daniel, Helms and Baker, 1979. Principles of Silviculture McGraw-Hill Book Company
- Smith D. M., Larson B. C., Ketty M. J. and Ashton P. M. S. 1997. The Practices of Silviculture Applied Forest Ecology. John Wiley & Sons.
- Evans J. 1982. Plantation Forestry in the Tropics. Clarendon Press, Oxford.
- Luna RK. 1989. Plantation Forestry in India. International Book Distributors, Dehra Dun.
- Kumar V. 1999. Nursery and Plantation Practices in Forestry. Scientific Publishers.
- Ram Prakash, Chaudhari DC and Negi SS. 1998. Plantation and NurseryTechniques of Forest Trees. International Book Distributors, Dehra Dun.
- Nair P. K. R. 1993. An Introduction to Agroforestry. Academic Pub.
- Nair P. K. R., Rai M. R. and Buck L. E. 2004. New Vistas in Agroforestry.

- Thampan P. K. 1993. Trees and Tree Farming. Peekay Tree Crops Development Foundation.
- Nair P. K. R. and Latt 1998. Directions in Tropical Agroforestry Research, Kluwer.
- Dwivedi A. P. 1992. Agroforestry: Principles and Practices. Oxford & IBH.
- Nair P. K. R., Rai M. R. & Buck L. E. 2004. New Vistas in Agroforestry.
- Buck L. E., Lassoie, Fernandes E. C. M 1999. Agroforestry in Sustainable Agri. Systems, CRC Press.
- Agarwal, A. P. Forests in India, Oxford and IBH.
- Gregorv, G. R. Forest Products, Production, Trade, Consumption, quantity and value of raw material requirements, Ford foundation, New Delhi.
- Puri, G. S. Indian Forest Ecology I and II, Oxford IBH, New Delhi

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	2	3	1	-	-	-	3	-	-	-	1	-	-
CO 2	3	1	-	-	-	-	3	-	-	-	1	-	-
CO 3	2	3	3	-	-	-	2	-	1	-	1	2	-
CO 4	-	3	3	1	-	1	-	-	1	-	2	1	1

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz/Written Test
- Assignment/Presentation
- Project/Practical
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project/Practical Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2		✓		✓
CO 3	✓	✓		✓
CO 4			✓	

Programme	B. Sc. BOTANY				
Course Title	**Plantation Science & Wood Technology**				
Type of Course	**Major Elective**				
Semester	**V**				
Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	Foundation level knowledge in plant growth process and plant anatomy				
Course Summary	The course offers a holistic understanding of sustainable agriculture practices and wood utilization techniques. The topics range from precision agriculture and climate-resilient crop varieties to timber processing and advanced wooc[illegible]ion methods.				

Course Outcomes (CO): After completing the C[illegible]andidate should be able to:-

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools
CO1	Assess the principles of plantation agriculture, and its ecological impacts	U	F	Written exams/Quiz
CO2	Apply precision agriculture techniques, by integrating technologies like remote sensing and GPS	Ap	P	Practical Assignments, Fieldwork reports
CO3	Analyse the effectiveness of climate-resilient crop varieties	An	C	Comparative analysis reports/Presentation
CO4	Evaluate the efficacy of agroforestry and diversification practices	E	C	Project reports/ Written test
CO5	Design value-added products and processing techniques for plantation crops and innovate in wood technology	C	C & P	Product development projects

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)

- Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs 48 + 12
I		**Plantation Agriculture**	**12**
	1	Introduction to Plantation Agriculture: Overview of plantation crops in Kerala, Geographical and climatic factors influencing plantation crops in Kerala, Economic significance of plantation agriculture	2
	2	Ecological and Environmental Impacts: Impact of plantation agriculture on local ecosystems, Biodiversity conservation in plantation areas, Soil and water conservation practices, Sustainable plantation management	3
	3	Precision Agriculture and Smart Farming: Integration of technology, such as remote sensing, GPS, and data analytics, to optimize plantation management. Use of precision agriculture techniques to monitor crop health, irrigation, and nutrient management.	3
	4	Sustainable and Organic Practices: Importance, objectives and methods. Agroecological approaches to promote biodiversity.	2
	5	Climate-Resilient Crop Varieties: Crop varieties that are more resilient to climate change, including variations in temperature, precipitation, and extreme weather events.	2
II		**Advancement in Plantation Science**	**12**
	7	Biotechnology in Plantation Crops: Breeding improved crop varieties with enhanced traits, such as disease resistance, yield, and quality. Biotechnological interventions for pest and disease management.	3
	8	Remote Sensing and GIS Applications: Monitoring and managing plantations, assessing crop health, identifying stress factors, and optimizing resource allocation.	3
	9	Agroforestry and Diversification: Agroforestry practices, integrating trees with agricultural crops-Scope and importance. Diversification of plantation crops-Scope and importance	2
	10	Climate-Smart Agriculture: practices, strategies- water conservation, soil health management, and carbon sequestration.	2
	11	Value-Added Products and Processing: Processing techniques - specialty foods, cosmetics, and pharmaceuticals. Processing-Sustainable and eco-friendly methods.	2
III		**Introduction to Wood Technology**	**12**
	12	Definition and importance of wood technology. Overview of wood anatomy, Basics of wood identification and classification.	2
	13	Wood Anatomy and Structure: Cellular structure of wood - fibers, vessels, and parenchyma, Growth rings and their interpretation, Heartwood vs. sapwood	3
	14	Chemical constituents of wood and bark, Cellulose: structure, chemical properties, effect of acids and bases. Hemi-cellulose: structure, chemical properties, effect of acids and bases.	3

		Lignin: structure and chemical properties.	
	15	Timber Processing and Utilization: Logging and timber extraction techniques, Sawmilling and wood conversion processes, Preservation methods to prevent decay and insect infestation.	2
	16	Wood Seasoning and Drying: Natural vs. artificial seasoning methods, Kiln drying and air-drying processes, Effects of moisture content on wood properties.	2
IV	**Recent Trends in Wood Technology**		**12**
	18	Advanced Wood Modification Techniques: Enhance properties such as durability, dimensional stability, and resistance to decay. Chemical and thermal modification methods to improve wood performance and extend its lifespan.	3
	19	Digital Technologies in Wood Processing: computer-aided design (CAD) and computer numerical control (CNC) machining, automation in sawmills and other processing facilities.	2
	20	Nanotechnology in Wood Science: enhance the mechanical and functional properties of wood. Development of nanocellulose-based materials-Scope and importance.	2
	21	Engineered Wood Products Innovation: cross-laminated timber (CLT), laminated veneer lumber (LVL), and glulam. Transparent Wood- Applications in architecture, design, and energy-efficient construction.	3
	22	Digital Wood Fabrication and 3D Printing: Potential for on-demand and customized wood products. Biophilic Design and Aesthetics: wood into architecture and interior design. Use of wood for its aesthetic and psychological benefits.	2
V	**Open ended** Practical or theory content as decided by the course teacher		**12**
	1. Cultivation Practices of the following crops 2. Tea, Coffee, Rubber, Black pepper, Cardamom 3. Case study on wood products: lumber, veneer, plywood, and particleboard		

Suggested Readings

- Prabhakaran Nair K. P. 2010. The Agronomy and Economy of Important Tree Crops of the Developing World. Springer India, New Delhi, India.
- Goyal R. K. 2016. Principles of Remote Sensing and GIS. BS Publications, Hyderabad, India.
- Mathur N. K., Dhillon. B. S. 2007. Agroforestry Systems in India: Livelihood Security & Environmental Sustainability. Daya Publishing House, New Delhi, India.
- Das P. M. 2004.Wood Science and Technology. New Central Book Agency, Kolkata, India.
- Sharma H. S. 2013. Wood Seasoning Mittal Publications, New Delhi, India.
- John V. Stafford. 2006. Introduction to Precision Agriculture. CRC Press, Boca Raton, Florida, USA.
- Eric Lichtfouse, Marjolaine Hamelin, et al. 2009. Sustainable Agriculture. Springer Netherlands, Dordrecht, Netherlands.
- Eero Sjöström and Raimo Alén. 2018. Wood Chemistry: Fundamentals and

Applications. Academic Press, London, UK.

Online Sources

- http://www.fao.org/home/en/ - Plantation Agriculture and Forestry
- https://www.icar.org.in/ - Agricultural Research and Development in India
- https://www.iufro.org/ - International Forestry Research Organizations
- https://www.iit.ac.in/ - Indian Institute of Technology (IIT) Agriculture and Forestry Department
- https://www.woodscience.com/ - Wood Science and Technology Resources.

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	1	-	-	-	-	2	-	-	-	-	1	-
CO 2	1	-	1	2	1	1	-	-	1	1	2	1	1
CO 3	-	2	2	1	1	1	-	-	1	-	1	2	1
CO 4	-	2	1	1	-	1	-	-	1	-	1	3	1
CO 5	-	3	3	1	-	3	-	-	2	-	1	-	3

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz/Written Test
- Fieldwork/Presentation
- Project/Practical
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Fieldwork/Presentation	Project/Practical Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2		✓	✓	✓
CO 3	✓			✓
CO 4	✓		✓	✓
CO 5			✓	

ST. JOSEPH'S COLLEGE (AUTONOMOUS), DEVAGIRI

Programme	B. Sc. BOTANY				
Course Title	**Climate Change & Ecosystem Management**				
Type of Course	**Major Elective**				
Semester	**VI**				
Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	-				
Course Summary	The course explores various components of ecosystem and its importance, ecosystem management methods and Understanding of the causes and management of climate change.				

Course Outcomes (CO): After completing the Cou[illegible]didate should be able to:-

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools
CO1	Define the various components of the ecosystem and their importance	U	C	Written exams/Quiz
CO2	Develop strategies for mitigating climate change and its environmental impacts	C	C & P	Group project/Presentations
CO3	Analyse data and trends related to climate change effects on ecosystems	An	C & P	Discussions
CO4	Identify the impact of climate change on ecologically fragile areas	Ap	P	Field work report/Practical assignments

* - Remember I, Understand (U), Apply (Ap), Analyse (An), Evaluate I, Create I
\# - Factual Knowledge(F) Conceptual Knowledge I Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (48+12)
I		**Climate Change & Its Causes**	**6**
	1	Definition of weather and climate, meteorology and climatology, elements, three basic climate groups: low latitude, mid-latitude, high latitude	2
	2	Concepts and mechanisms – Climate change, ozone layer depletion, global warming and greenhouse effect; Earth's natural greenhouse effect, the radiative balance.	3
	3	Measurement of climate change – Greenhouse gases in the atmosphere – sources, levels and mechanisms of action	1
II		**Climate Change – After Effects**	**12**
	4	Rise in earth's temperature; Effects on forests; Effects on agroecosystems; Desertification	2
	5	Effects on freshwater ecosystems; Effects on oceans – Sea level rise; melting of polar ice and glaciers; Effects on rainfall patterns; Socio-economic and public health consequences.	3
	6	Evidences of global warming and change in atmosphere/ocean circulations – El-Nino and La Nino; Climate extremes, Cyclones, thunderstorms, Tornadoes, Heat waves – Energy balance of the earth	3
	7	Floods and droughts, (Burning of fossil fuel, Industrial activity, Urbanization, Agriculture, transportation, waste generation) Removals of Sinks and LULUCF	2
	8	Climate change and food security – impacts of Climate Change on Population and food security	2
III		**Ecosystem Management**	**20**
	9	Energy Management – Conventional and non-conventional energy resources; renewable energy sources, solar photovoltaic and solar thermal, wind energy, tidal energy, ocean energy (OTEC)	3
	10	Energy recovery from wastes; bio-fuel; nuclear energy and management of nuclear wastes; energy conservation and energy management; national energy policy.	3
	11	Management of water resource – World water balance, conservation of freshwater resources; integrated water resource management; rainwater harvesting; watershed management	3
	12	Management of Coastal and Marine Resources – Coastal resources; mangrove and salt marsh ecosystems	3
	13	Integrated coastal zone management (ICZM); Threats to marine ecosystem; marine resource management.	2
	14	Management of Soil and Land Resources – soil degradation and soil erosion; integrated strategies for soil conservation and regeneration	2
	15	Wetland Management and Conservation – Wetlands – definition, functions, ecology and biodiversity	2
	16	Wetland loss and degradation; Ramsar sites; strategies for wetland conservation and management	2

IV	Climate Change – Mitigation		10
	17	Mitigation and adaptation – Carbon storage and sequestration, carbon management through abiotic sequestration	2
	18	Carbon management through biotic sequestration, Soil carbon sequestration; Carbon farming and carbon trading.	2
	19	India‘s response to climate change; National Action Plan on climate change; India‘s position and actions.	2
	20	International programmes (UNFCCC, CDM and Kyoto Protocol, REDD+, Copenhagen Accord)	2
	21	International response: Intergovernmental Panel on Climate Change (IPCC) and its role	2
V	Open Ended Module		12
	1. Case studies of ―Climate change impact‖ and adaptation 2. Analysis of different water quality parameters (temperature, pH, turbidity, free carbon dioxide, alkalinity, dissolved oxygen) in different water systems.		

Suggested Readings

- Khullar D. R. & Rao J. A. C. S. Environment & Disaster Management: Ecology, Climate Change , Biodiversity
- Pirot, J.-Y., Meynell P.J. and Elder D. 2000. Ecosystem Management: Lessons from Around the World. A Guide for Development and Conservation Practitioners. IUCN, Gland, Switzerland and Cambridge
- Jelte van Andel & James Aronson 2006. Restoration ecology: the new frontier, Blackwell Publishing
- Ravindranath N.H. & Jayant Sathaye. Climate change and developing countries
- Sushil Kumar Dash 2007. Climate Change – An Indian Perspective, Cambridge University Press India Pvt. Ltd
- Pathak H., Aggarwal P. K., Singh S.D. Climate Change Impact, Adaptation and Mitigation in Agriculture: Methodology for Assessment and Application

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	2	3	2	-	-	-	3	-	-	-	-	2	-
CO 2	-	2	3	-	-	3	-	-	1	-	1	2	2
CO 3	-	2	2	-	-	-	1	-	-	-	-	2	-
CO 4	-	3	1	-	-	-	2	-	-	-	3	1	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz/Written Test
- Fieldwork/Presentation
- Project/Practical
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Fieldwork/Presentation	Project/Practical Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2		✓	✓	✓
CO 3	✓		✓	✓
CO 4	✓		✓	✓

Programme	B. Sc. BOTANY				
Course Title	**Invasive Plant Ecology**				
Type of Course	**Major Elective**				
Semester	**VI**				
Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	Higher secondary level biology course				
Course Summary	The course provides students with a deep understanding of the ecological dynamics surrounding invasive plant species and their impact on native ecosystems.				

Course Outcomes (CO): After completing the Course, the student should be able to: -

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools
CO1	Define invasion in historical context, and explain the global significance of invasive species	U	C	Written Exams/ Historical Case Study Analysis
CO2	Examine various mechanisms through which invasive plants establish and spread in new environments	An	C	Research Projects
CO3	Analyse the ecological impacts of invasive plants on native ecosystems and community structure	An	C & P	Field Surveys, Data Analysis Reports
CO4	Evaluate the management approaches for controlling invasive plant species, including prevention, eradication, and restoration techniques	E	C & P	Case Studies, Management Plan Development
CO5	Combine the concepts and methods from ecology and environmental science to address the complex challenges associated with the invasives	An	P	Group Presentations

* - Remember I, Understand (U), Apply (Ap), Analyse (An), Evaluate I, Create I
\# - Factual Knowledge(F) Conceptual Knowledge I Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (48 +12)
I	**Introduction**		**12**
	1	Biological invasions – Introduction- Elton's hypothesis – Invasion patterns	2
	2	History of Biological Invasions	1
	3	Process of Biological Invasion – introduction, naturalization, colonization, and dispersal	2
	4	Biological attributes for invasion: Reproductive potential, Allelopathy, Phenotypic plasticity – fitness to the new environment.	2
	5	Hypotheses for invasion success: Natural enemy hypothesis- Evolution of invasiveness hypothesis-Empty niche hypothesis – Novel weapon hypothesis- Disturbance hypothesis and Propagule pressure hypothesis	3
	6	Databases for biological invasions	2
II	**Aquatic Invasions**		**12**
	7	Introduction – Native vs Invasive species, Natural and climate change mediated invasions – marine bio-invasion, vectors of marine invasions	3
	8	Biofouling – establishment of marine invasive species	2
	9	Algal blooms and their ecology in Indian waters	2
	10	Invasive species in Indian waters and their ecological impacts	2
	11	Study the origin, introduced region, invasive potentials and impacts of invasiveness of the following species: *Salvinia molesta*, *Eichhornia crassipes* and *Cabomba furcata*	3
III	**Terrestrial Invasions**		**12**
	12	Introduction – Native, Alien, Invasive & non-invasive plants.	2
	13	Patterns and processes of terrestrial plant invasion at different spatial scales – microhabitat, regional, global.	2
	14	Interactions between terrestrial invasive plants and native flora and fauna – predation/herbivory, competition, transmission of diseases, and hybridization with native species.	3
	15	Biotic resistance to plant invasions.	2
	16	Study the origin, introduced region, invasive potentials and impacts of invasiveness of the following species: *Lantana camara, Mikania micrantha, Chromolaena odorata, Senna spectabilis*	3
IV	**Assessment and Prevention methods**		**12**
	17	Assessment of Invasion: steps involved – Identification, Mapping, Impact assessment, risk assessment, management	2

		planning	
	18	Impacts of exotics on Biodiversity- Productivity- Nutrient cycling	2
	19	Economic damage caused by invasive species – Economic development and biological invasions	2
	20	Mathematical models for biological invasion – Role of remote sensing in invasion studies	2
	21	Management – Biocontrol programmes- Mechanical and chemical control- Positive utilization- Quarantine and EIA assessments	3
	22	Case study of successful management of Invasive plants in Kerala	1
V		**Open Ended Module** (Practical or theory content as decided by the course teacher)	**12**

Suggested readings:

- Charles S. Elton, Daniel Simberloff, Anthony Ricciardi 2020. The Ecology of Invasions by Animals and Plants. Springer International Publishing.
- Michael R. Ielmini, Thammineni Pullaiah 2021. Invasive Alien Species: Observations and Issues from Around the World. Wiley.
- Radu Cornel Guiasu 2016. Non-native Species and Their Role in the Environment: The Need for a Broader Perspective.Brill. ISBN:9789047426134, 9047426134
- Crooks JA. 2002. Characterizing ecosystem-level consequences of biological invasions: the role of ecosystem engineers. OIKOS
- Jonathan M. Jeschke, Tina Heger 2018. Invasion Biology: Hypotheses and Evidence. CABI. ISBN: 9781780647647, 1780647646
- Canning-Clode, João, 2016. Biological Invasions in Changing Ecosystems (Vectors, Ecological Impacts, Management and Predictions); OPEN ASSESS, ISBN 978-3-11-043866-6
- Rebecca Waterman, 2015. Biological Invasions: Patterns, Management & Economic Impacts (Environmental Research Advances) Nova Science Publishers Inc; UK ed. Edition ISBN- 10: 1634820193
- David Pimentel, 2011. Biological Invasions: Economic and Environmental Costs of Alien Plant, Animal, and Microbe Species, Second Edition, Taylor & Francis. ISBN 978143982990
- Quentin C.B. Cronk, Janice L. Fuller · 2017. Plant Invaders: The Threat to Natural Ecosystems. Taylor & Francis. ISBN: 1138158739, 9781138158733.
- Rilov, G. and Crooks. 2009. Biological invasions in marine ecosystems- ecological, Managemant and Geographic Perspectives. Springer-Verlag, Berlin Heideberg.
- Prabhat Kumar Rai. 2013. Plant Invasion Ecology Impacts and Sustainable Management. Nova Publishers.
- Gowher A. Wani, Manzoor A. Shah. 2020. The Eco-physiological and Genetic Basis of Invasiveness. Cambridge Scholars Publishing.
- Ramakrishnan, P.S. (1991). Ecology of Biological Invasion in the Tropics.

International Scientific Publications, New Delhi.

Online sources:

- https://doi.org/10.1111/j.1365-2745.2005.00979
- https://www.dakshin.org/wp-content/uploads/2017/06/MarineInvasives_0810_wb.pdf
- https://www.degruyter.com/document/doi/10.1515/9783110438666-003/html?lang=en
- https://docs.kfri.res.in/KFRI-OP/KFRI-OP-2012-001.pdf
- http://nbaindia.org/cebpol/pub/iasinland.pdf
- https://link.springer.com/article/10.1007/s11252-015-0524-y https://www.cabidigitallibrary.org/doi/epdf/10.1079/9781789242171.0009
- https://www.iucngisd.org/gisd/about.php#:~:text=GISD&text= The%20Global%20Invasive%20Species%20Database,species%20that%20negatively atively%20impact%20biodiversity

Mapping of COs with PSOs and POs :

S	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	1	1	-	-	-	3	-	-	-	1	1	-
CO 2	1	3	3	3	-	-	1	-	1	-	2	2	-
CO 3	1	3	3	3	-	-	1	-	1	-	2	2	-
CO 4	1	3	3	3	-	-	1	-	1	-	2	2	-
CO 5	1	3	3	3	-	-	1	-	1	-	2	2	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz/Written Test
- Fieldwork/Presentation
- Project/Practical
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Fieldwork/Presentation	Project/Practical Evaluation	End Semester Examinations
CO 1	✓	✓	✓	✓
CO 2	✓	✓	✓	✓
CO 3	✓	✓	✓	✓
CO 4			✓	
CO 5		✓		✓

Programme	B. Sc. BOTANY				
Course Title	**Plant Nanotechnology**				
Type of Course	**Major Elective**				
Semester	**VI**				
Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-		60
Pre-requisites	Higher secondary level Biology course				
Course Summary	The plant nanotechnology course explore the application of nanomaterials in agriculture and plant biology.				

Course Outcomes: After completing the Course, the candidate should be able to:-

COs	**Statement**	**Cognitive level***	**Knowledge Category#**	**Evaluation Tools**
CO1	Explain the importance of nanotechnology in plant science	U		Quiz/Written test
CO2	Compare various synthesis and characterization methods of nanoparticles	Ap	C & P	Presentation/Exam
CO3	Assess the role of nanotechnology in sustainable crop production and conservation	E	C & P	Group discussion/Written test

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus

Module	**Unit**	**Content**	**Hrs (48 + 12)**
I		**Introduction to nanotechnology**	**8**
	1	Overview of nanotechnology and its significance in plant science, Basic principles and techniques of nanotechnology	2

	2	Historical development and current trends in nanotechnology applications	2
	3	Nanoparticles- Physical & Chemical properties; Types – Organic, zero, one, two and three dimensional.	2
	4	Nanosensors and nanobiosensors: Design and fabrication of nanosensors	2
II		**Synthesis and Characterization of nanoparticles**	**10**
	5	Bottom-up and Top-down approaches in synthesis	2
	6	Physical, Chemical & Green synthesis methods (Brief account). Advantages of biological methods over other methods**.**	4
	7	Characterization: Optical (UV - Vis / Fluorescence), lithographic techniques, X ray diffraction , SEM, TEM, FTIR, IR, NMR, MS	4
III		**Applications of Nanotechnology in Crop Improvement**	**15**
	8	Application of nanotechnology for improvement of horticultural crops	3
	9	Essential nanomaterials utilized as nanopesticides or nanofertilizers, their uptake and translocation during plant growth	3
	10	Utilization of nano-based probes for detection, management of plant pathogens and future prospects	3
	11	Applications of nanoparticles in agricultural practices, including seed treatment, soil nutrient management, and pest control	3
	12	The role of nanoparticles in enhancing photosynthesis, nutrient uptake, and stress tolerance in plants.	3
IV		**Nanotechnology and Environment**	**15**
	13	Nanotechnology based water treatment strategies. Nanoporous polymers and their applications in water purification.	2
	14	Environmental Remediation through nanoparticles	2
	15	Nano Membranes, Nano Meshes, Nano Fibres, Nano Clays and Adsorbents, Nano catalysts	2
	16	Nanotechnology for waste reduction and improved energy efficiency.	2
	17	Nanomaterials in Energy Storage: Solar cell, nanomaterials for rechargeable batteries, carbon material for energy storage e.g. Graphene, GO, r-GO, fullerene, carbon nanotubes and carbon allotropes.	2

	18	Ethical considerations associated with nanotechnology integration in plant science	2
	19	Medical applications of nanoparticles: Drug and gene delivery, targeted therapy, diagnostics, cancer treatment.	3
V	**Open ended (Suggestive list)**		**12**
	1. Smart paper, atomically modified rice, nanorobotics, nanoscale thermometer 2. Regulatory guidelines and safety standards for nanomaterials in agriculture 3. Case studies and success stories in the context of crop improvement 4. Nanotechnology in everyday life		

Suggested Reading

- W.R. Fahrner 2005. Nanotechnology and Nanoelectronics: Materials, Devices, Measurement Techniques, Springer
- Mao Hong fan, Chin-pao Huang, Alan E Bland, Z Honglin Wang, Rachid Sliman, Ian Wright. 2010. Environanotechnology, Elsevier,
- Jennifer Kuzma and Peter VerHage 2006. Nanotechnology in agriculture and food production, Woodrow Wilson International Center
- Semiconductor for solar cells, H J Moller, Artech House Inc, MA, USA, 1993.
- Kole C., Sakthi Kumar D., Khodakovskaya M. V. 2016. Plant Nanotechnology-Principles and Practices, Springer
- Nanoelectronic and Nanosystems:From Transistors to Molecular Quantum Devices, K. Goser, P.Glosekotter & J. Dienstuhl, Springer, 2004.
- Lyshevski S. E. 2002. MEMS and NEMS: Systems, Devices and Structures, CRC Press.
- Minakshi G., Shree R. Singh, Venkateswarlu B. 2012. Nanotechnology: scope and limitations in agriculture, International Journal of Nanotechnology and Application (IJNA)
- Nick Serpone and Ezio Pelizzetti. 1989. Photocatalysis: Fundamentals and Application, Wiley Interscience
- Ryan Richard. Surface and Nanomolecular Catalysis (CRC) Taylor and Francis

Online Sources:

- https://www.azonano.com/article.aspx?ArticleID=4938
- https://jnanobiotechnology.biomedcentral.com/articles/10.1186/s12951-022-01477-8
- https://www.sciencedirect.com/science/article/pii/S2414644723000337#:~:text=Nanoparticles%20can%20be%20employed%20for,illness%20to%20improve%20selective%20diagnosis.

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	-	-	1	1	-	2	-	-	-	1	1	-
CO 2	-	-	1	1	-	-	-	-	-	-	3	-	1
CO 3	-	1	1	1	2	1	1	-	-	-	2	-	-

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz/Written Test
- Assignment/Presentation
- Project/Practical
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment/Presentation	Project/Practical Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓

Programme	B. Sc. BOTANY				
Course Title	**Botanical Entrepreneurship**				
Type of Course	**Major Elective**				
Semester	**VI**				
Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-		60
Pre-requisites	-				
Course Summary	The Botanical Entrepreneurship course is designed to provide students with the knowledge and skills needed to start and grow a successful business in the botanical industry.				

Course Outcomes: After completing the Course, the candidate should be able to:-

COs	Statement	Cognitive level*	Knowledge Category	Evaluation Tools
CO1	Develop a wide-range business plan to launch their own successful botanical enterprise	C	P	Presentation/Assignment
CO2	Develop an entrepreneurial mind-set by learning key skills such as design, personal selling, and communication	C	C	Simulations/ Presentations
CO3	Formulate effective branding strategies by identifying market trends	C	C & P	Market trend analysis reports/Customer surveys
CO4	Assess the available opportunities for new venture creation.	E	C & P	SWOT analysis reports/Case studies on successful ventures

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
\# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (48 + 12)
1		**Introduction**	**8**
	1	Introduction - Entrepreneurial traits, types and characterization, values - motivation, barriers and innovations	2
	2	Various form of business organization (sole proprietorship, partnership, corporations, Limited Liability Company)	2
	3	Communication - power of talk, personal selling, risk taking, resilience and negotiation	2
	4	Bio - Entrepreneurship: Definition, introduction, scope and opportunities	2
II		**Value Added Products**	**12**
	5	Mushroom cultivation - Structure and construction of mushroom house. Sterilization, culture media preparation Spawn production, Cultivation of oyster and paddy straw mushroom, Preservation of mushrooms - freezing, dry freezing, drying, canning. Value added products of mushrooms	3
	6	Processing and value addition of fruits - Products (jams, jellies and fruit slices in processing factories). Preservation by dehydration (Eg. banana chips), application of sugar (Eg. mango candy), application of salt (pickling). Fruit preservation by freezing	3
	7	Processing and value addition of vegetables - Products (flakes/chips of potato and onion; garlic powder). Frozen vegetables - Carrots, Green Peas,	3
	8	Preservation techniques - Causes of spoilage of food, removal of microorganisms, anaerobic situation and special methods - drying, thermal processing - pasteurization, sterilization and canning - low temperature, use of chemical preservatives and food additives. Preservation of sliced vegetables in factories by canning and bottling	3
III		**Bio-ventures**	**16**
	9	Spirulina Farming - Industrial culturing and utility of Spirulina	2
	10	Aromatic plants - essential oils; Medicinal plants - cultivation and extraction	2
	11	Botanicals in Cosmetic industry - Skin & Hair care products - Identification of the source plant, assessment of dosage, ensuring quality standards & analysis through post market surveillance	2

	12	Plant Nursery as an innovative way of self - employment	2
	13	Botanical specimens & permanent slides preparation for laboratories – collection of specimens, cleaning/processing, preservation methods, permanent slide preparation (brief), labelling & marketing	2
	14	Floriculture - Problems and prospects of Floriculture in Kerala. Cultivation methods, requirements and scope of growing Anthurium, Orchids and Jasmine in Kerala	2
	15	Sea weed liquid fertilizer - Definition, process and sources of extraction, derived products, applications, ecological and agronomic benefits. Advantages & disadvantages	2
	16	Biopesticide & Biofertilizer production: Various sources, extraction methodologies, applications and benefits.	2
IV	**Organizational Assistance**		**12**
	17	Entrepreneurship development programs of public and private agencies (MSME, DBT, BIRAC, Startup and Make in India). Patent landscape, IP protection and commercialization strategies.	3
	18	Mobilizing resources for start-up – financial assistance by different agencies. SIDCO - Micro Small and Medium Enterprises - support structure for promoting entrepreneurship - various governmental (Mudra Yojana, Pradhan Mantri Rozgar Yojana, Udyogini Scheme)	2
	19	Non-governmental schemes (MAHIA, Shakti Scheme, Women Entrepreneurs India Scheme) - Women supportive project SHG - TIIC, DIC, NABARD, MICROSTAT and DBT, Khadi and Village Industries Commission	2
	20	Regulatory affairs in Bio business-regulatory bodies and their regulations (eg. FDA, EU, DSIR, AYUSH, FSSAI etc.)	2
	21	Case study and biographical analysis of successful Bio-entrepreneurs.	3
V	**Open Ended (Suggestive list)**		**12**
	1. Market analysis of a Botanical product 2. Visit to a food processing industry, 3. Report Writing: Preparation of Project Proposal on a Bioventure		

Suggested Readings

- Desai V. 2015. Entrepreneurship Development, First Edition. Himalaya Publication House, Mumbai
- Khanna S. S. 2016. Entrepreneurial Development. S. Chand Company Limited, New Delhi
- Manohar D. 1989. Entrepreneurship of Small Scale Industries, vol. III. Deep and deep Publication, New Delhi

- Lal G., Siddhapa G. S. and Tandon, G. L. 1988. Preservation of fruits and vegetables. Indian Council of Agricultural Research (ICAR).
- Ranganna S. 2001. Hand book of analysis and quality control of fruits and vegetable products, Second Edition, Tata Mcgraw hill, New Delhi. .
- Cruses, W.V. and Fellows, P. J. 2000. Commercial fruits and vegetable processing. CRC press, United States
- Vasant Desai 2005. Dynamics of Entrepreneurial Development and Management, Himalaya Publishing House
- Prasannan. Projects Planning Analysis, Selection, Implementation & Review
- Khanka S. S. 2006. S. Entrepreneurship Development, Chand & Co
- Pathak V.N., Nagendra Yadav and Maneesha. 2000. Gaur Mushroom Production and Processing Technology, Vedams Ebooks Pvt Ltd., New Delhi
- Himadri Panda. The Complete Technology Book on Biofertilizer and Organic Farming

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	1	2	2	-	1	1	-	-	3	-	1	2	3
CO 2	1	2	2	-	1	1	-	-	3	-	1	2	3
CO 3	1	2	2	-	1	1	-	-	3	-	1	2	3
CO 4	1	1	1	-	1	1	1	1	3	-	1	-	3

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz/Written Test
- Assignment/Presentation
- Project/Practical
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment/Presentation	Project/Practical Evaluation	End Semester Examinations
CO 1	✓	✓	✓	✓
CO 2	✓	✓	✓	✓
CO 3		✓	✓	✓
CO 4		✓	✓	

Programme	B. Sc. BOTANY				
Course Title	**Forensic Botany**				
Type of Course	**Major Elective**				
Semester	**VI**				
Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	Higher secondary level Biology				
Course Summary	The forensic botany course explores the role of plants in forensic investigations, providing students with a unique perspective on how plant evidence can be used in criminal cases				

Course Outcomes (CO): After completing the Course, the candidate should be able to:-

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools
CO1	Assess how plant evidence can be utilized in forensic investigations	E		Exams/case study analyses/ Presentations
CO2	Examine pollen and spore samples, and interpret plant-related evidence found at crime scenes	An	P	Practical assessments/Written exams
CO3	Develop the skills necessary to assist law enforcement in solving crimes through botanical evidence	C	P	Practical assessments
CO4	Apply the knowledge of Plant Science to real-world forensic scenarios and make valuable contributions to the field of forensic botany	Ap	C	Case studies
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48+12)
I		**Forensic Botany- Introduction**	**8**
	1	Forensic Science: - Definition, introduction, basic principles & significance	2
	2	Organizational structure of forensic science laboratory, different divisions and units of forensic science laboratory	2
	3	Forensic Botany: Introduction, historical perspective and the evolution of forensic botany, importance and applications in forensic science, branches of forensic botany	2
	4	Forensic ethics- the importance of professional ethics to science practitioners, professional standards and guidelines for forensic botanists	2
II		**Botanical Evidences**	**17**
	5	Botanical evidences -The use of biological and botanical evidence in criminal investigations and its importance.	2
	6	Forensic dendrochronology - Introduction to tree-ring analysis in forensic investigations, collecting and interpreting tree-ring data, application of dendrochronology in aging and dating criminal evidence	2
	7	Plant ecology in forensic botany- Geographical distribution of plant species and its forensic relevance (gravesite analysis, time of deposition, geomorphology)	2
	8	Plant fluids- Identification and collection of sap, gum, latex, and volatile oils	1
	9	Types and identification of microbial organisms of forensic significance, role of fungal spores and algae	2
	10	Forensic limnology-Diatom types & morphology, methods of isolation of diatoms from different tissue, methods of identification and comparison, forensic significance in drowning cases	3
	11	Forensic palynology - ―Fingerprints‖ of localities, sample preparation for pollen spore and analysis. Techniques for collecting, processing, and analysing pollen and spores. Case studies and real-world applications of forensic palynology	3
	12	Laws and regulations related to handling and presenting botanical evidence	2
III		**Forensic toxicology**	**15**
	13	Toxicological examination and its significance.	1
	14	Plant poison: Introduction, classification and their main active constituents	2
	15	Common types of poisonous plants and their toxins – *Abrus*	4

		precatorius, Cinchona sps., Calotropis Strychnos nux vomica, Atropa belladonna, Gloriosa superba, Jatropha curcas, Nerium indicum, Ricinus communis and *Thevetia neriifolia*	
	16	Abused drug yielding plants - *Opium, Cannabis, Tobacco, Datura* and *Psilocybe* mushroom.	2
	17	Methods of extraction of plant material from biological sample, Identification by colour test and TLC and UV- Visible spectrophotometer and other instrumental techniques.	4
	18	Wildlife Forensics - Fundamentals of wildlife forensic, significance. Protected and endangered species of plants. Illegal trading of flowers and plants.	2
IV	**Collection and preservation of botanical evidences**		**8**
	19	Botanical samples - Collection methods, documentation, preservation and transportation	2
	20	Forensic photography - Types and importance	2
	21	Analysis of samples - DNA analysis, typing and barcoding.	2
	22	Contributions and Current Trends of Forensic Botany in Crime Scene Investigation Contributions and Current Trends of Forensic Botany in Crime Scene Investigation Contributions of forensic botany in crime scene investigations, role of a forensic botanist in criminal investigations	2
V	**Open ended (Suggestive list)**		**12**
	1. History of forensic science 2. Forensic botany case study 3. Careers in forensic biology 4. Emerging Trends in Forensic Botany 5. Illegal logging and endangered tree species harvested for timber. 6. DNA methods in plant identification 7. Visit to a forensic laboratory		

Suggested Readings:

- Coyle HM, Forensic Botany: Principles and applications to criminal casework, 1st Edition, CRC Press Pvt Ltd, Taylor and Francis Group, United Kingdom, 2004.
- Hall DW and Byrd J, Forensic Botany: a practical guide. 1st Edition, Wiley-Blackwell publishers Pvt Ltd, United States, 2012.
- James SH, Nordby JJ, Bell S, Forensic Science: An Introduction to Scientific and Investigative Techniques, 4th Edition, CRC Press Pvt Ltd, Taylor and Francis Group, United Kingdom, 2015.
- Ganesslen RE, Essentials of Forensic Science: Blood, Bugs and Plants, 1st Edition, Facts on File Publishers Pvt Ltd, New York, United States, 2008.
- Wessels T, Forensics – A Field Guide to Reading the Forested Landscape, 1st Edition, Norton and Company Pvt Ltd, New York, United states, 2013.
- Jane H. Bock, J. H. & Norris, D. O. Forensic Plant Science. Academic Press. 2016

- Avis-Riordan, K. (2020) Plant forensics: Cracking criminal cases. Royal Botanic Garden Kew. [Online] Available at: https://www.kew.org/read-and-watch/how-forensic-botany-plant-science-solve-crimes
- Forensic Botany and Its Applications. (2020) [Online] Available at: https://legaldesire.com/forensic-botany-and-its-applications/
- Margiotta, G. et al. (2015) Forensic botany as a useful tool in the crime scene: Report of a case. Journal of Forensic and Legal Medicine, 34, pp. 22-28. DOI: 10.1016/j.jflm.2015.05.003
- Aquila, I. et al. (2014) The role of forensic botany in crime scene investigation: case report and review of literature. Journal of Forensic Sciences, 59(3).
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- Coyle, H. et al. (2005) Forensic botany: using plant evidence to aid in forensic death investigation. Croatian Medical Journal, 46(4).

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	-	-	2	2	3	-	2	-	2	-	2	2	-
CO 2	3	-	3	3	3	-	3	-	2	-	2	2	-
CO 3	2	-	3	3	3	1	2	-	3	1	3	2	2
CO 4	2	2	3	3	2	-	2	1	3	-	3	2	2

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz/Written Test
- Assignment/Presentation
- Project/Practical
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment/Presentation	Project/Practical Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓		✓	✓
CO 3		✓	✓	
CO 4		✓	✓	

Programme	B. Sc. BOTANY				
Course Title	**Artificial Intelligence in Plant Science**				
Type of Course	**Major Elective/Minor**				
Semester	**VIII**				
Academic Level	400-499				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	Basic Knowledge in Botany and computer science principles, including familiarity with programming concepts. Prior coursework in introductory computer science is recommended.				
Course Summary	In a course on Artificial Intelligence in Plant Science, students will explore the innovative intersection of AI technology and plant biology. The course will cover topics such as machine learning algorithms, neural networks, and data analysis techniques used in plant science research. Students will learn how AI is revolutionizing plant breeding, crop monitoring, disease detection, and yield prediction.				

Course Outcomes (CO): After completing the Course, the candida e able to:-

COs	Statement	Cognitive level*	Knowledge Category#	Evaluation Tools
CO1	Recall and explain the fundamental concepts of AI and its application in botanical sciences	R	F	Written exams/Presentations
CO2	Analyse the effectiveness of AI tools in plant identification, ecosystem analysis, and genetic studies.	An	C	Case studies/ Practical assessments
CO3	Assess the capabilities and limitations of different AI methodologies in botany and create innovative AI-based solutions for complex botanical problems.	C	P	Research projects/ Presentations
CO4	Implement AI tools in botanical studies while critically	Apply	P	Ethical case studies

	evaluating the ethical implications and sustainability of these technologies in scientific research.			
CO5	Critically Analyse current AI trends in botany and predict future developments, preparing for evolving challenges and opportunities in this interdisciplinary field.	An	P	Literature review/Group discussions
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Module	Unit	Content	Hrs (48+12)
I		**Introduction to AI in Plant Sciences**	**14**
	1	Basics of AI and Machine Learning, History of Machine learning and AI, Algorithms, models, training data, overfitting vs underfitting, supervised vs unsupervised learning	3
	2	Expert systems and Fuzzy logic, Neural Networks, Generative AI, Comparison of Generative AI Models (Models by Open AI, Anthropic, Google, Meta etc)	3
	3	Artificial Neural Networks, predictive analytics, regression, classification, forecasting models	2
	4	Role of Botanical Data in ML (Iris Data Set), Big Data and Data Analysis.	2
	5	AI Applications in Plant Identification and Classification (PlantNet, iNaturlist), Machine Learning Models for Plant Identification, Image Processing for Plant Classification, AI in Phenotyping and Disease Detection	4
II		**AI in Botanical Research and Data Analysis**	**12**
	6	AI in Botanical Data Collection and Analysis - Traditional vs. AI-enhanced data collection methods, Sensors and Drones in Data gathering and vegetation mapping.	3
	7	Visualization of Botanical Data with AI Tools, IoT sensors to detect microenvironments	1
	8	Machine Learning Models in Plant Genetics - AI Applications in Gene Sequencing and Analysis	2
	9	Predictive Models for Genetic Modifications, AI for sequence assembly, variant calling, functional annotation, Deep Mind and protein Structure predictions	3
	10	AI in Ecosystem and Biodiversity Analysis - AI Tools for Ecosystem Monitoring and Management (deforestation, habitat degradation, and species distribution, early detection of wildfires, illegal logging, poaching), Predictive Modelling for Ecological Changes, Niche Modelling	3

III	**Advanced AI Tools and Programming**		**14**
	11	Programming for Botanical AI (Python), Basic Syntax and Programming Concepts (Variables, Data types, Operators, Control flow)	3
	12	Importance of Python in AI and Data Science, Libraries and Tools in Python for AI	2
	13	AI for Botanical Imaging and Analysis - Digital Imaging in Botany, Non-destructive analysis, Tools and Techniques for Image Analysis (OpenCV), Image segmentation, Feature extraction.	4
	14	AI and Database Management in Botany - Overview of Database Systems in Botanical Research, Data Storage, Retrieval and Management Concepts	3
	15	Automating Data Entry and Analysis with AI, Integrating AI Tools for Efficient Database Management	2
IV	**Ethical, Sustainable and Practical Aspects**		**8**
	16	Specific Ethical Considerations in Botanical Research, Data Privacy, Intellectual Property and AI Transparency, Crafting Ethical Guidelines for AI Use in Botanical Sciences	2
	17	Sustainability and AI in Botanical Sciences Examining AI's Role in Promoting Sustainable Agriculture and Conservation, AI in Climate Change Research and Its Implications	2
	18	Practical Challenges and Future Trends in Botanical AI - Identifying and addressing technical limitations of AI in Botany,	2
	19	Strategies for enhancing accessibility and usability of AI in Botanical Research, Exploration of Emerging AI Technologies in Botany	2
V	**Open Ended (Practical/Theory)**		**12**
	1. Group discussions 2. Workshop on AI tools 3. Guest lectures		

Suggested Readings

- Russell, Stuart J., and Peter Norvig. 2010. Artificial intelligence is a modern approach. London,
- Géron, Aurélien. 2022. Hands-on machine learning with Scikit-Learn, Keras, and TensorFlow. O'Reilly Media, Inc.
- Wäldchen, J., Mäder, P. 2018. Plant Species Identification Using Computer Vision Techniques: A Systematic Literature Review. Arch Computat Methods Eng 25, 507–543 https://doi.org/10.1007/s11831-016-9206-z
- Artifcial Intelligence: 2010. A Modern Approach Third Edition Stuart Russell and Peter Norvig,. Pearson Education, Inc.
- Hutter, Marcus 2005. Universal Artificial Intelligence. Berlin: Springer. ISBN 978-3-540- 22139-5.

- Neapolitan, Richard; Jiang, Xia 2018. Artificial Intelligence: With an Introduction to Machine Learning. Chapman & Hall/CRC. ISBN978-1-138-50238-3.
- Nilsson, Nils 1998. Artificial Intelligence: A New Synthesis. Morgan Kaufmann. ISBN 978-1-55860-467-4. Archived from the original on 26 July 2020. Retrieved 18 November 2019.
- Russell, Stuart J.; Norvig, Peter 2003. Artificial Intelligence: A Modern Approach (2nd ed.), Upper Saddle River, New Jersey: Prentice Hall, ISBN 0-13-790395-2.

Mapping of COs with PSOs and POs :

	PSO1	PSO 2	PS O3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	-	1	1	1	1	3	-	-	3	1	-	-
CO 2	1	2	3	3	3	3	1	-	3	3	3	-	3
CO 3	1	-	1	1	3	3	1	-	3	3	3	-	3
CO 4	1	-	1	1	3	3	1	-	3	3	3	-	3
CO 5	1	-	1	1	3	3	1	-	3	3	3	-	3

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz/Written Test
- Assignment/Presentation
- Project/Practical
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment/Presentation	Project/Practical Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓	✓	✓
CO 3		✓	✓	✓
CO 4		✓	✓	✓
CO 5		✓		✓

Programme	B. Sc. Botany				
Course Title	**Computational Biology & Data Analysis**				
Type of Course	**Major Elective**				
Semester	**VIII**				
Academic Level	400-499				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	Foundation level knowledge in Biology and Computer Science				
Course Summary	This course is designed to introduce undergraduate students of Botany to the fundamental concepts and practical applications of computational biology and data analysis. Emphasis will be placed on understanding biological databases, bioinformatics tools, and statistical methods to Analyse genomic and proteomic data.				

Course Outcomes (CO): After completing the Course, the candidate should be able to:-

CO	CO Statement	Cognitive Level*	Knowledge Category#	on Tools
CO1	Explain the basic principles and concepts of computational biology and how they apply to the analysis of biological data.	U	C	ams/Quiz
CO2	Apply computational methods and bioinformatics tools to process, Analyse, and visualize biological data.	Ap	P	Practical assessments
CO3	Analyse genomic and proteomic data to identify patterns, similarities, and differences that contribute to biological functions and processes.	An	P	Written exams/Quiz
CO4	Evaluate the impact of computational biology in advancing research and	E	C	Presentations/Discussions

	knowledge in Botany, using critical thinking to assess methodologies and conclusions.			
CO5	Create and execute data analysis projects using computational tools, demonstrating the ability to interpret and present biological findings.	C	C & P	Data analysis projects/Presentations

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
\# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (48 + 12)
I		**Introduction to Computational Biology**	**12**
	1	Role of Computational Biology and Its Importance in Botany Interdisciplinary Nature of Computational Biology: Combining Computer Science, Mathematics, and Botany	2
	2	Types of Biological Databases: Genomic, Proteomic, and Phylogenetic Navigating GenBank, EMBL, and DDBJ for Nucleotide and Protein Sequences Using Plant-Specific Databases: TAIR, Phytozome, and PlantGDB Data Retrieval and Querying Biological Databases for Research Purposes	3
	3	Overview of Genomic Science and Its Impact on Botany - Introduction to Proteomics and its Relevance to Plant Sciences Techniques for DNA Sequencing and Protein Identification Comparative Analysis Techniques in Genomics and Proteomics	2
	4	Basic Tools for Sequence Alignment: BLAST, ClustalW, and MUSCLE Introduction to Genome Browsers and Annotation Tools Software for Phylogenetic Analysis: MEGA, PhyML, and PAUP Overview of Programming Languages Used in Computational Biology: Python and Perl Basics	3
	5	Best Practices for Biological Data Management Data Sharing and Collaboration in the Scientific Community Ethical Considerations in Genomic and Proteomic Research Privacy, Consent, and Data Security in Biological Databases	2

II	**Data Analysis in Computational Biology**		**12**
	6	Statistical Foundations for Biological Research Descriptive Statistics and Inferential Statistics in Biology Introduction to Bayesian Analysis and Its Applications Experimental Design and Power Analysis in Biological Studies	3
	7	Principles of Data Visualization in Biology Using ggplot2 in R for Advanced Data Visualization Interactive Visualization with Python (Plotly, Matplotlib, Seaborn) Visualization of Phylogenetic Trees and Genomic Data	3
	8	Methods and Tools for Comparative Genomic Analysis Building and Analysing Phylogenetic Trees: Concepts and Computational Approaches Molecular Clocks and Their Use in Understanding Evolutionary Timescales	3
	9	Overview of Gene Expression Analysis in Plants Techniques for Measuring Gene Expression: Microarrays and RNA-Seq. Bioinformatics Tools for Analyzing Expression Data	3
III	**Advanced Tools and Techniques in Computational Biology**		**12**
	10	Introduction to Machine Learning and its Applications in Biology; Supervised vs. Unsupervised Learning in Genomic Data Analysis; Predictive Modeling for Gene Function and Phenotype Prediction	2
	11	Concepts of Network Biology: Gene Regulatory Networks, Protein Interaction Networks; Introduction to Systems Biology and Its Importance in Understanding Biological Systems Computational Tools for Network and Systems Analysis Applications of Network and Systems Biology in Plant Stress Response and Development	3
	12	High-throughput Data Analysis: Microarrays and Sequencing Technologies Overview of High-throughput Sequencing Technologies: RNA-Seq, ChIP-Seq, Metagenomics Data Processing and Analysis Pipelines for High-throughput Data Challenges in Big Data: Storage, Analysis, and Interpretation	3
	13	Computational Methods for Protein Structure Prediction: Homology Modeling, Ab Initio Methods Tools for Protein Structure Visualization and Analysis Protein-Protein Interaction Predictions and Their Implications in Botany	2
	14	Introduction to Metagenomics and its Role in Understanding Microbial Communities	2

		Tools and Techniques for Metagenomic Sequencing and Analysis Applications of Metagenomics in Plant-Microbe Interaction Studies	
IV		**Applications in Computational Biology**	**12**
	15	Disease Gene Identification Strategies for Identifying Disease Genes: Linkage Analysis, GWAS Computational Tools and Databases for Disease Gene Identification	3
	16	Evolutionary Biology Molecular Phylogenetics and the Evolution of Plant Families	3
	17	Plant Genomics Evolutionary Genomics of Domesticated Plants and Crops	2
	18	Environmental Genomics and Plant Biology Genetic Diversity and Conservation Studies Using Genomic Tools	2
	19	Impact of Climate Change on Plant Genomics Integrating Environmental and Genomic Data for Conservation Strategies	2
V		**Open Ended** Practical or theory content as decided by the course teacher	**12**

References

- David Mount. Bioinformatics: Sequence and Genome Analysis. 2004. Cold Spring Harbor Laboratory Press.
- Roderic D. M. Page. Comparative Genomics: Empirical and Analytical Approaches to Gene Order Dynamics, Map Alignment, and the Evolution of Gene Families. 2000. Springer.
- Anders Krogh, I. I. Ivanov, and J. E. Stormo. Introduction to Computational Genomics: A Case Studies Approach. 2007. Cambridge University Press.
- Teresa K. Attwood and David J. Parry-Smith. Introduction to Bioinformatics. 2001. Pearson Education.
- Neil C. Jones and Pavel A. Pevzner. An Introduction to Bioinformatics Algorithms. 2004. MIT Press.
- Shanmughavel P., B. K. Tyagi, and S. K. Gupta. Computational Biology and Bioinformatics: Gene Regulation. 2011. Springer India. Mumbai, Maharashtra, India.
- Muralidhar K., K. P. Mohan, and P. Nagaraj. Bioinformatics Basics: Applications in Biological Science and Medicine. 2000. Universities Press (India) Pvt. Ltd. Hyderabad, Telangana, India.
- Sowdhamini R. and K. H. Han. Bioinformatics: Databases and Systems. 2019. Springer India. Mumbai, Maharashtra, India.

	• Srivastava G. N. S. and A. K. Sharma. Computational Biology and Bioinformatics: Gene Regulation. 2012. Narosa Publishing House. New Delhi, India. • Jain V. K. and A. K. Tyagi. Introduction to Bioinformatics. 2009. CRC Press. Boca Raton, Florida, USA • https://www.ncbi.nlm.nih.gov/. National Center for Biotechnology Information (NCBI). • https://www.ebi.ac.uk/. European Bioinformatics Institute (EBI). • https://www.expasy.org/. ExPASy (Expert Protein Analysis System). • https://www.broadinstitute.org/. Broad Institute. • https://genome.ucsc.edu/. UCSC Genome Browser.

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	-	1	1	3	-	2	-	3	3	3	-	1
CO 2	3	-	1	1	3	-	2	-	3	3	3	-	1
CO 3	3	-	1	1	3	-	2	-	3	3	3	-	1
CO 4	3	-	1	1	3	-	2	-	3	3	3	-	1
CO 5	3	-	1	1	3	-	2	-	3	3	3	1	3

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz/Written Test
- Assignment/Presentation
- Project/Practical
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment/Presentation	Project/Practical Evaluation	End Semester Examinations
CO 1	✓	✓	✓	✓
CO 2	✓	✓	✓	✓
CO 3		✓		✓
CO 4		✓	✓	✓
CO 5		✓		✓

Programme	B. Sc. BOTANY				
Course Title	**Industrial Biotechnology & Plant Genetic Engineering**				
Type of Course	**Major Elective**				
Semester	**VIII**				
Academic Level	400-499				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	Basics of Plant Biotechnology				
Course Summary	Industrial Biotechnology involves using biological systems and organisms to develop new products and processes. Plant genetic engineering, on the other hand, focuses on modifying the genetic makeup of plants to improve traits like yield, resistance to pests and diseases, and nutritional content.				

Course Outcomes (CO): After completing the Course, the candidate should be able to:-

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools
CO1	Identify the principles and applications of biotechnology in industrial settings.	U	C	en test
CO2	Understand the processes involved in industrial biotechnology and plant genetic engineering, including genetic modification techniques.	U	C	Written test/Quiz/Home Assignments
CO3	Apply gene transfer techniques to advancements in the field of biotechnology and agriculture.	Ap	C & P	Presentations
CO4	Develop new strategies for modifying existing plant traits	Create	P	Presentations

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
\# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (48+12)
I		**Bioprocess technology**	**8**
	1	Introduction to bioprocess technology, broad areas of industrial biochemical processes - upstream processing, bioprocess or fermentation process, and downstream processing. Advantages of biochemical processes over chemical processes.	4
	2	Types of bioprocesses- batch, continuous and fed batch. Characteristics of ideal production media.	2
	3	Bioreactor - its parts and types -Airlift bioreactors, continuous stirred tank reactor and batch reactor.	2
II		**Applications**	**12**
	4	Industrial production - Overview of Industrial production of hormones (insulin), enzymes, bioplastics, vitamins, antibiotics, single cell proteins and probiotics.	4
	5	Biotechnology in Environment - Controlling environmental pollution through bioremediation. Use of immobilized microbial cell & enzyme in waste water treatment.	2
	6	Biofuels and Bioenergy - Types of biofuels, Biofuel production technologies and its characterization. The production of Bioethanol & biodiesel from renewable biomass (plants and microorganisms).	3
	7	Commercial Plant Tissue Culture - Commercial clonal propagation, steps, requirements, management - production planning. Commercial tissue culture production of Banana. Virus indexing of tissue cultured plants (biological and molecular).	3
III		**Tools and Techniques**	**15**
	8	Gene cloning – Introduction, TA cloning, TOPO cloning, GIBSON Assembly.	3
	9	DNA sequencing - Automation of DNA sequencing by Sanger‘s method, Advanced sequencing procedures: NGS, Brief idea of pyrosequencing, Illumina, ABI / SOLiD and their applications.	4
	10	Construction of libraries - Construction of genomic libraries and cDNA libraries, procedures for recombinant selection and library screening.	4
	11	Techniques in use -Real time PCR and its applications.	2
	12	DNA fingerprinting and Microarray (gene chip) technology.	2
IV		**Transgenics**	**13**
	13	Gene transfer techniques in plants - Indian scenario of transgenic technology, Regulatory agency in India - GEAE.	3
	14	Plant transformation techniques. Vacuum infiltration and Floral dip method. Promoters for plant transformation; Selection of transgenics– selectable marker and reporter genes (Luciferase, GUS, GFP).	3
	15	Gene Silencing – Introduction, RNAi/ post-transcriptional gene silencing (PTGS), mechanism and applications.	2

<table>
<tr><td></td><td>16</td><td>Genome Editing – Introduction, CRISPR Cas 9 for targeted knock ins and knock outs.</td><td>2</td></tr>
<tr><td></td><td>17</td><td>Metabolic engineering - Secondary metabolite production, hairy root culture, elicitation and biotransformation. Golden rice</td><td>3</td></tr>
<tr><td rowspan="2">V</td><td colspan="2">Open ended module (Suggestive list)
(Practical or Theory as decided by the course teacher)</td><td>12</td></tr>
<tr><td colspan="2">1. Preparation of Luria-Bertani medium and Nutrient agar and sterilization (Broth and plates).
2. Prepare a list of fermented food products in the market.
3. Isolation of lactic acid producing bacteria from curd and production of lactic acid
4. Group discussion on bioethanol production and prepare a flow chart on bioethanol production from starch and lignocellulose.
5. Demonstration of various steps of micropropagation. Preparation of commercial TC planting material production plan for a crop species.
6. Detailed report of the industrial lab visit and submit the report.
7. Preparation of a project report for a commercial TC unit.
8. Extraction and purification of plasmid and genomic DNA
9. Examination of the purity of DNA by agarose gel electrophoresis
10. Estimation of plasmid DNA and genomic by UV-VIS spectrophotometer‘
11. Demonstration of real time PCR machine, PCR primer and the technique (video/using photographs).
12. Discuss scenario of transgenic plants in global and India scenario.
13. Visit a well-equipped genetic engineering lab and submit a report along with the practical record.</td><td></td></tr>
</table>

Suggested Readings

- Debabrata Das and Soumya Pandit. 2021. Industrial Biotechnology, CRC press.
- Casida L. E. J. R. Industrial Microbiology, New Age International.
- Whitaker and Hall, 1995. Principles of Fermentation Technology, Stanbury, Butterworth-Heineman, New York
- James E Baily and David F Ollis. 1986. Biochemical Engineering Fundamentals, 2 nd edition, Mc Graw Hill Book company, New York.
- Loveleen Kaur and Robinka Khajuria. Industrial Biotechnology: Principles and Applications, Nova Publishers, New York.
- Aehle W. 2007. Enzymes in Industry: Production and Applications, John Wiley & Sons Inc.
- Prescolt S.C. 2009. Industrial Microbiology, Agrobios, Meerut.
- Whitaker and Hall. 1995. Principles of Fermentation Technology, 2 nd edition Stanbury, , Butterworth-Heineman, New York
- Bjorn, k, Lyndersen, Nancy A, D‘Elia and Kim L Nelson. 2010. Bioprocess Engineering-Systems, Equipments and Facilities, Wiley India Edition New Delhi.
- Shuler, Michael L. and Fikret Kargi 1992. Bioprocess Engineering, Prentice Hall
- Bhojwani and Razdan M. K. 2000. Plant Tissue Culture -Theory and practice, Elsevier India Pvt. Ltd.
- Brown T. A. Gene cloning and DNA analysis an introduction, Blackwell science publishers.
- Sambrook, Fritsch and Maniatis. Molecular cloning, Cold Spring harbour laboratories

- Narayan Swamy S. Plant cell and tissue culture, Tata Mc
- Singh B. D. 2009. Plant Biotechnology, Kalyani Publishers, Ludhiana.
- Gupta, P. K. 2009. Plant Biotechnology. Rastogi Publications, Meerut.
- Glick Pasternak and Patten. Molecular biotechnology, Principles and Applications of Recombinant DNA, 4th edition. Wiley International Publishers.
- Mantell S. H. Principles of plant biotechnology: An introduction to genetic engineering in plants
- Nair, A. J. Introduction to Genetic Engineering & biotechnology, Infinity Science Press, USA.
- An Introduction to Genetic Engineering, Desmond S.T, Cambridge Pub.

Online sources

- https://www.thermofisher.com
- https://www.neb.com/en/

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	-	1	1	3	2	1	2	3	-	3	1	3
CO 2	3	-	2	3	3	1	1	1	3	-	3	-	2
CO 3	1	-	3	3	3	3	-	1	3	-	3	1	3
CO 4	1	-	1	3	3	3	1	-	3	-	3	2	3

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz/Written Test
- Assignment/Presentation
- Project/Practical
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment/Presentation	Project/Practical Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3		✓		✓
CO 4		✓		✓

Programme	B. Sc. BOTANY				
Course Title	**Angiosperm Anatomy, Developmental Botany & Palynology**				
Type of Course	**Major Elective**				
Semester	**VIII**				
Academic Level	400 - 499				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	Basics of Plant Anatomy & Developmental Biology				
Course Summary	This course deals with the intricate world of Plant Anatomy, Developmental Anatomy, Plant Embryology, and Palynology. Topics include tissue differentiation, cell wall chemistry, xylem and phloem structure and function, cambial development, floral development, seedling anatomy, embryogenesis, endosperm types, and the study of pollen and spores. Emphasis is on understanding plant structures at a microscopic level and their significance in various disciplines.				

Course Outcomes (CO): After completing the Course, the candidate should be able to:-

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools
CO1	Recall the structures and processes involved in plant tissue differentiation, cambial development, floral anatomy, and embryogenesis.	R	F	Written exams/Observation of [illegible] skills
CO2	Assess the importance of anatomical studies in understanding plant evolution, taxonomy, and applications in wood utilization and pollen analysis.	An	C	Quiz/Presentations
CO3	Apply knowledge of plant anatomy to analyse and interpret microscopic plant structures and developmental processes.	Ap	C & P	Practical assessment/ Presentations
CO4	Critically evaluate the relationships between different plant structures and their functions in growth and development.	E	F & P	Assignments

* - Remember I, Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
\# - Factual Knowledge(F) Conceptual Knowledge I Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (48+12)
I		**Anatomy- Tissue Level Differentiation**	**10**
	1	Primary and Secondary cell walls, Ultra Structure and Chemistry of Cell Wall, Plasmodesmata. Secondary wall chemical constituents- lignin, suberin, callose	2
	2	Xylem, ontogeny, Phylogeny, Evolution, Ultra Structure and functions	2
	3	Phloem ontogeny, symplast and apoplast, phylogeny, Evolution Ultra Structure of Sieve tube elements and functions	3
	4	Cambium: Development of vascular cambium and cork cambium in root and stem; cell types in vascular cambium, infected vascular cambia, seasonal variations in cambial activity; role of cambium in wound healing and grafting	3
II		**Developmental Anatomy**	**14**
	5	Organization of shoot, root, Leaf growth and differentiation. Floral meristem. Flower development ABC model. Anatomy of floral axis and whorls	2
	6	Node – nodal patterns, Node-internode transition, Phylogeny of node. Leaf trace and branch trace- origin, departure; effect on stele and pith. Secondary growth in leaf traces	3
	7	Anomalous secondary growth: Concepts; modification of the common type of vascular cambium, unequal activity of the vascular cambium. Successive cambia. Anomalous placement of vascular cambium. Discontinuous, unidirectional and bidirectional activity of cambium	3
	8	Seedling anatomy: Concepts: anatomy of cotyledons, hypocotyl, seedling root, mesocotyl differentiation	3
	9	The Importance of anatomical studies in areas of wood utilization- an overview. Wood anatomy in relation to properties of wood. Scope of bamboo, canes, coconut palm and other fibrous lignocelluloses materials in wood based industry	3
III		**Reproductive Botany**	**12**
	10	Structure and development of male gametophyte, microsporogenesis	1
	11	Structure and development of female gametophyte, megasporogenesis	1
	12	Embryo sac- different types- ultra-structure of components-synergid and antipodal.	2
	13	Pollination – Significance of pollen – pistil interaction. Ultra-structure of stigma. Role of pollen wall proteins and stigma. Morphological and genetical Self incompatibility.	1
	14	Fertilization – Role of synergids – filiform apparatus,	1

		heterospermy and triple fusion.	
	15	Embryogenesis - Structure and development of Dicot (*Capsella bursa-pastoris*)and Monocot (*Najas*) embryos. Polyembryony.	3
	16	Endosperm - Types and its biological importance. Free nuclear (*Cocos nucifera*), cellular (*Cucumis*), helobial types. Ruminate and mosaic endosperm, endosperm haustoria	2
	17	Significance of embryology in taxonomic studies	1
IV	**Palynology**		**12**
	18	Introduction, scope and development. Contribution of eminent palynologists	1
	19	Palynology studies: Aerobiology, Forensic Palynology, Copra palynology, Paleopalynology and Palynostratigraphy	3
	20	General account of pollen / Spore morphology: Dicot, monocot, Gymnosperms. Chemical composition of pollen, Palynological techniques	3
	21	Melissopalynology: Role of bees in crop productivity, bee pollen in health care. Characters of bee pollen, Pollen analysis of honey: determination of floral source, unifloral/ bifloral/ multifloral,	3
	22	Aerobiology: General account and its applications, Methods used in atmospheric pollen monitoring, Pollen allergy.	2
V	**Practical/ Theory (Open Ended)** **(Suggestive list)**		**12**
	1. Anomalous secondary growth - stems of *Aristolochia, Strychnos,* Amaranthaceae, Nyctaginaceae, Bignoniaceae and Agavaceae. 2. Anomalous secondary growth - roots of Amaranthaceae 3. Study of living shoot apices by dissections using aquatic plants such as *Ceratophyllum* and *Hydrilla.* 4. Examinations of shoot apices in monocotyledons in both T.S. and L.S. to show the origin and arrangement of leaf primordial. 5. Microscopic examination of vertical section of leaves such as *Hibiscus, Nerium* and Paddy to understand the internal structure of leaf tissues and trichomes, glands 6. Study of microsporogenesis and gametogenesis in sections of anthers. 7. Pollen germination using hanging drop and sitting drop cultures, suspension culture and surface culture. 8. Observation permanent slides related to anther TS, Ovule types, Embryo and endosperm types 9. Pollen morphology of common angiosperm taxa using permanent slides. 10. Study of pollen in unifloral and multifloral honey. 11. Study of pollen wall by acetolysis.		

Suggested Readings

- Johri BM 1982. Experimental Embryology of Angiosperms. Springer, Berlin
- Bhojwani S.S. and Bhatnagar S. P. 2000. The Embryology of Angiosperms, Vikas publishing House, New Delhi.
- Fageri K. and Van der Piji L 1979. The Principles of Pollination Ecology .Pergamon Press, Oxford.
- Fahn A. 1982. Plant Anatomy (3rd edition) Pergamon Press Oxford.
- Bhojwani and Bhatnagar, Introduction to Embryology of Angiosperms - Oxford & IBH, Delhi
- Bhojwani Sant Saran, 2014. Current Trends in the Embryology of Angiosperms, Woong-Young Soh,Springer Netherlands,
- Coutler E. G. 1969. Plant Anatomy - Part I Cells and Tissues – Edward Arnold, London.
- Dickison, W. C. 2000. Integrative Plant Anatomy, Harcourt Academic Press, USA
- Eames A. J. Morphology of Angiosperms - Mc Graw Hill, New York.
- Esau, K. 1990. Plant Anatomy, Wiley Eastern Pvt Ltd New Delhi
- Evert, R.F. (2006) Esau‘s Plant Anatomy: Meristem, Cells, and Tissues of the Plant Body: Their Structure, Function and Development. John Wiley and Sons, Inc
- Upadhyay, Kanica & Dobhal, Sneha & Kumar, Rajneesh. (2022). Basics of Wood Anatomy.
- Sherwin carlquist (2001) Comparative Wood Anatomy- Systematic, Ecological, and Evolutionary Aspects of Dicotyledon Wood, Springer
- Agashe, S. N. (1997). Aerobiology. Oxford and IBH publishing company, pvt., Ltd., New Delhi.
- Agashe, S. N. (2006). Palynology and its Applications. Oxford and IBH publication Company, Pvt., Ltd., New Delh.
- Agashe, S. N. and Eric Caulton .(2009). Pollen and Spores. Applications with special Emphasis on Aerobiology and allergy. Science publisher New Hampshire use Netherlands.
- Erdtman, G.1952. Pollen morphology and plant taxonomy of Angiosperms, Almquist and Wiksell, Stockholm.
- Nair, P. K. K. 1970. Pollen Morphology of angiosperms; A historical and phylogenetic study, Scholar publishing house, Lucknow.
- Ogden, E. C. and Rayner, G. S. 1974 Manual for sampling Airborne pollen. Hafirer Press, Macmillan Publishing Co., Inc, New york

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	-	2	2	3	2	3	-	-	-	2	-	-
CO 2	3	2	2	2	2	2	2	-	-	-	2	-	-
CO 3	3	2	3	2	3	2	3	-	-	2	3	-	-
CO 4	2	2	3	2	2	2	2	-	-	2	3	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz/Written Test
- Assignment/Presentation
- Project/Practical
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment/Presentation	Project/Practical Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3		✓		✓
CO 4		✓		✓

Programme	B. Sc. BOTANY				
Course Title	**Advanced Plant Physiology & Metabolism**				
Type of Course	**Major Elective**				
Semester	**VIII**				
Academic Level	400-499				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	Basic knowledge on Plant Physiology & Metabolism				
Course Summary	The course aims to explore the intricate mechanisms governing plant nutrition, plant growth, development and metabolism at molecular and cellular level.				

Course Outcomes (CO): After completing the Course, the candidate should be able to:-

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools
CO1	Discuss the physiological processes like nutrient absorption, nutrient assimilation and photosynthesis in plants	U	C	Test/Presentation
CO2	Assess the role of phytohormones in signal transduction	E	C	tes[illegible]ion
CO3	Analyse the regulation of metabolic pathways in plants	An	C	Quiz/ Written test
CO4	Identify the plant responses to various stress conditions	Ap	p	Field observations and reports/Presentations

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
\# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (48+12)
I		**Plant nutrition**	**16**
	1	Nutrient elements in plants- classification based on biochemical functions. Physiological roles	1
	2	Plants and inorganic nutrition:1. Ion uptake by roots: diffusion, facilitated diffusion and apparent free space. Apoplastic and symplastic pathways. Membrane potential.	2

	3	Plants and inorganic nutrition: 2. Transport proteins: carriers-Michaelis - Menten kinetics. Channels: Voltage dependent K+ channels, voltage gated channels, Calcium channels, vacuolar malate channels. ATPase activity and electrogenic pumps. Patch clamp studies. Application of Nernst equation. Active transport and electrochemical potential gradients	3
	4	Nitrogen Assimilation - Inorganic nitrogen species (NO2, NO3, and NH4) and their reduction to amino acids-pathways and enzymes (GS, GOGAT and GDH)	1
	5	Sulphur assimilation - reduction of sulphates. Importance of Phosphorus, Iron, Magnesium, Calcium and Potassium assimilation Energetics of nutrient assimilation. Molecular physiology of micronutrient acquisition	3
	6	Photosynthesis - Light absorption and energy conversion, electron transfer system in chloroplast membranes: Photoinhibition and acclimation to high light, ATP synthesis in chloroplast	2
	7	Photosynthesis - Photosynthetic carbon reduction, carbon oxidation and photorespiratory cycles. Physiological and environmental consideration of photosynthesis	4
II		**Plant growth and development**	**14**
	8	Plant Growth - Analysis of plant growth: production of cells, growth velocity profile. Cytological and biochemical events	2
	9	Development - Initiation and regulation of development, genes involved in the control of development, role of protein kinases	2
	10	Types of development - flowering- floral induction, evocation and morphogenesis. Floral organ identity genes. Biochemical signaling - Theories of flowering, Control of flowering phytochrome, cryptochrome and biological clock	2
	11	Plant growth regulators - Biosynthesis, transport and mode of action -Auxins, Gibberellins, Cytokines, Ethylene, Abscisic acid and Brassinosteroids	2
	12	Phytohormones in signal transduction. Hormonal balance concept	1
	13	Fruit development and ripening - Physiology of ripening- cell wall architecture and softening, enzymes involved in biochemical changes	1
	14	Photoreceptors: 1. Phytochromes-photochemical and biochemical properties, functions. Mechanisms of phytochrome regulated differentiation. Signal transduction pathways.	2
	15	Photoreceptors: 2. Cryptochromes - blue light, hormones photo-physiology, effect on stem elongation, gene expression and stomatal opening	2

III		**Senescence and stress physiology**	**6**
	16	Senescence and programmed cell death: Apoptosis and necrosis. Programmed cell death in relation to reproductive development and stress response. Metabolism during senescence	3
	17	Stress physiology**:** Water deficit and drought resistance. Heat stress and heat shock, chilling and frost. Salinity stress. Stresses due to oxygen deficiency and heavy metal pollution	3
IV		**Metabolism**	**12**
	18	Metabolism of Carbohydrates: Regulation of Glycolysis and TCA Cycle. Gluconeogenesis, Pentose phosphate pathway, Glyoxylate cycle	3
	19	Amino Acid Metabolism - General reactions of amino acids metabolism, Urea cycle, regulation and biological significance.	3
	20	Nucleic Acid synthesis- Biosynthesis and regulation of Purines and Pyrimidines, Denovo and Salvage pathways.	2
	21	Catabolism of Purines and Pyrimidines.	2
	22	Lipid biosynthesis - Biosynthesis of fatty acids. Triacylglycerols, phospholipids and isoprenoids. Regulation	2
V		**Open ended Theory/Practical (suggestive list)**	**12**
		1. Quantitative estimation of chlorophyll using spectrophotometry. 2. Measurement of Photosynthesis - Hill Reaction 3. Proline estimation under various levels of abiotic stresses 4. Estimation of phenol content in plant tissues as affected by biotic stresses 5. Visit to a research station with facilities in the subject area and submission of a report.	

Suggested Readings

- Hopkins W. G. and Norman P. A., Huner N. P. A. Introduction to Plant Physiology. John Wiley & Sons, Inc.
- Taiz L., Zeiger E., Moller I. M. and Murphy A. Plant Physiology and Development. Sinauer Associates Inc. USA. 6th edition.
- Salisbury F. B. and Ross C.W. Plant Physiology 3rd edition. CBS publishers and distributers.
- Noggle G. R and Fritz G. J. Introductory Plant Physiology Prentice Hall.
- Bidwell R. G. S. Plant Physiology. Macmillan Publishing Corporation.
- Buchanan B. B., Gruissem W. and Johns R. L. Biochemistry and Molecular Biology of Plants. American Society of Plant Biologists.
- Devlin R. M. and Withan F. H. Plant Physiology. CBS Publishers & Distributers.
- Moore T.C. Research Experience in Plant Physiology- A Laboratory Manual. Springer Verlag.
- Steward F.C. Plant Physiology- A Treatise. Vol. I to X. Academic Press.
- Stumpf P.K. and Conn, E.E. The Biochemistry of Plants: A comprehensive Treatise. Academic Press
- Anderson J.W. and Boardall J. Molecular Activation of Plant Cells - An Introduction to Plant Biochemistry, Blackwell Scientific Publishers.
- Beck C. B. An Introduction to Plant Structure and Development. Cambridge University Press.

- Bajracharya D. Experiments in Plant Physiology: A Laboratory Manual. Narosa Publishing House, New Delhi.
- Wilkins M. B. Advances in Plant Physiology. Longman Scientific & Technical.
- Lehninger. Principles of Biochemistry, Macmillan, U.K.
- Zubay G. Biochemistry. Macmillan Publishing Company, New York.
- Voet D. and Voet, J.G. Biochemistry. Wiley
- Berg J., Gatto Jr. G., Hines J., Tymoczko J. L. and Stryer L. Biochemistry Macmillan Learning.

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO 4	PO5	PO6	PO7
CO 1	3	2	1	1	1	1	3	-	-	-	3	1	-
CO 2	3	2	-	-	-	-	3	-	-	-	3	1	-
CO 3	3	2	-	-	-	-	3	-	-	-	3	1	-
CO 4	3	2	1	1	1	1	3	-	-	-	3	1	-

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz/Written Test
- Assignment/Presentation
- Project/Practical
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment/Presentation	Project/Practical Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓	✓	✓

ST. JOSEPH'S COLLEGE (AUTONOMOUS), DEVAGIRI

Programme	B. Sc. BOTANY				
Course Title	**Genetics & Cancer Biology**				
Type of Course	**Major Elective**				
Semester	**VIII**				
Academic Level	400-499				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-		60
Pre-requisites	Basics of Genetics				
Course Summary	This course explores the principles of heredity and advanced cancer studies.				

Course Outcomes (CO): After completing the Course, the candidate should be able to:-

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools
CO1	Identify the complex genetic mechanisms like gene regulation & epigenetics	U	C	Quiz/Exam
CO2	Acquire the skill to work on the techniques in genetics	Ap	C & P	Practical Assignments
CO3	Interpret complex genomic data and identify its applications	An	C & P	[illegible]
CO4	Identify various aspects of cancer induction	Ap	P	Quiz/ Exams
CO5	Derive multiple measures to detect and eliminate the causes of cancer	Ap	P	Written Assessments

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
\# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (48+ 12)
I		**Foundations of Genetics**	**10**
	1	Mendel's Laws - Molecular basis	1
	2	Critical evaluation of Mendelian genetics on the basis of	2

		modern concept of genes	
	3	Polygenic inheritance & Pleiotropy	2
	4	Transposable elements - Transposable elements in bacteria. IS elements, Tn element, *Cmp* site transposon, *Copia* and P elements in *Drosophila*. *Ac*, *Ds* and *Mu* elements in maize.	2
	5	Population genetics – Human pedigree analysis, LOD score technique, Genetic disorders	3
II		**Genetic Regulation & variations**	**8**
	5	Epigenetics - DNA Methylation, Histone Modification	2
	6	RNA interference: Si RNA and Mi RNAs, riboswitches, anti-switches	2
	7	Molecular mechanism of mutation. Mutator & Anti-mutator genes	2
	8	Genetic recombination and mapping of genes in bacteria and Bacteriophages.	2
III		**Techniques in Genetics & Applications**	**12**
	9	Chromosome mapping - Deletion mapping and physical chromosome mapping through molecular analysis. Physical mapping of genes on chromosomes: *In situ* hybridization with DNA probes (FISH, multi colour FISH, GISH, fibre FISH).	4
	10	Mutation and Mutagenesis, types of gene mutations, mutation rate, Testing of mutation: Ames test. Detection of mutations in *Drosophila* (ClB method, Muller–5 method, attached X method), detection of mutations in plants and their practical application in crop improvement	4
	11	GWAS- Definition, Procedure & Applications.	1
	12	Quantitative genetics: QTL mapping, Hardy-Weinberg principle and estimation of gene frequencies.	3
IV		**Cancer Biology**	**18**
	13	Introduction to Cancer Biology: Tumor formation, Tumor Classification and Role of environmental factors in cancer.	2
	14	Phenotype of the transformed cell, Cancer and cell cycle. Metastasis. Interaction of cancer cells with normal cells.	2
	15	Oncogenes: *ras, myc* and *bcl-1* and Tumor Suppressor Genes: *p53* and *NF1*, and their role in cancer.	2
	16	TNM staging of Cancer – procedure and medical aspects	1
	17	Genetic Instability in Cancer: chromosomal instability (CIN) - copy number variation and aneuploidy, microsatellite instability (MSI or MIN)	3
	18	Epigenetics and Cancer, role of Mi RNA in cancer development.	2

	19	Cancer Stem Cells and Tumor Heterogeneity	2
	20	CRISPR/Cas9 and Genome Editing in Cancer Research	2
	21	Single-Cell Analysis in Cancer, high contrast single cell imager for identification and clonal outgrowth.	2
	22	PCR-Based Techniques in Cancer Research	1
V		**Practical/Theory (Open ended)**	**12**

Suggested readings

- Gupta, P.K. (2018 -19) Genetics. Revised edition. Rastogi Publications, Meerut
- John Ringo (2004) Fundamental Genetics Cambridge University Press.
- Klug, W.S., Cummings, M.R., Spencer, C.A. (2009).
- Concepts of Genetics. Benjamin Cummings. U.S.A. 9th edition.
- Lewin B. (2000) Genes VII Oxford University Press.
- Rastogi V.B. (2008) Fundamentals of Molecular Biology, Ane Books, India.
- Sinnot, W.L.C. Dunn & J. Dobzhansky (1996) Principles of Genetics. Tata McGraw Hill Publishing Company Ltd., New Delhi
- P.S. Verma, V.K. Agarwal. Cell Biology, Genetics, Molecular biology, Evolution and Ecology.
- B D Singh. Genetics. Kalyani Publishers, New Delhi
- Lewin Benjamin. (2017) Gene XII. Jones and Bartlett Publishers Inc
- VeerBala Rastogi. Genetics.
- Benjamine A. Pierce (2012), Genetics. A conceptual Approach, W.H Freeman. Fourth edition.

Online Sources:

- https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3176118/
- https://www.illumina.com/areas-of-interest/complex-disease-genomics/gwas.html#:~:text=Genome%2Dwide%20association%20studies%20(GWAS)%20use%20high%2Dthroughput,with%20a%20trait%20or%20disease.
- https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4385642/#:~:text=While%20whole%20genome%20or%20whole,or%20pathway%20genes%20in%20known
- https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3531285/
- https://www.genetics.edu.au/PDF/Cancer_genetics_fact_sheet-CGE

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	1	1	1	-	-	3	-	-	-	2	-	-
CO 2	1	1	3	3	3	3	1	-	3	-	2	-	2
CO 3	3	1	2	3	3	1	1	-	3	1	3	-	2
CO 4	3	-	1	3	3	1	3	-	1	-	2	3	1
CO 5	3	-	1	3	3	1	3	-	1	-	2	3	1

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / / Discussion
- Assignment/ Seminar
- Project/Practical
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment/Seminar	Practical/Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2			✓	✓
CO 3			✓	✓
CO 4	✓			✓
CO 5	✓	✓		✓

Programme	B. Sc. BOTANY				
Course Title	**Instrumentation Biology**				
Type of Course	**Major Elective**				
Semester	**VIII**				
Academic Level	400-499				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	Basic awareness on lab equipment				
Course Summary	This course introduces students to the principles of various advanced instrumentation techniques used in the field of plant science for various purposes and also detailing the working procedures of the same				

Course Outcomes (CO): After completing the Course, the candidate should be able to:-

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools
CO1	Recall the fundamental principles and terminology associated with various botanical instruments	R	F	Quiz/Tests/ Assignments
CO2	Understand the working principles behind different instrumentation techniques used in botany	U	C	Practical E[illegible]
CO3	Apply the various instrumentation techniques for doing varied analysis	Ap	P	L[illegible]

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
\# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (48+12)
I		**Microscopy**	**14**
	1	Instrumentation in Botany - Introduction, Importance in botanical research	1
	2	High-resolution imaging of plant structures and ultrastructures, Confocal microscopy: 3D imaging in plant biology, Principles and applications	2

	3	Fluorescence microscopy: FISH, chromosome banding, chromosome painting	2
	4	Atomic force microscopy: Imaging and manipulation of plant cells, Basics of atomic force microscopy- techniques and applications	3
	5	Transmission and scanning electron microscopy- sample preparation, cryofixation, negative staining, shadow casting, freeze etching	3
	6	Spectroscopy: principles and applications, Fluorescence spectroscopy, Atomic Absorption spectroscopy, Flame Emission Spectroscopy, Infrared spectroscopy, NMR and ESR Spectroscopy, Mass spectrometry-ESI-MS, MALDI-TOF	3
II		**Separation Techniques**	**10**
	7	Chromatography Techniques - Ion chromatography, Gel permeation chromatography, HPLC, HPTLC - Principles and Applications	4
	8	Electrophoresis: Agarose gel electrophoresis, SDS-PAGE: Protein separation and analysis in plants, Protein sample preparation and loading, Techniques and Applications	3
	9	Isoelectric focusing: Techniques for protein purification, Principles of isoelectric focusing, Applications	3
III		**Imaging Techniques**	**10**
	10	Imaging Techniques - X-ray imaging: Principles and Applications	2
	11	MRI and CT scanning: Non-invasive imaging techniques in plant biology. Basics of Magnetic Resonance Imaging (MRI) and Computed Tomography (CT) and their applications	3
	12	PET and SPECT imaging: Functional imaging in plant research- Introduction to Positron Emission Tomography (PET) and Single-Photon Emission Computed Tomography (SPECT), Laser Emission Tomography, Applications	3
	13	Hyperspectral imaging: Basics of hyperspectral imaging and applications	2
IV		**Analytical techniques**	**14**
	14	Histochemical techniques: methods for localising macromolecules and metabolites in plant tissues, staining procedures,	2
	15	Microtomy- basic principle and types, ultramicrotomy	2
	16	Tracer techniques: Radioisotopes in plant science research: autoradiography, pulse chase experiment, liquid scintillation spectrometry	2
	17	Flow cytometry: Principles, Measurement of nuclear DNA content, Applications of flow cytometry in plant science	2

	18	Immunological techniques: Immunodiffusion, immunoelectrophoresis, ELISA, RIA, non isotopic methods	3
	19	Recent advances and trends - Overview of recent advancements in instrumentation in botany, Impact of new methodologies on advancing our understanding of plant biology, Future directions and challenges in botanical instrumentation	3
V	**Open Ended (Practical/Theory)**		**12**

Suggested Readings

- Bajpai, P.K. 2006. Biological Instrumentation and methodology. S. Chand & Co. Ltd.
- K. Wilson and J. Walker Eds. 2005. Biochemistry and Molecular Biology. Cambridge University Press.
- K. Wilson and K.H. Goulding. 1986. Principles and techniques of Practical Biochemistry. (3 edn) Edward, Arnold, London.
- Dawson C. 2002. Practical research methods. UBS Publishers, New Delhi.
- 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.
- Ruzin, S.E. 1999. Plant micro technique and microscopy. Oxford, University Press, New York, U.S.A.
- Wilson K & Walker J. 2000. Principles and Techniques of Practical Biochemistry.5thEdition. Cambridge Univ. Press.
- Bryan L. Williams & Keith Wilson 2010. Principles and Techniques of practical biochemistry. Cambridge Cambridge University Press.
- David Freifelder. 1983. Physical Biochemistry: Applications to Biochemistry and Molecular Biology. 2nd Edition. W. H. Freeman.
- Rodney F. Boyer. 1993. Modern Experimental Biochemistry. 3rdEdition. Benjamin Cummings Pub.
- S. K. Sawhney and Randhir Singh. 2000. Introductory Practical biochemistry. 2nd Edition. Narosa Publisher.
- Saroj Dua and Neera Garg. 2013. Biochemical Methods of Analysis: Theory and Applications. 1st Edition. Alpha Science Intl Ltd.
- John F. Robyt and Bernard J. White. 1987. Biochemical Techniques: Theory and Practice, CBS Publishers.
- Okotore R.O. 1998. Basic Separation Techniques in Biochemistry Paperback. 1st Edition. Professional Book Publishers.

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	1	-	-	-	1	-	1	-	1	-	-	-	-
CO 2	1	-	-	-	1	-	1	-	1	-	-	-	-
CO 3	-	-	3	1	3	1	1	-	2	-	2	-	1

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion
- Assignment/ Seminar
- Project/Practical
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment/Seminar	Practical/Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓		✓	✓
CO 3			✓	✓

Programme	B. Sc. BOTANY				
Course Title	**Biosafety, IPR & Patenting**				
Type of Course	**Major Elective**				
Semester	**VIII**				
Academic Level	400-499				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	-				
Course Summary	This subject aims to introduce students to Intellectual Property Rights and apprise them of Patent and related rules and regulations in the biological sciences and the laws pertaining to these in both the global and national context.				

Course Outcomes (CO): After completing the Course, the candidate should be able to:-

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools
CO1	Recall key concepts and regulations related to biosafety, intellectual property rights (IPR), and patenting	R	F	Instructor created exam/Quiz
CO2	Understand the importance of biosafety measures in biological research	U	F	Case study analysis/Written assignment discussions
CO3	Apply their knowledge of IPR and patenting laws to protect intellectual property in biological innovations	Ap	C & P	Scenario-b questions
CO4	Create biosafety plans and patent applications that demonstrate a deep understanding of the principles and practices in the field.	C	C & P	Project work/Oral presentations

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (48 +12)
I		**Biosafety**	**12**
	1	Introduction, Definition and requirement, biosafety issues; Biological Safety Cabinets & their types; Primary Containment for Biohazards.	3
	2	Biosafety Levels of Specific Microorganisms. Biosafety guidelines and regulations (National and International).	2
	3	GMOs/LMOs- Concerns and Challenges	2
	4	Role of Institutional Biosafety Committees (IBSC), RCGM, GEAC etc. for GMO applications in food and agriculture.	2
	5	Laws relating to Biosafety in India: The Biological Diversity Act, 2002, International Legal Instruments on Biosafety-Cartagena Protocol on Biosafety.	3
II		**Risk Analysis**	**12**
	6	Environmental release of GMOs; Risk Analysis; Risk Assessment; Risk management and communication	3
	7	Use of Animals in Research and Testing, and Alternatives for Animals in Research, Animal Cloning, Human Cloning and their Ethical Aspects.	3
	8	Testing of Drugs on Human Volunteers, Public and Non-Governmental Organizations (NGOs), Participation in Biosafety and Protection of Biodiversity	3
	9	Bioethics in Plants, Animals and Microbial Genetic Engineering, Biopiracy	3
III		**Intellectual Property**	**10**
	10	Introduction to Intellectual Property Rights - Types of IP, Patents, Trademarks, Copyright , Trade secrets, Industrial Design and Rights, Traditional Knowledge, Geographical Indications - importance of IPR	4
	11	Relevance of Intellectual Property Rights for Science and Technology, patentable and non-patentable - patenting life	2
	12	Patenting Living Organisms, Special Patents, Patenting Biological products	2
	13	Legal protection of biotechnological inventions Ethics, Pros and Cons of IP protection.	2
IV		**Patenting Authorities And Treaties**	**14**
	14	General Agreement on Trade and Tariff (GATT); Trade Related Aspects of Intellectual Property Rights (TRIPS)	2
	15	Establishment of WIPO - Mission and Activities; Indian IPR legislations, Indian Patent Act 1970 & recent amendments	2
	16	Budapest Treaty on international recognition of the deposit of microorganisms; Patent Co-operation Treaty (PCT)	2
	17	Types of patent applications: Ordinary, PCT, Conventional, Divisional and Patent of Addition; An introduction to Patent Filing Procedures; Patent licensing and agreement	2

	18	Patent owner - Ownership of patent, Rights and Duties, Transfer of patent Rights, Limitations of patent Rights, Restoration of Patents	2
	19	Patent infringement, revocation- meaning, scope, litigation, Offences, Actions against Infringement: Remedies/Relief, Patent Agent	2
	20	Patent Case study - Basmati Case, Neem Controversy, Turmeric Case	2
V	**Open Ended (Practical/Theory)**		**12**

Suggested Readings

- Paul Goldstein, Intellectual Property Rights
- Nair K. R. G., Ashok Kumar, Intellectual Property Rights
- Kilner, John, et.al, eds. 2002. Cutting-Edge Bioethics. Eerdmans
- Wadera B. L., Patents, Trademarks, Copyright, Designs and Geographical Indications
- Deepa Goel and Shomini Parashar, IPR, Biosafety and Bioethics, Pearson Publisher
- Singh K., Intellectual Property Rights on Biotechnology, BCIL, New Delhi.

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	-	1	1	-	-	3	-	1	-	1	-	-
CO 2	3	-	1	2	2	-	1	-	2	-	2	1	1
CO 3	3	3	3	1	3	1	1	-	3	-	1	1	3
CO 4	3	3	3	1	3	1	1	-	3	-	1	1	3

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion
- Assignment/ Seminar
- Project/Practical
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment/Seminar	Practical/Project Evaluation	End Semester Examinations
CO 1	✓	✓	✓	✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		

Programme	B. Sc. BOTANY				
Course Title	**Research Methodology in Botany**				
Type of Course	**Major Elective**				
Semester	**VIII**				
Academic Level	400-499				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	UG level course in Botany				
Course Summary	This course provides students with the essential knowledge and skills needed to conduct scientific research in the field of botany. Students will learn how to formulate research questions, design experiments, collect and analyse data, and draw meaningful conclusions using statistical tools.				

Course Outcomes (CO): After completing the Course, the candidate should be able to:-

COs	Statement	Knowledge Category*	Cognitive level#	Evaluation Tools
CO1	Outline and conduct scientific research in the field of botany	F	U	Research proposal/ Literature review/ Research presentations
CO2	Understand the principles of probability, sampling and hypothesis testing	F	U	Written Test
CO3	Analyse and interpret data, make decisions based on statistical results, and communicate findings effectively	C & P	An	Group projects/ Research presentations
CO4	Formulate research questions, design experiments and draw meaningful conclusions	C & P	C	Research propos Project report an presentation

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
\# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (48+12)
I		**Basic concepts of research**	**12**
	1	Research- definition and types of research (library, field and laboratory).	2
	2	Research Proposal and experimental design- Key elements- Objective, Introduction, Design or Rationale of work, Guidelines for design of experiments, Material and methods, Designing	3

		biological experiments.	
	3	Literature-review and its consolidation (sources of literature like Google Scholar, INFLIBNET, Shodhganga)	1
	4	Access to laboratory; laboratory practices and cleanliness; laboratory hazards (chemical, fire, electrical, noise, radiation), safety measures. (Wet & Dry Lab)	2
	5	Maintaining a laboratory record; Tabulation and generation of graphs.	1
	6	Imaging of tissue specimens and application of scale bars, Importance of photography.	3
II		**Scientific writing and presentation**	**12**
	7	Format of research paper and report writing, Major scientific publishers	2
	8	Reference writing, Procedure of Reference Citation (different styles) (open software for grammar and language checking)	2
	9	Effective presentation of research findings.	2
	10	Impact factor and citation index- Impact factor of journal as per journal citation report, SNIP, SJR, IPP, Cite Score	2
	11	Metrics: h- index, g-index, i10-index, altmetrics	2
	12	Major research institutes related to plant sciences in India. A brief idea about government research agencies such as DBT, DST, ICMR, CSIR and UGC.	2
III		**Scientific Conduct**	**12**
	13	Ethics with respect to science and research, Intellectual honesty and Research integrity	2
	14	Scientific misconducts: falsification, fabrication and plagiarism	2
	15	Publication ethics: definition, introduction and importance	2
	16	Violation of Publication ethics, authorship and contributor ship; Conflicts of interest	3
	17	Redundant Publications duplicate and overlapping Publications, Salami Slicing	3
IV		**Statistical applications**	**12**
	18	Statistical methods- basic principles, sampling methods (random and stratified sampling); Collection of primary and secondary data, its tabulation and presentation.	2
	19	Measures of central tendency - Mean, median, mode, standard deviation, standard error	3
	20	Correlation, regression, chi square analysis, Students _t‘ test; merits and demerits of measures of central tendency	3
	21	Probability distributions: Binomial, Poisson and Normal Distributions	2
	22	Introduction to statistical software – SPSS, PRISM, Origin, XLSTAT	2

V	Open ended (Suggestive list)	12
	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 plant material. 3. Chi square analysis, Analysis of Students'_t' test using suitable example. 4. Group discussion a) Subject specific ethical issues b) Conflicts of interest c) Complaints and appeals: examples and fraud from India and abroad 5. Software tools-Use of plagiarism software like Turnitin, Urkund 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	

Suggested Readings:

- Danniel, W.W. 1987. Biostatistics. New York, NY: John Wiley Sons.
- Campbell, R.C. 1974. Statistics for Biologists. Cambridge University Press.
- Dawson, C. 2002. Practical research methods. New Delhi: UBS Publishers.
- Freedman, P. 1949. The Principles of scientific research. Washington DC.: Macdonald And Company Limited.
- Gurumani, N. 2006. Research Methodology for Biological sciences. Chennai, TN: MJP Publishers.
- 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.
- Sundar Rao, P. S. S., & Richards, J. 2012. An introduction to Biostatistics, and Research Methods, New Delhi: PHI learning Pvt. Ltd.
- Parikh, M. N. and Nithya Gogtay, ABC of Research Methodology and Applied Biostatistics.
- Chaudhary C.H. Research Methodology, RBSA Publication

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	1	-	3	3	3	-	-	-	-	-	3	-	3
CO 2	3	-	-	-	1	-	2	-	-	-	2	-	2
CO 3	-	-	2	1	2	1	1	-	-	2	3	-	2
CO 4	-	-	3	3	3	3	1	1	1	2	3	1	3

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz/Written Test
- Assignment/Presentation
- Project/Practical
- Final Exam

Mapping of Cos to Assessment Rubrics :

	Internal Exam	Assignment/Presentation	Project/Practical Evaluation	End Semester Examinations
CO 1	✓	✓	✓	✓
CO 2	✓	✓	✓	✓
CO 3	✓			✓
CO 4	✓	✓	✓	✓

MINOR COURSES

Programme	B. Sc. BOTANY				
Course Title	**Plant Ecology, Conservation & Plant Interactions**				
Type of Course	**Minor**				
Semester	**I**				
Academic Level	100-199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	-				
Course Summary	This course offers basic knowledge related to the relationships between plants and their environment, the importance of conservation efforts and the interactions between different plant species.				

Course Outcomes (CO): After completing the Course, the student should be able to:

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools
CO1	Explain the ecological relationships between plants and the environment	U	C	Test/Assignments/Field study
CO2	Summarise the significance of conservation practices	U	F	Class Discussions
CO3	Explain various interactions that occur among plant species	U	C	Test/Field study/Group project
CO4	Develop the skills necessary to contribute to the conservation and sustainable management of plant ecosystems	Ap	C	Volunteer Projects/Reflective essays
CO5	Apply conservation strategies suitable for neighbouring ecosystems	Ap	P	Case studies/Presentations/Field reports

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus

Module	Unit	Content	Hrs (45 + 30)
I		**Plant Ecology**	**9**
	1	Ecology - Definition, Ecosystem: ecological factors - biotic and abiotic.	2
	2	Ecological adaptations - Morphological and anatomical adaptations of the following types: Hydrophyte (*Vallisnaria*), Xerophyte (*Opuntia*)	2
	3	Halophyte (*Avicennia*), Epiphytes (*Vanda*) and parasites (*Cuscuta*)	2
	4	Ecological succession - Process of succession, types of succession, Hydrosere	3
II		**Biodiversity, Loss and its Consequences**	**18**
	5	Biodiversity - Definition, types of biodiversity - habitat diversity, species diversity and genetic diversity	3
	6	Values of Biodiversity - Economic and aesthetic value, Medicinal values	2
	7	Concept of Biodiversity Hotspots, Biodiversity hot spots of India.	2
	8	Concept of endemism and endemic species. ICUN plant categories with special reference to Western Ghats.	2
	9	Estimates of extinction rates worldwide and in India, causes of extinction/changes in biodiversity	2
	10	Habitat fragmentation and destruction	3
	11	Threats to biodiversity: Overexploitation, Invasive species	2
	12	Consequences: loss of gene pool, loss of ecosystem services, livelihood	2
III		**Biodiversity Conservation**	**8**
	13	Conservation methods - *In-situ* and *ex-situ* methods.	2
	14	*In-situ* methods - Biosphere reserves, National parks, Sanctuaries, Sacred grooves	2
	15	*Ex-situ* methods - Botanical gardens, Seed bank, Gene banks, Pollen banks	2
	16	Cryopreservation	2
IV		**Plant Interactions**	**10**
	17	Plant interactions: overview, Plant - microbe interactions: Mycorrhizae	1
	18	Plant - herbivore interactions, Plant defences against herbivores	2
	19	Plant - pollinator interactions, Pollination syndromes and floral specialisation	2
	20	Ant-plant interactions	1
	21	Plant-animal interactions as ecosystem services	2
	22	Conservation aspect of plant-animal interactions	2

V	Practical (Mandatory Experiments)	30
	1. Study the morphological and anatomical adaptations of the hydrophytes, xerophytes, halophytes, epiphytes and parasites mentioned in the syllabus 2. Study of a pond/forest ecosystem and recording the different biotic and abiotic components 3. Field observations of plant-animal interactions in natural environments around campus 4. Field visit: To study different types of local vegetation/ecosystems and the report to be recorded.	
	Practical (Open Ended-Suggestive list)	
	4. Case studies: Contemporary Indian wildlife and biodiversity issues 5. Group presentations in an area of conservation biology 6. Discussion on biodiversity (Man-animal conflict, human interference, climate change)	

Suggested Readings

- Rajak, A. 2020. Textbook of Biodiversity. 1st edition, Notion Press, India.
- Mahanty, S. and Srivastava, A. 2016. Biodiversity and It's Conservation. Disha International Publishing House, India.
- Singh, J.S., Singh, S.P. and Gupta, S.R. 2008. Ecology, Environment and Resource Conservation. Anamaya Publications (New Delhi).
- Krishnamurthy, K.V. 2004. An Advanced Text Book of Biodiversity - Principles and Practices. Oxford and IBH Publications Co. Pvt. Ltd. New Delhi.
- Gaston, K J. and Spicer, J. I. 1998. Biodiversity: An Introduction. Blackwell Science, London, UK.
- Primack, R. B. 2002. Essentials of Conservation Biology (3rd edition). Sinauer Associates, Sunderland, USA.
- Chittka, L. and Thompson, J. D. (Eds.). 2001. Cognitive Ecology of Pollination- Animal Behaviour and Floral Evolution. Cambridge University Press.
- Herrera, C. M. and Pellmyr, O. (Eds.). 2002. Plant-Animal Interactions: An Evolutionary Approach. Blackwell Publishing.
- Schaeffer, H.M., and Ruxton, G.D. (Eds). 2011. Plant-Animal Communication. Oxford University Press.

Online Sources

- https://www.igntu.ac.in/eContent/IGNTU-eContent-313628797582-M.Sc-EnvironmentalScience-4-ManojkumarRai-MicrobialEcology-2-3.pdf
- http://www.eagri.org/eagri50/AMBE101/lec29.html
- http://eagri.org/eagri50/AMBE101/pdf/lec29.pdf
- ales.arizona.edu/classes/ento415/LECTURES/ENTO415_PlantInteractions.pdf
- https://entnemdept.ufl.edu/baldwin/webbugs/3005_5006/Docs/notes/notes10.pdf

Mapping of COs with POs:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	2	-	-	-	1	2	-
CO2	2	-	-	-	1	2	-
CO3	2	-	-	-	-	2	-
CO4	2	-	-	-	-	2	-
CO5	2	-	-	-	-	2	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion
- Assignment/ Seminar
- Project/Practical
- Final Exam

Mapping of COs to Assessment Rubrics

	Internal Exam	Assignment/Seminar	Practical/Project Evaluation	End Semester Examinations
CO 1	✓	✓	✓	✓
CO 2	✓	✓		✓
CO 3	✓		✓	✓
CO 4	✓		✓	

Programme	B. Sc. BOTANY				
Course Title	**Plant Morphology, Physiology & Plant Resources**				
Type of Course	**Minor**				
Semester	**II**				
Academic Level	100-199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Higher secondary level Biology course				
Course Summary	This course covers a comprehensive study of the structure, function, and utilization of plants. Students will explore the morphology of plants, and the physiological processes that occur within plants. Furthermore, students will learn about the diverse uses of plants as valuable resources for food, medicine, and more.				

Course Outcomes (CO): After completing the Course, the student should be able to:-

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools
CO1	Explain the various morphological characteristics of a plant	U	F	Quiz/ Test/Assignments/ Practical/ Field studies
CO2	Identify the physiological processes that drive plant growth, development and responses to the environment	Ap	C	Assignments/Quiz/Test
CO3	Apply knowledge of plant morphology and physiology to analyse and solve real-world problems related to plant health and productivity	Ap	C & P	Field Work/Presentations
CO4	Evaluate the importance of plants as valuable resources for food, medicine and more	E	C	Group project/Class discussion

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (45 + 30)
I		**Plant Morphology**	**7**
	1	Morphology of leaf; Structure, simple, compound, venation and phyllotaxy.	2
	2	Inflorescence - Racemose, cymose, special, types with examples	2
	3	Flower - as a modified shoot, structure of flower, symmetry of flower, floral parts - their arrangement, types of aestivation, relative position of parts, cohesion and adhesion of stamens and placentation.	3
II		**Plant Physiology**	**18**
	4	Water relations: Permeability, Imbibition, Diffusion, Osmosis and water potential.	2
	5	Absorption of water: passive mechanism.	1
	6	Ascent of sap: Transpiration pull or cohesion-tension theory.	2
	7	Transpiration: Types, mechanism of stomatal movement: K^+ ion theory.	2
	8	Significance of transpiration, antitranspirants.	2
	9	Photosynthesis: Introduction, significance, Two pigment systems, red drop, Emerson enhancement effect, action and absorption spectra.	3
	10	Mechanism of photosynthesis: Light reaction, cyclic & non-cyclic photo phosphorylation, Dark reactions-Calvin cycle, C_4 cycle, photorespiration (a brief account only). Factors affecting photosynthesis.	6
III		**Plant Growth**	**10**
	11	Plant growth - Definition, phases of growth, Auxins, gibberellins, cytokinin, abscisic acid and ethylene, their physiological roles.	2
	12	Senescence and abscission.	2
	13	Photo-periodism and vernalization.	2
	14	Dormancy of seeds - Factors causing dormancy, photoblasticism, techniques to break dormancy.	2
	15	Physiology of fruit ripening.	2
IV		**Plant Resources**	**10**
	16	Brief account on the various categories of plants based on their economic importance	1
	17	Study the following plants with special reference to their binomial, family, morphology of the useful part and their uses. Cereals: Paddy, Wheat; Pulses: Black gram, Green gram; Oil: Coconut, Gingelly	3
	18	Fibre: Cotton; Latex: Rubber; Beverages: Tea, Coffee	2

<table>
<tr><td></td><td>19</td><td>Spices: Pepper, Cardamom, Clove</td><td>2</td></tr>
<tr><td></td><td>20</td><td>Medicinal plants: Rauvolfia serpentina, Justicia adhatoda, Santalum album and Curcuma longa.</td><td>2</td></tr>
<tr><td>V</td><td colspan="2">Practical (Mandatory experiments)</td><td>30</td></tr>
<tr><td></td><td colspan="3">1. Identify the types of inflorescences mentioned in the syllabus.
2. Learn the principle and working of the following apparatus/experiments
▪ Thistle funnel osmoscope
▪ Ganong's potometer
▪ Ganong's light-screen
▪ Absorbo transpirometer
▪ Mohl's half-leaf experiment
▪ Experiment to show evolution of O_2 during photosynthesis
3. Identify at sight the economically important plant produces and products mentioned in module IV, and learn the binomial and family of the source plants, morphology of the useful parts and uses</td></tr>
<tr><td colspan="4">Practical (Open ended)</td></tr>
</table>

Suggested Readings

- Sporne K. R. 1974. Morphology of Angiosperms. Hutchinson.
- William G. Hopkins. 1999. Introduction to Plant Physiology, 2nd edition, John Wiley & Sons, Inc.
- Frank B. Salisbury and Cleon W. Ross. 2002. Plant Physiology 3rd edition. CBS publishers and distributers.
- G. Ray Noggle and George J. Fritz. 1983. Introductory Plant Physiology Prentice Hall.
- Pandey B. P. 1987. Economic Botany
- Verma V. 1984. Economic Botany
- Hill A.W. 1981. Economic Botany, McGraw Hill Pub
- Alam, Afroz. 2020. A Textbook of Economic Botany and Ethnobotany. IK International Publishing House.
- Atal C.K. and Kapur B. M. 1982. Cultivation and Utilization of Medicinal Plants. CSIR-RRL, Jammu.
- Sambamurty and Subrahmanyam, N. S. 2008. A Textbook of Modern Economic Botany. CBS Publishers & Distributors Pvt. Ltd.
- Bhutya, R. K. 2021. Medicinal Plants of India Vol. I & II. Scientific Publishers.

Mapping of COs with POs:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	2	-	-	-	1	1	-
CO2	2	-	-	-	1	1	-
CO3	2	-	1	-	1	1	-
CO4	2	-	1	-	1	1	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion
- Assignment/ Seminar
- Project/Practical
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment/Seminar	Practical/Project Evaluation	End Semester Examinations
CO 1	✓	✓	✓	✓
CO 2	✓	✓		✓
CO 3	✓		✓	✓
CO 4	✓			

ST. JOSEPH'S COLLEGE (AUTONOMOUS), DEVAGIRI

Programme	B. Sc. BOTANY				
Course Title	**Plant Diversity & Angiosperm Taxonomy**				
Type of Course	**Minor**				
Semester	**III**				
Academic Level	200-299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Higher secondary level Biology course				
Course Summary	This course covers a wide range of topics related to the classification and identification of plants. Students will learn about the diversity of plant species and the characteristics that define different plant groups. The course will also cover Taxonomy of Angiosperms and the methods and techniques used in it.				

Course Outcomes (CO): After completing the Course, the student should be able to:

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools
CO1	Identify wide range of plant species based on their morphological characteristics.	U	F	Quiz/ Tests/ Lab Practical / Field Studies/ Assignments
CO2	Understand the evolutionary relationships between different plant groups.	U	C	Quiz/Test/ Assignments/ Lab Practical/ Class Discussions
CO3	Demonstrate proficiency in using various tools to identify unknown plant specimens.	U	C & P	Lab Practical/ Field Work/ Assignments/ Quiz/Tests
CO4	Apply various classification systems and taxonomic principles to categorize and organize plant species.	Ap	P	Quiz/Test/ Assignments/ Lab Practical/ Projects
CO5	Appraise plant diversity and taxonomy in ecological and conservation contexts.	E	C	Essays/ Case Studies/ Field Studies/ Presentations

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)

- Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus

Module	Unit	Content	Hrs (45 + 30)
I		**Cyanobacteria, Algae and Fungi**	**15**
	1	Cyanobacteria - General Account, Ecological and Economic importance.	2
	2	*Nostoc* - Structure, life history and ecological significance.	2
	3	Algae - General characteristics, Thallus organization & reproduction , Ecological and economic importance.	2
	4	*Spirogya* - Structure and life cycle.	2
	5	Fungi - General characteristics, Nutrition and reproduction. Economic and ecological significance of fungi.	2
	6	Morphology, reproduction and life history of *Agaricus* (developmental details not required)	2
	7	Symbiotic Associations - Lichens: General features, reproduction, ecological and economic importance.	2
	8	Mycorrhiza - General account and its significance.	1
II		**Bryophytes & Pteridophytes**	**8**
	9	Bryophytes - General characteristics, Thallus diversity, Ecology and economic importance.	2
	10	Morphology, anatomy and reproduction of *Riccia.*	2
	11	Pteridophytes - General account, Ecological and economical importance of Pteridophytes.	2
	12	Morphology, Anatomy and life history of *Pteris.*	2
III		**Gymnosperms**	**5**
	13	Gymnosperm - General account. Ecological and economic importance.	2
	14	Morphology, anatomy and reproduction of *Cycas.*	3
IV		**Angiosperms**	**17**
	15	Angiosperms - General characters, reproduction, life cycle pattern	2
	16	Nomenclature - Binomial system of nomenclature	2
	17	Basic rules of nomenclature	1
	18	Systems of classification - Bentham & Hooker's system	2
	19	Herbarium techniques: collection, drying, poisoning, mounting & labelling	2
	20	Significance of herbaria and botanical gardens	1
	21	Important herbaria and botanical gardens in India	1

	22	Study the following families and their economic importance: Fabaceae (with sub-families), Rubiaceae, Euphorbiaceae and Poaceae	6
V	**Practical (Mandatory experiments)**		**30**
	1. Microscopic observation of vegetative and reproductive structures of *Nostoc* and *Spirogyra.* 2. Make suitable micro preparations of vegetative and reproductive structures of *Agaricus, Riccia, Pteris* and *Cycas.* 3. Study of vegetative and floral characters of the families in the syllabus. Students shall be able to describe the plants in technical terms and draw the L.S. of two plants of the families and record the same. 4. Mounting of properly dried and pressed specimen of any five wild plants of the families mentioned in the syllabus, with proper herbarium label.		
Practical (Open Ended-Suggestive list)			
	5. Observation of algal diversity in ponds. 6. Field visit, identification and documentation of common Algae, Bryophytes and Pteridophytes. 7. Determine the systematic position of local plants comes under the syllabus based on their vegetative and floral characters. 8. Campus walk to identify and record campus plants.		

Suggested Readings

- Fritsch, F.E. 1935. The structure and reproduction of the algae. Vol. 1 and II, Uni. Press. Cambridge.
- Morris, I. 1967. An Introduction to the algae. Hutchinson and Co. London.
- Papenfuss, G.F. 1955. Classification of Algae.
- B.R. Vasishta. Introduction to Algae
- Mamatha Rao. 2009. Microbes and Non-flowering plants. Impact and applications. Ane Books, New Delhi.
- Sanders, W.B. 2001. Lichen interface between mycology and plant morphology, Bioscience, 51: 1025-1035.
- B.R. Vasishta. Introduction to Fungi.
- P.C. Vasishta. Introduction to Bryophytes.
- B.P. Pandey. Introduction to Pteridophytes
- Chamberlain C.J. 1935. Gymnosperms – Structure and Evolution, Chicago University Press.
- Sreevastava H.N. 1980. A Text Book of Gymnosperms. S. Chand and Co. Ltd., New Delhi.
- Vasishta P.C. 1980. Gymnosperms. S. Chand and Co., Ltd., New Delhi.
- Radford, A.E. 1986. Fundamentals of Plant Systematics. Harpor & Row Publishers, New York.
- Sivarajan, V.V. 1991. Introduction to Principles of Plant Taxonomy. Oxford & IBH, New Delhi.

- Jeffrey, C. 1968. An introduction to Plant Taxonomy, Cambridge University Press, London.
- Gurucharan Singh. 2001. Plant Systematics. Theory and practice. Oxford & IBH Publications New Delhi.
- Sharma O.P. 1990. Plant Taxonomy – Tata McGraw Hills. Publishing company Ltd.
- Subramanyam N.S. 1999. Modern Plant Taxonomy. Vikas Publishing House Pvt Ltd.
- Pandey & Misra. 2008. Taxonomy of Angiosperms. Ane books Pvt Ltd.

Mapping of COs with POs:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	2	-	-	-	1	1	-
CO2	2	-	-	-	1	1	-
CO3	2	-	-	1	1	1	-
CO4	1	-	1	-	1	1	1
CO5	2	-	-	-	1	1	-

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion
- Assignment/ Seminar
- Project/Practical
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment/Seminar	Practical/Project Evaluation	End Semester Examinations
CO 1	✓	✓	✓	✓
CO 2	✓	✓	✓	✓
CO 3	✓	✓	✓	✓
CO 4	✓	✓	✓	✓
CO 5				✓

ST. JOSEPH'S COLLEGE (AUTONOMOUS), DEVAGIRI

INDUSTRIAL BOTANY

Programme	B. Sc. BOTANY				
Course Title	**Phytochemistry**				
Type of Course	**Minor**				
Semester	**I**				
Academic Level	200 - 299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Higher secondary level biology course				
Course Summary	This course explores the chemical compounds produced by plants, their biosynthesis, and their significance in nature and human applications. The course covers the classification, extraction, and analysis of phytochemicals, with a focus on their pharmacological properties and uses in traditional and modern medicine.				

Course Outcomes (CO): After completing the Course, the candidate should be able to:-

CO	CO Statement	Cognitive Level*	Knowledge Category #	Evaluation Tools
CO1	Identify and classify different types of phytochemicals and their sources.	R	F	Quiz/Exams/Group presentations
CO2	Explain the biosynthetic pathways and ecological roles of phytochemicals.	U	C	Written assignments/Oral presentations
CO3	Demonstrate the extraction, isolation, and analysis of phytochemicals using laboratory techniques.	Ap	C & P	Practical exams
CO4	Compare and contrast the chemical structures and properties of various phytochemicals.	An	C	Comparative reports
CO5	Assess the therapeutic and ecological significance of major classes of secondary metabolites, in pharmaceutical and ecological contexts.	E	C & P	Group discussions/Seminars/ Literature Surveys
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)
I		**Phytochemistry - Introduction**	**12**
	1	Introduction to Phytochemistry, Primary and secondary metabolites -Overview	1
	2	Carbohydrates: Classification, and functions of monosaccharides, disaccharides and plant polysaccharides.	2
	3	Amino acids: Classification and functions	2
	4	Proteins: Classification and functions, Peptide bonds and protein folding.	2
	5	Enzymes: Classification and functions	1
	6	Lipids: basic information of fatty acids and triglycerides, phospholipids and sterols, waxes and cutins	2
	7	Nucleotides: Classification and functions of nucleotides and nucleotide derivatives.	2
II		**Secondary Metabolites**	**12**
	8	Major classes of secondary metabolites - alkaloids, flavonoids, terpenoids, phenolics, and glycosides.	2
	9	Extraction methods - Hot & Cold extraction, Maceration, Soxhlet extraction	2
	10	Solvents used in extraction of secondary metabolites - Polarity of solvents	2
	10	Isolation Techniques: Chromatographic methods (TLC, HPLC, GC), Electrophoresis, Precipitation and crystallization	2
	11	Purification and Characterization: Purification strategies, Structural elucidation (NMR, MS, IR), Spectroscopic techniques	2
	12	Quantification of Phytochemicals: Analytical techniques (UV-Vis spectroscopy, colorimetry), Standardization and calibration, Validation of analytical methods	2
III		**Phytochemicals and their Biological Activities**	**12**
	13	Antioxidant Properties: Mechanisms of antioxidant action, Health benefits of antioxidants	2
	14	Antimicrobial and Antiviral Activities: Phytochemicals with antimicrobial properties, Applications in medicine and agriculture	2
	15	Anti-inflammatory and Analgesic Effects: Phytochemicals with anti-inflammatory properties, Clinical applications and acheivements	2
	16	Anticancer Properties: Phytochemicals with anticancer activity, Acheivements	2
	17	Cardiovascular Health: Phytochemicals beneficial for cardiovascular health, examples of achievements	2
	18	Other therapeutic applications: Overview of Neuroprotective effects, Antidiabetic properties, Phytochemicals in skin care	2
IV		**Phytochemicals in Industry and Agriculture**	**9**
	19	Phytochemicals in the Pharmaceutical Industry: Drug discovery and development, examples of plant-derived drugs	3

	20	Phytochemicals in the Food Industry: Natural preservatives and additives, Functional foods and nutraceuticals	2
	21	Phytochemicals in Agriculture: Biopesticides and bioherbicides, Plant growth regulators, Soil health and phytoremediation	2
	22	Economic and Environmental Impacts: Economic importance of phytochemicals, Sustainable sourcing and conservation, Environmental benefits	2
V	**Practical (Mandatory list)**		**30**
	1. Qualitative test for carbohydrate 2. Qualitative test for Protein 3. Qualitative test for alkaloids 4. Qualitative test for glycosides 5. Qualitative test for phenols		
	Practical (Open ended/Suggestive list)		

Suggested Readings

- Mukherjee, Pulok K. 2019. Quality Control of Herbal Drugs: An Approach to Evaluation of Botanicals, Business Horizons, New Delhi.
- Kokate, C.K., Purohit, A.P., and Gokhale, S.B. 2015. Pharmacognosy. Nirali Prakashan, Pune.
- Aneja, K.R. Experiments in Microbiology, Plant Pathology and Biotechnology. 2017. New Age International Publishers, New Delhi.
- Trease, G.E., and Evans, W. C. 2009.Pharmacognosy. Elsevier, New Delhi.
- Sivarajan, V.V., and Balachandran, I. 1994. Ayurvedic Drugs and Their Plant Sources. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
- Harborne, J.B. Phytochemical Methods: A Guide to Modern Techniques of Plant Analysis. 1998. Springer, Dordrecht.
- Bruneton, J. Pharmacognosy, Phytochemistry, Medicinal Plants. 1999. Intercept Ltd., Andover.
- Wagner, H., and Bladt, S. Plant Drug Analysis: A Thin Layer Chromatography Atlas. 1996. Springer, Berlin.
- Gurib-Fakim, A. Medicinal Plants: Traditions of Yesterday and Drugs of Tomorrow. 2006. CRC Press, Boca Raton.
- Dewick, P.M. Medicinal Natural Products: A Biosynthetic Approach. 2009. John Wiley & Sons, Chichester
- www.ncbi.nlm.nih.gov National Center for Biotechnology Information (NCBI)
- www.pharmacognosy.us American Society of Pharmacognosy
- www.phytochemicalsociety.org Phytochemical Society of Euro

Mapping of COs with POs:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	1	-	1	-	1	-	1
CO2	1	-	1	-	1	-	1
CO3	1	-	1	-	1	-	2
CO4	1	-	1	-	1	-	-
CO5	1	-	1	-	1	-	1

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion
- Assignment/ Seminar
- Project/Practical
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment/Seminar	Practical/Project Evaluation	End Semester Examinations
CO 1	✓	✓	✓	✓
CO 2	✓	✓	✓	✓
CO 3	✓	✓	✓	✓
CO 4	✓	✓	✓	✓
CO 5				✓

Programme	B. Sc. BOTANY				
Course Title	**Secondary Metabolites & Biofuels**				
Type of Course	**Minor**				
Semester	**II**				
Academic Level	100 - 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Higher secondary level biology course				
Course Summary	The students will explore the diversity of secondary metabolites, their biosynthetic pathways, and how these compounds can be harnessed for biofuel production. The course emphasizes the importance of sustainable energy solutions and the role of biotechnology in developing alternative fuels. The students will gain a comprehensive understanding of the current challenges and future prospects in biofuel technology.				

Course Outcomes (CO): After completing the Course, the candidate should be able to:-

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools
CO1	Identify and describe various secondary metabolites and types of biofuels.	R	F	Quiz/Exam/ Group Presentation
CO2	Explain the biosynthetic pathways and ecological functions of secondary metabolites and the production processes of biofuels.	U	C	Written Assignments/ Presentations
CO3	Demonstrate the extraction and analysis of secondary metabolites and biofuels using appropriate techniques.	Ap	C & P	Practical exam
CO4	Compare and contrast different types of secondary metabolites and biofuels based on their chemical properties and applications.	An	C	Class discussions/Written test
CO5	Assess the potential of secondary metabolites and biofuels in various industrial and environmental applications.	E	C & P	Review articles/Case studies

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
\# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)
		Introduction to Secondary Metabolites	**12**
I	1	Overview of Secondary Metabolites - Definition and classification, Differences between primary and secondary metabolites, Biological significance and functions, Industrial applications	2
	2	Types of Secondary Metabolites - Alkaloids, Terpenoids, Phenolics (Structure, examples, and functions)	2
	3	Production of secondary metabolites - Factors (physical & chemical) that influence the production, Control mechanisms - phenylpropanoid pathway, shikimate pathway.	2
	4	Extraction and Isolation Techniques - Solvent extraction methods	2
	5	Analytical Techniques for Secondary Metabolites: Chromatography and spectroscopy basics, Mass spectrometry in metabolite analysis, Bioinformatics tools for metabolite analysis	2
	6	Genetic Engineering of Secondary Metabolites - Metabolic engineering techniques, Genetic modification of plants and microbes, Transgenic plants for enhanced metabolite production	2
II		**Applications of Secondary Metabolites**	**12**
	7	Industrial Applications of Secondary Metabolites: Pharmaceuticals and nutraceuticals, Agriculture and pest management, Cosmetics and personal care products	2
	8	Role of Secondary Metabolites in Human Health - Antioxidant properties, Antimicrobial and anticancer activities, Anti-inflammatory and other therapeutic effects	2
	9	Secondary Metabolites in Agriculture - Bioherbicides and biopesticides, Growth regulators and soil conditioners, Biostimulants and plant growth promoters	2
	10	Industrial Production of Secondary Metabolites - Fermentation and bioreactor technology	2
	11	Microbial Secondary Metabolites - Antibiotics, pigments, and mycotoxins	2
	12	Marine Secondary Metabolites - Marine natural products-Sponges, algae, and microorganisms	2
III		**Introduction to Biofuels**	**12**
	13	Introduction to Biofuels - First, second, and third-generation biofuels. Comparison with fossil fuels	2
	14	Types of Biofuels Bioethanol: Production, properties, and applications: Biodiesel: Production, properties, and applications Biogas: Production, properties, and applications	2
	15	Feedstocks for Biofuel Production Plant-based feedstocks (e.g., corn, sugarcane, algae) Waste materials (e.g., agricultural residues, food waste) Microbial feedstocks (e.g., yeast, bacteria)	2
	16	Biofuel Production Processes: Fermentation processes for bioethanol, Transesterification process for biodiesel	2

	17	Biogas and Advanced Biofuels: Anaerobic digestion and biogas production, Synthetic biology in biofuels: Algal biofuels and synthetic hydrocarbons.	2
	18	Analytical Techniques for Biofuels - Gas chromatography (GC) for biofuel analysis, High-performance liquid chromatography (HPLC), Mass spectrometry (MS)	2
IV		**Environmental Impact and Sustainability of Biofuels**	**9**
	19	Life Cycle Analysis of Biofuels - Principles and methodology, Impact on greenhouse gas emissions, Carbon footprint	3
	20	Socio-economic Impacts of Biofuel Production - Impact on food security and land use.	2
	21	Biofuels and Biodiversity - Effects on land use and water resources, Conservation strategies, Sustainable biofuel certification schemes	2
	22	Potential of Secondary Metabolites in Biofuels - Role of secondary metabolites in biofuel production processes - Microbial biofuel production, Secondary metabolites as biofuel additives	2
V		**Practical (Mandatory list)**	**30**
		1. Solvent extraction 2. Chromatographic separation 3. Anaerobic digestion for biogas production	
		Practical (Open ended/Suggestive list)	
		4. Production of bioethanol from a chosen feedstock 5. Case Studies and Real-World Applications 6. Visit to biofuel industry	

Suggested Readings

- Ramasamy Vijayakumar, Raja S. S. 2020. Secondary Metabolites: Biotechnology and Applications. Springer Nature, New Delhi.
- Jain A.K. 2016. Plant Secondary Metabolites. Scientific Publishers, Jodhpur.
- Casida L. E. 2019. Industrial Microbiology. New Age International Publishers, New Delhi.
- Ashok Pandey, M.A. Kalamdhad, K. Binod, S. Khanal. Biofuels: Production and Future Perspectives. 2015. Elsevier India, New Delhi.
- Chellapan S., Pandey A., Bhaskar T. 2014. Algal Biofuels: Recent Advances and Future Prospects. CRC Press, India.
- Ramasamy Vijayakumar (Ed.). 2020. Secondary Metabolites - Sources and Applications. IntechOpen, London.
- Ana Maria Loureiro da Seca, Antoaneta Trendafilova (Eds.). 2022. Isolation and Identification of Bioactive Secondary Metabolites. MDPI, Basel.
- Mann J. 2001. Natural Products: The Secondary Metabolites. Royal Society of Chemistry, Cambridge.
- Rafael Luque, Carol Sze Ki Lin, Karen Wilson, James Clark (Eds). 2016. Handbook of Biofuels Production. Woodhead Publishing, Cambridge.
- Ashok Pandey, Thallada Bhaskar, Michael Stöcker, Rajeev Sukumaran (Eds.). 2011. Biofuels: Biochemical Conversion Processes for Liquid Fuel Production. Elsevier, Amsterdam.

Mapping of COs with POs:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	1	1	-	2	1	1
CO2	2	-	1	-	2	-	2
CO3	2	-	1	-	2	-	1
CO4	2	-	1	-	2	-	1
CO5	2	-	1	-	2	-	1

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion
- Assignment/ Seminar
- Project/Practical
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment/Seminar	Practical/Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓		✓	✓
CO 4	✓	✓		✓
CO 5	✓	✓	✓	✓

Programme	B. Sc. BOTANY				
Course Title	**Essential Oils of Aromatic Plants**				
Type of Course	**Minor**				
Semester	**III**				
Academic Level	100 - 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Higher secondary level biology course				
Course Summary	This course provides an in-depth study of aromatic plants and their essential oils. It provides a comprehensive understanding of the production, composition, and applications of essential oils. Students will explore the botanical sources of essential oils, methods of extraction, chemical analysis, and the therapeutic and commercial uses of these volatile compounds. The course also includes a practical module where students will gain hands-on experience in oil extraction and analysis.				

Course Outcomes (CO): After completing the Course, the candidate should be able to:-

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools
CO1	Identify and list various aromatic plants and their respective essential oils.	R	F	Test/Presentation
CO2	Explain the extraction processes and chemical properties of essential oils.	U	C	Oral presentations/Assignments
CO3	Demonstrate the extraction and analysis of essential oils using appropriate techniques.	Ap	C & P	Observation of practical skill/
CO4	Compare and contrast different essential oils based on their chemical composition and therapeutic properties.	An	C	Comparative essays/Report/Class discussion
CO5	Assess the effectiveness of essential oils in various applications.	E	C & P	Research projects/Review articles/Group discussions

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)
I		**Introduction to Aromatic Plants and Essential oils**	**12**
	1	Overview of Aromatic Plants and History and Origin of Essential Oils, Introduction to aromatic plants	2
	2	Historical uses of essential oils, Traditional extraction methods, Evolution of essential oil industry	2
	3	Botanical Sources of Essential Oils - Classification of aromatic plants, Parts of plants used for oil extraction	2
	4	Extraction Methods - Steam Distillation, Solvent Extraction, Cold Press Extraction, Supercritical Fluid Extraction and CO_2 extraction	2
	5	Quality Control and Standards - Purity and adulteration, ISO standards for essential oils	2
	6	Applications of Essential Oils - Therapeutic uses (aromatherapy, medicine), Industrial uses (cosmetics, food and beverages), Emerging applications (nanotechnology, pest control)	2
II		**Chemical and Physical Properties**	**10**
	7	Chemical Composition of Essential Oils Major chemical constituents (terpenes, alcohols, esters), Factors affecting chemical composition	2
	8	Solubility and Miscibility - Solubility in water and oils, Emulsification and formulation, Compatibility with other ingredients	2
	9	Volatility and Stability - Factors affecting volatility, Stability and shelf life, Storage conditions	2
	10	Methods of chemical analysis - Analytical techniques (GC-MS, HPLC)	2
	11	Spectroscopy and Chromatography - UV-Vis and IR spectroscopy, Gas chromatography (GC), Liquid chromatography (HPLC)	2
III		**Therapeutic Properties and Medicinal Uses**	**12**
	12	Bioactivity of Essential Oils - Antimicrobial properties, Antioxidant activity, Anti-inflammatory effects	2
	13	Aromatherapy - Principles of aromatherapy, Methods of application (diffusion, topical)	2
	14	Toxicology and Safety - Dosage and toxicity levels, Allergic reactions and contraindications, Regulatory guidelines	2
	15	Skin and Hair Care - Essential oils in dermatology, Formulation of skincare products, Benefits for hair health	2
	16	Respiratory and Immune System - Essential oils for respiratory conditions, Immune-boosting properties, Methods of administration	2
	17	Pain Management and Musculoskeletal System - Analgesic properties, Use in massage therapy, Treatment of muscle and joint pain	2

Unit	No.	Topic	Hours
IV	**Sustainable Practices and Innovation**		**11**
	18	Sustainable Cultivation - Organic farming practices, Conservation of aromatic plants, Ethical sourcing	3
	19	Market and Trade of Essential Oils - Global market trends, Major producing countries, Economic impact	2
	20	Environmental Impact - Carbon footprint of essential oil production, Waste management and recycling, Eco-friendly extraction techniques	2
	21	Technological Innovations - Advances in extraction technology, Novel formulations and delivery systems, Integration with biotechnology	2
	22	Regulatory and Certification Aspects - Certification standards (USDA Organic, Fair Trade), Legal regulations and compliance, Labelling and consumer information	2
V	**Practical (Mandatory list)**		**30**
	1. Collection and identification of 10 aromatic plants 2. Preparation of plant materials for extraction 3. Demonstrate Steam distillation process 4. Solvent extraction methods 5. Paper Chromatographic Analysis of Essential Oils		
	Practical (Open ended/Suggestive list)		
	6. Sensory evaluation of essential oils (odor, color, viscosity) 7. Demonstrate Cold pressing techniques 8. Interpretation of GC-MS of essential oil 9. Visit to essential oil extraction units/Visit to aroma oil industry & submission of report		

Suggested Readings

- Raghava T.S., Mishra R.K., and Sharma. R.K. 2017. Essential Oil Plants and Their Cultivation. Scientific Publishers, Jodhpur, India.
- Sandhya S. Amin. 2018. Aromatherapy: The Essential Blending Guide. New India Publishing Agency, New Delhi, India.
- Jain S.K. and DeFilipps A. 1991. Aromatic Plants of India. CRC Press, Boca Raton, FL, USA.
- Robert Tisserand and Rodney Young. 2014. Essential Oil Safety: A Guide for Health Care Professionals. Churchill Livingstone, London, UK.
- Valerie Ann Worwood. 2016. The Complete Book of Essential Oils and Aromatherapy. New World Library, Novato, CA, USA.
- Gabriel Mojay. 1999. Aromatherapy for Healing the Spirit: Restoring Emotional and Mental Balance with Essential Oils. Healing Arts Press, Rochester, VT, USA.
- Julia Lawless. 2013. The Encyclopedia of Essential Oils: The Complete Guide to the Use of Aromatic Oils in Aromatherapy, Herbalism, Health, and Well-Being. Conari Press, San Francisco, CA, USA.
- National Institute of Aromatherapy: www.aromatherapycouncil.org
- Aromatherapy Science: www.aromatherapyscience.com
- International Federation of Essential Oils and Aroma Trades (IFEAT): www.ifeat.org
- American Botanical Council: www.herbalgram.org
- Essential Oil Resource Consultants (EORC): www.essentialorc.com

Mapping of COs with POs:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	2	-	1	-	1	1	1
CO2	2	-	2	-	1	1	1
CO3	2	-	2	-	1	1	1
CO4	2	-	1	-	1	1	1
CO5	2	-	1	-	1	1	1

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion
- Assignment/ Review
- Project/Practical
- Final Exam

Mapping of COs to Assessment Rubrics :

	Quiz/Test	Assignment/ Review	Practical/Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3			✓	✓
CO 4	✓	✓		✓
CO 5	✓	✓	✓	✓

PLANTS IN HUMAN WELLNESS

Programme	B. Sc. BOTANY				
Course Title	**Economic Botany**				
Type of Course	**Minor**				
Semester	**I**				
Academic Level	100-199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Nil				
Course Summary	Economic Botany explores the use of plants in various economic sectors. The course examines the roles of plants in agriculture, medicine, industry, and culture				

Course Outcomes (CO): After completing the Course, the candidate should be able to:-

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools
CO1	Explain various categories of economically important plants	U	F	Instructor-created exams
CO2	Identify medicinal plants, understand their therapeutic properties	U	C	Practical exams/Exam
CO3	Develop an awareness of conservation efforts to protect plant biodiversity	Ap	C & P	Group discussions
CO4	Analyse the economic impact of plant resources	An	C	Class discussions/ Debates

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (45 + 30)
		Module I	**14**
I	1	Importance of Plant Resources; Plant Genetic Resources and their conservation.	2
	2	Introduction and Origin of Cultivated Plants - Vavilov‘s concept for the Origin of cultivated plants;	2
	3	Centres of Origin (Primary and Secondary); Centres of diversity, Harlan‘s concept of gene pools.	2
	4	Cereals - Rice (Morphology Production, Parboiling, Uses) Wheat (Morphology, Production, and Importance)	3
	5	Other cereals - Economic importance of Maize, Barley, Oats, Millets (jowar, bajra, ragi) and Pseudocereals	2
	6	Legumes - General account (Nutritive Value of Pulses, Protein Malnutrition, Lathyrism, Favism, Ecological Importance); chick pea and pigeon pea (Production, Morphology and Economic Importance). Fodder legumes and Green manure crops	3
II		**Module II**	**15**
	7	Sugars and Starches - Sugarcane (Morphology, Ratooning, Products and By- products); Potato (Morphology, Seed Tubers vs True Potato Seeds and Economic uses)	3
	8	Beverages - Types of Beverages (Alcoholic and Non-Alcoholic) with examples, Tea and coffee (Morphology, Processing and Economic Importance)	3
	9	Fruits & Nuts - Tropical & Temperate; *Citrus*, Mango, Banana, Apple, Pineapple, Papaya; Nuts: Cashew, Walnut, Almond & Pistachio (Uses, Economic importance)	3
	10	Oil - Yielding Plants - Fatty Oils and Essential Oils, Comparison between Fatty Oils and Essential Oils; Coconut (Morphology and Economic Importance); Essential Oils (General characteristics, Methods of Extraction and Economic Importance, with examples).	3
	11	Spices, Condiments & Flavourings - General Account (Spices, Condiments, Culinary Herbs and Essences, with examples), Importance of Spices. Morphology of part used and Economic Importance of Clove, Pepper, Ginger, Turmeric, Cardamom, Coriander, Nutmeg, Vanilla	3
III		**Module III**	**9**
	12	Medicinal and Drug-Yielding Plants - Brief Account of Therapeutic Drugs with Examples; Morphology, Chemical Constituents, Economic Importance of *Adhatoda, Rauwolfia*	2
		Rubber - Para Rubber - (Morphology, Tapping of latex, Processing, Products and Economic Importance)	2
	13	Fibres and Fibre - yielding plants - Classification of Fibres based upon their Origin (surface fibres, bast fibres, and leaf fibres, with examples); Coir, Cotton (processing and economic importance)	3

	14	Petro-crops - Calotropis, Jatropha	2
IV	**Module IV**		**7**
	16	Underutilized Leafy vegetables of Kerala	2
	17	Wild edible plants of Kerala	2
	18	Techniques to cultivate and conserve underutilized plants	2
	19	Role of organisations	1
V	**Practical (Mandatory)**		**30**
	Familiarise plants given above using specimens/digital resources/products (raw or processed)		
	Practical (open ended)		

Suggested Readings

- Kochhar, S.L. 2011. Economic Botany in the Tropics, MacMillan Publishers India Ltd., New Delhi. 4th edition.
- Kochhar, S.L. 2016. Economic Botany: A comprehensive study, Fifth edition, Cambridge University Press, NY.
- Pandey, B.P. 1999. Economic Botany. S. Chand, New Delhi.
- Singh, H. B. and R.K. Arora. 1978. Wild edible plants of India (1st ed.). ICAR Publication, New Delhi.
- Wickens, G. E. 2004. Economic Botany: Principles and Practices, Springer
- Kochhar,S. L. 2012. Economic Botany in Tropics. New Delhi, India: MacMillan & Co.
- Wickens, G. E. 2001. Economic Botany: Principles & Practices. The Netherlands: Kluwer Academic Publishers.
- Chrispeels, M.J., Sadava, D. E. 1994. Plants. Genes and Agriculture. Jones & Bartlett- Publishers.
- Berg L. 2008. Introductory Botany: Plants, People, And The Environment,
- Cook F.E.M. 1995. Economic Botany: Data Collection Standard Royal Botanic
- http://www.eagri.org/eagri50/GPBR212/lec01.pdf

Mapping of COs with POs:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	2	-	-	-	1	-	-
CO2	2	-	1	-	1	-	-
CO3	2	-	-	-	1	1	1
CO4	2	-	1	-	1	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion
- Assignment/ Review
- Project/Practical
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal exam	Discussion/ Assignment	Practical/Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓	✓	✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓

Programme	B. Sc. BOTANY				
Course Title	**Plant Nutraceuticals**				
Type of Course	**Minor**				
Semester	**II**				
Academic Level	100-199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	-				
Course Summary	This course offers basic knowledge on the various plant supplements and advantages of functional foods over conventional medicine to avoid potential side-effects.				

Course Outcomes (CO): After completing the Course, the candidate should be able to:-

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools
CO1	Understand the basic concepts of nutraceuticals and functional foods.	U	F	Exam/Class discussion
CO2	Understand the source of various nutraceuticals and functional foods	U	C	Quiz/Group presentations
CO3	Apply various nutraceuticals and functional foods towards managing chronic diseases.	Ap	P	Case study/debates
CO4	Utilise personalized food with respect to genetics.	Ap	P	Group project
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 + 30)
I		**Introduction to Nutraceuticals**	**12**
	1	Introduction to Nutraceuticals, Historical perspective, classification, scope & future prospects	2
	2	Sources of Nutraceuticals.	2

	3	Nutraceuticals bridging the gap between food and drug	2
	4	Relation of Nutraceutical Science with other Sciences: Medicine, Human physiology, genetics, food technology, chemistry and nutrition	3
	5	Sources and role of Isoprenoids, Isoflavones, Flavonoids, carotenoids, Tocotrienols, polyunsaturated fatty acids, sphingolipids, lecithin, choline, lycopene and terpenoids.	3
II	**Nutraceutical remedies**		**15**
	6	Functional food and nutraceuticals for disease management	2
	7	Remedies for common disorders like Arthritis, Bronchitis, circulatory problems, hypoglycemia	3
	8	Nutraceuticals for nephrological disorders, liver disorders, osteoporosis, psoriasis and ulcers	3
	9	Role of nuts in cardiovascular disease prevention.	2
	10	Nutraceuticals for specific situations such as cancer, heart disease, diabetes, stress, osteoarthritis, hypertension.	3
	11	Role of Dietary fibres in disease prevention.	2
III	**Nutraceutical supplements**		**8**
	12	Plant Based Nutraceuticals: Glucosamine, Octacosanol, Carnitine, Melatonin and Ornithine alpha ketoglutarate, Chlorophyll, Caffeine, Green tea, Lecithin, soyabean	2
	13	Probiotic, prebiotics and symbiotic foods, and their functional role.	2
	14	Fruit based nutraceuticals: grape products, Lycopene, carotene, flaxseed oil, proanthocyanidins.	2
	15	Algae based nutraceuticals	2
IV	**Functional Foods**		**10**
	16	Functional Foods: Definition and classification. Concept of free radicals and antioxidants.	2
	17	Nutritive and Non-nutritive food components with potential health effects.	2
	18	Effects of processing, storage and interactions of various environmental factors on the potentials of such foods.	2
	19	Different foods as functional food: cereal products (oats, wheat bran, rice bran, etc.), fruits and vegetables, milk and milk products, legumes, nuts, oil seeds and sea foods, herbs, spices and medicinal plants.	2
	20	Marketing and regulatory issues for functional foods and nutraceuticals: CODEX Guidelines, EU guidelines and FSSAI guidelines	2
V	**Practical (suggestive list)**		**30**
	1. Analysis of foods: Determination of reducing and non-reducing sugar,		

	protein, determination of ash/total protein/moisture in dietary fibres. 2. Extraction and estimation of total sugars from food products (dairy product, fruit juices, bread). 3. Industrial visit to a nutraceutical firm

Suggested Readings:

- Giuseppe Mazza; Functional Foods: Biochemical and Processing Aspects, Volume 1; CRC Press
- Robert E.C. Wildman; Handbook of Nutraceuticals and Functional Foods, Second Edition; CRC Press
- Massimo Maffei; Dietary Supplements of Plant Origin; CRC Press
- Fereidoon Sahidi, Deepthi K. Weerasinghe; Nutraceutical Beverages, Chemistry, Nutrition and Health Effects; American Chemical Society
- Ronald R. Watson; Vegetables, Fruits, and Herbs in Health Promotion; CRC Press
- Fruit and Cereal Bioactives: Sources, Chemistry and Applications; Özlem Tokusoglu; Clifford Hall III; CRC Press
- Susan Sungsoo Cho, Mark L. Dreher; Marcel; Dekker Handbook of Dietary Fibre
- John Shi, G. Mazza and Marc Le Maguer, Functional Foods, Vol.2 Biochemical and Processing Aspects CRC Press
- Aluko, Rotimi. 2012. Functional Foods and Nutraceuticals, Springer-Verlag New York Inc.
- Satinder Kaur Brar, Surinder Kaur and Gurpreet Singh Dhillon. 2014. Nutraceuticals Functional Foods,
- Robert E.C. Wildman, Robert, Wildman, Taylor C. 2002. Handbook of Nutraceuticals and Functional Foods, Third Edition, Wallace
- Pathak Y. Handbook of Nutraceuticals; Ingredient, Formulations, and Applications. CRC Press, Taylor & Francis Group, London

Mapping of COs with POs:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	1	-	-	-	-	-	-
CO2	1	-	-	-	-	-	-
CO3	1	-	1	-	-	-	1
CO4	1	-	-	-	-	-	1

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Exam
- Assignment/ presentation
- Project/Practical
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal exam	Presentation/ Assignment	Practical/Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓		✓	✓
CO 4		✓		✓

Programme	B. Sc. BOTANY				
Course Title	**Ethnobotany**				
Type of Course	**Minor**				
Semester	**III**				
Academic Level	200-299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Nil				
Course Summary	This course explores the relationship between plants and people, focusing on how different cultures use plants for food, medicine, rituals, and other purposes. The course also explains the traditional knowledge and practices of indigenous communities.				

Course Outcomes (CO): After completing the Course, the candidate should be able to:-

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools
CO1	Assess the intricate relationship between plants and human cultures.	E	C	Quiz/Group presentations
CO2	Identify and analyse the traditional knowledge and practices of Indigenous communities regarding plant use.	An	C	Fieldwork report/Case study analysis/Oral presentations
CO3	Appreciate and respect the invaluable wisdom of Indigenous peoples	E	C	Reflective essays/Class discussions/Debates
CO4	Develop strategies for conserving traditional plant knowledge.	C	C & P	Group projects
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs 45 + 30
I		**Introduction**	**13**
	1	Ethno-botany - Introduction, concept, scope and objectives; Ethnobotany as an interdisciplinary science. The relevance of ethnobotany in the present context	2
	2	Methods to study ethnobotany a) Field work b) Herbarium c) Ancient literature and oral traditions d) Religious and sacred places e) Archaeological findings	2
	3	Indigenous knowledge system; Documentation methods (Audio, Video recording, Photographs, Interviews, Questionnaire), Authentication of plant species using floras and herbariums; Traditional Knowledge Digital Library	2
	4	Tribal Communities in Kerala - Anthropology and Ethnobotany; Brief overview with special reference to Kurichiya, Adiyan, Paniya, Cholanaikan, Kadar, Kurumba, Kuruman, Kani, Mannan, Ulladan; Exploration of their customs, beliefs, and unique Ethnobotanical practices	3
	5	Plants used by the indigenous societies a) Food plants b) Medicinal plants c) intoxicants and beverages d) Resins and oils and miscellaneous uses (common name & uses)	3
	6	Plant used for rituals and ceremonies (common name & uses)	1
II		**Ethnobotany & Conservation**	**10**
	10	Role of ethnic groups in conservation of plant genetic resources. Endangered taxa and forest management (participatory forest management).	2
	11	Ethnobotany and legal aspects - Biopiracy, Intellectual Property Rights and Traditional Knowledge.	2
	12	Ethnobotany as a tool to protect interests of ethnic groups. Sharing of wealth concept with few examples from India.	2
	13	Centers of Ethnobotanical Studies - The International Center for Ethnobotanical Education, Research, and Service (ICEERS) in India - AICRPE (All India Coordinated Research Project on Ethnobiology), FRLHT (Foundation for the Revitalisation of Local Health Traditions)	2
	14	Contributions (J. W. Harshberger, R. E. Schultes, E. K. Janakiammal, S. K. Jain, K. S. Manilal, V. V Sivarajan & P. Pushpangadan).	2
III		**Ethnopharmacology**	**10**
	15	Definition and Scope of Ethnopharmacology, Historical Perspective and Contributions to Modern Pharmacology	2
	16	Crude Drug: Classification and sources of crude drugs, Quality, Safety, and Efficacy of Herbal Medicines. Ensuring standards in herbal medicines/nutraceuticals	3
	17	Role of Ethnopharmacology in ensuring quality and safety. Importance of ethnopharmacological studies in drug discovery	3
	18	Ethnopharmacologic contribution to Bioprospecting natural products; emerging opportunities in ethnopharmacology	2

IV	**Applied Ethnobotany**		**12**
	6	Medico-ethnobotanical sources in India; Case studies of traditional medicines leading to development of modern pharmaceutical products (use of *Trichopus zeylanicus* by kani tribe and Artemesia sp. for malaria cure)	4
	7	Significance of the following plants in ethnobotanical practices (along with their habitat and morphology) - Neem, Tulsi, Vitex, Gloriosa, Pongamia, Cassia, Indigofera	3
	8	Application of natural products to certain diseases - Jaundice, cardiac, infertility, diabetics, Blood pressure and skin diseases	3
	9	Palaeo - ethnobotany, ethnoecology	2
V	**Practical (Mandatory list)**		**30**
	1. Documentation, literature survey, and collection of information on ethno-botanically useful plants from traditional healers 2. Students should be able to identify the plants mentioned above 3. Research papers from various Scientific Journals for case studies		
	Practical (Open ended- Suggestive list)		
	Field trip to tribal settlement to survey & document people-plant relationship.		

Suggested Readings:

- Jain S. K. 1989. Methods and approaches in ethnobotany. Society of Ethnobotanists, Lucknow, India.
- Jain S. K. 1990. Contributions of Indian ethnobotany. Scientific publishers, Jodhpur.
- Jain S. K. 1995. Manual of Ethnobotany, Scientific Publishers, Jodhpur, 1995.
- Rajiv K. Sinha 1996. Ethnobotany The Renaissance of Traditional Herbal Medicine - INA - SHREE Publishers, Jaipur.
- Rama Ro, N. and A. N. Henry 1996. The Ethnobotany of Eastern Ghats in Andhra Pradesh, India. Botanical Survey of India. Howrah.
- Colton C. M. 1997. Ethnobotany-Principles and applications. John Wiley and sons Chichester.
- Jain S. K. 1981. Glimpses of Indian. Ethnobotany, Oxford and I B H, New Delhi.
- Jain, S. K. 2010. Manual of Ethnobotany. Rajasthan: Scientific Publishers.
- Martin, G. J. 1995. Ethnobotany: A Methods Manual. Chapman Hall
- Cunningham A. B. 2001. Applied Ethnobotany: People, Wild Plant Use and Conservation. Earthscan, London.
- Young, K. J. 2007. Ethnobotany. Infobase Publishing, New York.
- Schmidt, B. M., Cheng, D.M.K. (Eds.) 2017. Ethnobotany: A Phytochemical Perspective. John Wiley & Sons Ltd. Chichester, UK.

Online sources

- https://www.upcollege.ac.in/Upload/econtent/135.pdf
- https://uou.ac.in/sites/default/files/slm/MSCBOT-608.pdf

Mapping of COs with POs:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	-	-	3	3	1
CO2	3	2	-	-	3	3	1
CO3	1	2	-	-	-	2	-
CO4	2	1	-	-	2	1	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Exam
- Assignment/ presentation
- Project/Practical
- Final Exam

Mapping of COs to Assessment Rubrics:

	Internal exam	Presentation/ Assignment	Practical/Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3				
CO 4		✓	✓	✓

VOCATIONAL MINOR COURSES

COMPUTATIONAL BOTANY

Programme	FYUGP Botany				
Course Title	**Computational Botany**				
Type of Course	**Vocational Minor**				
Semester	**I**				
Academic Level	100-199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Higher secondary level biology course				
Course Summary	The course on Computational Botany provides students with a comprehensive understanding of the application of computational techniques in the field of botany. It covers various topics such as data analysis, modeling and simulation, genomics, metabolomics, artificial intelligence, and ethical considerations.				

Course Outcomes (CO): After completing the Course, the candidate should be able to:-

COs	Statement	Cognitive level *	Knowledge Category #	Evaluation Tools
CO1	Describe various computational techniques and their applications in the field of botany	U	C	Written Assignments/Oral presentations
CO2	Explain how computational models and simulations can be used to study plant physiology and development	U	C	Simulation projects/Interactive discussions
CO3	Apply computational tools to analyse genetic data and predict plant traits	Ap	C & P	Practical lab exercises
CO4	Analyse large datasets to identify patterns and relationships in plant ecology	An	C & P	Presentation
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 + 30)
I		**Introduction to Computational Botany**	**10**
	1	Computational Biology: Definition, History, and interdisciplinary nature.	1
	2	Introduction to computational science and its relevance to botany. Data handling and manipulation techniques	1
	3	Computational Tools for Plant Morphology Analysis Significance of computational tools in modern plant biology research. Popular software and tools: PlantCV, FIJI/ImageJ, PhenoPhyte, PhenoFront, The Plant Image Analysis Platform (PIAP). Applications of computational tools	3
	4	Plant Physiology Modelling and Simulations Plant Physiology modelling approaches (mechanistic, empirical, hybrid) Applications of Physiology Modelling and Simulations	3
	5	Significance of modelling and simulations in plant biology research.	2
II		**Data Analysis in Botany**	**12**
	6	Methods for collecting botanical data (fieldwork, experiments, databases, etc.) Quality control in botanical data analysis	2
	7	Importance of data visualization in botany research Techniques for visualizing botanical data (plots, graphs, maps, etc.)	2
	8	Tools and software for data visualization Importance of data visualization in botany. Importance of choosing appropriate tools and software for effective visualization.	3
	9	Tools and software for data analysis Importance of data analyses. Importance of choosing appropriate tools and software for analyses. Examples of softwares.	3
	10	Applications of machine learning in plant science (species identification, phenotyping, etc.)	2
III		**Modelling and Simulation in Botany**	**12**
	11	Mathematical Modelling of Plant Growth and Development Role of mathematical modelling in studying plant growth and development. Types of mathematical models.	2
	12	Simulation Techniques for Plant Ecological Models Types of Plant Ecological Models: individual-based models (IBMs), population models, community models, and ecosystem models. Examples.	2
	13	Modeling and Simulation of Plant-Environment Interactions Types of Plant-Environment Interaction Models: physiological models, process-based models, and statistical models.	3
	14	Computational Models for Plant Disease Spread	3

		Types of Plant Disease Spread Models: compartmental models, spatially explicit models, and network models. Applications of Disease Spread Models: in plant pathology, epidemiology, and disease management.	
	15	Modeling and Simulation of Plant-Pathogen Interactions Types: used to simulate plant-pathogen interactions, including epidemiological models, mechanistic models, and molecular models.	2
IV		**Applications of Computational Botany**	**11**
	16	Computational Tools for Crop Improvement Computational Techniques in Crop Breeding and Genetics. Applications of Computational Tools in Crop Improvement	1
	17	Overview of Genome sequencing and assembly, Genome-wide association studies (GWAS)	1
	18	Computational Approaches in Plant Breeding Computational Techniques in Plant Breeding: Marker-assisted selection (MAS), Genomic selection (GS)	2
	19	Applications of Computational Approaches in Plant Breeding: Disease resistance breeding, Yield improvement, Stress tolerance enhancement, Quality traits enhancement	1
	20	Computational Methods for Conservation and Biodiversity Data Collection and Management, Computational Techniques for Biodiversity Analysis Applications of Computational Methods in Conservation	2
	21	Applications of Computational Analysis in Plant Evolution: Molecular dating of plant lineages, Comparative genomics for studying genome evolution, Evolutionary relationship inference among plant taxa	2
	22	Big Data in Botany Overview of big data challenges and opportunities in botany. Scalable computing techniques for handling big data in botany.	2
V		**Practical (Mandatory list)**	**30**
	1. Basics of programming languages: Python, R. 2. Overview of using R to perform basic statistical analysis on biological data 3. Demonstrate D3.js library		
	Practical (Open ended/Suggestive list)		
	4. Demonstrate PlantCV 5. Demonstrate FIJI/ImageJ 6. Demonstrate Plant Image Analysis Platform (PIAP) 7. Demonstrate Plotly 8. Demonstrate PlantVis		

Suggested Readings:

- Sushmita Mitra and Tinku Acharya. Computational Intelligence in Image Processing. 2018. CRC Press, Broken Sound Parkway NW, Suite 300, Boca Raton, FL 33487, USA.
- Prabir Bhattacharya and Subhrajit Bhattacharya. Computational Intelligence in Data Mining.
- 2015. Springer, New York, NY 10013, USA.

- Sowdhamini R. and N. Srinivasan. Computational Biology: A Practical Introduction to BioData Processing and Analysis with Linux, MySQL, and R. 2019. CRC Press, Broken Sound Parkway NW, Raton, USA.
- Manju Bansal and Narinder Singh. 2019. Computational Biology and Bioinformatics: Gene Regulation. Springer, Spring Street, New York.
- Richard A. White. 2017. Plants and Their Application in Computational Botany. Wiley, River Street, Hoboken, USA.
- George A. 2006. Moulton. An Introduction to Computational Biology: Maps, Sequences and Genomes. Chapman and Hall/CRC, Broken Sound Parkway USA.

Online Sources

- Website: Computational Biology and Evolutionary Genomics
- URL: http://www.compbio.dundee.ac.uk/
- Website: Indian Journal of Computational Biology and Bioinformatics
- URL: http://www.ijcbb.com/
- Website: Computational Biology Research Center - Indian Statistical Institute
- URL: http://www.isical.ac.in/~cbr/
- Computational Biology Lab - Centre for DNA Fingerprinting and Diagnostics
- URL: https://www.cdfd.org.in/biology/

Mapping of COs with PSOs and POs:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	-	1	3	2	-	1
CO2	3	-	1	3	2	-	1
CO3	3	-	1	3	2	-	2
CO4	3	-	1	3	2	2	2

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Exam/Discussion
- Assignment/ presentation
- Project/Practical
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal exam	Presentation/ Assignment	Practical/Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓		✓	
CO 4		✓		✓

Programme	FYUGP Botany				
Course Title	**Biostatistics**				
Type of Course	**Vocational Minor**				
Semester	**II**				
Academic Level	100-199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	-				
Course Summary	This course gives a comprehensive understanding of Biostatistics and its application in biological research, with a special focus on computer assisted data analysis. It introduces students to the use of MS Excel, R programming, and SPSS for data analysis.				

Course Outcomes (CO): After completing the Course, the candidate should be able to:-

COs	Statement	Cognitive level *	Knowledge Category #	Evaluation Tools
CO1	Understand the benefits of computer assisted data analysis.	U	F	Reflective essays/Oral presentations/ Literature reviews
CO2	Utilize MS Excel for data organization, statistical analysis, and visualization.	Ap	C & P	Practical lab exercises/Hands-on assessments
CO3	Gain a basic understanding of R programming and use it for data manipulation, statistical analysis, and visualization.	U	F	Project-based assessments
CO4	Use SPSS for data organization, statistical analysis, and interpretation of output.	Ap	C & P	Practical lab exercises/Group projects
CO5	Apply knowledge of different software tools for data analysis in biological research.	Ap	C & P	Presentation /Peer assessments
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 + 30)
I		**Introduction to Biostatistics and Descriptive Statistics**	**10**
	1	Basic concepts and terminologies in Biostatistics	2
	2	Levels of measurement and types of data	2
	3	Measures of central tendency: mean, median, mode	2
	4	Measures of dispersion: range, variance, standard deviation	2
	5	Tabular and graphical representation of data	2
II		**Probability, Distributions, and Hypothesis Testing**	**12**
	6	Basic concepts of probability	2
	7	Common probability distributions: binomial, poisson, normal	2
	8	Concepts of null and alternative hypothesis	1
	9	Types of errors	1
	10	Commonly used tests: t-test, chi-square test, ANOVA	2
	11	Concepts of correlation and regression	2
	12	Types of correlation, Simple and multiple regression	2
III		**Post Hoc Tests**	**10**
	13	The need and applications of Post Hoc tests.	1
	14	Definition, application, procedure and interpretation of results of Tukey's Honest Significant Difference (HSD) Test	3
	15	Definition, application, procedure and interpretation of results of the following: Bonferroni Correction Scheffé's Method	3
	16	Definition, application, procedure and interpretation of results of the following: Newman-Keuls test Dunnett‘s Test	3
IV		**Computer Assisted Data Analyses & Software Tools**	**13**
	17	Importance of computer assisted data analyses	1
	18	Overview of various software tools	1
	19	Online resources for Biostatistical analysis	1
	20	Data analysis using MS Excel Introduction to Excel, Inputting and organizing data, Formulas and functions, Using Excel for statistical analysis (Descriptive statistics, correlation, regression), Creating charts and graphs	3

	21	Introduction to R Programming for Data Analysis Basics of R programming, Installing and using RStudio, Data manipulation in R, Using R for statistical analysis (Descriptive statistics, correlation, regression, Post Hoc tests), Visualizing data with ggplot2	4
	22	Introduction to SPSS Inputting and organizing data, Conducting statistical analysis in SPSS (Descriptive statistics, correlation, regression, Post Hoc tests), Interpreting output from SPSS	3
V		**Practical (Mandatory list)**	**30**
	1. Calculation of range, variance, standard deviation 2. Perform t-test 3. Perform chi-square test 4. Perform ANOVA 5. Calculation of Mean, Median and Mode in MS Excel		
	Practical (Open ended/Suggestive list)		
	6. Calculation of range, variance, standard deviation in MS Excel 7. Perform t-test in SPSS 8. Perform chi-square test in SPSS 9. Perform ANOVA in MS Excel 10. Perform ANOVA using R programme		

Suggested Readings:

- Burt Gerstman B. Basic Biostatistics. 2020. Jones & Bartlett Learning, 5 Wall St, Burlington, United States.
- Wayne W. Daniel and Chad L. Cross. Biostatistics: Basic Concepts and Methodology for the Health Sciences. 2018. Wiley, United States.
- Wayne W. Daniel. 2018. Biostatistics: A Foundation for Analysis in the Health Sciences. Wiley, 111 River St, Hoboken, United States.
- Geoffrey R. Norman and David L. Streiner. 2014. Biostatistics: The Bare Essentials. PMPH-USA, 6 Industrial Drive, Charleston, United States.
- Marc M. Triola and Mario F. Triola. 2018. Biostatistics: A Foundation for Analysis in the Health Sciences. Pearson, Hudson St, New York, NY.
- Wayne W. Daniel. 2018. Biostatistics: How to Design, Analyze, and Interpret Results of Scientific Research. Wiley, United States.
- Heather M. Bush and Marie Diener-West. 2021. Biostatistics: An Applied Introduction for the Public Health Practitioner. Springer.
- Pranab Kumar Banerjee. Introduction to Biostatistics. 2017. Wiley, 111 River St, Hoboken, United States.
- Ann G. Ryan and Bonnie L. Callen. 2015. Biostatistics: Basic Concepts and Methodology for the Health Sciences. Jones & Bartlett Learning, Burlington, United States.
- Philip Miller J. and Frank E. Harrell Jr. 2018. Biostatistics: A Foundation for Analysis in the Health Sciences. Wiley, River St, Hoboken, United States.

Online Sources

- https://www.khanacademy.org/math/statistics-probability - Khan Academy: Statistics and Probability
- https://stattrek.com/ - StatTrek: Statistics and Probability
- https://www.graphpad.com/guides/prism/latest/statistics/index.htm - GraphPad Learning Center
- https://www.rstudio.com/online-learning/ - RStudio: R for Beginners
- https://www.ibm.com/support/pages/spss-tutorials - IBM: SPSS Tutorials

Mapping of COs with POs:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	1	-	1	3	1	-	-
CO2	1	-	1	3	1	-	-
CO3	1	-	1	3	1	-	-
CO4	1	-	1	3	1	-	-
CO5	1	-	1	3	1	-	-

Correlation Levels:

Level	**Correlation**
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Exam/Discussion
- Assignment/ presentation
- Project/Practical
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal exam	Presentation/ Assignment	Practical/Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓	✓	✓
CO 3	✓	✓		✓
CO 4	✓		✓	✓
CO 5		✓		✓

ST. JOSEPH'S COLLEGE (AUTONOMOUS), DEVAGIRI

Programme	B. Sc. BOTANY				
Course Title	**Bioinformatics**				
Type of Course	**Vocational minor**				
Semester	**III**				
Academic Level	200-299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	5	-	-	75
Pre-requisites	Basic awareness in computer-based data search				
Course Summary	This course helps students in understanding the basics of molecular biology and its amalgamation with various aspects of bioinformatics including database search, sequence alignment analyses cum interpretations and application at research level in plant science.				

Course Outcomes (CO): After completing the Course, the student should be able to:-

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools
CO1	Explain the structural organisation of the two macromolecules, the DNA and Proteins.	U	C	Written test
CO2	Apply modern techniques in proteomics studies	Ap	P	Practical test/Quiz
CO3	Use various databases and obtain practical expertise in addressing research level problems.	Ap	C & P	Lab test/Group discussion
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45+30)
I		**Introductory Bioinformatics**	**7**
	1	Introduction to Bioinformatics in correlation with the molecular logic of life and diverse organisation of living forms	2
	2	WetLab vs WebLab	1
	3	Structural Biology – DNA, Protein structure; Protein- Protein interaction, Protein- DNA interaction, Forces of interactions, DNA binding proteins; Structure visualization tools- Rasmol, Pymol, Chimera and Molmol	4

II	**Genomics and Proteomics**		**12**
	4	Genome organisation- Organellar genome with special reference to chloroplast genome in botanical research. Linkage mapping, FISH and different types, STS mapping	3
	5	Whole genome sequencing- its role in identifying mutations and establishing phylogenetic relations. Ethical and social challenges- *E. coli*, Yeast, *Arabidopsis thaliana* and Humans. IPR in genome sequencing.	3
	6	Proteomics- expression, structural and functional classifications-challenges and applications – Human proteome project (HPP). Role of motifs and domains in analysis- Role of protein families	3
	7	Technologies in proteomic studies- PAGE and its different types, Protein characterisation and identification, ESI-MS, TANDEM-MS, MALDI-TOF-MS-HPLC, Peptide mass fingerprinting (PMF).	3
III	**Biological sequences and Databases**		**18**
	8	DNA & protein sequences – analysis and interpretation of similarity between sequences- Homologous, orthologous, paralogous and analogous sequences- Symbols for representing nucleotides and aminoacids	3
	9	Sequence alignment – Pairwise and multiple alignment- Scoring matrices- TIGR, EST analytical tools. PAM, BLOSUM, BLAST, PSI- BLAST, CLUSTAL W- Phylogenetic analysis- PHYLIP, MEGA, Phylogenetic tree representations. Evolutionary studies- Bootstrapping method	4
	10	Patterns in sequences - motifs and profiles - PSI-BLAST searches- analysis and interpretation of data	2
	11	Data models - concepts Entity and relationship sets– Hierarchical data models- Database management systems, Data processing	3
	12	DNA databases – EmBL, DDBJ, GenBank, Unigene,	3
	13	Protein databases – PIR, SWISS PROT, TrEMBL, PROSITE BLOCKS, PFAM; Reactome and KEGG databases	3
IV	**Applications**		**8**
	14	Protein structure prediction and structure-based drug design (SBDD), Homology modelling	3
	15	Areas of Bioinformatics: Functional and comparative genomics, Cheminformatics, Pharmacogenomics and medical informatics	3
	16	Research areas in Bioinformatics	2
V	**PRACTICALS**		**30**
	1. Retrieval of sequence data from the given databases 2. Pairwise and multiple alignment using prescribed programmes 3. Phylogenetic analysis using PHYLIP/MEGA 4. Retrieve any protein/enzyme structure from PDB 5. Retrieve the key metabolic pathways from Reactome and KEGG 6. Visualisation of structures using Pymol		

Mapping of COs with POs:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	1	-	-	-	2	-	1
CO2	1	-	-	-	2	-	1
CO3	1	-	-	3	2	-	1

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Exam/Discussion
- Assignment/ presentation
- Project/Practical
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal exam	Presentation/ Assignment	Practical/Project Evaluation	End Semester Examinations
CO 1	✓		✓	✓
CO 2	✓	✓	✓	✓
CO 3	✓		✓	✓

ST. JOSEPH'S COLLEGE (AUTONOMOUS), DEVAGIRI

HORTICULTURE TECHNIQUES

Programme	B. Sc. BOTANY				
Course Title	**Horticulture and Nursery Management**				
Type of Course	**Vocational Minor**				
Semester	**I**				
Academic Level	100-199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	-				
Course Summary	This course provides an introduction to the principles and practices of horticulture and nursery management. Students will gain practical experience on landscaping, nursery design, layout and management				

Course Outcomes (CO): After completing the Course, the candidate should be able to:-

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools
CO1	Recall the importance of horticulture in food production, landscaping, and environmental conservation.	R	F	Quiz/Exams/Oral Presentations/Class Discussions
CO2	Apply nursery management principles to design and layout a nursery facility considering factors like soil type, drainage, and microclimate for optimal plant growth.	Ap	P	Practical Projects/Case Studies
CO3	Analyse different propagation techniques and select the most appropriate method based on plant characteristics and environmental conditions.	An	C	Written Assignments/Practical Exams
CO4	Evaluate the financial viability of a horticultural business venture by analysing budgets, marketing strategies, and regulatory compliance requirements.	E	C	Business Plan Development/Simulations

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
\# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus

Module	Unit	Content	Hrs (45 + 30)
I		**Introduction to Horticulture and Nursery Management**	**15**
	1	Importance of horticulture in food production, landscaping, and environmental conservation	2
	2	Plant taxonomy and nomenclature: understanding botanical names, local names and trade name	2
	3	Nursery Management Basics - Nursery infrastructure and facilities: greenhouses, shade houses, polyhouses	2
	4	Nursery inventory management: tracking plant varieties, quantities, and ages	1
	5	Types of Horticultural Crops- Classification of horticultural crops based on growth habit, reproductive structures, and economic importance	2
	6	Site Selection and Nursery Layout- Factors influencing site suitability: soil type, drainage, topography, and microclimate	2
	7	Nursery layout principles: zoning for production, propagation, and storage areas.	2
	8	Utilization of space efficiency techniques: vertical gardening, raised beds, container systems	2
II		**Soil and Water Management in Horticulture**	**10**
	9	Soil Preparation and Management- Soil physical properties: texture, structure, porosity, and water-holding capacity	2
	10	Soil chemical properties: pH, nutrient availability, soil testing	2
	11	Soil Conservation Practices- Soil erosion processes and prevention methods: contour plowing, terracing;	2
	12	Sustainable soil management practices: cover cropping, crop rotation, and no-till farming	2
	13	Irrigation Methods and Techniques- Irrigation system components and design considerations: pumps, pipes, valves, and emitters. Drip irrigation, rainwater harvesting, and mulching techniques	2
III		**Pest and Disease Management**	**10**
	14	Integrated pest management (IPM) strategies: cultural, biological, and chemical control methods, Biocontrol agents	2
	15	Pesticide application principles: dosage calculation, application equipment calibration, and safety measures	2
	16	Cultural disease control practices: sanitation, crop rotation, and resistant cultivar selection	2
	17	Post-harvest Pest and Disease Management- Post-harvest physiology of horticultural crops: respiration rates, ethylene production, and senescence processes	2
	18	Storage facilities and handling protocols: temperature and humidity control, sanitation practices, and packaging materials, Integrated approaches to post-harvest pest control	2

IV		Business and Marketing in Horticulture	10
	19	Introduction to Horticultural Business- Entrepreneurial skills and traits: risk management, decision-making, and innovation	3
	20	Business legal structures and regulatory compliance: business registration, taxation, and intellectual property rights	3
	21	Marketing Strategies for Horticultural Products	2
	22	Financial Management in Horticulture- Financial planning and budgeting processes	2
V		**Practical (Mandatory Experiments)**	**30 hrs**
		1. Preparation of organic pesticide (Any one) 2. Nursery Design and layout 3. Horticulture station/ Garden/ Nursery visit and report submission	
		Practical (Open Ended-Suggestive list)	
		4. Conduct hands-on demonstrations on soil testing, soil preparation techniques, and irrigation system setup to illustrate soil and water management principles. 5. Identify common pests and diseases affecting horticultural crops using field guides and reference materials. 6. Market analysis for a selected horticultural product, including researching consumer preferences, pricing strategies, and distribution channels. 7. Guide students through the process of developing a basic business plan for a hypothetical horticultural enterprise, covering aspects such as start-up costs, production goals, and marketing strategies.	

Suggested Readings

- Richards C. M., Davies K. M., & Shaffer J. L. 2009. Principles of Horticulture. Butterworth-Heinemann.
- Chopra V. L., Verma B. S., & Raghavan S. R. 2002. Principles of Plant Propagation. Tata McGraw-Hill Education.
- Lal R. 2008. Soil Science: Methods and Applications. CRC Press.
- Follett P. A., & Duan J. J. 2000. Integrated Pest Management for Crops and Pastures. CSIRO Publishing.
- Anderson A., & Smith G. A. 2006. Horticulture Business Management. CABI Publishing.
- Arteca R. N. 2004. Introduction to Horticulture. Thomson Delmar Learning.
- Hartmann H. T., Kester D. E., Davies Jr. F. T. & Geneve R. L. 2011. Plant Propagation: Principles and Practices. Prentice Hall.
- Ross E. A. 2011. Soil and Water Conservation: Principles and Practices. Pearson.
- Ruberson J. R. 2018. Handbook of Pest Management in Agriculture. CRC Press.
- Stanton J. L., Stacey S. D. & Haynes F. J. 2009. Horticulture Marketing: A Resource and Training Guide. University of Florida, Institute of Food and Agricultural Sciences.

Mapping of COs with POs:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	1	-	-	-	1	1	-
CO2	3	1	3	-	1	-	1
CO3	3	1	3	-	1	-	1
CO4	3	1	3	-	1	-	3

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Exam/Discussion
- Assignment/ presentation/Project
- Project/Practical
- Final Exam

Mapping of COs to Assessment Rubrics :

	Quiz/discussion	Presentation/ Assignment/Project	Theory/Practical Internal exam	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓		✓	✓
CO 3	✓	✓	✓	✓
CO 4		✓		

ST. JOSEPH'S COLLEGE (AUTONOMOUS), DEVAGIRI

Programme	B. Sc. BOTANY				
Course Title	**Plant Propagation Techniques**				
Type of Course	**Vocational Minor**				
Semester	**II**				
Academic Level	100-199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	-				
Course Summary	Plant Propagation Techniques is a comprehensive course covering the principles and methods of plant propagation, with hands-on learning experiences. Students will gain the skills and knowledge needed to propagate plants effectively for agricultural, horticultural, and conservation purposes.				

Course Outcomes (CO): After completing the Course, the student should be able to:-

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools
CO1	Recall the principles underlying different propagation techniques, such as seed germination, cutting propagation, and grafting.	U	F	Quiz/Exam
CO2	Analyse the advantages and disadvantages of different propagation methods in various contexts, such as commercial horticulture, conservation, and restoration.	An	C	Exam/Group discussion
CO3	Evaluate the quality of seeds and plant materials for propagation, applying criteria such as viability, vigour, and genetic purity.	E	C & P	Practical test
CO4	Design and implement propagation plans for specific plant species or projects, considering factors such as propagation goals, available resources, and environmental conditions.	C	C & P	Project

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
\# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus

Module	Unit	Content	Hrs (45 + 30)
I		**Introduction to Plant Propagation**	**8**
	1	Importance and Scope of Plant Propagation-Economic and Ecological importance	1
	2	Scope in Food Security and Biodiversity Conservation	1
	3	Historical Perspectives on Plant Propagation: Early Methods of Propagation, Contributions of Pioneers in Propagation Science	2
	4	Factors Affecting Plant Growth and Propagation: Environmental Factors (Light, Temperature, Water, Nutrients)	2
	5	Genetic Factors, Interactions with Microorganisms	2
II		**Sexual Propagation Techniques**	**8**
	6	Seed Propagation: Principles and Practices-Seed Formation and Structure, Seed Treatment and Pre-germination Techniques	2
	7	Seed Dormancy and Germination- Types of Dormancy, Factors Affecting Dormancy Breakage, Environmental Requirements	2
	8	Seed Quality Assessment and Enhancement: Seed Viability and Vigour Testing	2
	9	Seed Certification and Standards	1
	10	Seed Enhancement Techniques (Scarification, Stratification, Priming)	1
III		**Vegetative and Asexual Propagation**	**20**
	11	Vegetative Reproduction: Types, Advantages and Disadvantages, Application in Plant Breeding and Clonal Selection	2
	12	Cutting Propagation: Types and Techniques-Types of Cuttings (Softwood, Hardwood, Semi-hardwood), Rooting Hormones and Substrates	2
	13	Layering and Its Variations-Methods of Layering (Simple, Air, Tip, Compound), Factors Affecting Success, Applications in Woody Plant Propagation	3
	14	Grafting and Budding Techniques-Principles of Graft Compatibility, Types of Grafting (Cleft, Whip and Tongue, Bark, Approach), Bud Grafting Techniques (T-budding, Chip budding)	3
	15	Micropropagation - Tissue Culture Basics, Process (Initiation, Multiplication, Rooting, Acclimatization), Applications in Mass Propagation and Disease Elimination	4
	16	Natural Modes of Asexual Reproduction: Propagation Techniques for Offsets, Suckers, and Runners	2
	17	Bulb Propagation Methods-Scaling, Twin Scaling	2
	18	Rhizome and Tuber Propagation, Rhizome Cuttings, Tuber Division, Tissue Culture for Rhizome and Tuber Propagation	2
IV		**Advanced Propagation Techniques and Applications**	**9**
	19	Propagation in Specialized Environments- Hydroponics: Principles and Systems	2
	20	Aeroponics: Techniques and Benefits, Aquaponics: Integration of	2

		Aquaculture and Hydroponics	
	21	Propagation of Endangered Species, Ecological Restoration Techniques	2
	22	Innovations and Future Trends in Plant Propagation: Sustainable Practices in Propagation Technology	2
V	**Practical (Mandatory experiments)**		**30 hrs**
	1. Budding, Grafting, Layering (with suitable plant material – any two types form each 2. Demonstration of Hydroponics cultivation in glass bottles (any one plant) 3. Seed viability testing (Any suitable method)		
	Practical (Open ended-Suggestive list)		
	4. Practice on seed enhancement techniques 5. Field Trip to a Nursery or Botanical Garden: 6. Cutting Propagation Trials: Using various plant species and types of cuttings (softwood, hardwood, semi-hardwood). Students can experiment with different rooting hormones, substrates, and environmental conditions to optimize rooting success and learn practical skills in vegetative propagation. 7. Introduce students to tissue culture techniques through a micropropagation lab. 8. Community Propagation Project: Engage students in a community propagation project aimed at propagating plants for conservation, restoration, or beautification purposes. 9. Students can collaborate with local organizations, schools, or community gardens to propagate native plants, endangered species, or ornamentals.		

Suggested Readings

- Chopra V. L., & Vashistha, B. B. 2012. Plant Propagation: Principles and Practices.
- Dhankhar O. P., & Sidhu, A. S. 2017. Principles of Seed Technology.
- Singh A. K., & Singh V. P. 2015. A Textbook of Plant Propagation and Nursery Management.
- Singh S. P. 2009. Propagation of Horticultural Crops.
- Bhojwani S. S. & Razdan M. K. 1996. Plant Tissue Culture: Theory and Practice.
- Creech J. L. & Nissen R. L. 2007. Vegetative Propagation of Horticultural Crops
- Dirr M. A. & Heuser Jr. C. W. 2019. The Reference Manual of Woody Plant Propagation: From Seed to Tissue Culture.
- Thomas P. A. 2000. Practical Plant Propagation.
- George E. F., Hall M. A. & De Klerk G.-J. 2008. Plant Propagation by Tissue Culture: Volume 1. The Background.

Mapping of COs with POs:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	-	1	-	1	1	1
CO2	2	-	2	-	3	2	2
CO3	3	-	1	-	1	1	1
CO4	2	-	2	-	3	2	3

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Exam/Discussion
- Assignment/ presentation/Project
- Project/Practical
- Final Exam

Mapping of COs to Assessment Rubrics :

	Quiz/discussion	Presentation/ Assignment/Project	Theory/Practical Internal exam	End Semester Examinations
CO 1	✓			✓
CO 2	✓	✓		✓
CO 3			✓	✓
CO 4		✓		✓

Programme	B. Sc. BOTANY				
Course Title	**Biofertilizer Technology**				
Type of Course	**Vocational Minor**				
Semester	**III**				
Academic Level	200-299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	-				
Course Summary	This course covers introduction to types of biofertilizers and their microbial composition, and their importance in sustainable agriculture				

Course Outcomes (CO): After completing the Course, the student should be able to:-

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools
CO1	Identify different types of Biofertilizers	U	F	Quiz/Lab Exercise
CO2	Evaluate, and utilize biofertilizers effectively to enhance soil fertility and crop productivity.	E	C & P	Practical test/Group project
CO3	Develop skills in cultivating and utilizing biofertilizers	Ap	P	Practical test
CO4	Develop practical experience necessary to contribute to sustainable agriculture practices through the use of biofertilizers	Ap	P	Lab test/Group work
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 + 30)
		Introduction to Biofertilizers	**10**
	1	Introduction, scope, General account about the microbes used as biofertilizer	2
	2	Cyanobacteria (blue green algae), Anabaena, Cylindrospermum, Gloeocapsa, Lyngbya, Nostoc, Plectonema. Azolla and Anabaena azollae association, nitrogen fixation, factors affecting growth, blue green algae and Azolla in rice	4

		cultivation. Cyanobacteria (BGA), Bacteria and Mycorrhizae - Cyanobacteria (BGA) as biofertilizers - and Tolypothrix. Algalization, Azolla - Anabaena as biofertilizers.	
	3	Isolation of cyanobacteria. Formation of Fogg's medium - Mass cultivation of Azolla - Cyanobacterial biofertilizers - Symbiotic association of Cyanobacteria - Field application of Cyanobacterial inoculants	4
I		**Bacterial biofertilizers**	**15**
	4	Bacterial biofertilizers - Introduction, scope. A general account of bacterial biofertilizers organisms. Azospirillum, Azotobacter, Frankia, Phosphobacteria and Rhizobium.	2
	5	Rhizobium - isolation, identification, mass multiplication, and carrier based inoculants, Actinorrhizal symbiosis.	4
	6	Azospirillum - isolation and mass multiplication – carrier based inoculant, associative effect of different microorganisms.	4
	7	Azotobacter - classification, characteristics – crop response to Azotobacter inoculum, maintenance and mass multiplication.	2
	8	Phosphate solubilizing microbes (any one) - Isolation, characterization, mass inoculum production, field Application	3
	9	Biochemistry and molecular basis of nitrogen fixation - Phosphate solubilization and mobilization.	3
II		**Mycorrhizal Association**	**10**
	10	Introduction, Introduction, scope. A general account of Ecto, Endo and Arbuscular mycorrhizae (AM)	2
	11	Methods of collection, wet sieving and decanting method and inoculum production.	2
	12	Culture of mycorrhizae in Modified Melin - Norkrans (MMN) agar medium - Cultural characteristics of Ecto mycorrhizal fungi. Techniques of Ectomycorrhizal inoculum,	3
	13	Endo mycorrhizae of orchids. Isolation and method of inoculation of Arbuscular mycorrhizae (AM), Legume - AM interactions -	3
III		**Application Technology**	**10**
	14	Application technology for seeds, seedlings, tubers etc.	3
	15	Biofertilizers - Storage, shelf life, quality control and marketing.	3
	16	Factors influencing the efficacy of biofertilizers	2
	17	National and Regional Biofertilizers Production and Development Centres.	2
V		**Practical (Suggestive list)**	**30**
		1. Mass multiplication of BGA and *Azolla* and its application in paddy field 2. Preparation of plan of biofertilizers production unit 3. Familiarise with the Equipment, machinery and tools used for biofertilizers production. 4. Preparation of media used for biofertilizers production.	

Suggested Readings

- Dubey, R. C. 2008. A Textbook of Biotechnology. S. Chand & Co., New Delhi.
- Newton, W. E. et al. 1977. Recent Developments in Nitrogen Fixation. Academic Press, New York.

- Schwintzer, C. R. and Tjepkema, J. D. 1990. The Biology of Frankia and Actinorhizal Plants. Academic Press Inc., San Diego, USA.
- Stewart, W. D. P. and Gallon, J. R. 1980. Nitrogen Fixation. Academic Press, New York.
- Subba Rao N. S. 1982. Advances in Agricultural Microbiology. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
- Subba Rao, N. S. 2002. Soil Microbiology. 4th ed. Soil Microorganisms and Plant Growth. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
- Subba Rao, N. S. and Dommergues, Y. R. 1998. Microbial Interactions in Agriculture and Forestry. Vol. I, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
- Verma, A. 1999. Mycorrhiza. Springer Verlag, Berlin. • Wallanda, T. et al. (1997). Mycorrhizae. Backley's Publishers
- https://www.openaccessgovernment.org/biofertilizers-towards-sustainable-agriculture/111024/

Mapping of COs with POs:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	-	1	-	1	-	1
CO2	3	-	1	-	1	-	2
CO3	3	1	1	-	1	-	1
CO4	3	-	1	-	1	-	3

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Exam/Discussion
- Assignment/ presentation/Project
- Project/Practical
- Final Exam

Mapping of COs to Assessment Rubrics :

	Quiz/discussion	Presentation/ Assignment/Project	Theory/Practical Internal exam	End Semester Examinations
CO 1	✓		✓	✓
CO 2		✓	✓	✓
CO 3			✓	✓
CO 4		✓	✓	✓

MULTI DISCIPLINARY COURSES

Programme	B. Sc. BOTANY				
Course Title	**Incredible Plant Kingdom**				
Type of Course	**MDC**				
Semester	**I**				
Academic Level	100-199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	3	3			45
Pre-requisites	-				
Course Summary	The course offers a fascinating journey into the diverse and extraordinary world of plant which provides students with an understanding of the plant kingdom's complexity, beauty, and importance to life on Earth.				

Course Outcomes (CO): After completing the Course, the student should be able to:-

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools
CO1	Appreciate the unique characters of the plant groups and their importance in sustaining life on Earth	U	F	Written exam/Presentation
CO2	Identify the amazing facts about different plants and appreciate the curious characters	U	F	Self-assessment
CO3	Assess the important plant adaptations & modifications according to the changing habitats.	An	C	Written test/Observation of practical skills
CO4	Explore the unique wonders of plants to inspire future generations to conserve and appreciate their biodiversity.	E	C & P	Group presentation

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (36+9)
I		**Introduction**	**15**
	1	Plant groups: Unique characters and Importance of - Algae, Fungi, Bryophytes, Pteridophytes, Gymnosperms and Angiosperms.	4
	2	Bizarre Botanical Structures.	2
	3	Weird Plant interaction: Allelopathy, mimicry, deception, myrmecophily, hydraulic redistribution	3
	4	Natural warriors - plastic degrading plants, toxin absorbing, toxin degrading	3
	5	Intelligent networking systems in plants	3
II		**Amazing plants**	**9**
	6	Aromatic plants, fertilizing plants, camouflage plants (*Corydalis hemidicentra*), stinky plants (Titan arum)	2
	7	*Victoria regia* - special features	1
	8	Weird Plants - Dragon's blood tree, Baobab Tree, Rafflesia, Lithops, Black Bat flower, Welwitschia	2
	9	Unusual orchids - types, examples and curious	1
	10	Expensive plant derivatives: Cultivation, harvest, processing and uses - Food (White & Black truffles, Saffron, Kopi luwak Coffee, Tieguanyin Tea, Macadamia Nut), Sekai-Ichi apple, Perfumery (Oudh, Bulgarian rose, Lavender), Ornamentals (Kadupul, Juliet Rose, Shenzhen Nongke Orchid)	3
III		**Curious plants**	**6**
	10	Tallest, largest, oldest and smallest plants	1
	11	Magnitudes in size, flowers, leaves and fruits	1
	12	Pollution indicators & Mineral indicators	1
	13	Bioluminescent plants – Fluorescent algae, mushrooms, night-glowing plants, principle and significance	1
	14	Carnivorous plants - Venus' fly-trap, Pitcher plant	1
	15	Reproductive wonders - spore dispersal mechanisms, Extreme pollination mechanisms, deceptive pollination mechanisms - fig, bee orchid, Vallisneria	1
IV		**Extreme plants**	**6**
	15	Plants and their adaptations: Definition of various plant types, Morphological adaptations of Hydrophyte (*Eichhornia*), Xerophyte (*Opuntia*), Parasite (*Cuscuta*), Halophyte (*Avicennia*), Epiphytes (*Vanda*)	3
	16	Plants thriving in space (Chlorella), volcanoes (Hawaiian argyroxiphium), alpine (junipers), Tundra (Arctic lichen).	2
	17	Thermophiles – Definition, examples	1
V		**Open ended**	**9**

Suggested Readings

- Pandey B.P. 2005 College Botany: Vol I, 5th edn. S. Chand & Company LTD. New Delhi.

- Raven PH Evert RF and Eichhorn SE 2013. Biology of plants. VIII th Ed. W.H. Freeman Publishers
- Santna, S.C.Chatterjee, T.P and A.P. Das. 2004. College Botany Practical (Vol II) New Central Book Agency (P) KolKatta.
- Starr C.2007. Biology: concepts and applications. VI edn. ISBN 81-315-0284-8

Online Sources

- https://www.thehindu.com/sci-tech/science/a-tiny-plant-that-can-digest-low-density-plastic-sheets/article36794827.ece
- https://www.youtube.com/watch?v=0o7kBQ-Pl2A
- https://www.youtube.com/watch?v=TWSF3df6jUs

Assessment Rubrics:

- Quiz / Exam/Discussion
- Assignment/ Presentation/Project
- Project/Practical
- Final Exam

Mapping of COs to Assessment Rubrics :

	Quiz/ discussion	Presentation/ Assignment/Project	Theory/Practical Internal exam	End Semester Examinations
CO 1	✓	✓	✓	✓
CO 2				✓
CO 3	✓	✓	✓	✓
CO 4		✓		✓

Programme	B. Sc. BOTANY				
Course Title	**Plant Propagation**				
Type of Course	**MDC**				
Semester	**I**				
Academic Level	100-199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	3	3			45
Pre-requisites	Nil				
Course Summary	This course covers techniques for plant propagation and the utilization of plant resources. Students will learn about various methods of plant propagation, including seed propagation, cutting propagation, and tissue culture.				

Course Outcomes (CO): After completing the Course, the student should be able to:-

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools
CO1	Explain various plant propagation structures and their utilization	U	F	Quiz/Test
CO2	Summarise various methods of plant propagation	U	C	Quiz/Written Test
CO3	Demonstrate skills related to vegetative plant propagation techniques such as cuttings, layering, grafting and budding.	U	P	Practical Test
CO4	Apply specific propagation technique for a given plant species.	Ap	P	Field work
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (36 + 9)
I		**Plant Propagation**	**9**
	1	Propagation: Definition, need and potentialities for plant multiplication	2
	2	Asexual and sexual methods of propagation - advantages and disadvantages.	2
	3	Propagation facilities: Mist chamber, humidifiers, greenhouses, glasshouses, cold frames, hot beds, poly-houses	3
	4	Nursery - tools and implements (Brief account)	2
II		**Steps of Growing Plants**	**9**
	5	Soil: Composition, Types	1
	6	Chemical fertilizers: types, application, merits and demerits, Biofertilizers	2

	7	Organic manure: types, application, merits and demerits	2
	8	Need of water: Irrigation – Surface, spray, drip irrigation, sprinklers	2
	9	Plant protection: Biological, Physical and mechanical, Chemical, biopesticide	2
III		**Propagation methods**	**9**
	10	Seed propagation – Seed dormancy, seed treatment, conditions for successful propagation, raising of seed beds	2
	11	Care of seedling, transplanting techniques	1
	12	Vegetative propagation: Cutting (stem, roots), Grafting (approach, cleft)	2
	13	Budding (T-budding, patch), Layering (simple, air)	2
	14	Micro propagation- General account	2
IV		**Botany in everyday life**	**9**
	15	Vegetable gardening	2
	16	Mushroom cultivation	2
	17	Bonsai and Terrarium preparation	3
	18	Orchid and Anthurium cultivation	2
V		**Open ended (Suggestive list)**	**9**
		1. Demonstration of vegetative propagation 2. Visit to nursery/garden 3. Hands on training- Bonsai and Terrarium preparation	

Suggested Readings

- Nishi Sinha: Gardening in India, Abhinav Publications, New Delhi.
- Andiance and Brison. 1971. Propagation Horticultural Plants.
- Chanda, K.L. and Choudhury, B. Ornamental Horticulture in India.
- Premchand, Agriculture and Forest Pest and their Management, Oxford Publication.
- George Acquaah, Horticulture: Principles and Practices. Pearson Education, Delhi.
- Kolay, A.K. Basic Concepts of Soil Science. New Age International Publishers, Delhi.
- Rodgran, M.K. Plant Tissue Culture, Oxford & IBH Publishing Ltd., New Delhi.
- Hudson, T. Hartmann, Dale K. Kester, Fred T. Davies, Robert L. Geneve, Plant Propagation, Principles and Practices.

Assessment Rubrics:

- Quiz / Exam/Discussion
- Assignment/ presentation/Project
- Project/Practical
- Final Exam

Mapping of COs to Assessment Rubrics:

	Quiz/ discussion	Presentation/ Assignment/Project	Theory/Practical Internal exam	End Semester Examinations
CO 1	✓	✓	✓	✓
CO 2	✓	✓	✓	✓
CO 3			✓	✓
CO 4		✓		✓

Programme	B. Sc. BOTANY				
Course Title	**Ecosystem Diversity in India**				
Type of Course	**MDC**				
Semester	**II**				
Academic Level	100-199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	3	3		-	45
Pre-requisites	-				
Course Summary	This course provides an in-depth exploration of ecosystem diversity in India from a multidisciplinary perspective. It covers the classification, characteristics, and importance of various terrestrial and aquatic ecosystems found in India.				

Course Outcomes (CO): After completing the Course, the student should be able to:-

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools
CO1	Define various types of ecosystems found in India	R	F	Quiz/Test
CO2	Demonstrate an understanding of interdisciplinary approaches to ecosystem management	U	C	Literature survey/Discussion
CO3	Analyse the human-induced threats to Indian ecosystems and propose appropriate conservation strategies.	An	C & P	Field report
CO4	Apply theoretical knowledge through practical activities, fieldwork, and group projects to address real-world challenges in ecosystem conservation and management.	Ap	C & P	Group project
CO5	Evaluate the importance of ecosystem diversity for biodiversity conservation and human well-being.	E	C & P	Written Test/Discussion
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (36 + 9)
I	**Introduction to Ecosystem Diversity**		**9**
	1	Understanding Ecosystems - Definition of ecosystems, Components of ecosystems: biotic and abiotic factors, Importance of ecosystem diversity	2

	2	Classification of Ecosystems - Terrestrial ecosystems: forests, grasslands, deserts, etc. Aquatic ecosystems: freshwater, marine, and estuarine ecosystems; Urban ecosystems: parks, gardens, and urban forests	4
	3	Factors Affecting Ecosystem Diversity - Natural factors: climate, topography, and geological feature, Anthropogenic factors: deforestation, pollution, and urbanization; Conservation efforts: protected areas and sustainable management	3
II		**Ecosystem Diversity in India**	**12**
	4	Overview of India's Biodiversity: Richness of flora and fauna; Biogeographic zones: Himalayas, Western Ghats, Indo-Gangetic plains, etc.; Endemic species and hotspots	3
	5	Terrestrial Ecosystems in India-Tropical rainforests: Western Ghats, Northeast India; Deciduous forests: Eastern Ghats, Central India; Desert ecosystems: Thar Desert, Cold deserts of Ladakh	3
	6	Aquatic Ecosystems in India: Rivers and lakes: Ganges, Brahmaputra, Chilka Lake; Coastal ecosystems: Mangroves, Coral reefs; Marine ecosystems: Arabian Sea, Bay of Bengal	3
	7	Human Impact on Indian Ecosystems: Deforestation and habitat loss, Pollution of water bodies, Climate change effects	3
III		**Conservation and Management of Ecosystem Diversity**	**8**
	8	Importance of Conservation: Ecosystem services: biodiversity, water purification, climate regulation; Economic value: tourism, agriculture, pharmaceuticals	2
	9	Conservation Strategies: Protected areas: National parks, wildlife sanctuaries, biosphere reserves; Sustainable resource management: community-based conservation, eco-tourism; Legal frameworks: Wildlife Protection Act, Forest Rights Act	3
	10	Case Studies of Successful Conservation Projects: Project Tiger, Western Ghats biodiversity hotspot conservation, Coral reef conservation in Lakshadweep	2
	11	Ecosystem damage: Natural and Anthropogenic – Exotic species invasion, habitat fragmentation	1
IV		**Role of Interdisciplinary Approaches in Ecosystem Diversity**	**7**
	12	Ecological Economics: Valuation of ecosystem services, Sustainable development goals and ecosystem diversity	2
	13	Socio-cultural Perspectives: Traditional ecological knowledge and conservation	1
	15	Policy and Governance: Role of government policies in conservation	1
	16	International agreements: Convention on Biological Diversity, Paris Agreement	1
	17	Future Directions and Challenges: Addressing socio-economic factors such as poverty, population growth, and resource conflicts that impact ecosystem diversity	2

V	Open ended (Suggestive list)	9
	1. Field trips to different ecosystems (forests, wetlands, coastal areas) 2. Presentations on case studies of successful conservation projects 3. Hands-on activities: tree planting, habitat restoration, and water quality testing 4. Debates and discussions on contemporary issues related to ecosystem diversity and conservation 5. Participation in community-based conservation initiatives	

Suggested Readings

- Michael Begon, Colin R. Townsend, John L. Harper. 2006. Introduction to Ecosystem Diversity: Ecology: From Individuals to Ecosystem, Blackwell Publishing.
- Whittaker R. H. & Likens G. E. 1975. Ecosystem Diversity in India: Indian Ecology: Patterns and Processes, Oxford University Press
- Scott P. Carroll, Charles W. Fox. 2008. Conservation and Management of Ecosystem Diversity: Conservation Biology: Evolution in Action, 1st Edition, Oxford University Press.
- Chris Maser. 2009. Role of Interdisciplinary Approaches in Ecosystem Diversity: "Interdisciplinary Environmental Studies: A Primer, CRC Press
- Manuel C. Molles Jr. 2015. Understanding Ecosystems and Factors Affecting Ecosystem Diversity: Ecology: Concepts and Applications, McGraw-Hill Education
- Peter Kareiva, Michelle Marvier, Brian Silliman. 2011. Conservation Strategies and International Agreements: Conservation Science: Balancing the Needs of People and Nature, Roberts and Company Publishers.

Assessment Rubrics:

- Quiz / Exam/Discussion
- Assignment/ presentation/Project
- Project/Practical
- Final Exam

Mapping of COs to Assessment Rubrics:

	Quiz/discussion	Presentation/ Assignment/Project	Theory/Practical Internal exam	End Semester Examinations
CO 1	✓		✓	✓
CO 2				✓
CO 3				✓
CO 4	✓	✓	✓	✓
CO 5	✓		✓	✓

<table>
<tr><td>Programme</td><td colspan="5">B. Sc. BOTANY</td></tr>
<tr><td>Course Title</td><td colspan="5">Plants in Everyday Life</td></tr>
<tr><td>Type of Course</td><td colspan="5">MDC</td></tr>
<tr><td>Semester</td><td colspan="5">II</td></tr>
<tr><td>Academic Level</td><td colspan="5">100-199</td></tr>
<tr><td rowspan="2">Course Details</td><td>Credit</td><td>Lecture per week</td><td>Tutorial per week</td><td>Practical per week</td><td>Total Hours</td></tr>
<tr><td>3</td><td>3</td><td>-</td><td></td><td>45</td></tr>
<tr><td>Pre -requisites</td><td colspan="5">-</td></tr>
<tr><td>Course Summary</td><td colspan="5">This course is designed to give an overview of how plants are indispensable to humans. It gives a broad exposure to the various aspects of plant resources & its utilization.</td></tr>
</table>

Course Outcomes (CO): After completing the Course, the student should be able to:

COs	Statement	Cognitive level*	Knowledge Category#	Evaluation Tools
CO1	Recall various economically and medicinally important plant species used in day-to-day life	R	F	Quiz/Exam
CO2	Explain the uses of economically important plants and illustrate the processing of various plant parts.	U	C	Written Assignments, Lab exam/ Quiz
CO3	Analyse the utilization of various plant resources in day-to-day life.	An	C	Discussion/Presentation
CO4	Apply theoretical knowledge in utilization, and report generation of economical and medicinal plants.	Ap	C & P	Project reports/ collaborative report writing
CO5	Evaluate the quality and content of products used in everyday life	E	P	Analytical reports

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
\# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus

<table>
<tr><th>Module</th><th>Unit</th><th>Content</th><th>Hrs (36+9)</th></tr>
<tr><td rowspan="3">I</td><td colspan="2">Role of plants</td><td>9</td></tr>
<tr><td>1</td><td>Introduction to Plant resources.</td><td>1</td></tr>
<tr><td>2</td><td>Role of plants: Air purifier (photosynthesis); plants used in rituals/festivals; nutrient source (litter manure, organic manure).</td><td>2</td></tr>
</table>

	3	Pollution removal (phytoremediation and its types), pollution indicator (lichens).	2
	4	Common medicinal plants around us: Tulsi, *Adhatoda*, *Phyllanthus*, *Aloe*, *Andrographis*, *Eclipta*, *Coleus aromaticus* (Botanical source, part of the plant used, and medicinal uses).	3
	5	Plants as biofertilizers – *Azolla* (method of cultivation) *Gliricidia* - Uses and benefits.	1
II		**Plant resources and utilization-I**	**9**
	5	Brief description of plants, parts used and uses. Cereals: Rice, Wheat Millets: Ragi, Jowar	2
	6	Legumes: Bengal gram, Green gram, Black gram Edible oils: Sesame, Coconut	2
	7	Cash crops: Cashew, Cocoa	1
	8	Starch and tuber crops: Tapioca, Sweet potato and Yam	2
	9	Vegetable crops: Red amaranth, Lady‘s finger	2
III		**Plant resources and utilization-II**	**9**
	10	Spices: Clove, Black pepper, Cardamom Beverages: Tea and Coffee (including processing).	2
	11	Oils: Eucalyptus, Clove, Rose and Rosemary	2
	12	Fibres: Coir, Cotton, Jute, Banana and Sisal (Methods of separation of fibre, drying and processing of any two)	4
	13	Timber: Teak, Rose wood	1
IV		**Eco-friendly products from plants**	**9**
	14	Eco friendly alternatives-Introduction and scope	1
	15	Compostable garbage bags and Tableware: Example and preparation method	2
	16	Natural cleaning products and disinfectants: (One example for each and its preparation)	2
	17	Natural fabric dye, hair dye and hair and face wash, face pack, creams and gel	4
	18	Shampoo, Conditioner - (One example for each and its preparation)	
	19	Benefits of eco-friendly lifestyle	1
V		**Open ended (Suggestive list)**	**9**
		1. Field visit in the campus to identify useful plants 2. Report on eco-friendly products used in your area 3. Demonstration on preparation of various plant-based products	

Suggested Readings

- Billings S. and Collingwood S. 2013. The Big book of home remedies. Lulu.com publisher.
- Buckley, C. 2020. Plant Magic: Herbalism in Real Life. Roost Books Publishers, New York.

- Chrispeels, M. J. and Sadava, D. E. 1994. Plants, Genes and Agriculture. Jones & Bartlett Publishers.
- Fuller, K.W. and Gallon, J. A. 1985. Plant Products and New Technology. Clarendon Press, Oxford, New York.
- Hill, A. F. 1952. Economic Botany: A Textbook of Useful Plants and Plant Products. McGraw Hill Publishing Company Ltd., New Delhi.
- Kochhar, S. L. 2012. Economic Botany in the Tropics. MacMillan India Ltd., New Delhi.
- Purohit, S. S. and Vyas, S. P. 2008. Medicinal Plant Cultivation: A Scientific Approach. Agrobios, India.
- Rao, R. S. 1985) Everyday Ayurveda: The complete book of Ayurvedic home remedies. Notion Press, India.
- Sambamurty and Subramanyam N. S. 1989. A Textbook of Economic Botany. Wiley Eastern Ltd., New Delhi.
- Sen, S. 2009. Economic Botany. NCBA Publishers, New Delhi.
- Sharma, O. P. 1996. Economic Botany. Tata McGraw Hill Publishing Company Ltd., New Delhi.
- Simpson B. B. and Conner-Ogorzaly M. 1986. Economic Botany - Plants in Our World. McGraw Hill, New York.
- Singh V, Pande P. C. and Jain D. K. 2009. A Text Book of Economic Botany. Rastogi Publications, Uttar Pradesh.
- Trivedi, P. C. 2006. Medicinal Plants: Ethnobotanical Approach. Agrobios, India.
- Upadhyay, R. 2023. Economic Botany: Principles & Practices. Kluwer Academic Publishers, The Netherlands.

Assessment Rubrics:

- Quiz / Exam/Discussion
- Assignment/ presentation/Project
- Project/Practical
- Final Exam

Mapping of COs to Assessment Rubrics :

	Quiz/ discussion	Presentation/ Assignment/Project	Theory/Practical Internal exam	End Semester Examinations
CO 1	✓			✓
CO 2	✓		✓	✓
CO 3	✓	✓		
CO 4		✓		✓
CO 5		✓		

VALUE-ADDED COURSES

Programme	B. Sc. BOTANY				
Course Title	**Biodiversity & Conservation**				
Type of Course	**VAC**				
Semester	**III**				
Academic Level	**100-199**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	3	3	-	-	45
Pre-requisites	-				
Course Summary	This course explores importance of biodiversity for ecosystem stability, the threats facing biodiversity, various conservation strategies and initiatives aimed at protecting and restoring biodiversity				

Course Outcomes (CO): After completing the Course, the student should be able to:

COs	Statement	Cognitive level *	Knowledge Category #	Evaluation Tools
CO1	Recall and define key terms related to biodiversity and conservation	R	F	Quiz, Glossary creation assignments
CO2	Demonstrate an understanding of the importance of biodiversity for ecosystem health and human well-being	U	C	Essays/ Discussion forums, Case study analysis
CO3	Analyse the various threats to biodiversity and evaluate their impact on ecosystems	An	C & P	Research papers/ Presentations/ Impact Assessment Reports
CO4	Apply conservation principles and strategies to real-world scenarios, proposing solutions to mitigate biodiversity loss	Ap	C & P	Group projects
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (36+9)
I	**Introduction to Biodiversity**		**9**
	1	Concept of biodiversity; genetic, species and ecosystem diversity	2
	2	Biogeographical classification of India	2

	3	Value of biodiversity: Economic values, ecological (role in hydrological and biogeochemical cycling) and ecosystem services (social, aesthetic, consumptive, and ethical values of biodiversity).	3
	4	Biodiversity Hotspots - concepts, distribution and significance	2
II		**Threats and Management of Biodiversity**	**9**
	5	Natural and anthropogenic threats; Over-exploitation, Habitat destruction, Fragmentation, climate change and Species extinctions	2
	6	Estimates of extinction rates worldwide and in India; Invasions - causes and impacts	2
	7	Consequences: loss of gene pool, loss of ecosystem services, livelihood	2
	8	IUCN threatened categories; Red data book	1
	9	Ecotourism - impact	2
III		**Measurement of Biodiversity**	**9**
	10	Biodiversity estimation: Floristic sampling strategies and surveys	2
	11	Qualitative and quantitative methods: scoring, richness, density, frequency, abundance, evenness, diversity,	3
	12	Community diversity estimation: alpha, beta and gamma diversity.	2
	13	Documentation - need, methods, PBR, process in PBR preparation, Functions of NBA, SBB	2
IV		**Conservation of Biodiversity**	**9**
	14	In-situ conservation (Biosphere Reserves, National Parks, Wildlife Sanctuaries, Sacred grooves)	2
	15	Ex-situ conservation (botanical gardens, zoological gardens, gene banks and seed banks); role of traditional knowledge system in conservation	2
	16	Ecological restoration; afforestation; social forestry; agroforestry; joint forest management.	3
	17	Organizations associated with biodiversity management - IUCN, UNEP, WWF, UNESCO, NBPGR, Biodiversity Board. Biodiversity Acts.	2
V		**Practical/Theory (Open ended)**	**9**
		1. Group discussion on biodiversity (Man-animal conflict, human interference, climate change, policy) 2. Documentation of biodiversity of the campus 3. Preparation of field report based on the visit to nearby Wild Life Sanctuary/National Park/Biosphere Reserve	
Suggested Readings: • Rajak, A. 2020. Textbook of Biodiversity. 1st edition, Notion Press, India. • Mahanty, S. and Srivastava, A. 2016. Biodiversity and its Conservation. Disha International Publishing House, India. • Myneni, S. R. 2020. Law of Biodiversity Protection. New Era Law Publication, India.			

- Singh, J. S., Singh, S. P. and Gupta, S. R. 2008. Ecology, Environment and Resource Conservation. Anamaya Publications (New Delhi).
- Krishnamurthy, K.V. 2004. An Advanced Text Book of Biodiversity - Principles and Practices. Oxford and IBH Publications Co. Pvt. Ltd. New Delhi.
- Magurran, Anne E. 2003. Ecological diversity and its measurements. Blackwell Publications.
- Gaston, K J. and Spicer, J. I. 1998. Biodiversity: An Introduction. Blackwell Science, London, UK
- Primack, R.B. 2002. Essentials of Conservation Biology (3rd edition). Sinauer Associates, Sunderland, USA.
- Sodhi, N. S., Gibson, L. and Raven, P. H. 2013. Conservation Biology: Voices from the Tropics. Wiley-Blackwell, Oxford, UK.
- Heywood V. H. and Watson R.T. (Ed). 1995. Global Biodiversity Assessment: UNEP. Cambridge University Press.

Mapping of COs with PSOs and POs:

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	-	-	-	-	1	-	-	-	-	-	-
CO2	1	1	1	-	-	-	1	-	-	-	1	1	-
CO3	3	1	2	3	-	-	2	-	-	-	2	1	-
CO4	1	3	3	1	-	-	-	-	-	-	2	3	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Exam/Discussion
- Assignment/ presentation/Project
- Project/Practical
- Final Exam

Mapping of COs to Assessment Rubrics :

	Quiz/ discussion	Presentation/ Assignment/Project	Theory/Practical Internal exam	End Semester Examinations
CO 1	✓	✓	✓	✓
CO 2	✓		✓	✓
CO 3		✓	✓	✓
CO 4		✓		

Programme	B. Sc. BOTANY				
Course Title	**Environment & Climate Change**				
Type of Course	**VAC**				
Semester	**IV**				
Academic Level	100-199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	3	3	-	-	45
Pre-requisites	-				
Course Summary	The course provides an overview of the interconnected issues surrounding environmental sustainability, the impact of climate change, strategies for mitigation and adaptation, and the importance of global co-operation in addressing these challenges.				

Course Outcomes (Cos): After completing the Course, the student should be able to:-

COs	Statement	Cognitive level *	Knowledge Category #	Evaluation Tools
CO1	Recall and define key terms related to climate change	R	C	Quiz/Written Test
CO2	Explain the interconnected issues surrounding environmental sustainability and the impact of human activities on the environment	U	C & P	Essays/ Discussion forums/ Case study analysis
CO3	Analyse the causes and effects of climate change	An	C & P	Data analysis projects/ Presentations
CO4	Evaluate strategies for mitigation and adaptation to address environmental challenges	E	C & P	Comparative studies/ Evaluation reports
CO5	Apply their knowledge to propose sustainable solutions for environmental issues	Ap	C & P	Group projects

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
\# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (36 + 9)
I		**Environment and Climate change**	**9**
	1	Introduction - environmental science, natural resources and their management, Renewable energy sources and sustainable practices	2
	2	Definition of climate and weather, climate of India, Natural greenhouse effect, climate change factors - Natural factor &Anthropogenic factor.	2
	3	Global warming - Greenhouse gases, role of CO_2, role of CH_4, Global warming potential, CO_2 Emission - Remedial measure to reduce global warming, Global cooling.	2
	4	Ozone Layer Depletion - Vienna convention on the protection of ozone layer – 1985, Montreal protocol, protection and maintenance of ozone layer, Indian efforts for ozone layer protection. El-Nino and its effects, La-Nina, impact of climate change on India.	3
II		**Climate change - Impact**	**9**
	5	Impact of Climate Change in India: Pattern change of Rainfall, Drought, Effects on water resources, Sea Level Rise	3
	6	Impacts on Agriculture, impact on food security, impact on Health	2
	7	Impacts on Glacier, Impacts on energy security, Impacts on Biodiversity	2
	8	Climate change & disaster in India, Urban flood, Cyclone, Forest fire, Heat wave	2
III		**Environment Management**	**9**
	10	Energy Management - Conventional and non-conventional energy resources; renewable energy sources	2
	11	Energy recovery from wastes; bio-fuel; energy conservation and energy management; national energy policy	3
	12	Management of water resource - World water balance, conservation of freshwater resources; integrated water resource management; rainwater harvesting; watershed management	2
	13	Management of Soil and Land Resources - soil degradation and soil erosion; integrated strategies for soil conservation and regeneration	2
IV		**Mitigation and Adaptation Strategies for Climate Change**	**9**
	14	Mitigation and adaptation - Carbon storage and sequestration, carbon management through abiotic sequestration	2

	15	Carbon management through biotic sequestration, Soil carbon sequestration; Carbon farming and carbon trading	2
	16	Environmental policies and regulations	1
	17	Brundtland Commission, UN Environmental Agenda, role of U.N. agencies, World Environment Organization, climate change convention-1992, Earth Summit, Agenda 21, IPCC, Global Environment Facility	2
	18	Sustainable development and green technologies. Environmental ethics and social responsibility	2
V	**Practical/Theory (Open ended)**		**9**
	1. Case studies on environmental issues and climate change impacts		

Suggested Readings:

- George Philander. 2008. Encyclopedia of Global Warming and Climate Change, SAGE Publications Inc.
- Roger G. Barry, Richard J. Chorley. 2010. Atmosphere, Weather and Climate, CRC Press.
- John Houghton. 2009. Global Warming - The Complete Briefing, Cambridge University Press
- Pirot J.Y., Meynell P. J. & Elder D. 2000. Ecosystem Management: Lessons from Around the World. A Guide for Development and Conservation Practitioners. IUCN, Gland, Switzerland and Cambridge, UK.
- Jelte van Andel & James Aronson. 2006. Restoration ecology: the new frontier, Blackwell Publishing.
- Ravindranath N. H. & Jayant Sathaye. Climate change and developing countries.
- Sushil Kumar Dash. 2007. Climate Change - An Indian Perspective, Cambridge University Press India Pvt. Ltd.
- Pathak H., Aggarwal P.K., Singh S.D. Climate Change Impact, Adaptation and Mitigation in Agriculture: Methodology for Assessment

Mapping of COs with PSOs and POs:

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	-	-	-	-	1	-	-	-	-	-	-
CO2	3	3	3	-	-	-	3	-	-	-	2	3	-
CO3	3	3	3	-	-	-	3	-	-	-	2	3	-
CO4	3	3	3	-	-	-	3	-	-	-	2	3	-
CO5	3	3	3	-	-	-	3	-	-	-	2	1	1

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Exam/Discussion
- Assignment/ presentation/Project
- Project/Practical
- Final Exam

Mapping of COs to Assessment Rubrics :

	Quiz/ discussion	Presentation/ Assignment/Project	Theory/Practical Internal exam	End Semester Examinations
CO 1	✓		✓	✓
CO 2	✓	✓	✓	✓
CO 3	✓		✓	✓
CO 4	✓	✓		✓
CO 5		✓		✓

SKILL ENHANCEMENT COURSES

Programme	B. Sc BOTANY				
Course Title	**Herbal Technology**				
Type of Course	**SEC**				
Semester	**V**				
Academic Level	100-199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	3	3	-	-	45
Pre-requisites	-				
Course Summary	The skill enhancement course on herbal technology provides undergraduate students with the necessary knowledge and practical skills to explore the diverse applications of plants in various industries. Through a structured curriculum encompassing plant identification, extraction techniques, processing methods, and applications of herbal technology, students will be equipped to contribute to the growing field of herbal medicine, cosmetics, and other related sectors.				

Course Outcomes (COs) After completing the Course, the student should be able to:-

COs	Statement	Cognitive level *	Knowledge Category #	Evaluation Tools
CO1	Identify various medicinal plants and understand their botanical characteristics	U	C	Test/Lab test
CO2	Employ appropriate techniques for the collection, preservation, and sustainable harvesting of medicinal plants	Ap	C & P	Written test/Field work
CO3	Demonstrate proficiency in extraction and processing methods used in herbal technology	Ap	C & P	Practical Test/Written test
CO4	Apply quality control measures and adhere to regulatory standards in the production of herbal products	Ap	C & P	Quiz/Discussions
CO5	Utilize herbal technology for the formulation and production of herbal cosmetics, supplements, medicines, and pest control products	Ap	C & P	Group project
* - Remember I, Understand (U), Apply (Ap), Analyse (An), Evaluate I, Create I # - Factual Knowledge(F) Conceptual Knowledge I Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hours (36 + 9)
I	**Introduction to Herbal Technology**		**9**
	1	Introduction to Herbal Medicine	1
	2	Definition of herb, Classification of herbs-usage, active constituents, period of life, herbal medicine, Source of Herbs	3
	3	Selection, identification and authentication of herbal materials, Processing of herbal raw material	2
	4	Regulations and Standards in Herbal Industry, Plant based industries and institutions involved in work on medicinal and aromatic plants in India.	3
II	**Plant Identification, and Standardization of herbal products**		**9**
	5	Identification, Collection and Preservation of Medicinal Plants	2
	6	Importance of standardization, Problems involved in the standardization of herbs, Estimation of parameter limits used for standardization	3
	7	Standardization of herbal products-WHO guidelines for quality standardized herbal formulations	2
	8	Sustainable Harvesting Practices and Ethical Considerations in Plant Collection	2
III	**Extraction and Processing Methods**		**9**
	9	Extraction Techniques: Solvent Extraction, Steam Distillation, and Supercritical Fluid Extraction	2
	10	Processing of Medicinal Plants: Drying, Grinding, and Formulation	3
	11	Quality Control and Standardization of Herbal Products	2
	12	Packaging and Labelling Regulations	2
IV	**Applications of Herbal Technology**		**9**
	13	Herbal Cosmetics: Formulation and Production	3
	14	Herbal Supplements and Nutraceuticals	2
	15	Herbal Medicine: Preparation and Administration	2
	16	Entrepreneurship opportunities in Herbal Industry	2
V	**Open ended**		**9 hrs**
	1. Hands on training 2. Industry visit		

Suggested Readings

- Tyler V. E., Brady L. R., and Robber J. E. 1988. Textbook of Pharmacognosy. Lee & Febiger
- Kokate C. K., Purohit A. P. and Gokhale. 2007. Pharmacognosy. Nirali Prakashan

- Ansari S. H. Essential of Pharmacognosy
- Rangari V. D. Pharmacognosy & Phytochemistry by
- Council of Research in Indian Medicine & Homeopathy. Pharmacopeial standards for Ayurvedic Formulation
- Mukherjee, P.W. 2002. Quality Control of Herbal Drugs: An Approach to Evaluation of Botanicals. Business Horizons Publishers, New Delhi, India,
- Kokate C. K., and Gokhale A. S. Cultivation of Medicinal plants, Nirali Publication
- Kokate C. K. –Practical Pharmacognosy.‖ Vallabh Prakashan Delhi
- Clarke E. C. G, Isolation and Identification of drugs, The pharmaceutical Press, London
- Chaudhary R. D. Herbal Drug Industry
- Mukherjee P.V. Quality Control methods of Herbal Drugs

Mapping of COs with PSOs and POs:

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	1	1	-	-	-	3	-	-	-	2	-	-
CO2	2	3	1	-	-	1	-	-	1	-	3	1	1
CO3	1	1	2	1	3	-	1	-	3	-	2	1	2
CO4	1	1	2	1	3	-	1	-	3	-	2	1	2
CO5	1	1	2	1	3	-	1	-	3	-	2	1	2

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion
- Assignment/ Seminar
- Project/Practical
- Final Exam

Mapping of Cos to Assessment Rubrics :

	Internal Exam	Assignment/ Seminar	Practical/Project Evaluation	End Semester Examinations
CO 1	✓	✓	✓	✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5			✓	

Programme	B. Sc BOTANY				
Course Title	**Landscaping & Gardening**				
Type of Course	**SEC**				
Semester	**V**				
Academic Level	100-199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	3	3	-	-	45
Pre-requisites	-				
Course Summary	This course provides undergraduate students with practical skills and knowledge essential for successful landscaping and gardening. This course equips students with the necessary expertise to pursue careers in horticulture, landscaping, or agricultural extension services.				

Course Outcomes (COs) After completing the Course, the student should be able to:-

COs	**Statement**	**Cognitive level ***	**Knowledge Category #**	**Evaluation Tools**
CO1	Develop practical skills in planting, pruning, and maintaining various types of gardens and outdoor spaces	U	P	Lab Test
CO2	Identify common pests and diseases affecting plants and implement integrated pest management strategies for effective pest control in gardens and nurseries	Ap	C & P	Quiz/ Practical test/ Field work
CO3	Design and maintain gardens with an understanding of plant selection, landscape design principles, and seasonal gardening practices	C	P	Group Project
CO4	Equip with the knowledge and skills necessary to pursue a career in landscaping and gardening or to enhance their own outdoor living spaces	C	C & P	Self assessment/ Presentation
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hours (36 + 9)
I	**Fundamentals of Gardening**		**9**
	1	Introduction to Gardening: Objectives and Benefits	1
	2	Principles of Plant Selection and Landscape Design	3
	3	Soil Preparation and Management for Garden Beds	2
	4	Planting Techniques and Seasonal Gardening Practices	3
II	**Landscaping**		**9**
	5	Definition, Importance, Objectives, Factors affecting landscape planning	2
	6	Landscape design principles: Simplicity, Focal point, Balance, Proportion, Rhythm, Unity	3
	7	Xeriscaping, Streetscaping	2
	8	Urban planning, planting avenues	2
III	**Agronomy and Irrigation Techniques**		**9**
	9	Basic Agronomic Practices: Fertilization, Mulching, and Weed Control	3
	10	Principles of Irrigation Management: Watering Schedules and Techniques	2
	11	Sustainable Irrigation Practices: Drip Irrigation, Sprinkler Systems, and Rainwater Harvesting	3
	12	Soil Moisture Monitoring and Irrigation Scheduling	1
IV	**Introduction to Hydroponics**		**9**
	13	Introduction to Hydroponic Systems: Types and Components	2
	14	Nutrient Solutions and Formulations for Hydroponic Growing	1
	15	Fertigation Equipment and Application Methods	2
	16	Common Pests and Diseases in Gardens and Nurseries	2
	17	Integrated Pest Management (IPM) Strategies for Sustainable Pest Control	2
V	**Open ended (Suggestive list)**		**9 hrs**
	1. Hands on training 2. Garden visits		

Suggested Readings

- Butts E. and Stensson K. 2012. Sheridan Nurseries: One hundred years of People, and Plants. Dundurn Group Ltd.
- Russell, T. 2012. Nature Guide: Trees: The world in your hands (Nature Guides).
- Sudhir P. 2018. Landscape gardening. Scientific Publishers India.
- Gavino Merlo 2018. Floriculture and landscaping. Scitus Academics LLC.

- Percy Lancasters 2004. Gardening in India. Oxford & IBH publishers.
- Laeeq Futehally 2008. Gardens. National book trust India Publishers.
- Ekta Chaudhary 2022. Garden Up. Penguin Random House India publishers.
- Prathap Rao M 2020. Landscape Design. Standard Publishers and Distributors Pvt.
- Percy Lancasters 2008. Gardening in India. 2^{nd} Edition, Oxford & IBH publishers
- Kumar N. 1997. Introduction to Horticulture. Rajalakshmi Publications

Online Sources

- https://plantsciences.montana.edu/horticulture/ASHS_Teaching_MethodsWG/Landscape-Design/Vendrame_Basic%20Principles%20of%20Landscape%20Design.pdf
- https://www.egyankosh.ac.in/bitstream/123456789/73049/1/Unit-1.pdf
- https://www.agrimoon.com/wp-content/uploads/Principles-of-Landscape-Gardening.pdf

Mapping of COs with PSOs and POs:

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	-	-	2	1	-	3	-	-	3	-	2	-	3
CO2	-	-	2	1	-	3	-	-	3	-	2	-	3
CO3	1	3	2	-	3	1	1	2	3	-	1	2	3
CO4	1	1	-	-	2	1	-	-	3	-	1	1	3

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Presentation
- Assignment/ Field work
- Project/Practical
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment/ Field work	Practical/ Project Evaluation	End Semester Examinations
CO 1	✓	✓	✓	✓
CO 2	✓	✓	✓	✓
CO 3	✓	✓		✓
CO 4			✓	

Programme	B. Sc. BOTANY				
Course Title	**Phytochemical Techniques**				
Type of Course	**SEC**				
Semester	**VI**				
Academic Level	100-199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	3	3	-	-	45
Pre-requisites	-				
Course Summary	The skill enhancement course on Phytochemical Techniques for undergraduate students provides a basic understanding of phytochemistry's significance in drug development and natural product research. Students explore extraction techniques, fractionation, and identification methods, learning about different plant secondary metabolites and their roles in biological activities.				

Course Outcomes (COs): After completing the Course, the student should be able to:-

COs	Statement	Cognitive level *	Knowledge Category #	Evaluation Tools
CO1	Explain various extraction techniques and the principles behind each technique	U	C	Written exams/ Quiz Laboratory reports/Presentation
CO2	Demonstrate proficiency in fractionation methods, both physical and chemical, and chromatographic separation techniques	U	C & P	Practical assessments/ Presentation
CO3	Demonstrate skills in qualitative phytochemical screening	U	C & P	Laboratory practical exams
CO4	Evaluate the biological activities of phytochemicals, including antimicrobial, anti-inflammatory, anti-cancer, and toxicity	E	C & P	Research projects/Literature reviews

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
\# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (36 + 9)
I		**Introduction to Phytochemistry**	**9**
	1	Importance and applications of phytochemical analysis and Classes of plant secondary metabolites	2
	2	Role of phytochemicals in drug development and natural product research	2
	3	Extraction Techniques: Solvent selection - importance, factors to be considered	1
	4	Different extraction methods: maceration, digestion, decoction, infusion, percolation, Soxhlet extraction, superficial extraction, ultrasound-assisted, and microwave-assisted extractions	4
II		**Fractionation and Identification**	**9**
	5	Fractionation - Principle and methods (Physical and Chemical methods)	2
	6	Chromatographic separation - Mechanism and methods of Paper chromatography, Thin Layer Chromatography, and Column Chromatography	3
	7	Principle, Mechanism and applications of HPLC, HPTLC	2
	8	Identification of compounds by UV Spectrum, IR Spectrum, NMR, GC-MS, and LC-MS	2
III		**Qualitative and quantitative phytochemical analysis**	**9**
	9	Qualitative Phytochemical Screening: Detection of different classes of Phytoconstituents by test tube methods	2
	10	Quantification of primary and secondary metabolites: Principle and methods of Spectroscopic analysis (Total sugar, Total protein, Phenol)	3
	11	Extraction of essential oil - Principle and Methods	2
	12	Identification of essential oil constituents by GC-MS	2
IV		**Bioassays**	**9**
	13	Antimicrobial Studies - Principle and methods	3
	14	Anti-inflammatory studies (In vitro and in vivo) - Principle and methods	2
	15	Anti-cancer studies (In vitro and in vivo) - Principle and methods	2
	16	Toxicity studies (In vitro and in vivo) - Principle and methods	2
V		**Open ended**	**9**
		1. Hands on training 2. Phytochemistry Lab visit	

Suggested Readings

- Raaman N. 2006. Phytochemical Techniques. New India Publishing Agency
- Harborne A. J. 1998. Phytochemical Methods A Guide to Modern Techniques of Plant Analysis. Springer Dordrecht
- Fischer, Nikolaus H., Isman, Murray B., Stafford, Helen A. (Eds.). 2020. Modern Phytochemical Methods. Dattani Book Agency

- Deepa P. and Trupti P. S. 2019. Phytochemicals - Extraction, Separation & Analysis Techniques. Global Education Limited
- Egbunu C., Ifemeje J. C., Maryann C. M., Kumar S. 2018. Phytochemistry. Apple Academic Press.

Online resources

- https://www.arcjournals.org/pdfs/ijarcs/v2-i4/5.pdf
- https://ijbpas.com/pdf/2021/August/MS_IJBPAS_2021_5593.pdf
- https://www.essencejournal.com/pdf/2017/vol5issue2/PartA/5-31-491.pdf
- https://www.pharmacy.dypvp.edu.in/pharmaceutical-resonance/downloads/original-research-articles/Volume-5-Issue-1/3.pdf
- https://ijariie.com/AdminUploadPdf/A_Guide_To_Phytochemical_Analysis_ijariie9430.pdf

Mapping of COs with PSOs and POs:

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	-	2	1	3	1	-	-	2	-	2	-	2
CO2	3	-	2	1	3	1	-	-	2	-	2	-	2
CO3	3	-	2	1	3	1	-	-	2	-	2	-	2
CO4	3	-	2	3	3	1	-	-	2	-	2	-	2

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion
- Assignment/ Seminar
- Project/Practical
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment/Seminar	Practical/Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓	✓	✓
CO 3	✓	✓	✓	✓
CO 4		✓	✓	

Programme	B. Sc BOTANY				
Course Title	**Essential Oil & Perfumery**				
Type of Course	**SEC**				
Semester	**VI**				
Academic Level	100-199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	3	3	-	-	45
Pre-requisites	-				
Course Summary	The Essential Oil and Perfumery course offers a comprehensive understanding of the principles and practices involved in creating fragrances and extracting essential oils from natural sources. Through theoretical knowledge and hands-on experience, students learn the intricate art of blending scents and harnessing the therapeutic properties of essential oils for various applications.				

Course Outcomes (COs): After completing the Course, the student should be able to:-

COs	Statement	Cognitive level *	Knowledge Category #	Evaluation Tools
CO1	Recall the names and characteristics of various fragrance families	R	F	Quiz/Written Test
CO2	Demonstrate proficiency in perfume formulation techniques and fragrance composition	U	C	Lab sessions
CO3	Apply aromatherapy principles for therapeutic purposes in perfumery	Ap	C & P	Presentation/ Assignments
CO4	Evaluate fragrance formulations for their market suitability and adherence to regulatory standards	E	C & P	Research projects analyzing market trends
CO5	Design innovative fragrance formulations tailored to specific market demands and consumer preferences	Create	C & P	Group projects

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (36 + 9)
I	**Introduction to Perfumery and Essential Oil Technology**		**9**
	1	Introduction to perfumery and essential oils, History and evolution of perfumery	3
	2	Factors Influencing Essential Oil Quality: Plant variety, Growth Conditions, and Harvesting Techniques	3
	3	Quality control and assurance in perfumery, Regulatory aspects in the fragrance industry	3
II	**Chemistry of Fragrance**		**9**
	4	Chemical composition of essential oils	1
	5	Aroma chemistry: understanding fragrance molecules	2
	6	Fragrance Families and Classification: Floral, Oriental, Woody, and Citrus	2
	7	Odour classification and sensory evaluation	2
	8	Chemical analysis techniques in perfumery	2
III	**Essential Oil Production and Processing**		**9**
	9	Principal perfume and oil plants	1
	10	Extraction techniques: steam distillation, solvent extraction, enfleurage, etc	3
	11	Carrier oils: for diluting, carrying and delivering essential oils	1
	12	Post-extraction processing and refinement	2
	13	Some major essential oils and their applications; Aromatherapy- Benefits and risks	2
IV	**Perfume Formulation and Evaluation**		**9**
	15	Basics of perfume formulation	2
	16	Blending techniques and fragrance creation	2
	17	Factors influencing scent perception, Perfume stability and shelf-life	2
	18	Packaging Design and Branding Strategies	2
	19	Market analysis and consumer preferences	1
V	**Open ended (Suggestive List)**		**9**
	1. Internship: Training at fragrance companies or essential oil distilleries to gain hands-on experience in the field. 2. Industry visits: visit perfume manufacturing facilities and essential oil production units to gain practical insights. 3. Perfume formulation workshop: to create own fragrances under the guidance of industry professionals.		

Suggested readings:

- Dove R. 2018. The Essence of Perfume. Black Dog Publishing. United Kingdom.
- Tisserand R. & Young, R. 2013. Essential Oil Safety: A Guide for Health Care Professionals. Churchill Livingstone. United Kingdom.
- Rowe D. 2005. Chemistry and Technology of Flavours and Fragrances. Blackwell Publishing. United States.
- Sell C. S. 2006. Fragrance Chemistry: The Science of the Sense of Smell. Royal Society of Chemistry. United Kingdom.
- Rhind J. P. 2012. Essential Oils: A Comprehensive Handbook for Aromatic Therapy. Singing Dragon. United Kingdom.
- Rostagno M. A. & Prado, J. M. (Eds.). 2016. Essential Oil Extraction: Methods, Techniques, and Applications. CRC Press. United States.
- Calkin R. R. & Jellinek J. S. 1994. Perfumery: Practice and Principles. Wiley. United States.
- Sell C. S. (Ed.). 2006. The Chemistry of Fragrances: From Perfumer to Consumer. Royal Society of Chemistry. United Kingdom.

Mapping of COs with PSOs and POs:

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	1	-	-	-	1	-	-	-	1	-	-
CO2	2	1	2	1	3	3	1	-	3	-	1	-	3
CO3	2	1	2	1	3	3	1	-	3	-	1	-	3
CO4	2	1	2	1	3	3	1	-	3	-	1	-	3
CO5	2	1	2	1	3	3	1	-	3	-	1	-	3

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion
- Assignment/ Seminar
- Project/Practical
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment/ Seminar	Practical/Project Evaluation	End Semester Examinations
CO 1	✓		✓	✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4		✓	✓	
CO 5			✓	

Programme	B. Sc. BOTANY				
Course Title	**Seaweed Farming**				
Type of Course	**SEC**				
Semester	**VI**				
Academic Level	100-199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	3	3	-		45
Pre-requisites	Nil				
Course Summary	The Seaweed Farming course provides an overview of the principles and practices involved in cultivating seaweed for various purposes. The course aims to equip students with the knowledge and skills needed to contribute to the growing seaweed farming industry and promote sustainable marine resource management.				

Course Outcomes (COs) After completing the Course, the student should be able to:-

COs	**Statement**	**Cognitive level***	**Knowledge Category#**	**Evaluation Tools**
CO1	Demonstrate the knowledge of the different types of seaweed species and their cultivation requirements	U	F	Written Test/Lab practical
CO2	Analyse the importance of physico-chemical parameters in seaweeds	An	C	Written Test
CO3	Apply various farming techniques and best practices for seaweed cultivation, such as selecting suitable cultivation sites and managing pests	Ap	C & P	Practical Test/Quiz/Group discussion
CO4	Evaluate the economic viability of seaweed farming and develop a business plan for a seaweed farming operation	C	C & P	Literature survey/Project plan
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Module	Unit	Content	Hrs (36 + 9)
1		**Introduction**	**8**
	1	Seaweed morphology; Classification and distribution of seaweeds	2
	2	Life cycle of seaweeds.	2
	3	Identification of cultivable seaweeds	2
	4	Global status - Present trend and scope in India and Kerala	2
II		**Seaweed cultivation**	**12**
	5	Seaweed spore collection, Site selection - Physico - chemical parameters, site preparation	3
	6	Farming methods - Construction specifications for cultivable species	2
	7	Bamboo Raft, Monoline, Tube net methods	2
	8	Seaweed Cultivation period; Disease management, Farm management, harvesting method	3
	9	Post-harvest technology, preservation of seaweeds	2
III		**Seaweed Byproducts**	**10**
	10	Phycocolloids - Agar, agarose, carrageenan, Algin -sources and use	2
	11	Seaweed as food - Porphyra, Laminaria, Monostroma, Enteromorpha, Caulerpa etc.	3
	12	Nutritional composition of edible seaweeds	1
	13	Seaweed Compost, Seaweed liquid fertilizer, Agricultural biostimulants, Animal fodder	2
	14	Seaweeds as Pharmaceuticals and cosmetics	2
IV		**Seaweed in Blue economy**	**6**
	15	Seaweed resources of Kerala coast and its economic potential	2
	16	Seaweed based industries in India, PMSSY in seaweeds, CSMCRI - Subsidy for seaweed farming, seaweed cultivation as livelihood.	2
	17	Current trends and Prospects of Seaweed Farming in India	2
V		**Open Ended (Suggestive list)**	**9**
	Visit to a seaweed farming centre		

Suggested Readings

- John B. 2023. Seaweeds of the World: A Guide to Every Order. Princeton University Press
- Leonel P. 2016. Edible seaweeds of the world Taylor & Francis
- Leonel P., Kiril, B., and Joshi N. H. (eds) 2019. Seaweeds as Plant Fertilizer, Agricultural Biostimulants and Animal Fodder. CRC Press
- Ole G. Mouritsen, Jonas Drotner Mouritsen, Mariela Johansen 2013. Seaweeds: Edible, Available, and Sustainable 3rd edition. University Of Chicago Press 304pp.

Online Sources

- http://eprints.cmfri.org.in/7537/1/565
- http://masujournal.org/107/S.K._YADAV.pdf
- http://eprints.cmfri.org.in/10671/1/12.%20Gulshad.pdf

- https://epubs.icar.org.in/index.php/IndFarm/article/download/136580/52191/383295
- https://naas.org.in/Policy%20Papers/policy%2022.pdf
- https://nph.onlinelibrary.wiley.com/doi/epdf/10.1111/nph.13278
- https://dof.gov.in/sites/default/files/2020-07/Seaweed_Cultivation.pdf
- https://repository.oceanbestpractices.org/handle/11329/1282
- https://www.fao.org/4/y4765e/y4765e0b.htm
- https://www.fao.org/4/y4765e/y4765e0b.htm
- https://egyankosh.ac.in/bitstream/123456789/9949/1/Unit%204.pdf
- http://eprints.cmfri.org.in/7612/1/628SDMRI_Research_Publication___Kaliaperumal_2003.Pdf
- http://eprints.cmfri.org.in/17847/1/AARDO_2023_Johnson%20B.pdf

Mapping of COs with PSOs and POs:

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	1	1	2	2	1	2	1	-	2	-	2	-	-
CO2	1	1	2	2	1	2	1	-	2	-	2	-	-
CO3	1	1	2	2	1	2	1	-	2	-	2	3	3
CO4	1	1	2	2	1	2	1	-	2	-	2	3	3

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Discussion
- Assignment/ Seminar
- Project/Practical
- Final Exam

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment/ Seminar	Practical/Project Evaluation	End Semester Examinations
CO 1	✓		✓	✓
CO 2	✓	✓		✓
CO 3	✓	✓	✓	✓
CO 4			✓	

LIST OF ONLINE COURSES

https://onlinecourses.swayam2.ac.in/nou24_es11/preview
https://onlinecourses.swayam2.ac.in/nou24_es12/preview
https://onlinecourses.swayam2.ac.in/nou24_es07/preview
https://nptel.ac.in/courses/102101007
https://nptel.ac.in/courses/102103012
https://nptel.ac.in/courses/102103016
https://nptel.ac.in/courses/102103013
https://onlinecourses.swayam2.ac.in/cec24_bt21/preview
https://onlinecourses.nptel.ac.in/noc19_bt20/preview

MODEL QUESTION PAPERS

I Semester B.Sc. (CUFYUGP) Degree Examinations

AESTHETIC BOTANY

(Credits: 4)

Maximum Time: 2 hours **Maximum Marks: 70**

Section A

[Answer All. Each question carries 3 marks] (Ceiling: 24 Marks)

1. Define the term "Aesthetic botany" and explain its significance
2. Define microphotography and macrophotography and explain their significance in botany
3. What is bio pesticides? Give two examples
4. Define potting and discuss its importance in plant care and cultivation
5. What is Aquascaping?
6. Give an account of Ikebana type floral arrangement
7. What are the key factors to consider when selecting plants for indoor gardening?
8. List out the precaution to be taken to avoid pest and diseases in plants
9. What is digital documentation of plants
10. What is bonsai, and how does it differ from traditional gardening?

Section B

[Answer All. Each question carries 6 marks] (Ceiling: 36 Marks)

11. Explain the principles of design in landscaping and how they can be applied to create aesthetically pleasing outdoor gardens.
12. Mention a few garden tools and their uses.
13. Discuss the concept of symmetry in botany. Provide examples of plants with symmetrical features and explain their significance in aesthetics
14. Explain the benefits of using hydroponic systems for indoor gardening and outline the basic components of a hydroponic setup.
15. Compare and contrast drip irrigation and sprinkler irrigation systems, including their advantages and disadvantages.
16. Discuss the role of botanical illustration in scientific research, education, and conservation
17. Explain different types of Plant propagating structures
18. Explain the process of Botanical printing

Section C

[Answer any one. Each question carries 10 marks] (1x10=10marks)

19. Explain the various elements of a garden
20. Explain various plant propagation methods

II Semester B.Sc. (CUFYUGP) Degree Examinations
Microbial Diversity and Phytopathology
(Credits: 4)

Maximum Time: 2 hours **Maximum Marks: 70**

Section A

[Answer All. Each question carries 3 marks] (Ceiling: 24 Marks)

1. Explain the phases represented by the S-curve in bacterial population growth.
2. What are the distinctive features of Mycoplasma, and how does the absence of a cell wall impact its structure and function?
3. Discuss the key characteristics, spread, and global impact of viral outbreaks with special focus on COVID -19.
4. Define glycocalyx and briefly explain its role in bacterial physiology.
5. Detail three asexual methods of reproduction employed by bacteria.
6. Explain the processes involved in bacterial conjugation, emphasizing the role of plasmids.
7. Explain the importance of Plant Growth Promoting Bacteria (PGPB) in agriculture
8. Explain the concept of probiotics and their role in microbial therapeutics.
9. Discuss the key aspects of Quick Wilt disease in pepper plants, including its symptoms and effective management strategies.
10. Assess the role of viruses in Genetic Engineering.

Section B

[Answer All. Each question carries 6 marks] (Ceiling: 36 Marks)

11. Explain the role of Microbiome in microbial therapeutics.
12. Write on the importance of Bacteria in industrial fermentation
13. What are the importance of Antibiotics. Give two examples with their source.
14. What is the significance of cell wall in bacteria. Explain with reference to Gram staining.
15. Write any two viral plant diseases. Its causative agent, symptoms and management.
16. What are Phytoalexins. Explain its importance
17. What are the different methods of preparation of bacterial pure culture
18. Write on Biological disease management. Give two examples

Section C

[Answer any one. Each question carries 10 marks] (1x10=10 marks)

19. Give a detailed account on morphology and structure of Bacteria with illustration. Give its medical importance.
20. Explain defense strategies in Plants to pathogens and write on host pathogen interaction.