

DEPARTMENT OF BOTANY

SYLLABUS FOR FOUR YEAR UNDERGRADUATE PROGRAMME (FYUGP) (FIRST- EIGHT SEMESTER)

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ARYA VIDYAPEETH COLLEGE (AUTONOMOUS)
ARYA NAGAR, GUWAHATI – 16

CONTENT

Serial No	Content Name	Page No.
1	Preface	1
2	Structure of Four Year Undergraduate Course	2
3	Semester Wise Credit Distribution	3
4	Graduate Attributes	4
5	Undergraduate Programme Outcome	6
6	Core Syllabus	9
7	Minor Syllabus	95
8	Skill Enhancement Course (SEC) Syllabus	123
9	Interdisciplinary Course (IDC) Syllabus	134
10	Certificate Course on Mushroom Production Technology	143

PREFACE

“Education is not preparation for life; education is life itself.”— John Dewey

The aim of imparting education is not only to increase the knowledge but also to create the possibilities for a student to invent and discover. The purpose of this syllabus is to establish minimum basic concepts for each course to meet the needs of all our students. All the elements in this syllabus amalgamate to bring out the best in every student and enable them to be on the path of continuous progress.

The syllabus is framed based on Learning Outcome Based Education (LOCF) –the spirit of NEP, 2020. The programmes offered by the college are :

- i. Bachelor Degree in Arts
- ii. Bachelor Degree in Science
- iii. Bachelor Degree in Commerce

Under the above programme, the following courses are offered by the college:

- i. Core Course
- ii. Minor Course
- iii. Skill Enhancement Course
- iv. Interdisciplinary Course
- v. Ability Enhancement Course
- vi. Value Added Course
- vii. Internship

Programme outcome of each programme and Programme Specific Outcomes of each discipline/subject offered by the college is mapped with course learning outcome of each course. Graduate attributes of students obtaining Undergraduate Degree from the college are also incorporated in the syllabus.

The syllabus includes eight semesters where there will be 23 Core Courses, 8 Minor Courses, 2 Value Added Courses, 3 SEC Courses, 3 IDC Courses, 4 AEC courses and internship. The total credit offered for eight semesters is 160.

The syllabus framed takes into account the different styles of learning – audio, visual and experiential. The syllabus correlates academics to real life situations balancing social and emotional stimulation among the students and imbibe human values. Also the syllabus gives the opportunity for the theoretical knowledge to be pursued ensuring maximum application of it.

Structure of Four Year Undergraduate Course

Semester	Type	Core	Minor	SEC	IDC	AEC	VAC/FC	IN
	Credit	4	4	3	3	2	4(2 + 2)	2
I		CE-1114	MN-1114	SE-1113	ID-1113	AE-1112	VL-1112 (Two Courses)	-
II		CE-2114	MN-2114	SE-2113	ID-2113	AE-2112	VL-2112 (Two Courses)	-
III	CE-3214	MN-3214	SE-3213	ID-3213	AE-3212	-	-	-
	CE-3224							
IV	CE-4214	MN-4214	-	-	AE-4212	-	-	IN-4212
	CE-4224							
	CE-4234							
V	CE-5314	MN-5214	-	-	-	-	-	-
	CE-5324							
	CE-5334							
	CE-5344							
VI	CE-6314	MN-6214	-	-	-	-	-	-
	CE-6324							
	CE-6334							
	CE-6344							
VII	CE-7414*	MN-7314	-	-	-	-	-	-
	CE-7424**							
	CE-7434**							
	CE-7444**							
VIII	CE-7454**	MN-8314	-	-	-	-	-	-
	CE-8414 [#]							
	CE-8424 [#]							
	CE-8434 [#]							

*Compulsory for all students in the 7th semester.

**Students are required to choose any three courses from the remaining four core courses in the 7th semesters.

Students who wish to pursue a Bachelor Degree with Honours must choose any four of the five core courses in the 8th semester.

NOTE: Students who secure a minimum of 7.5 CGPA at the end of the 6th semester (without any arrears) may opt for a Bachelor Degree with Honours and Research. Those students shall have to choose one core course out of the given five courses in the 8th semester and have to complete a Research Dissertation of 12 credits.

Course code: First two letters is the abbreviation of course component

First digit implies semester number

Second digit implies course level

Third digit implies course

Fourth digit implies credit points per course.

Digit	Course Level
1	100 - 199
2	200 - 299
3	300 - 399
4	400 - 499

Semester Wise Credit Distribution

Semester	CREDIT DISTRIBUTION							
	CORE	MINOR	SEC	AEC	IDC	VAC/FC	IN	TOTAL
FIRST	1 x 4	1 x 4	1 x 3	1 x 2	1 x 3	2x 2	--	20
SECOND	1 x 4	1 x 4	1 x 3	1 x 2	1 x 3	2x 2	--	20
THIRD	2x 4	1 x 4	1 x 3	1 x 2	1 x 3	--	--	20
FOURTH	3x 4	1 x 4	--	1 x 2	--	--	1 x 2	20
FIFTH	4x 4	1 x 4	--	--	--	--	--	20
SIXTH	4x 4	1 x 4	--	--	--	--	--	20
SEVENTH	4x 4	1 x 4	--	--	--	--	--	20
EIGHT	4x 4	1 x 4	--	--	--	--	--	20

SEC: SKILL ENHANCEMENT COURSE

AEC: ABILITY ENHANCEMENT COURSE

IDC: INTERDISCIPLINARY COURSE

VAC/FC: VALUE ADDED COURSE

IN: INTERNSHIP

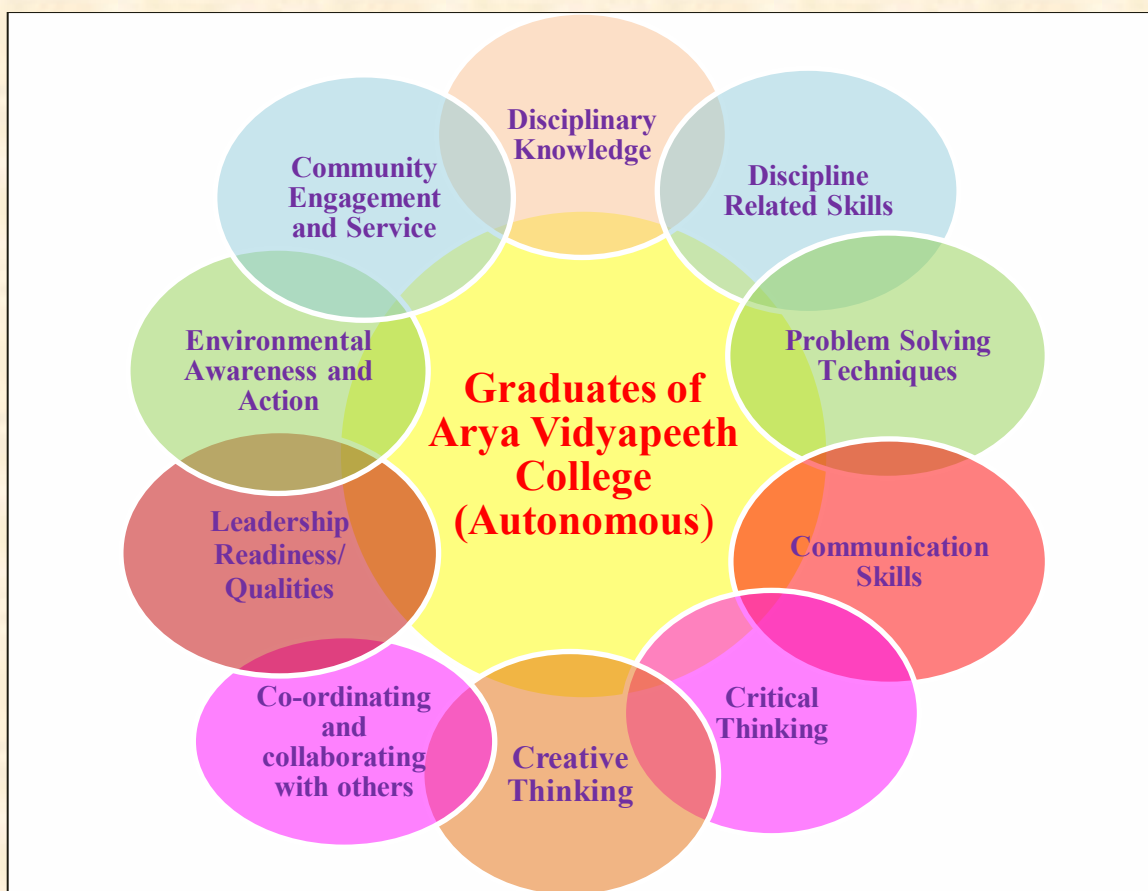
Abbreviation of Course Components:

CE (Core), MN (Minor), SE(Skill Enhancement Course), AE (Ability Enhancement Course), VL (Value added Course), ID (Interdisciplinary Course), IN (Internship)

GRADUATE ATTRIBUTES

Graduate Attributes:

Graduate Attributes are the qualities, skills and understandings that the students should develop during their time with the college. These attributes consequently shape the contribution they are able to make to their profession and society. They are the qualities that also prepare graduates as agents of social good in an unknown future. These attributes sets them apart from those without a degree. The graduate attributes of Arya Vidyapeeth College (Autonomous) are:



Model of Graduate Attributes

1. **Disciplinary knowledge:** Graduates shall acquire comprehensive knowledge and understanding of their subject area, the ability to engage with different traditions of thought, and the ability to apply their knowledge in practice including in multi-disciplinary or multi-professional contexts.
2. **Discipline related skills:** Skills in areas related to specialization in the chosen disciplinary/interdisciplinary/major/minor area(s) of learning in a broad multidisciplinary context. In addition create, select, and apply appropriate modern techniques, resources and IT tools.
3. **Problem solving skills:** A capacity for problem identification, the collection of evidence, synthesis and dispassionate analysis and apply one's learning in real – life situations.

4. **Communication Skills:** Ability to recognize and value communication as the tool for negotiating and creating new understanding, collaborating with others, and furthering their own learning.
5. **Critical Thinking:** Graduates acquire the capacity for problem identification, collection of evidence, synthesis and dispassionate analysis. They also acquire the capacity for attentive exchange, informed argument and reasoning.
6. **Creative Thinking:** The graduates acquire an ability to create, perform or think in different and diverse ways about the same objects or scenarios and also the ability to communicate effectively for different purposes and in different contexts. They should also be able to work independently and as part of a team.
7. **Co-ordinating and collaborating with others:** The graduates need to possess the ability to function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. They should also be able to work productively with others, no matter their culture, perspective or background, and complete joint projects and also to work in partnership.
8. **Leadership readiness/qualities:** The graduates should be able to lead and support others by inspiring them with a clear vision and motivating them to achieve goals. They also need to acquire ability to map out the tasks of a team or an organization and setting directions.
9. **Environmental Awareness and action:** The graduates shall earn the capacity to realize the individual's responsibility in protecting and conserving the environment. They need to gain the capacity to understand the impact of the professional solutions in societal and environmental contexts, and demonstrate the knowledge of need for sustainable development.
10. **Community engagement and service:** The graduates need to develop an understanding of social and civic responsibilities, and of the rights of individuals and groups. The graduates should be able to demonstrate the capability to participate in community-engaged services/ activities for promoting the wellbeing of the society which includes participation in NSS,NCC, adult literacy etc.

UNDERGRADUATE PROGRAMME OUTCOME (PO)

BACHELOR DEGREE IN SCIENCE: (B.Sc.)

1. **SPO-1 Knowledge:** Learners are encouraged to apply the knowledge of mathematics and science fundamentals to various solutions of complex problems. As such, knowledge of the subject is the sole objective of any student learner. A student is exposed to a wide range of topics in various subjects and is given intensive training in each of the courses that have laboratory related work. The learner is encouraged to use various mathematical methods (analytical and numerical) and experimental methods as an application to the acquired concepts and principles that help in studying various branches of sciences. At the end of the program, students are able to gain thorough knowledge in key areas in the subjects offered.
2. **SPO-2 Problem Analyses:** Well equipped with an understanding of the analytical methods involved, they are in a position to interpret and analyze results so obtained from experiments and draw suitable conclusions against their supported data acquired. At the end of the program, students will be able to identify, formulate and analyze scientific problems and reach concrete solutions using various principles of mathematics and sciences.
3. **SPO-3 Designing Solutions:** Having acquired knowledge of subjects, students are trained to think out of the box, design and conduct an experiment or a series of experiments that demonstrate their understanding of the methods and processes involved.
4. **SPO-4 Modern tool usage:** Learners are trained to create, select, and apply appropriate techniques, resources and IT tools in the analysis and synthesis of data within limitations. (Outcome of final year project).
5. **SPO-5 Effective Communication:** Proficiency in speaking, reading, writing and listening in English and one Indian language and find meaning of the world by connecting people, ideas, books, media and technology.
6. **SPO-6 Employability:** This programme enables the learners to perform the jobs in diverse fields such as science, engineering, industries, survey, education, banking, development-planning, business, public service, self business etc. efficiently. They will also be able to appear for competitive examinations
7. **SPO-7 Ethics:** While it is necessary to instil the spirit of competitiveness among students in a world of increasing competition, it is equally vital to develop a strong sense of ethics among learners that will help them develop some positive attitudes and values. This includes appreciation of the various principles and theories that evolved in science, the impact that science has on social, economical and environmental issues. One of the main objectives of any academic

exercise, therefore, should be to produce well-groomed individuals who understand the significance of ethical values and abide by them even in the most pressing circumstances. In this programme, this process is enabled through courses and facilitators who integrate the teaching of ethics in everyday pedagogy. As such, at the end of this programme students will be able to develop, internalise and exercise ethics in their professional as well as personal practices.

8. **SPO-8 Environment and Sustainability:** ‘Environmental sustainability’ has become the watchword of the 21st century. An increased engagement with environment related concerns is appearing tangibly on global fronts; academics cannot and should not remain quarantined from this massive development. Through classroom discussions and research projects, this programme facilitates active dialogues with factors which influence human-ecology interactions. As such, at the end of this programme students will be able to identify and analyze socio-political, cultural and economic problems which act as deterrents to environmental sustainability and provide creative solutions towards the same.
9. **SPO-9 Soft-Skill Development:** Apart from the attainment of knowledge and hands-on skills in practical applicability of the subject, learners need to be equipped with soft-skills and values which will help them function effectively as an individual, and as a member or leader in diverse teams and in multidisciplinary groups. These soft skills include leadership, teamwork, project-management, positive outlook, innovative approaches and effective articulation. Several soft skill programs are organized for learners through various agencies that tie up with the state government. As such, at the end of this programme, students will be able to hone the soft-skills required in positively enhancing their academic, professional and personal pursuits towards self and societal advancement.
10. **SPO-10 Science and Society:** The learners are encouraged to apply logical reasoning based on the knowledge, skills, designing solutions to assess societal, health, safety issues and the responsibilities that go along with the scientific practice. As an extension activity to society, learners are encouraged to take up specific projects such as impact of salinity on fresh water wells in an adopted village, and provide effective solutions.
11. **SPO-11 Life-long learning:** With the pursuit of knowledge for either personal or professional reasons, learners are also encouraged to volunteer and be self-motivated that not only enhances society values, active participation and personality development, but also enhances self-sustainability, competitiveness and employability. As such, learners will be able to recognize the need for, and have the preparation and ability to engage in independent and life-long learning in every broad context of technological changes.

CORE

LIST OF COURSES:

Semester	Course Name	Course Code
1	Biodiversity (Microbes, Algae, Fungi and Archegoniate)	BT – CE – 1114
2	Plant Ecology and Taxonomy	BT – CE – 2114
3	Applied Mycology and Plant Pathology	BT – CE – 3214
	Biomolecules and Cell Biology	BT – CE – 3224
4	Morphology, Anatomy of Angiosperms and Embryology	BT – CE – 4214
	Advances in Plant Systematics	BT – CE – 4224
	Plant Physiology	BT – CE – 4234
5	Plant Metabolism and Biochemistry	BT – CE – 5314
	Classical Genetics and Plant Breeding	BT – CE – 5324
	Phylogenomic and Paleobotany	BT – CE – 5334
	Application of Plant Ecology and Environment	BT – CE – 5344
6	Advanced Microbiology	BT – CE – 6314
	Molecular Biology and Biotechnology	BT – CE – 6324
	Natural Resources Management	BT – CE – 6334
	Recent Trends in Plant Sciences OR Dissertation	BT – CE – 6344

7	Research Methodology	BT – CE – 7414
	Microbiology and Plant Pathology	BT – CE – 7424
	Lower Cryptogams (Algae and Fungi)	BT – CE – 7434
	Higher Cryptogams and Lower Phenerogams	BT – CE – 7444
	Advanced Plant Systematics	BT – CE – 7454
8	Plant Physiology and Biochemistry	BT – CE – 8414
	Plant Ecology and Resource Management	BT – CE – 8424
	Molecular Biology	BT – CE – 8434
	Cytogenetics and Plant Breeding	BT – CE – 8444
	Biodiversity Conservation and Traditional Knowledge	BT – CE – 8454

Programme Specific Outcomes of Bachelor of Science – Botany Core (PSO)

PSO No.	Name	Outcome
PSO-1	Importance of plants and their functions (BTL: Remember, Understanding)	To develop a conceptual understanding of principles and importance of Botany. Students will be able to understand and explain different specializations of Botany such as systematics, evolution, ecology, developmental biology, physiology, biochemistry, plant interactions with microbes and insects, morphology, anatomy, reproduction, genetics, cell and molecular biology of plants.
PSO-2	Laboratory Skills (BTL: Application, Evaluate)	Acquire practical skills in laboratory settings, including microscopy, experimental design, and data analysis. Students are also familiarized with the use of bioinformatics tools and databases and in the application of statistics to biological data. Students will be trained in various analytical techniques of plant biology, use of plants as industrial resources or as support system for human livelihood and will be well versed with the use of transgenic technologies for both basic and applied research in plants.
PSO-3	Development of Research Mindset (BTL: Create)	Plan and execute field investigation, collect, analyze and interpret data using appropriate methods including appropriate IT and accurately report the findings of the field investigation. The will be able to identify and analyze various issues prevailing in the societies, like, socio-political, socio-economic, socio-religious, ethnic issues, health issues in bio-cultural context, ethno botanical, ethno medicine, environmental issues, etc.
PSO-4	Applied Botany (BTL: Apply)	Demonstrate a thorough understanding of the human past with special emphasis on prehistoric and proto historic phase of the past and documentation of prehistoric implements for collection and preservation in museums.
PSO-5	Critical Thinking and Problem-Solving (BTL: Analyse)	Have gained the skill to formulate, analyse and document the outcomes of both biological and socio-cultural aspects of the subject through assignments and project work. Have proficiency in connecting with different communities according to their culture.
PSO-6	Communication Skills (BTL: Apply)	Be motivated for further higher studies and research in different sub-disciplines of anthropology.
PSO-7	Ethical and Professional Standards (BTL: Evaluate)	Cultivate ethical values and professional standards in scientific research, respecting intellectual property rights and promoting responsible conduct in the field of botany. To understand patterns of heredity and variation among individuals, species and populations and apply principles for improvement of quality and yield.
PSO-8	Closeness with nature (BTL: Evaluate)	Students will be eligible in diverse fields in research organization, government services, education sector, human resources, public services, hospitality, industries, corporate sectors, entrepreneur, business, tourism industry, media and Non-Governmental organization.
PSO-9	Continuous Learning (BTL: Create)	The primary ethics of the subject is to ensure appreciation of human diversity and it helps to analyze critically the issues that are relevant in contemporary society.

Course Learning Outcome (CLO) – Core

Semester	Course Name & Code	Course Learning Outcome(CLO)	
1	Biodiversity (Microbes, Algae, Fungi and Archegoniate) BT – CE – 1114	CLO - 1	Combination of theoretical and practical components of this course will provide comprehensive information and insight into the fascinating world of microbes and plants.
		CLO - 2	Hand on training will help students learn use of the microscope, mounting, section cutting and staining techniques for the study of plant materials.
		CLO - 3	Making drawing in practical records will enhance understanding morphology and structural details and related functional aspects in diverse plant groups.
		CLO - 4	This paper is both informative and interesting and will enable student to learn about biodiversity not only as plant or nature lover but also for higher academic pursuits, particularly in the field of biological sciences, environment and biodiversity conservation. .
2	Plant Ecology and Taxonomy BT – CE – 2114	CLO - 1	Student would have understanding of various ecological parameters of plant in nature pertaining to influencing ecological factors and their analysis of practical data on individual, population, community and ecosystem level along with their relationships.
		CLO - 2	Student also would have understanding about basic knowledge of plant taxonomy with the modern taxonomic approaches.
		CLO - 3	Practical knowledge of the course material will develop the skill of identification and classification of plant diversity and characterization of angiospermic families along with their phyto geographical analysis.
3	Applied Mycology and Plant Pathology BT – CE – 3214	CLO - 1	Understanding the practical application of Mycology in Biotechnology and its impact on day- today life
		CLO - 2	Proficiently recognize and classify plant diseases caused by various pathogens, including fungi, bacteria, viruses, and nematodes.

3	Applied Mycology and Plant Pathology BT – CE – 3214	CLO - 3	Understanding the biology, lifecycle, and interactions of plant pathogens to develop targeted and sustainable disease control measures.
	Applied Mycology and Plant Pathology BT – CE – 3214	CLO - 4	Apply knowledge to integrate cultural, biological, and chemical approaches for sustainable disease control.
		CLO - 5	Familiarize various diagnostic tools and techniques used in plant pathology for accurate disease assessment and identification
		CLO - 6	Communicate findings effectively, motivating stakeholders and farmers on disease management and its impact on crop productivity.
		CLO - 7	Effectively communicate disease-related information to diverse audiences, emphasizing the importance of disease prevention and management in crop production.
	Biomolecules and Cell Biology BT – CE – 3224	CLO - 1	Students will be able to obtain knowledge of structure, classification, and physicochemical properties of different biomolecules.
		CLO - 2	Students will be able to know about the detailed structure, properties, and functions of a cell and its components.
		CLO - 3	Students will be acquainted with practical knowledge of properties of cell and cell membranes, nucleic acid and microscopy of the plant cell.
		CLO - 4	Students will be able to identify various biomolecules in the laboratory by qualitative tests of biomolecules.
4	Morphology, Anatomy and Embryology of Angiosperms BT – CE – 4214	CLO - 1	After studying the different topic knowledge will be enhanced on Morphology, Anatomy and reproductive biology of angiosperm.
		CLO - 2	Basic and advanced practical knowledge will be acquired in the field of anatomy, morphology and reproductive biology of angiosperm
		CLO - 3	Student will acquire good understanding of the mentioned field of angiosperm
		CLO - 4	Advanced knowledge of pollen morphology will be acquired by the learners(students)
		CLO - 5	Basic theoretical knowledge will help in understanding of the subject matter primarily on advanced morphology, anatomy of angiosperm.
	Advances in Plant Systematics BT – CE – 4224	CLO - 1	Students are expected to gain theoretical knowledge and acquire basic skills on the plant taxonomy with special reference to angiosperms. Upon completion of the course, the students will be able to illustrate the types; merits & demerits of various systems of classification

4	Advances in Plant Systematics BT – CE – 4224	CLO - 2	Students are expected to gain theoretical knowledge and acquire basic skills on the plant taxonomy with special reference to Angiosperms. Upon completion of the course, the students will be able to relate taxonomy and other fields of botany
		CLO - 3	Students are expected to gain theoretical knowledge and acquire basic skills on the plant taxonomy with special reference to Angiosperms. Upon completion of the course, the students will be able to combine classical plant taxonomy with modern molecular phylogeny
		CLO - 4	Students are expected to gain theoretical knowledge and acquire basic skills on the plant taxonomy with special reference to Angiosperms. Upon completion of the course, the students will be able to Integrate concepts of plant evolution and speciation into and understanding of how organisms are classified in a molecular phylogenetic framework.
		CLO - 5	Students are expected to gain theoretical knowledge and acquire basic skills on the plant taxonomy with special reference to Angiosperms. Upon completion of the course, the students will be able to learn the norms of ICBN and Construction of keys.
		CLO - 6	Students are expected to gain theoretical knowledge and acquire basic skills on the plant taxonomy with special reference to Angiosperms. Upon completion of the course, the students will be able to Identify the angiosperms families with specific key characters.
		CLO - 7	Students are expected to gain theoretical knowledge and acquire basic skills on the plant taxonomy with special reference to Angiosperms. Upon completion of the course, the students will be able to Learn various advanced tools to study plant taxonomy.
	Plant Physiology BT – CE – 4234	CLO - 1	Understand the intricate mechanisms of photosynthesis and respiration, including the biochemical processes and their significance in plant energy metabolism.
		CLO - 2	Explore how plants grow, develop, and respond to environmental cues at a physiological level.
		CLO - 3	Study nutrient acquisition, assimilation, and utilization in plants, linking these processes to growth and overall plant health.

4	Plant Physiology BT – CE – 4234	CLO - 4	Analyze plant hormones and their roles in growth, development, and stress responses and evaluate the significance of regulatory molecules in controlling life forms.
		CLO - 5	Apply physiological insights to enhance crop yield, quality, and stress tolerance and the principles of plant physiology to solve problems in related fields
		CLO - 6	Enhance critical thinking skills by evaluating and interpreting experimental results and applying theoretical knowledge to solve physiological problems and advancing agricultural practices and sustainability.
5	Plant Metabolism and Biochemistry BT – CE – 5314	CLO - 1	At the end of the course the student will know different types of chemical reactions that run the biological system
		CLO - 2	At the end of the course the student will know the details of carbon assimilation,
		CLO - 3	At the end of the course the student will understand the role of enzymes in regulating metabolic pathways for molecules like carbohydrates, lipids and proteins.
		CLO - 4	At the end of the course the student will understand the coordination of various biochemical reactions with reference to cell requirement and energy (ATP)
		CLO - 5	At the end of the course the student will establish link between theoretical concepts and experimental evidences.
		CLO - 6	At the end of the course the student will Practically learn advance techniques of analysis which will help in future research activities.
	Classical Genetics and Plant Breeding BT – CE – 5324	CLO - 1	Understanding Mendelian principles, genetic inheritance patterns, and their application in plant breeding.
		CLO - 2	Students also learn about breeding techniques, selection methods, and the genetic basis of desirable traits in plants.
		CLO - 3	Students should gain practical knowledge to apply genetic principles for improving crop plants through selective breeding.
		CLO - 4	Appreciate the historical contributions of key figures in classical genetics, including Mendel, Morgan, and Bateson.
		CLO - 5	Explore the utilization of genetic resources, including wild relatives and germplasm collections, in plant breeding programs.

5	Classical Genetics and Plant Breeding BT – CE – 5324	CLO - 6	Apply breeding principles to develop new cultivars with desired traits, addressing agricultural challenges and contributing to food security and sustainability.
	Phylogenomics and Paleobotany BT – CE – 5334	CLO - 1	By the end of this course, the student shall be able to Able to explain how life evolved through time and reach the present status, with particular emphasis on the evolution of land plants.
		CLO - 2	By the end of this course, the student shall be able to critically analyse and understand the famous saying “Nothing in Biology makes sense except in the light of evolution
		CLO - 3	By the end of this course, the student shall be able to explain about speciation, polyploidy, hybridisation and adaptation.
		CLO - 4	By the end of this course, the student shall be able to understand the genetic background of parasitism, horizontal gene transfer and overall origin and diversification of angiosperms.
		CLO - 5	By the end of this course, the student shall be able to develop the ability to read, understand, analyse, and explain research articles from prestigious journals through the project exercise.
		CLO - 6	By the end of this course, the student shall be able to adapt oneself to the use of computer during this course.
		CLO - 7	Students will be proficient in the molecular techniques used in phylogenomic studies, through both theory and practical sessions, including the use of molecular markers, DNA sequencing technologies, and the construction of phylogenetic trees.
	Application of Plant Ecology and Environment BT – CE – 5344	CLO - 1	Basic and practical knowledge in the field of applied ecology and environment will be enhanced.
		CLO - 2	Learner's will have a good incite in understanding practical and applied aspects of ecology and environment dealt in the areas of the paper.
		CLO - 3	Ecotourism and eco-restoration introduced in the paper will help learner to develop self-sustenance and good understanding in the field of study.
		CLO - 4	Pollution study in the paper will help the learners in understanding current problems and very sensitive issue in sustenance of the environment
		CLO - 5	Total biodiversity issue will be sorted out after learning the various aspect in this field

6

Advanced Microbiology
BT – CE – 6314

CLO - 1

Upon successful completion of the course, students will be able to trace the historical development of microbiology and appreciate its role in shaping scientific knowledge.

CLO - 2

Upon successful completion of the course, students will be able to identify and discuss real-world examples of how microbiology contributes to different scientific and industrial domains.

CLO - 3

Upon successful completion of the course, students will be able to demonstrate an understanding of the nutritional needs of microorganisms and the metabolic processes that sustain their growth.

CLO - 4

Upon successful completion of the course, students will be able to comprehend the microbiology of soil, air, and water, recognizing the roles microorganisms play in these environments with a focus on the biological nitrogen fixation process.

CLO - 5

Upon successful completion of the course, students will be able to differentiate the characteristics of Rickettsiae, Chlamydiae, Actinomycetes, Archaeobacteria, and Mycoplasma and the diseases caused by these microorganisms and their impact on human health.

CLO - 6

Upon successful completion of the course, students will be able to understand the principles and applications of synthetic biology and microbial engineering and application of ethical frameworks to evaluate potential advancements in the field.

CLO - 7

Upon successful completion of the course, students will be able to foster collaborative learning and communication skills through teamwork, group discussions, seminars, and home assignments.

Molecular Biology and
Biotechnology
BT – CE – 6324

CLO - 1

Conduct Molecular Experiments: Execute laboratory experiments using molecular techniques, interpret results, and generate accurate and reliable data.

CLO - 2

Apply gene cloning and recombinant DNA technology to design and execute experiments aimed at modifying genes for specific purposes.

CLO - 3

Analyze data from biotechnological experiments, draw conclusions, and present findings effectively, both orally and in writing.

CLO - 4

Demonstrate problem-solving skills by applying molecular biology and biotechnological knowledge to address real-world challenges in agriculture, medicine, and industry.

6	Molecular Biology and Biotechnology BT – CE – 6324	CLO - 5	Work collaboratively in a laboratory setting, demonstrating effective communication and teamwork in the execution of experiments and projects.
		CLO - 6	Critically evaluate the ethical, societal, and environmental implications of biotechnological applications, and make informed decisions, based on this understanding
	Natural Resources Management BT – CE – 6334	CLO - 1	Upon successful completion of the course, students will be able to demonstrate an integrated understanding of ecosystem dynamics, recognizing the interconnected relationships among living organisms, their environments, and the services ecosystems provide.
		CLO - 2	Upon successful completion of the course, students will be able to evaluate and apply principles of sustainable resource management, demonstrating the ability to balance human needs with the preservation of ecosystems and biodiversity.
		CLO - 3	Upon successful completion of the course, students will be able to develop the skills to identify, assess, and implement conservation strategies, with a focus on preserving biodiversity, protecting endangered species, and maintaining ecosystem resilience.
		CLO - 4	Upon successful completion of the course, students will be able to analyze environmental policies and governance structures related to natural resource management, and demonstrate the ability to propose, evaluate, and advocate for effective policies that align with sustainability goals.
		CLO - 5	Upon successful completion of the course, students will be able to understand the importance of involving local communities and stakeholders in decision-making processes related to natural resource management. They will demonstrate the ability to foster collaboration, address conflicts, and integrate diverse perspectives for sustainable outcomes.
	Recent Trends in Plant Science BT – CE – 6344	CLO - 1	Gain a comprehensive understanding of recent advancements in botanical sciences, spanning molecular biology, genomics, and bioinformatics, enhancing knowledge of cutting-edge research methodologies and techniques.
		CLO - 2	Explore the interdisciplinary nature of botany, analyzing its connections with ecology, biotechnology, and climate science, fostering a holistic perspective on plant biology and its implications for global challenges.

6	Recent Trends in Plant Science BT – CE – 6344	CLO - 3	Develop critical thinking skills to evaluate and integrate complex scientific information from diverse sources, fostering creativity and innovation in addressing contemporary issues in botany.
		CLO - 4	Acquire proficiency in conducting research, including experimental design, data analysis, and interpretation, enabling contribution to scientific advancements in botany.
		CLO - 5	Enhance communication skills to effectively disseminate research findings and engage in interdisciplinary dialogues, promoting collaboration and knowledge exchange within the scientific community.
		CLO - 6	Recognize and adhere to ethical standards in botanical research and applications, emphasizing integrity, transparency, and responsible conduct in scientific inquiry.
		CLO - 7	Foster a passion for lifelong learning and engagement with current trends and advancements in botany, preparing for future careers in academia, industry, or research institutions.
7	Research Methodology BT – CE – 7414	CLO - 1	Understand principles of research methodology, research ethics, integrity, and plagiarism detection.
		CLO - 2	Identify research problems, conduct literature reviews, and design experimental/observational research.
		CLO - 3	Apply good laboratory practices, safety protocols, teamwork, and promote knowledge sharing.
		CLO - 4	Analyze and present data using statistical tools, prepare abstracts/posters, and communicate research effectively.
	Microbiology And Plant Pathology BT – CE – 7424	CLO - 1	Knowledge on Microbial interactions, bio-remediation, biofertilizers and bio-control of plant diseases.
		CLO - 2	Knowledge on soil microbes, soil metagenomics.
		CLO - 3	Knowledge on Industrial production of organic acids, antibiotics, ethanol, vitamins and amino acids
		CLO - 4	Microbial genetics, tools and techniques of genetic engineering and microbial biotechnology.
		CLO - 5	Knowledge on plant disease, symptoms of fungal, bacterial and viral diseases.

7		CLO - 6	Knowledge on different defense mechanism of plants against disease, air, soil and seed born diseases
		CLO - 7	Biological controls of disease, quarantine and seed certification
	Lower Cryptogams (Algae And Fungi) BT – CE – 7434	CLO - 1	The course will increase the understanding of the students about the diversity, classification, structure, and growth of lower cryptogams- algae and fungi.
		CLO - 2	It will also develop theoretical knowledge and technical skills in fundamental of Phycology and mycology
		CLO - 3	Students will realize the heterogeneity and polyphyletic nature of both algae and fungi as a group. They will also be apprised of their diversity in form, structure and reproduction and the diverse habitats of fungi
		CLO - 4	Students will realize the vast economic, ecological and biotechnological project and realized potential of these groups.
	Higher Cryptogams and Lower Phanerogams BT – CE – 7444	CLO - 1	The organ formation occurred in the early land plants that resulted in the diversity of species of “bryophytes”, “pteridophytes” and “gymnosperms”.
		CLO - 2	The strategies for conduction of water and photosynthesis in land plants
		CLO - 3	The reproductive strategies and breeding systems in plants through lineage of bryophytes, pteridophytes and gymnosperms.
		CLO - 4	The ecological and economic importance of bryophytes, pteridophytes and gymnosperms that help to understand their role in ecosystem functioning.
	Advanced Plant Systematics BT – CE – 7454	CLO - 1	Explain the principles, concepts, and historical development of plant classification systems.
		CLO - 2	Apply the International Code of Nomenclature (ICN) and construct taxonomic keys and descriptions.
		CLO - 3	Evaluate morphological, anatomical, cytological, and molecular data as taxonomic evidence.
		CLO - 4	Interpret phylogenetic trees using molecular sequence data and bioinformatic tools.
		CLO - 5	Identify and classify angiosperm families based on diagnostic characteristics.

7	Advanced Plant Systematics BT – CE – 7454	CLO - 6	Demonstrate field and herbarium techniques for plant collection, preservation, and documentation.
		CLO - 7	Assess the role of systematics in biodiversity conservation, ecology, and applied plant sciences.
8	Plant Physiology and Biochemistry BT – CE – 8414	CLO - 1	Knowledge on structure and function of membranes and biomolecules.
		CLO - 2	Knowledge on biosynthesis, storage, breakdown, transport, physiological effects and mechanism of action of plant hormones.
		CLO - 3	Practical knowledge on extraction and estimation of proteins, carbohydrate, phenolics and chloroplast pigments.
		CLO - 4	Knowledge on mechanism phytochrome and sensory photobiology
	Plant Ecology and Resource Management BT – CE – 8424	CLO - 1	Students will be able to obtain knowledge of environment and various component ecology
		CLO - 2	Students will be able to understand and apply various management principles environmental issues, biodiversity and conservation aspects.
		CLO - 3	Students will be able to obtained knowledge and applied aspects of various environmental management policies/
		CLO - 4	Students will be able to obtain knowledge and sustainable utilization of plant resources.
		CLO - 5	Students will be able to obtain knowledge about phytogeography.
	Molecular Biology BT – CE – 8434	CLO - 1	Understand the molecular mechanisms of DNA replication, repair, transcription, and translation.
		CLO - 2	Explore gene regulation in prokaryotes and eukaryotes.
		CLO - 3	Analyze experimental techniques used in molecular biology
		CLO - 4	Appreciate the application of molecular biology in research and medicine
	Cytogenetics and Plant Breeding BT – CE – 8444	CLO - 1	Students will be able to obtain knowledge of structure, function and aberration of chromosomes.

8	Cytogenetics and Plant Breeding BT – CE – 8444	CLO - 2	Students will be able to understand and apply principles of plant breeding
		CLO - 3	Students will be able to interpret the phylogenetic relationship
		CLO - 4	Students will be acquainted with practical knowledge of behaviour of chromosomes
		CLO - 5	Students will be able to establish connections between cytogenetics and plant breeding to understand how genetic principles drive plant improvement and biodiversity.
	Biodiversity Conservation and Traditional BT – CE – 8454	CLO - 1	Students will be able to obtain knowledge on conservation and management of biodiversity
		CLO - 2	Students will be able to understand and apply various management principles Ex-situ and In-situ conservation.
		CLO - 3	Students will be acquainted with practical knowledge of various aspects of Ethnobotany.
		CLO - 4	Students will be able to know about the traditional knowledge; it's relevance in present day context.

MAPPING OF PROGRAMME OUTCOME (PO) AND COURSE LEARNING OUTCOME (CLO)

Attributes: Co-relation Levels

“1” : Minimum Co-relation

“2” : Moderate Co-relation

“3” : Maximum Co-relation

“-” : No Co-relation

Course Code	CLO	PROGRAMME OUTCOME										
		SPO1	SPO2	SPO3	SPO4	SPO5	SPO6	SPO7	SPO8	SPO9	SPO10	SPO11
BT-CE-1114	CLO-1	3					2	2			3	3
	CLO-2	3	3	2	3		3				-	-
	CLO-3	3	3	2	3		3				-	-
	CLO-4	3	3	3	3		3				-	-
BT-CE-2114	CLO-1	-	1	-			3				-	-
	CLO-2	-	3	1	2		3				2	3
	CLO-3	-	1	-	1		3				2	3
BT-CE-3214	CLO-1	-	1	2	-	-	-	-	-	-	-	-
	CLO-2	1	-	-	-	-	-	-	-	-	-	-
	CLO-3	-	1	-	-	-	-	-	3	-	-	-
	CLO-4	-	-	1	-	-	-	-	-	-	-	-
	CLO-5	-	-	-	1	-	-	-	-	-	-	-
	CLO-6	-	2	-	-	1	-	-	-	-	-	-
	CLO-7	-	-	1	-	-	-	-	3	-		
BT-CE-3224	CLO-1	1	3	2	2	3	3	2	2	3	2	2
	CLO-2	1	2	2	2	3	3	2	2	3	2	2
	CLO-3	1	2	1	1	2	2	2	2	3	2	2
	CLO-4	1	1	1	1	2	2	2	2	3	2	2
BT-CE-4214	CLO-1	1	-	-	-	-	-	-	-	-	-	-
	CLO-2	2	-	-	-	-	-	-	-	-	-	-
	CLO-3	-	1	-	-	-	-	-	-	-	-	-
	CLO-4	-	3	1	-	-	-	-	-	-	-	-
	CLO-5	-	1	-	-	-	-	-	-	-	-	-
BT-CE-4224	CLO-1	1	-	-	-	-	-	-	-	-	-	-
	CLO-2	1	-	-	-	-	-	-	-	-	-	-
	CLO-3	-	1	-	-	-	-	-	-	-	-	-
	CLO-4	-	3	1	-	-	-	-	-	-	-	-
	CLO-5	-	1	-	-	-	-	-	-	-	-	-
	CLO-6	-	2	1	-	-	-	-	-	-	-	-
	CLO-7	-	-	-	1	-	-	-	-	-	-	-
BT-CE-4234	CLO-1	1	-	-	-	-	-	-	-	-	-	-
	CLO-2	1	-	-	-	-	-	-	2	-	-	-
	CLO-3	1	-	-	-	-	-	-	-	-	-	-
	CLO-4	-	1	2	-	-	-	-	-	-	-	-
	CLO - 5	-	1	-	-	-	-	-	-	2	-	-
	CLO - 6	-	1	2	-	-	-	-	-	-	-	-
BT-CE-5314	CLO-1	1	-	-	-	-	-	-	-	-	-	-
	CLO-2	1	-	-	3	-	-	-	2	-	-	-
	CLO-3	1	-	-	-	-	-	-	-	-	-	-
	CLO-4	-	2	2	-	-	-	-	-	-	-	-

Course Code	CLO	PROGRAMME OUTCOME										
		SPO1	SPO2	SPO3	SPO4	SPO5	SPO6	SPO7	SPO8	SPO9	SPO10	SPO11
BT-CE-5314	CLO - 5	-	1	-	-	3	-	-	-	2	-	-
	CLO - 6	-	1	2	-	-	-	-	-	-	-	-
BT -CE-5324	CLO-1	-	1	-	-	-	-	-	-	3	-	-
	CLO-2	-	-	-	1	-	-	-	-	-	-	-
	CLO-3	1	-	-	-	-	-	-	-	-	-	-
	CLO-4	1	-	-	-	-	-	-	-	-	-	-
	CLO - 5	-	-	3	-	-	-	-	-	1	-	-
	CLO - 6	-	-	1	-	-	-	-	-	-	-	-
BT-CE-5334	CLO-1	2	2		1	2	3	2	3	1		
	CLO-2		3			2	1	3	2			
	CLO-3		2			2	1	3	2			
	CLO-4		2			2	1	3				
	CLO - 5	3		2	3	3	1		2	3	1	3
	CLO-6			2	3		1			1		3
	CLO - 7	1		2	3		3					3
BT-CE-5344	CLO-1	-	-	-	2	1	-	-	-	-		
	CLO-2	1	-	-	-	-	-	-	-	-		
	CLO-3	-	2	-	-	3	-	-	-	-		
	CLO-4	1	-	-	-	-	-	-	-	-		
	CLO-5	-	-	-	3	-	-	-	-	-		
BT-CE-6314	CLO-1	1	-	-	-	-	-	-	-	-	-	-
	CLO-2	-	1	-	-	-	-	-	-	-	-	-
	CLO-3	1	-	-	-	-	-	-	-	-	-	-
	CLO-4	1	-	-	-	-	-	-	2	-	-	-
	CLO-5	1	3	-	-	-	-	-	-	-	-	-
	CLO-6	-	1	-	-	-	-	2	-	-	-	-
	CLO-7	-	-	-	-	3	-	-	-	-	1	-
BT-CE-6324	CLO-1	-	-	1	-	-	-	-	-	2	-	-
	CLO-2	-	-	-	1	-	-	-	-	-	-	-
	CLO-3	-	-	1	-	-	-	-	-	-	-	-
	CLO-4	-	2	-	-	-	-	-	-	1	-	-
	CLO-5	-	-	-	1	-	-	-	-	-	-	-
	CLO-6	1	-	-	-	-	-	2	-	-	-	-
BT-CE-6334	CLO-1	1	-	-	-	-	-	-	-	-		
	CLO-2	-	-	-	-	1	-	-	-	-		
	CLO-3	-	1	-	-	-	-	3	-	-		
	CLO-4	-	2	1	-	-	-	-	-	-		
	CLO - 5	-	-	-	-	1	2	-	-	-		
BT-CE-6344	CLO-1	1	-	2	-	-	-	-	-	-	-	-
	CLO-2	1	-	-	-	-	-	-	2	-	-	-
	CLO-3	-	2	-	-	-	-	-	-	1	-	-
	CLO-4	-	1	2	3	-	-	-	-	-	-	-
	CLO - 5	-	-	-	-	1	-	-	-	-	3	-
	CLO-5	-	-	-	-	-	-	1	-	-	-	-
	CLO - 6	-	-	-	-	-	1	-	-	2	3	-

BT-CE-7414	CLO 1	3	1	1	1	3	2	3	3	2	1	1
	CLO 2	1	3	2	2	2	3	3	2	3	2	2
	CLO 3	3	3	2	1	1	3	2	2	3	3	2
	CLO 4	3	1	3	3	2	3	2	1	3	2	3
BT-CE-7424	CLO 1	3	1	1	1	3	2	2	3	1	2	1
	CLO 2	2	3	2	2	2	3	3	2	3	3	2
	CLO 3	3	3	2	1	3	3	3	3	3	3	2
	CLO 4	3	3	3	2	3	3	2	3	3	3	1
	CLO 5	3	3	3	1	1	3	3	3	3	1	3
	CLO 6	3	2	3	3	2	2	3	1	3	3	3
	CLO 7	3	2	1	1	2	1	3	3	3	1	3
BT-CE-7434	CLO 1	3	1	1	2	3	2	3	2	1	2	1
	CLO 2	3	2	3	2	2	3	2	3	1	3	2
	CLO 3	3	3	2	1	2	3	3	2	3	3	1
	CLO 4	3	1	3	1	3	3	2	3	3	2	3
	CLO 5	3	3	2	1	1	3	2	3	3	2	3
BT-CE-7444	CLO 1	3	1	1	1	3	2	3	3	1	2	1
	CLO 2	3	3	3	2	2	3	2	3	3	3	2
	CLO 3	3	3	2	1	2	3	3	3	3	3	2
	CLO 4	3	3	2	3	2	3	2	3	3	3	3
BT-CE-7454	CLO1	3	1	1	1	3	2	3	3	1	2	1
	CLO2	3	3	3	2	2	3	3	3	3	3	2
	CLO3	3	3	2	1	3	3	3	3	3	3	2
	CLO4	3	3	3	3	3	3	3	3	3	3	3
	CLO5	3	3	3	1	1	3	3	3	3	3	3
	CLO6	3	2	3	3	2	3	3	3	3	3	3
	CLO7	3	2	1	1	2	3	3	3	3	3	3
BT-CE-8414	CLO 1	3	1	1	1	2	2	3	2	1	2	1
	CLO 2	2	3	2	2	1	3	3	3	2	3	2
	CLO 3	3	3	2	1	3	2	3	3	3	1	2
	CLO 4	1	3	2	3	3	3	3	2	3	3	3
	CLO 5	3	2	3	1	1	3	2	3	3	1	3
BT-CE-8424	CLO1	3	1	2	1	3	2	2	3	1	2	1
	CLO2	2	3	3	2	2	3	2	3	3	2	2
	CLO3	1	3	2	1	3	3	2	3	1	3	2
	CLO4	3	3	2	3	3	1	3	3	2	3	3
	CLO5	3	3	3	1	1	3	2	3	3	3	2
BT-CE-8434	CLO1	3	1	2	1	3	2	2	3	1	2	2
	CLO2	3	3	3	2	2	3	1	3	2	3	2
	CLO3	2	3	1	1	3	2	3	3	2	3	1
	CLO4	3	3	2	3	3	3	2	3	2	3	3
BT-CE-8444	CLO 1	1	3	2	2	3	3	2	2	3	2	2
	CLO 2	1	2	2	2	3	3	2	2	3	2	2
	CLO 3	1	2	1	1	2	2	2	2	3	2	2
	CLO 4	1	1	1	1	2	2	2	2	3	2	2
	CLO 5	1	2	2	1	3	2	1	2	3	2	2
BT-CE-8454	CLO1	3	1	1	1	3	2	3	3	1	2	1
	CLO2	3	3	3	2	2	3	3	3	3	3	2
	CLO3	3	3	2	1	3	3	3	3	3	3	2
	CLO4	3	3	3	3	3	3	3	3	3	3	3

MAPPING OF PROGRAMME SPECIFIC OUTCOME (PSO) AND COURSE LEARNING OUTCOMES (CLO)

Attributes: Co-relation Levels

“1” : Minimum Co-relation

“2” : Moderate Co-relation

“3” : Maximum Co-relation

“-” : No Co-relation

Course Code	CLO	PROGRAMME SPECIFIC OUTCOME								
		PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8	PSO 9
BT-CE-1114	CLO-1	1					2	2		
	CLO-2	1	1	2	3		3			
	CLO-3	3	2	2	3		3			
	CLO-4	3	2	3	3		1			
BT-CE-2114	CLO-1	-	1	-			1			
	CLO-2	-	1	1	2		-			
	CLO-3	-	1	-	1		3			
BT-CE-3214	CLO-1	-	-	-	1	-	-	-	-	-
	CLO-2	1	-	-	-	-	-	-	-	-
	CLO-3	-	-	3	-	1	-	-	-	-
	CLO-4	2	-	-	-	1	-	-	-	-
	CLO-5	-	2	-	-	-	-	-	-	-
	CLO-6	-	-	-	-	3	1	-	-	-
	CLO-7	-	-	1	2	-	-	-	-	-
BT-CE-3224	CLO-1	1	3	2	2	2	2	2	3	1
	CLO-2	1	3	2	2	2	2	2	3	1
	CLO-3	1	1	1	1	2	2	2	2	1
	CLO-4	1	1	1	1	2	2	2	2	1
BT-CE-4214	CLO-1	2	-	-	-	-	-	-	-	-
	CLO-2	2	-	-	-	-	-	-	-	-
	CLO-3	-	-	1	-	-	-	-	-	-
	CLO-4	-	-	-	-	1	-	-	-	-
	CLO-5	-	-	-	2	3	-	-	-	-
BT-CE-4224	CLO-1	1	-	-	-	-	-	-	-	-
	CLO-2	2	-	-	-	-	-	-	-	-
	CLO-3	-	-	1	-	-	-	-	-	-
	CLO-4	-	-	-	-	1	-	-	-	-
	CLO-5	-	-	-	1	3	-	-	-	-
	CLO-6	-	-	1	-	-	-	-	-	-
	CLO-7	-	1	-	-	-	-	-	-	-
BT-CE-4234	CLO-1	1	-	-	-	3	-	-	-	-
	CLO-2	-	2	1	-	-	-	-	-	-
	CLO-3	1	-	-	-	-	-	-	-	-
	CLO-4	-	-	-	1	-	-	-	-	-
	CLO – 5	-	1	-	-	3	-	-	-	-
	CLO – 6	-	-	-	2	1	-	-	-	-
BT-CE-5314	CLO-1	1	-	-	-	3	-	-	-	-
	CLO-2	-	2	2	-	-	-	-	-	-
	CLO-3	1	-	-	-	-	-	-	-	-
	CLO-4	-	-	-	2	-	-	-	-	-

Course Code	CLO	PROGRAMME SPECIFIC OUTCOME								
		PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8	PSO 9
BT-CE-5314	CLO – 5	-	1	-	-	3	-	-	-	-
	CLO – 6	-	-	-	2	1	-	-	-	-
BT -CE-5324	CLO-1	-	-	-	2	1	-	-	-	-
	CLO-2	1	-	-	-	-	-	-	-	-
	CLO-3	-	1	-	-	3	-	-	-	-
	CLO-4	1	-	-	-	-	-	-	-	-
	CLO – 5	-	-	-	1	-	-	-	-	-
	CLO – 6			3	1	-	-	-	-	-
BT-CE-5334	CLO-1	3		1		3	1	1	3	1
	CLO-2	2		3		3	1	1	3	1
	CLO-3	2		2	1	3		1	3	1
	CLO-4	2		3	1	3		1	3	1
	CLO – 5	1	3	3	2	3	3	1	3	2
	CLO-6		3	2	2	3	3	2	3	2
	CLO – 7	1	3	3	3	3	3	3	3	2
BT-CE-5344	CLO-1	-	-	-	2	1	-	-	-	-
	CLO-2	1	-	-	-	-	-	-	-	-
	CLO-3	-	2	-	-	3	-	-	-	-
	CLO-4	1	-	-	-	-	-	-	-	-
	CLO-5	-	-	-	2	-	-	-	-	-
BT-CE-6314	CLO-1	1	-	-	-	-	-	-	-	-
	CLO-2	-	-	-	1	2	-	-	-	-
	CLO-3	1	-	-	-	-	-	-	-	-
	CLO-4	1	-	-	-	2	-	-	-	-
	CLO-5	1	-	-	-	-	-	-	-	-
	CLO-6	-	1	2	-	-	-	-	-	-
	CLO-7	-	-	-	-	-	1	-	-	-
BT-CE-6324	CLO-1	-	1	3	-	-	-	-	-	-
	CLO-2	-	-	1	2	-	-	-	-	-
	CLO-3	-	-	-	-	1	-	-	-	-
	CLO-4	-	-	2	1	-	-	-	-	-
	CLO-5	-	1	2	-	-	-	-	-	-
	CLO-6	1	-	-	-	-	-	2	-	-
BT-CE-6334	CLO-1	1	-	-	-	-	-	-	-	-
	CLO-2	-	-	-	-	1	-	-	-	-
	CLO-3	-	1	-	-	-	-	3	-	-
	CLO-4	-	2	1	-	-	-	-	-	-
	CLO – 5	-	-	-	-	1	2	-	-	-
BT-CE-6344	CLO-1	1	-	-	-	-	-	-	-	-
	CLO-2	1	-	-	-	2	-	-	-	-
	CLO-3	-	-	-	-	1	-	-	-	-
	CLO-4	-	2	1	-	-	-	-	-	-
	CLO – 5	-	-	-	-	-	1	-	-	-
	CLO-5	-	-	-	-	-	-	1	-	-
	CLO -6	-	-	-	-	-	-	-	-	1

BT-CE-7414	CLO 1	3	1	1	2	3	2	3	1	1
	CLO 2	3	3	3	3	3	3	3	3	2
	CLO 3	1	2	3	3	2	2	3	2	2
	CLO 4	3	3	3	2	3	2	3	3	2
BT-CE-7424	CLO 1	3	1	1	3	2	2	3	1	1
	CLO 2	3	3	2	3	2	3	3	1	2
	CLO 3	2	3	3	3	3	2	3	2	2
	CLO 4	1	3	3	2	3	2	3	3	3
	CLO 5	3	3	2	3	2	3	3	1	3
	CLO 6	1	3	3	2	3	3	3	3	1
	CLO 7	3	1	2	3	1	2	3	2	3
BT-CE-7434	CLO 1	3	2	1	2	3	2	3	1	1
	CLO 2	3	2	3	1	3	3	2	3	2
	CLO 3	3	2	3	1	3	2	3	1	2
	CLO 4	3	3	2	3	3	2	1	3	3
	CLO 5	3	1	3	3	2	3	3	2	3
BT-CE-7444	CLO 1	3	1	1	2	2	2	3	1	1
	CLO 2	3	2	3	3	3	3	2	3	2
	CLO 3	3	3	2	3	3	2	3	2	2
	CLO 4	3	2	3	2	3	2	3	3	3
BT-CE-7454	CLO1	3	1	1	2	2	2	3	1	1
	CLO2	3	3	3	3	3	3	3	3	2
	CLO3	3	3	3	3	3	2	3	2	2
	CLO4	3	3	3	3	3	2	3	3	3
	CLO5	3	3	3	3	3	3	3	3	3
	CLO6	3	3	3	3	3	3	3	3	3
	CLO7	3	1	2	3	3	2	3	2	3
BT-CE-8414	CLO 1	3	1	1	3	2	2	3	1	1
	CLO 2	2	3	2	3	3	1	3	3	2
	CLO 3	1	3	3	2	3	2	1	2	2
	CLO 4	3	2	3	2	3	2	3	3	1
	CLO 5	2	3	3	3	2	3	3	1	3
BT-CE-8424	CLO1	3	1	1	2	3	2	3	1	2
	CLO2	3	2	3	3	2	3	1	3	2
	CLO3	2	3	3	1	3	2	3	1	2
	CLO4	3	2	3	1	3	2	3	3	3
	CLO5	3	2	3	3	2	3	3	1	3
BT-CE-7444	CLO1	3	1	1	2	3	2	3	1	1
	CLO2	3	3	2	3	3	3	2	3	2
	CLO3	3	2	3	2	3	2	3	1	2
	CLO4	2	3	1	3	3	2	3	2	3
BT-CE-8444	CLO 1	1	3	2	2	2	2	2	3	1
	CLO 2	1	3	2	2	2	2	2	3	1
	CLO 3	1	1	1	1	2	2	2	2	1
	CLO 4	1	1	1	1	2	2	2	2	1
	CLO 5	1	3	2	2	1	2	3	3	1
BT-CE-8454	CLO1	3	1	1	2	2	2	3	1	1
	CLO2	3	3	3	3	3	3	3	3	2
	CLO3	3	3	3	3	3	2	3	2	2
	CLO4	3	3	3	3	3	2	3	3	3

COURSE NAME: BIODIVERSITY (Microbes, Algae, Fungi And Archegoniate)

COURSE CODE: BT – CE – 1114

Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)

THEORY: 3 CREDITS

Total Lectures:45

COURSE OBJECTIVE:

The course includes modules on basic knowledge of the plant kingdom viz. Microbes, Algae, Fungi and Archegoniate, with the main objective of giving a sense of mooring to the undergraduates.

COURSE LEARNING OUTCOME:

On completion of this course

CLO-01: *Combination of theoretical and practical components of this course will provide comprehensive information and insight into the fascinating world of microbes and plants.*

CLO-02: *Hand on training will help students learn use of the microscope, mounting, section cutting and staining techniques for the study of plant materials.*

CLO-03: *Making drawing in practical records will enhance understanding morphology and structural details and related functional aspects in diverse plant groups.*

CLO-04: *This paper is both informative and interesting and will enable student to learn about biodiversity not only as plant or nature lover but also for higher academic pursuits, particularly in the field of biological sciences, environment and biodiversity conservation.*

Unit- I: Microbes (Lectures:9)

Viruses: General Structure, DNA virus (T Phase), Lytic and Lysogenic Cycle, RNA virus (TMV). Economic Importance.

Bacteria: General Characteristic and Cell structure, Reproduction – Vegetative, Asexual and Recombination (Conjugation, Transformation and Transduction), Economic importance.

Unit- II: Algae (Lectures: 9)

General characteristic, Range of thallus organization and reproduction, Classification of algae (F E Fritsch classification), Morphology and life cycles of Nostoc, Chlamydomonas, Vaucheria, and Polysiphonia, Economic importance of algae.

Unit- III: Fungi (Lectures: 9)

General characteristic, nutrition, reproduction and classification (G.C Ainsworth classification). Life cycles of Rhizopus (Zygomycota), Phytophthora (Oomycetes) Penicillium, (Ascomycota), Puccinia Agaricus (Basidiomycota), Symbiosis Association – Lichen. General account and significance of Mycorrhiza.

Unit- IV: Introduction to Archegoniate(Lectures: 2)

Unifying features of archegoniates, Transition to land habit, alternation of generation.

Unit-V: Bryophytes (Lectures:6)

General characteristic, adaptation of land habit, Classification (upto family), Morphology, anatomy and reproduction of Marchantia, Anthoceros and Polytrichum, Ecology and economic importance of bryophytes with special mention of Sphagnum.

Unit-VI: Pteridophytes (Lectures:5)

General characteristics, classification, Early land plants – Rhynia and Psilotum. Morphology, anatomy and reproduction of Selaginella, and Pteris. Heterospory and seed habit, Stellarevolution.

Unit-VII: Gymnosperms (Lectures:5)

General characteristics, Classification. Morphology, anatomy and reproduction of Cycas, Pinus and Gnetum, Ecological and economical importance.

PRACTICAL(Lectures:30)

1. Model of Virus -TPhage; Lytic and Lysogenic Cycle from Photographs.
2. Study of bacterial reproduction–Binary Fission and Conjugation from slides/ photographs.
3. Gram staining process.
4. Study of vegetative and reproductive structure of Nostoc, Chlamydomonas and Polysiphonia.
5. Study of vegetative and reproductive structure of Penicillium and Puccini.
6. Study of vegetative and reproductive structure of Marchantia and Polytrichu.
7. Study of vegetative and reproductive structure of Selaginell.
8. Study of vegetative and reproductive structure of Cycas and Gnetum.

RECOMMENDED BOOKS:

1. Pelczar, M.J. (2001)– Microbiology, 5th Edition, Tata McGraw–Hill Co, New Delhi.
2. Sarma, P. D. (2009)–Microbiology, Latest Edition, Rastogi Publication, Meerut.
3. Sahu, D. (2000)–Farming the Ocean: Sea Weeds Cultivation and Utilization. Ara Vali International, New Delhi
4. Kumar, H.D. (1999)–Introductory Phycology. Affiliated East West Press, Delhi
5. Alexopoulos, C. J.; Mims, C. W.; Blackwell, M. (1996) – Introductory Mycology, J. and Sons, 4th Edition.
6. Vashista, P. C.; Singha, A. K., Kumar, A. (2010) – Pteridophyta, S. Chand, Delhi, India.
7. Parihar, N. S. (1991) – An Introduction to Embryophyta, Vol I – Bryophyta, Central Book Depot. Allahabad.
8. Bhatnagar, S. P.; Moitra, A. (1996) – Gymnosperms, New Age International (P) Ltd, Publishers, New Delhi, India.

COURSE NAME: PLANT ECOLOGY AND TAXONOMY

COURSE CODE: BT – CE – 2114

Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)

THEORY:3CREDITS

Total Lectures:45

COURSEOBJECTIVE:

The main objective of study plant ecology is to examine the relationship of plants with the physical and biotic environment. Plant Taxonomy is the science of discovering, identifying, describing, classifying and naming plants. The main objective of plant taxonomy is to identify characteristics of undiscovered species by comparing with known species, to specify characteristics of recently discovered species, to arrange them in respective “taxa” after looking at their similarities and to give them specific names.

COURSE LEARNING OUTCOME:

On completion of this course

- CLO-01:** *Student would have understanding of various ecological parameters of plant in nature pertaining to influencing ecological factors and their analysis of practical data on individual, population, community and ecosystem level along with their relationships.*
- CLO-02:** *Student also would have understanding about basic knowledge of plant taxonomy with the modern taxonomic approaches.*
- CLO-03:** *Practical knowledge of the course material will develop the skill of identification and classification of plant diversity and characterization of angiospermic families along with their phyto geographical analysis.*

Unit- I: Ecological Factor (Lectures:8)

Soil: Origin, formation, composition, of soil profile. Water: State of water in the environment, precipitation types. Light and Temperature: Variation, optimal and limiting factors; Shelford Law of Tolerance. Adaptation of Hydrophytes and Xerophytes. Biological indicators.

Unit- II: Plant Communities (Lectures: 4)

Characters; Ecotone and Edge Effect; Succession; Processes and Types.

Unit- III: Ecosystem (Lectures: 8)

Structure; Energy flow trophic organisation; Food chains and Food webs, Ecological Pyramids, Production and Productivity; Biogeochemical Cycle, Carbon, Nitrogen and Phosphorus Cycles.

Unit- IV: Phytogeography (Lectures: 2)

Principle of Bio-geographical Zones; Endemism.

Unit- V: Introduction to Plant Taxonomy (Lectures: 2)

Aim and objective of Plant Taxonomy. Identification, Classification and Nomenclature.

Unit- VI: Identification (Lectures: 4)

Function of Herbarium, Important Herbaria and Botanical Gardens of the world and India;
Documentation: Flora, Kyes – Single access and Multiassess.

Unit- VII: Modern Trends of Taxonomy (Lectures: 5)

Taxonomy in relation to Palynology, Cytology, Phytochemistry and Molecular data

Unit- VIII: Botanical Nomenclature (Lectures: 4)

Principles and Rules (ICBN): Ranks and Names; Binomial system, Typification, Authorcitation, Valid Publication, Rejection of names, Principle of Priority and its Limitation

Unit- IX: Taxonomic Classification (Lectures: 2)

Types of classification; Bentham and Hooker system of classification

Unit- X: Angiospermic families (Lectures: 6)

Poaceae, Orchidaceae, Magnoliceae, Solanaceae, Lamiaceae and Asteraceae

PRACTICAL (Lectures:30)

1. Study of instruments use to measure micro climatic variables – Anemometer, Hygrometer and Lux meter
2. Study of morphological adaptation of hydrophytes and xerophytes.
3. Study of vegetative and floral characters of Solanaceae, Lamiaceae, Asteraceae and Orchidaceae
4. Collection, processing, drying and preparation of a Herbarium of a wild herbaceous plant species.

RECOMMENDED BOOKS:

1. Kormondy, E. J. (1996)–Concept of Ecology, 4th Edition, Prentice Hall, USA.
2. Sharma, P.D. (2010)–Ecology and Environment, 8th Edition, Rastogi Publication, Meerut, India.
3. Singh, G. (2012)– Plant Systematics: Theory and Practice, 3rd Edition, Oxford & IBH Publishing Co Pvt Ltd, New Delhi.
4. Pandey, B.P. (2018)–A Text Book of Botany: Angiosperms, S. Chand Publishing, 7361, Ram Nagar, Qutab Road, New Delhi

COURSE NAME: APPLIED MYCOLOGY AND PLANT PATHOLOGY

COURSE CODE: BT- CE - 3214

Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)

THEORY:3CREDITS

Total Lectures:45

COURSE OBJECTIVE:

The course objectives are to study of application of mycology in Biotechnology. Recognize and classify plant diseases caused by pathogens like fungi, bacteria and viruses. Understand the lifecycle, behavior, and interactions of pathogens with host plants to design targeted control methods. Enhance crop yield and quality through disease prevention, minimizing economic losses and reducing reliance on chemical interventions. Motivate farmers and stakeholders on disease identification, prevention, and integrated disease management practice.

COURSE LEARNING OUTCOME:

- CLO-01:** *Student Understanding the practical application of Mycology in Biotechnology and its impact on day to day life.*
- CLO-02:** *Proficiently recognize and classify plant diseases caused by various pathogens, including fungi, bacteria, viruses, and nematodes.*
- CLO-03:** *Understanding the biology, lifecycle, and interactions of plant pathogens to develop targeted and sustainable disease control measures.*
- CLO-04:** *Apply knowledge to integrate cultural, biological, and chemical approaches for sustainable disease control*
- CLO-05:** *Familiarize various diagnostic tools and techniques used in plant pathology for accurate disease assessment and identification.*
- CLO-06:** *Communicate findings effectively, motivating stakeholders and farmers on disease management and its impact on crop productivity.*
- CLO-07:** *Effectively communicate disease-related information to diverse audiences, emphasizing the importance of disease prevention and management in crop production.*

Unit- I: Applied Mycology (Lectures: 10)

Role of Fungi in biotechnology; Food industry (Flavour and texture, Fermentation, Baking, Organic Acids, Enzymes, Mycoproteins), Pharmaceutical (Secondary Metabolites and Mycotoxins), Agriculture (Biofertilisers, Mycofungicides, Mycoherbicides, Mycoinsecticides, Myconematocides), Application of Medical Mycology.

Unit- II: Introduction (Lectures: 4)

Definition of disease and its components (disease pyramid); Classification of diseases; History and significance of Phytopathology.

Unit- III: Basic concepts of Plant Pathology (Lectures: 4)

Definitions (Pathogenesis; Pathogen; symptoms; etiology); Types of pathogens and their Symptoms (Fungus, Oomycetes, Bacteria, Virus, Nematode, Phytoplasma); Koch's Postulates; Disease cycle (Components) – Epidemiology and forecasting of Plant diseases.

Unit- IV: Host-Pathogen relationship (Lectures: 4)

Mode of infection - penetration; post-penetration and colonization). Plant Defense mechanisms (Constitutive and induced, structural and biochemical).

Unit- V: Fungal diseases(Lectures: 8)

Causal Organism, Symptoms, Disease Cycle and control: Powdery mildew of Pea; Ergot of Rye, Late blight of potato, Red rot of sugarcane, Rusts of Wheat; Smut of Barley.

Unit- VI: Bacterial Diseases (Lectures: 2)

General symptoms; Disease cycle and Control measures of Citruscanker.

Unit- VII: Viral Diseases (Lectures: 2)

General symptoms; Mode of transmission and Control measures-Tobacco mosaic disease; Citrus exortis.

Unit- VIII: Nematode Diseases(Lectures: 1)

General symptoms, Disease cycle and Control measures – Root knot disease of Brinjal.

Unit- IX: Plant Disease Control (Lectures: 10)

Plant quarantine and its significance; Methods of disease control - Physical, Chemical and biological Integrated Diseases Management system

PRACTICAL (Lectures:30)

1. Study of late blight of Potato through specimens, temporary mounts (V.S. of leaf showing infection) and permanent slides.
2. Study of Black stem Rust of Wheat: Symptoms on wheat and barberry. Observed spores and teleutospores on V.S. wheat leaf/ to study stem spore stages of *Pucciniagraministritici* with the help of temporary tease/section mount of wheat. Permanent slides of somatic and reproductive phases on both the hosts.
3. Study of symptom and causal organism (with photograph) - Smut of Barley, Powdery mildew of Pea, Red Rot of Sugarcane, Citrus Canker, Tobacco Mosaic Disease and Citrus exortis
4. Isolation of pathogens from disease material.
5. Submission specimens of a Plant Diseases Album.

RECOMMENDED BOOKS:

1. Agrios, G.N. (2005) *Plant Pathology* 5th edition: Elsevier Academic Press, Amesterdam.
2. Sharma, P.D. (2014) *Plant Pathology* Rastogi Publications, Meerut, U.P.
3. Singh, R.S. (2018) *Plant Diseases*.10th Edition Medtech, New Delhi
4. Ownley, Bonnie and Trigiano, Robert N. (2017). *Plant Pathology: Concepts and Laboratory Exercises*, 3rd Edition, CRC Press.

COURSE NAME: BIOMOLECULES AND CELL BIOLOGY

COURSE CODE: BT - CE - 3224

TotalCredits:4(Theory:3+Practical/Tutorial:1)

THEORY:3 CREDITS

Total Lectures:45

COURSE OBJECTIVE:

The course objectives are to accommodate the widening horizons of the Botany discipline, to reflect about the dynamism of cell biology and biomolecules, to understand the properties, functions and roles of different molecules, to reveal the relationship between the structure and function of various biomolecules at the chemical level and hands-on approach and laboratory techniques by performing different related experiments

COURSE LEARNING OUTCOME:

On completion of this course

- CLO-01:** *Students will be able to obtain knowledge of structure, classification, and physicochemical properties of different biomolecules.*
- CLO-02:** *Students will be able to know about the detailed structure, properties, and functions of a cell and its components.*
- CLO-03:** *Students will be acquainted with practical knowledge of properties of cell and cell membranes, nucleic acid and microscopy of the plant cell.*
- CLO-04:** *Students will be able to identify various biomolecules in the laboratory by qualitative tests of biomolecules.*

Unit- I: Introduction to biomolecules (Lectures 03)

Definition of biomolecules, Types of biomolecules, Types of chemical bonds holding cellular biomolecules

Unit- II: Water (Lectures 03)

Structure and properties.

Unit- III: Carbohydrates (Lectures 03)

Structures, Nomenclature, Classification and function.

Unit- IV: Lipids and Fatty Acid(Lectures 04)

Structure, Classification, Types and functions.

Unit-V: Amino acids and Proteins (Lectures 05)

Structure and functions.

Unit-VI: Nucleic Acids (Lectures 06)

Nitrogenous bases, Nucleotides, Types and functions of nucleic acids, Structure of B and Z type of DNA.

Unit-VII: Enzymes (Lectures 04)

Classification, structure and functions

Unit-VIII: Introduction to cell (Lectures 06)

Cell as a unit of structure and function; Characteristics of prokaryotic and eukaryotic cells, Cell cycle and Check points, Mitosis and meiosis

Unit-IX: Cell wall and plasma membrane (Lectures 05)

Chemistry, Structure and function of Plant cell wall, Cytoskeleton. Membrane structure and functions, Fluid mosaic model

Unit-X: Cell organelles (Lectures 06)

Nucleus, Ribosome, Chloroplast, Mitochondria, Peroxisomes, Endoplasmic Reticulum, Golgi Apparatus, and Lysosomes/

PRACTICAL(Lectures:30)

1. Qualitative tests for carbohydrates, reducing sugars, proteins.
2. Study of plant cell structure with the help of epidermal peel mount of Onion.
3. Demonstration of the phenomenon of protoplasmic streaming in *Hydrilla*..
4. Study different stages of mitosis.
5. Demonstration of meiosis.

RECOMMENDED BOOKS:

1. Berg JM, Tymoczko JL and Stryer L (2011) Biochemistry, W.H. Freeman and Company.
2. Campbell MK (2012) Biochemistry, 7th Edition. Published by Cengage Learning
3. Campbell PN, Smith AD (2011) Biochemistry Illustrated, 4th Edition, Published by Churchill Livingstone.
4. Cooper GM, Hausman RE (2009) The Cell: A Molecular Approach. 5th edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA
5. Hardin J, Becker G, Skliensmith LJ (2012) Becker's World of the Cell, Pearson Education Inc. U.S.A. 8th Edition.

**COURSE NAME: MORPHOLOGY, ANATOMY AND EMBRYOLOGY OF
ANGIOSPERMS**

COURSE CODE: BT- CE - 4214

Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)

THEORY: 3 CREDITS

Total Lectures: 45

COURSE OBJECTIVE:

This paper is meant to give adequate knowledge on morphology, anatomy and reproductive biology of Angiosperm. Special stress has been given on basic learning in Advanced Morphology. Anatomical study of plant body of Angiosperm and different theories are dealt with this paper. A thorough knowledge of Reproductive Biology of Angiosperm is being tried to offer in this paper.

COURSE LEARNING OUTCOME:

- CLO-01:** *After studying the different topic knowledge will be enhanced on Morphology, Anatomy and reproductive biology of angiosperm.*
- CLO-02:** *Basic and advanced practical knowledge will be acquired in the field of anatomy, morphology and reproductive biology of angiosperm.*
- CLO-03:** *Student will acquire good understanding of the mentioned field of angiosperm.*
- CLO-04:** *Advanced knowledge of pollen morphology will be acquired by the learners (students).*
- CLO-05:** *Basic theoretical knowledge will help in understanding of the subject matter primarily on advanced morphology, anatomy of angiosperm*

Unit- I: Introduction to Plant Morphology (Lectures: 05)

Morphology of inflorescence, stamen, carpel, telome-theory, Phyllode-theory.

Unit- II: Applied aspect of Plant Anatomy (Lectures 02)

Anatomy in forensic science, pharmacognosy.

Unit- III: Tissue, tissue system, vascular cambium and wood (Lectures: 10)

Simple and complex tissue, tissue systems; Types of stomata, Hydathode, Lithocytes, Ergastic substances, secondary growth of stem and root, cambium-primary and secondary, periderm.

Unit- IV: Structure and development of plant body (Lectures: 06)

Cytodifferentiation, organogenesis in embryonic development dicot and monocot, Kranz anatomy.

Unit-V: Apical meristems and adaptive systems (Lectures 06)

Organizational theories of shoot and root apices, adcrustation, incrustation. Anatomical adaptation of xerophytes and hydrophytes.

Unit-VI: Anther and Pollen Biology (Lectures 06)

Structure and function of anther wall, microsporogenesis, microgametogenesis, Structure of MGU(Male Germ Unit), NPC system. Palynology and its scopes.

Unit-VII: Ovule (Lectures 03)

Types of ovules, megasporogenesis, megagametogenesis

Unit-VIII: Pollination, fertilization, embryo, endosperm and seed (Lectures 07)

Types of pollination and significance, fertilization and double fertilization, types of female gametophytes, types of endosperms, monocot and dicot embryo polyembryony, Apomixes and structure of seed.

PRACTICAL(Lectures:30)

1. Study of special type of inflorescence, cyathium, hypanthodium, verticillaster.
2. Study of types of stomata, trichomes, glandular and non-glandular, raphides, cystolith.
3. Study of secondary growth in stem and root of dicot and monocot plants.
4. Study of anatomical features of xerophytes and hydrophytes.
5. Pollen morphology by acetolysis method.
6. Types of ovules (from slides or photographs).
7. Types of endosperms (from slides or photographs).
8. Types of embryos(from slides or photographs).

RECOMMENDED BOOKS:

1. A.J Eames, Morphology of angiosperm.
2. K.R Sporne – Morphology of angiosperm.
3. A.J Eames and L.H MacDaniels – An introduction to Plant Anatomy.
4. A.Fahn – Plant anatomy.
5. Arthur J Eames – An Introduction to Plant Anatomy.
6. P. Maheshwari – Embryology of Angiosperm
7. SS Bhojwani and SP Bhattnagar – Embryology of Angiosperm
8. K R Shivanna – Pollen biology and biotechnology

COURSE NAME: ADVANCES IN PLANT SYSTEMATICS

COURSE CODE: BT - CE - 4224

Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)

THEORY: 3 CREDITS

Total Lectures: 45

COURSE OBJECTIVE:

The course objectives are to understand the various aspects of plant nomenclature and classification. To understand the classical and modern trends of Angiosperm taxonomy. To understand the salient features of angiosperm families with special reference to sexual characters.

COURSE LEARNING OUTCOME:

Students are expected to gain theoretical knowledge and acquire basic skills on the plant taxonomy with special reference to Angiosperms. Upon completion of the course, the students will be able to:

CLO-01: *Illustrate the types; merits & demerits of various systems of classification.*

CLO-02: *Relate taxonomy and other fields of botany.*

CLO-03: *Combine classical plant taxonomy with modern molecular phylogeny.*

CLO-04: *Integrate concepts of plant evolution and speciation into and understanding of how organisms are classified in a molecular phylogenetic framework*

CLO-05: *Learn the norms of ICBN and Construction of keys.*

CLO-06: *Identify the angiosperms families with specific key characters.*

CLO-07: *Learn various advanced tools to study plant taxonomy.*

Unit- I: Introduction (Lectures: 04)

Components of Systematics: Nomenclature, Identification, Classification; Taxonomy and its phases - Pioneer, Consolidation, Bio systematic and Encyclopaedic; alpha- and omega- taxonomy.

Unit- II: Nomenclature (Lectures: 06)

Type method, Publication, Rank of taxa, Rules of priority, Retention and rejection of names, Author Citation, Effective and valid publication, Elementary knowledge of ICN- Principles.

Unit- III: Systems of Classification (Lectures: 07)

Broad outline of Bentham & Hooker (1862-1883) and Takhtajan (1997)- systems of classification with merits and demerits. Brief idea of angiosperm phylogeny group (APG IV classification)

Unit- IV: Systematics in Practice (Lectures: 02)

Herbaria and Botanic Gardens – their role in teaching and research.

Unit-V: Dichotomous keys (Lectures: 02)

Indented and Bracketed Keys.

Unit-VI: Brief idea on Phenetics and Cladistics (Lectures: 02)

Monophyletic, polyphyletic and paraphyletic groups; Plesiomorphy and apomorphy.

Unit-VII: Numerical and Molecular Taxonomy (Lectures: 03)

Methods and Significance of numerical taxonomy

Unit-VIII: Data sources in Taxonomy (Lectures: 04)

Supportive evidences from Phytochemistry, Cytology, Palynology and Molecular biology data (Protein and Nucleic acid homology).

Unit-IX: Systematic study of Angiosperm taxa :Monocotyledons (Lectures: 06)

Diagnostic features, systematic position (Bentham & Hooker) and economically important plants (parts used and uses) of the following families - Gramineae (Poaceae), Palmae (Arecaceae), Musaceae, Zingiberaceae, Orchidaceae.

Unit-X: Systematic study of Angiosperm taxa :Dicotyledons (Lectures: 09)

Diagnostic features, systematic position (Bentham & Hooker) and economically important plants (parts used and uses) of the following families - Magnoliaceae, Leguminosae (subfamilies), Euphorbiaceae, Labiatae (Lamiaceae), Cruciferae (Brassicaceae), Solanaceae, Rubiaceae, Compositae (Asteraceae) Umbelferae (Apiaceae)

PRACTICAL (Lectures: 30)

1. **Work out of Angiosperms :** Dissection, description, preparation of floral formula and floral diagram, identification up to genus with the help of suitable literature of wild plants and systematic position according to Bentham and Hooker system of classification from the following families: Musaceae, Euphorbiaceae, Labiatae (Lamiaceae), Solanaceae, Rubiaceae, Compositae (Asteraceae).
2. **Spot identification :**(Binomial, Family) of common wild plants from families included in the theoretical syllabus. App based / Artificial Intelligence based plant identification.
3. **Field Visit and Report:** Field visit to a places of botanical importance, Submission of Herbarium specimens, Field Note Book and Field Report based on vegetation study.

RECOMMENDED BOOKS:

1. Paria, N.D., Plant Taxonomy & Biodiversity, 2022, Santra Publication Pvt. Ltd.
2. Judd, W.S., Campbell, C.S., Kellogg, E.A., Stevens, P.F. and Donoghue, M.J. Plant Systematics, A Phylogenetic Approach (4th ed.), 2016, Sinauer Associates, Inc.
3. Jones, S.B. and Luchsinger, A.E. Plant Systematics (2nd ed.), 1987, McGraw Hill Book Company.
4. Singh, G. Plant Systematics: An Integrated Approach (3rd ed.), 2016, CRC Press.

5. Sambamurty, A.V.S.S. Taxonomy of Angiosperms, 2005, I.K. International Pvt. Ltd.
6. Sivarankan, V.V. Principles of Plant Taxonomy (2nd ed.), 1991, Oxford & IBH
7. Subrahmanyam, N.S. Modern Plant Taxonomy, Latest Ed., Vikas Publishing House.
8. Naik, V.N. Taxonomy of Angiosperms, Latest Ed., Tata McGraw Hill.
9. Stace, C. A Plant Taxonomy & Biosystematics, Latest Ed., Arnold Publishers
10. Mitra, J.N. An Introduction to Systematic Botany & Ecology, Latest Ed., World Press.
11. Dutta, S.C. Systematic Botany, Latest Ed., Wiley Eastern.
12. Lawrence, G.H.M. Taxonomy of Vascular Plants Ed., Oxford & IBH.
12. Prain, D. Bengal Plants (Vol I & II), Bishen Singh Mahendra Pal Singh.
13. Jeffrey, C. An Introduction to Plant Systematics, Latest Ed., Allied Publishers Pvt. Ltd.
14. Radford. A.B. Fundamentals of Plant Systematics, Latest Ed., Harper & Row.
15. Simpson, G. Plant Systematics, 2006, 2010, 2019, Springer.
16. Bhattacharya, B. Systematic Botany, 2006, Narosa Publishing House.
17. Heywood, V.H. Plant Taxonomy 1967, Edward Arnold, London.
18. Cronquist, A. The Evolution & Classification of Flowering Plant, 1988 (2nd ed.), New York Bot. Garden Bronx. New York.
19. Cronquist, A. An Integrated System of Classification of Flowering Plants.1981. Bishen Singh Mahendra Pal Singh.
20. Subramanyam, N.S. Laboratory Manual of Plant Taxonomy (2nd ed.) 1999, Vikas Publishing House.
21. Heywood, V.H. Flowering Plants of the World 1978, Oxford University Press.

COURSE NAME: PLANT PHYSIOLOGY

COURSE CODE: BT- CE - 4234

Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)

THEORY:3 CREDITS

Total Lectures: 45

COURSE OBJECTIVE:

The course objectives are to introduce the basic principles of plant structure and function and its application in related fields. Photosynthesis and metabolism: Investigate the processes of photosynthesis, respiration, and metabolism to comprehend energy and nutrient utilization. Analyze plant hormones and their roles in growth, development, and stress responses. Apply physiological insights to enhance crop yield, quality, and stress tolerance. Research and innovation: Conduct experiments to unravel complex plant processes, advancing agricultural practices and sustainability.

COURSE LEARNING OUTCOME:

- CLO-01:** *Understand the intricate mechanisms of photosynthesis and respiration, including the biochemical processes and their significance in plant energy metabolism.*
- CLO-02:** *Explore how plants grow, develop, and respond to environmental cues at a physiological level.*
- CLO-03:** *Study nutrient acquisition, assimilation, and utilization in plants, linking these processes to growth and overall plant health.*
- CLO-04:** *Analyze plant hormones and their roles in growth, development, and stress responses and evaluate the significance of regulator molecules in controlling life forms.*
- CLO-05:** *Apply physiological insights to enhance crop yield, quality, and stress tolerance and the principles of plant physiology to solve problems in related fields.*
- CLO-06:** *Enhance critical thinking skills by evaluating and interpreting experimental results and applying theoretical knowledge to solve physiological problems and advancing agricultural practices and sustainability.*

Unit- I: Plant-water relations (Lectures: 08)

Water potential and its components, water absorption by roots, water movement via symplast, apoplast and aquaporins, root pressure, ascent of sap - cohesion-tension theory, transpiration, Mechanism of stomatal movement, factors affecting transpiration, anti-transpirants.

Unit- II: Mineral nutrition (Lectures: 04)

Essential and beneficial elements, macro and micro-elements, criteria for essentiality, mineral deficiency symptoms, role of essential elements, chelating agents, Ion antagonism and toxicity. Hydroponics and Aeroponics.

Unit- III: Nutrient uptake (Lectures: 08)

Soil as a nutrient reservoir, Transport of ions across cell membrane, passive absorption, simple and facilitated diffusion (carrier and channel proteins), Fick's law, active absorption, proton ATP as pump, electrochemical gradient, ion flux, uniport, co-transport (symport, antiport)

Unit- IV: Trans-location*inthephloem (Lectures: 08)

Composition of phloem sap, Experimental evidence in support of phloem as the site of sugar translocation, phloem loading and unloading, Pressure-Flow Model, source-sink relationship.

Unit-V: Plant growth regulators (Lectures: 10)

Chemical nature (basic structure, precursor), physiological roles, bioassays and applications of Auxins, Gibberellins, Cytokinins, Abscissic Acid, Ethylene; Other growth regulators-Jasmonic Acid, Brassinosteroids, Nitric Oxide. Mechanism of action of Auxin. Introduction to interactions among plant growth regulators and Plant Extract as growth regulator.

Unit-VI: Physiology of photo-sensory molecules (Lectures: 03)

Discovery, chemical nature, mode of action and role of phytochrome, cryptochrome and phototropin in photomorphogenesis.

Unit-VII: Physiology of flowering Seed dormancy (Lectures:04)

Concept of florigen, photoperiodism, CO-FT Mode of flowering, vernalization. Causes and methods to induce and/ or overcome seed dormancy

PRACTICAL (Lectures: 30)

1. Determination of osmotic potential of plant cells by plasmolytic method.
2. Determination of water potential of potato tuber cells by weight method.
3. Calculation of stomatal index and stomatal frequency from the lower surface of leaves of a mesophyte and a xerophyte.
4. To study the effect of different concentrations of ABA on stomatal closure.
5. To study the effect of auxin on rooting.
6. Hydroponics Culture of tomato / spinach / strawberry.

RECOMMENDED BOOKS:

1. Hopkins, W. G., Huner, N. P. A. (2009). Introduction to Plant Physiology, 4th edition. New Delhi, Delhi: Wiley India Pvt. Ltd.
2. Taiz, L., Zeiger, E., Moller, I.M., Murphy, A. (2018). Plant Physiology and Development, 6th edition. New York, NY: Oxford University Press, Sinauer Associates.
3. Kochhar, S.L., Gujral, S.K. (2020). Plant Physiology: Theory and Applications. New Delhi, Delhi: Foundation Books, 2nd Edn. Cambridge University Press India Pvt, Ltd.
4. Bajracharya, D. (1999). Experiments in Plant Physiology: A Laboratory Manual. New Delhi, Delhi: Narosa Publishing House.
5. Bhatla, S.C., Lal, M.A. (2018). Plant Physiology, Development and Metabolism. Singapore: Springer Nature, Singapore Pvt. Ltd.

COURSE NAME: PLANT METABOLISM AND BIOCHEMISTRY

COURSE CODE: BT- CE - 5314

Total Credits: 4 (Theory:3 + Practical/Tutorial:1)

THEORY: 3 CREDITS

Total Lectures: 45

COURSE OBJECTIVE:

The course objectives are to understand different pathways of metabolism in plant cells. To understand how various metabolic pathways work in a synchronized manner

COURSE LEARNING OUTCOME:

At the end of the course the student will:

- CLO-01:** *Know different types of chemical reactions that run the biological system.*
- CLO-02:** *Know the details of carbon assimilation, oxidation, synthesis of ATP- the energy currency of the cell, nitrogen fixation and lipid metabolism.*
- CLO-03:** *Understand the role of enzymes in regulating metabolic pathways for molecules like carbohydrates, lipids and proteins.*
- CLO-04:** *Understand the coordination of various biochemical reactions with reference to cell requirement and energy (ATP) economy.*
- CLO-05:** *Establish link between theoretical concepts and experimental evidences.*
- CLO-06:** *Practically learn advance techniques of analysis which will help in future research activities.*

Unit- I: Concepts in Metabolism (Lectures: 04)

Introduction, anabolic and catabolic pathways, endergonic and exergonic reactions, coupled reactions, redox reactions. ATP: structure, its role as a energy currency molecule.

Unit- II: Enzymes (Lectures: 03)

Structure, classification and mechanism of action, Michaelis- Menten equation (no derivation), Hill Spot, Enzyme inhibition (competitive, non-competitive and uncompetitive), allosteric regulation and covalent modulation, factors affecting enzyme activity.

Unit- III: Carbon Assimilation (Lectures: 10)

- a) Photochemical reaction; Introduction, Concept of light absorption and action spectra, photosynthetic pigments, their types and functions (including epoxycycle); PSI, PSII; antenna molecules and reaction centres, Q-cycle, LHC, photosynthetic electron transport and photophosphorylation (cyclic and non-cyclic).
- b) Thermochemical Reactions (Dark reactions): CO₂ reduction in C₃, C₄ pathways and CAM, photorespiration, factors affecting CO₂ reduction.

Unit- IV: Carbon Metabolism(Lectures: 04)

Metabolite pool and exchange of metabolites, synthesis and degradation of sucrose and starch.

Unit-V: Carbon Oxidation (Lectures: 06)

Glycolysis, fate of pyruvate- aerobic, anaerobic respiration and fermentation, regulation of glycolysis, oxidative pentose phosphate pathway, oxidative decarboxylation of pyruvate, Krebs cycle and its regulation, amphibolic role of Krebs cycle, mitochondrial electron transport, oxidative phosphorylation, cyanide-resistant respiration.

Unit-VI: ATP Synthesis (Lectures: 06)

Mechanism of ATP synthesis-substrate level phosphorylation, oxidative and photophosphorylation, chemiosmosis, ATP synthase- structure and functions (Boyers conformational model, Racker's experiment, Jagendorf's experiment; role of uncouplers).

Unit-VII: Lipid Metabolism (Lectures: 04)

Triglycerides: synthesis, degradation through alpha and beta -oxidation, glyoxylate cycle, gluconeogenesis and its role in mobilisation of lipids during seed germination.

Unit-VIII: Nitrogen Metabolism (Lectures: 06)

Nitrate assimilation (NR and NiR); biological nitrogen fixation in root nodule heterosis; role of denitrigenase. Nitrogenase enzyme: structure and mechanism of action; Ammonia assimilation: GS-GOGAT, reductive amination and transamination.

Unit-IX: Abiotic Stress Physiology in Plants (Lectures: 02)

Introduction to concept of stress, Plant response to Water stress, Temperature stress and Salt stress. ROS, RNS and anti-oxidative defence strategies.

PRACTICAL (Lectures: 30)

1. Study the effect of pH on the activity of catalase enzyme.
2. Chemical separation of photosynthetic pigments (liquid-liquid partitioning).
3. Amino acid separation by paper chromatography.
4. Estimation of sugar.
5. Determination of TAN in plant materials.

RECOMMENDED BOOKS:

1. Nelson, D.L., Cox, M.M. (2017). Lehninger Principle of Biochemistry, 7th edition. New York, NY: W.H. Freeman, Macmillan learning.
2. Taiz, L., Zeiger, E., Moller, I. M. & Murphy, A. 2018. Plant Physiology and Development, International 6th edn, Oxford University Press, Sinauer Associates, New York, USA..
3. Hopkins, W.G., Huner, N. (2008). Introduction of Plant Physiology, 4th edition. New Jearsey, U.S.: John Wiley and sons
4. Jones, R., Ougham, H., Thomas, H., Waaland, S. (2013). The molecular life of plants. Chichester, England: Wiley-Blackwell

5. Buchanan, B.B., Gruissem, W. and Jones, R.L. (2015). *Biochemistry and Molecular Biology of Plants*, 2nd edition. New Jersey, U.S.: Wiley Blackwell.
6. Kochhar, S.L. & Gujral, S.K. 2020. *Plant Physiology: Theory and Applications*, 2nd Edition. Cambridge University Press, UK.
7. Bhatla, S.C., Lal, M.A. (2018). *Plant Physiology, Development and Metabolism*. Singapore: Springer.

COURSE NAME: CLASSICAL GENETICS AND PLANT BREEDING

COURSE CODE: BT- CE - 5324

Total Credits:4 (Theory:3+Practical/Tutorial:1)

THEORY: 3 CREDITS

Total Lectures: 45

COURSE OBJECTIVE:

1. *Understand the basic principles of classical genetics, including Mendelian inheritance, chromosome theory, and genetic variation*
2. *Genetic Analysis Skills: Develop proficiency in genetic analysis techniques, such as Punnett squares, pedigree analysis, and genetic crosses*
3. *Application in Research: Apply classical genetic principles to analyze and interpret inheritance patterns in various organisms, facilitating further research in genetics and related field.*
4. *Breeding Objectives: Understand the goals and objectives of plant breeding, including improving yield, quality, resistance to biotic and abiotic stresses, and adaptation to specific environments.*
5. *Breeding Methods: Learn breeding methods such as hybridization, selection, and hybrid vigor to develop improved plant varieties*

COURSE LEARNING OUTCOME:

- CLO-01:** *Understanding Mendelian principles, genetic inheritance patterns, and their application in plant breeding.*
- CLO-02:** *Students also learn about breeding techniques, selection methods, and the genetic basis of desirable traits in plants.*
- CLO-03:** *Additionally, the course may cover the principles of population genetics and how they relate to plant breeding strategies. Finally students should gain practical knowledge to apply genetic principles for improving crop plants through selective breeding.*
- CLO-04:** *Historical Context: Appreciate the historical contributions of key figures in classical genetics, including Mendel, Morgan, and Bateson.*
- CLO-05:** *Explore the utilization of genetic resources, including wild relatives and germplasm collections, in plant breeding programs*
- CLO-06:** *Apply breeding principles to develop new cultivars with desired traits, addressing agricultural challenges and contributing to food security and sustainability*

Unit- I: Introduction to Genetics (Lectures: 08)

Historical Perspective on Genetics, Mendelian principles, Monohybrid and dihybrid cross, Non-Mendelian Inheritance, (Multiple alleles, polygenic inheritance, epistasis), Extensions of Mendelian Genetics, (Co dominance and incomplete dominance) Chromosomal theory of inheritance.

Unit- II: Molecular Basis of Inheritance (Lectures: 04)

DNA structure and replication, Gene expression and regulation, Genetic mutations, point mutations, nonsense codon, tautomeric and frame shifts mutations.

Unit- III: Population Genetics (Lectures: 06)

Hardy-Weinberg equilibrium, factors effecting in equilibrium, Genetic drift and gene flow, Evolution theory and Natural selection, modern synthetic selection

Unit- IV: Classical Plant Breeding (Lectures: 06)

Basics of plant breeding, Breeding objectives and strategies, Hybridization techniques, artificial fertilization.

Unit-V: Quantitative and Molecular Genetics (Lectures: 04)

Quantitative trait inheritance, Marker-assisted selection, Genomic selection.

Unit-VI: Breeding for Disease Resistance (Lectures: 04)

Plant-pathogen interactions, Resistance breeding approaches, Biotechnological interventions.

Unit-VII: Breeding for Abiotic Stress Tolerance (Lectures: 04)

Understanding abiotic stress factors, Breeding for stress tolerance, Molecular approaches in stress breeding.

Unit-VIII: Seed Science and Technology (Lectures: 04)

Seed development and maturation, Seed quality and testing, Seed enhancement techniques

Unit-IX: Ethical and Regulatory Aspects (Lectures: 05)

Ethical considerations in plant breeding, Intellectual property rights, Plant varieties and GI, Regulatory frameworks for Geneon Editing and Transgenic

PRACTICAL (Lectures: 30)

1. Mendelian Inheritance: Perform experiments to understand Mendelian inheritance patterns using model organisms like pea plant.
2. Genetic Crosses: Conduct genetic crosses to analyze inheritance of traits, including monohybrid and dihybrid crosses, to study segregation and independent assortment.
3. Chromosome Mapping: Use recombination data to construct genetic maps and understand the linkage and recombination of genes on chromosomes.
4. Germplasm Evaluation: Study diverse germplasm collections to identify genetic variability and potential sources of novel traits for breeding programs.
5. Emasculation.

RECOMMENDED BOOKS:

1. Lewines, Gene XI.
2. T. A Brown, Genome.
3. Alberts *et al*, Molecular Biology of the Cell
4. J D Watson, Molecular biology of the Gene

5. Primrose and Twyman, Principles of Gene Manipulation and Genomics
6. Reinhard Renneberg, Biotechnology for Beginners.

COURSE NAME: PHYLOGENOMICS AND PALEOBOTANY

COURSE CODE: BT- CE - 5334

Total Credits: 4 (Theory: 3 + Practical/Tutorial:1)

THEORY: 3 CREDITS

Total Lectures: 45

COURSE OBJECTIVE:

1. *A course on the experimental and comparative analysis of evolutionary processes, speciation, and phylogenetic patterns in plants.*
2. *The course aims to provide students with a deep understanding of the evolution of plants, integrating principles of phylogenomics, speciation and insights from palaeobotany.*
3. *Through a combination of theoretical knowledge and practical applications, students will gain an appreciation for the diversity of plant life and the evolutionary processes that have shaped it over geological time scales.*

COURSE LEARNING OUTCOME:

By the end of this course, the student shall be able to

- CLO-01:** *Able to explain how life evolved through time and reach the present status, with particular emphasis on the evolution of land plants.*
- CLO-02:** *Critically analyse and understand the famous saying “Nothing in Biology makes sense except in the light of evolution”.*
- CLO-03:** *Able to explain about speciation, polyploidy, hybridisation and adaptation.*
- CLO-04:** *Understand the genetic background of parasitism, horizontal gene transfer and overall origin and diversification of angiosperms.*
- CLO-05:** *Develop the ability to read, understand, analyse, and explain research articles from prestigious journals through the project exercise.*
- CLO-06:** *Able to adapt oneself to the use of computer during this course.*
- CLO-07:** *Students will be proficient in the molecular techniques used in phylogenomic studies, through both theory and practical sessions, including the use of molecular markers, DNA sequencing technologies, and the construction of phylogenetic trees*

Unit- I: Palaeobotany(Lectures: 06)

Definition of Palaeobotany; Fossils- Importance, Types of Fossil Plants, Types of Fossils, Fossilisation process, Different types of rocks; Gondwana; Geological time scale with biological events.

Unit- II: Origin of Life(Lectures: 06)

Evidences of organic evolution; Mechanism of evolution-Variation, Adaptation, Heredity etc.; Elementary knowledge of theories related to evolution of life- Pre-Darwinian, Lamarck's,

Darwin's, Pangenesis, Weismann's, De Vries', Modern synthetic theory.

Unit- III: Population and Evolutionary Genetics (Lectures: 05)

Population genetics, Hardy-Weinberg Law; Genetic drift, Gene pool, Allele frequencies, Chromosomal variation and Mutation, Speciation

Unit- IV: Phylogeny of Angiosperms (Lectures: 12)

Terms and concepts (primitive and advanced, homology and analogy, parallelism and convergence, monophyly, paraphyly, polyphyly and clades). Origin & evolution of angiosperms; co- evolution of angiosperms and animals; Morphological vs Molecular Phylogeny, Methods of illustrating evolutionary relationship-phylogenetic tree, cladogram, rooted vs unrooted tree, distance approach (UPGMA, NJ) and character state approach (Parsimony, Maximum Likelihood, Bayesian).

Unit-V: Phylogenomics (Lectures: 06)

Introduction to Phylogenomics, Definition, Scope, Applications of phylogenomics in understanding the tree of life (including plants); Chloroplast phylogenomics of different plant groups; Phylogenomics and plant adaptations; Perspectives on co-evolution of pollinators; adaptation to parasitism in plants; horizontal gene transfer.

Unit-VI: Plant Adaptations and Diversification(Lectures: 05)

Evolution of plant adaptations to different environments; Evolutionary trends in plant reproductive strategies; Plant-animal interactions and coevolution; Impact of plant evolution on terrestrial ecosystems; Evolutionary response to climate change.

Unit-VII: Molecular techniques in plant evolution (Lectures: 05)

Molecular clock hypothesis and its application; Role of genetic regulation in plant evolution; DNA sequencing techniques, Next Generation Sequencing, Single Nucleotide Polymorphism, Microsatellites or SSRs, Nucleotide and Chloroplast sequencing for concept of conserved sequences, Ancient DNA from herbarium, Environmental DNA (e-DNA).

PRACTICAL (Lectures: 30)

1. Identification and study of different plant fossils.
2. Construction of two phylogenetic trees using sequence data from NCBI.
3. Case study / Assignment in Phylogenomics and presentation of these data (Discuss any recent research papers published in world's topmost prestigious journals)– Case study topics can be allotted on the first day but the last 3 practical slots to be used for their presentations: individual seminars if number of students is less; else group discussions / group presentation (3 lecture hour equivalents).

RECOMMENDED BOOKS:

1. Niklas, K. J., & Kutschera, U. (2012). The Evolutionary Biology of Plants. University Of Chicago Press.
2. Taylor, T. N., Taylor, E. L., & Krings, M. (2009). Paleobotany: The Biology and Evolution of Fossil Plants. Academic Press.

3. Soltis, D. E., & Soltis, P. S. (2018). The Rise of Angiosperms: A Genomic View. *Advances in Botanical Research*, 85, 1–36.
4. Jiao, Y., & Huang, J. (2016). Phylogenomic Analysis of the Triticeae. *Current Genomics*, 17(2), 185–198.
5. Dutta, A.C., & Dutta, T.C. (1995). *Botany for Degree Students*. Sixth Edition, Oxford University Press.
6. Bromham, L. (2015). *An Introduction to Molecular Evolution and Phylogenetics*. Second Edition, Oxford University Press.
7. Lemey, P., Salemi, M. & Vandamme, A-M, eds. (2009). *The Phylogenetic Handbook: A Practical Approach to Phylogenetic Analysis and Hypothesis Testing*. Second Edition, Cambridge: Cambridge University Press.
8. Weising, K., Nybom, H., Pfenninger, M., Wolff, K., & Kahl, G. (2005). *DNA Fingerprinting in Plants: Principles, Methods, and Applications*, Second Edition, CRC Press.

COURSE NAME: APPLICATION OF PLANT ECOLOGY AND ENVIRONMENT

COURSE CODE: BT- CE - 5344

Total Credits: 4 (Theory: 3 + Practical/Tutorial:1)

THEORY: 3 CREDITS

Total Lectures: 45

COURSE OBJECTIVE:

1. *This paper shall try to give an insight into practical and theoretical knowledge of Applied Ecology and environment*
2. *This paper deals with mathematical application on biodiversity.*
3. *Unit on ecotourism and Eco restoration will help in understanding in the field of above area and its practical utility and restoration of environmental study.*
4. *Forestation and pollution study will help the learners to develop some practical knowledge to mitigate and develop solution to the current menace confronting the environment.*

COURSE LEARNING OUTCOME:

- CLO-01:** *Basic and practical knowledge in the field of applied ecology and environment will be enhanced.*
- CLO-02:** *Learner's will have a good insight in understanding practical and applied aspects of ecology and environment dealt in the areas of the paper.*
- CLO-03:** *Ecotourism and eco-restoration introduced in the paper will help learner to develop self-sustenance and good understanding in the field of study.*
- CLO-04:** *Pollution study in the paper will help the learners in understanding current problems and very sensitive issue in sustenance of the environment.*
- CLO-05:** *Total biodiversity issue will be sorted out after learning the various aspect in this field.*

Unit- I: Forestry (Lectures: 05)

Definition, forest types, global deforestation, threats to and loss of biodiversity, extinction crisis, causes of extinction, habitat loss, bio-invasion, invasive species, exotic species, afforestation, re-forestation, mass-extinction.

Unit- II: Biodiversity and measurement (Lectures: 10)

Definition, magnitude, level of diversity, species diversity, tree diversity in tropical forest, measurement of genetic diversity, agro-biodiversity, measurement of biodiversity, species-richness evenness frequency, density, I.V.I(importance value index), diversity indices, Shannon Simpson indices, fisher's indices, biodiversity conservation, threats, global biodiversity.

Unit- III: Environmental pollution (Lectures: 12)

Definition, environmental pollution and pollutants, types of pollution, air, water, soil and noise pollution, causes, effects, control, bio-magnification, particulate matters (PM), photochemical

smog, PAN tropospheric ozone, radioactive pollutants, heavy metals pollution, eutrophication, indoor air pollutants, solid waste management, liquid waste management.

Unit- IV: Ecological application(Lectures: 06)

Organic farming, sustainable development, ecological sustainability, bio-pesticides, bio-fertilizers, integrated pest management, biological monitoring of the environment - indicator species, ecosystem services, exobiology, types of life supporting systems, ecology of space travel.

Unit-V: Ecotourism (Lectures: 09)

Definition, historical background, identification of potential sites for ecotourism, conventional and mass-tourism, nature-based tourism, role of parks and gardens in ecotourism, community involvement in ecotourism, development and management. Role of photographs and electronic media in ecotourism, environmental impact, trends, and future of ecotourism, recreation, conservation and economic development.

Unit-VI: Eco-restoration(Lectures: 03)

Definition, restoration of wasteland, forests, soil fertility, ground water, restoration of ecology in urban and industrial center, indicators of restoration and reclamation.

PRACTICAL (Lectures: 30)

1. Instrumentation: pH meter, B.O.D incubator, titrimetry, spectrophotometry, chromatography, gravimetry, photographs/instrument.
2. Determination of soil types, texture, pH, nitrogen, potassium, phosphorus and organic matters.
3. Dissolved oxygen measurement by Winkler's method.
4. Determination of frequency, density and abundance of local area.
5. Analysis of importance value index (I.V.I) with phytographs.
6. Field visits to different areas to identify ecological degradation, industrial establishment to know more about pollution devices and management

RECOMMENDED BOOKS:

1. E.P. Odum- Fundamental of ecology.
2. P.D. Sharma- Ecology and Environment.
3. R.S. Ambhast- Plant ecology.
4. Willard, Merritt and Dean- Instrumental Analysis.
5. JomBockins- Environmental Chemistry.
6. Lauret Hodges- Environmental Pollution
7. Brady- The nature of properties of soil
8. M.N. Rao and A.K. Datta- Waste water treatment
9. H.C. Parkins- Air pollution
10. C.S. Rao- Environmental science and engineering
11. Martha Honey- Ecotourism and sustainable development, Island press, Washington DC
12. B.K Tiwari, Surendra Singh- Eco-restoration of degraded Hills.

COURSE NAME: ADVANCED MICROBIOLOGY

COURSE CODE: BT - CE - 6314

Total Credits: 4 (Theory: 3 + Practical/Tutorial:1)

THEORY: 3 CREDITS

Total Lectures: 45

COURSE OBJECTIVE:

1. *To understand the historical development of microbiology and its significance in scientific discovery.*
2. *Explore the scope of microbiology and its applications in various fields.*
3. *To comprehend the nutritional requirements and metabolic processes of microorganisms.*
4. *To understand the microbiology of soil, air, and water, and their roles in biogeochemical cycles; the mechanism and significance of biological nitrogen fixation.*
5. *To gain insight into the modern concept of bacterial cell structure and function.*
6. *To understand the principles of bioremediation and waste treatment using microorganisms*
7. *To understand the principles and applications of synthetic biology and microbial engineering and also explore ethical considerations related to synthetic biology.*

COURSE LEARNING OUTCOME:

Upon successful completion of the course, students will be able to

- CLO-01:** *Trace the historical development of microbiology and appreciate its role in shaping scientific knowledge.*
- CLO-02:** *Identify and discuss real-world examples of how microbiology contributes to different scientific and industrial domains.*
- CLO-03:** *Demonstrate an understanding of the nutritional needs of microorganisms and the metabolic processes that sustain their growth.*
- CLO-04:** *Comprehend the microbiology of soil, air, and water, recognizing the roles microorganisms play in these environments with a focus on the biological nitrogen fixation process.*
- CLO-05:** *Differentiate the characteristics of Rickettsiae, Chlamydiae, Actinomycetes, Archaeobacteria, and Mycoplasma and the diseases caused by these microorganisms and their impact on human health.*
- CLO-06:** *Understand the principles and applications of synthetic biology and microbial engineering and application of ethical frameworks to evaluate potential advancements in the field.*
- CLO-07:** *Foster collaborative learning and communication skills through teamwork, group discussions, seminars, and home assignments.*

Unit- I: Introduction(Lectures: 06)

History and development, scope of Microbiology, introduction to microbial world, microbial taxonomy and its modern trends.

Unit- II: Microbial Metabolism(Lectures: 10)

Microbial nutrition, growth and metabolism, microbiology of soil, air and water, role of microorganisms in biogeochemical cycles (N, C, S cycles) in nature, biological nitrogen fixation.

Unit- III: Structure and Growth of Microbes(Lectures: 08)

Modern concept of Bacterial cell, Reproduction and Growth of Bacteria- genetic recombination; General account of Rickettsiae, Chlamydeae and diseases caused by them. Distinguishing features of Actinomycetes, Archaeobacteria and Mycoplasma.

Unit- IV: Industrial Microbiology (Lectures: 10)

Microorganisms in food and beverage production, Bioremediation and waste treatment; Medical Microbiology: Pathogenesis of microbial infections, Antimicrobial resistance; Microbial Control..

Unit-V: Immunology (Lectures: 05)

Concept of immunology, types of immunity, cell mediated and humoral immunity, primary and secondary immune responses, antigen and antibody structure and classes, vaccine.

Unit-VI: Application aspects of Microbiology (Lectures: 04)

Synthetic Biology and Microbial Engineering: Engineering microorganisms for various applications; Ethical considerations in synthetic biology; Recent Advances in Microbiology Research.

PRACTICAL (Lectures: 30)

1. Culturing and monitoring microbial growth using different culture.
2. Isolation and identification of microorganisms from environmental samples.
3. Analysis of microbial diversity in soil, air, and water samples.
4. Microscopic examination of bacterial cell structures.
5. Visualization of bacterial morphology using advanced microscopy techniques.
6. Hands-on experience in the production of microbial products (e.g., fermentation of food and beverages).

RECOMMENDED BOOKS:

1. Dubey, R.C & D.K. Maheswari: A Text Book of Microbiology.
2. Kaushik, P.: Microbiology.
3. Kumar, H.D. & S. Kumar: Modern Concept of Microbiology.
4. Pelczar, Chan and King: Microbiology.
5. Purohit, S.S.: Microbiology.
6. Rangaswami, R. & C.K.J. Panikar: Text Book of Microbiology
7. Sharma, P.D.: Microbiology and Pathology
8. Singh, U.S. & K. Kapoor: Introductory Microbiology

9. Trivedi, P.C. Pandey, S. & Seema Hadauria: Text Book of Microbiology.
10. Banerjee, A.K. & N. Banerjee: Fundamentals of Microbiology and Immunology.

COURSE NAME: MOLECULAR BIOLOGY AND BIOTECHNOLOGY

COURSE CODE: BT- CE - 6324

Total Credits: 4 (Theory: 3 + Practical/Tutorial:1)

THEORY: 3 CREDITS

Total Lectures: 45

COURSE OBJECTIVE:

1. *To provide students with a comprehensive understanding of the principles and concepts underlying biotechnology, including molecular biology, genetics, and biochemistry, forming the foundation for advanced studies and research in the field.*
2. *To develop practical skills in biotechnological techniques, such as DNA manipulation, protein purification, cell culture, and genetic engineering, through hands-on laboratory exercises and experiments.*
3. *To familiarize students with the diverse applications of biotechnology in various sectors, including agriculture, pharmaceuticals, healthcare, and environmental science, enabling them to appreciate the real-world impact and potential of biotechnological advancements.*
4. *To cultivate awareness of ethical issues, safety protocols, and regulatory frameworks governing biotechnological research and applications, fostering responsible conduct and decision-making in the field.*
5. *To encourage interdisciplinary learning by integrating concepts from biology, chemistry, physics, and engineering into the study of biotechnology, preparing students to address complex scientific challenges through collaborative and innovative approaches.*
6. *To enhance critical thinking skills by challenging students to analyze and solve biotechnological problems, fostering creativity, adaptability, and resilience in tackling scientific inquiries and technological developments*

COURSE LEARNING OUTCOME:

- CLO-01:** *Conduct Molecular Experiments: Execute laboratory experiments using molecular techniques, interpret results, and generate accurate and reliable data.*
- CLO-02:** *Apply Genetic Engineering Techniques: Apply gene cloning and recombinant DNA technology to design and execute experiments aimed at modifying genes for specific purposes.*
- CLO-03:** *Analyze Biotechnological Data: Analyze data from biotechnological experiments, draw conclusions, and present findings effectively, both orally and in writing.*
- CLO-04:** *Solve Biotechnological Problems: Demonstrate problem-solving skills by applying molecular biology and biotechnological knowledge to address real-world challenges in agriculture, medicine, and industry.*

CLO-05: *Collaborate in a Laboratory Setting: Work collaboratively in a laboratory setting, demonstrating effective communication and teamwork in the execution of experiments and projects*

CLO-06: *Critically Evaluate Biotechnological Applications: Critically evaluate the ethical, societal, and environmental implications of biotechnological applications, and make informed decisions, based on this understanding.*

Unit- I: Introduction to Molecular Biology(Lectures: 06)

Overview of Molecular Biology- Concept of chromosome and chromatin, structure of nucleosome, chronology of historical mile stones, Synthesis and Processing of DNA, Concept of intron splicing..

Unit- II: Genetic Information flow(Lectures: 06)

Central Dogma, RNA Processing, Unidirectional flow Transcription and translation, Reverse transcription and the basis of gene hunting, genetic code (three letter codon), codon bias, protein synthesis, regulation of gene expression - prokaryotes and eukaryotes, Epigenetics.

Unit- III: Molecular Techniques(Lectures: 04)

Gel Electrophoresis, SDS PAGE – 1 D, 2 D electrophoresis and Agarose Gel Electrophoresis, Polymerase Chain Reaction (PCR), DNA sequencing, Molecular Cloning.

Unit- IV: Recombinant DNA Technology(Lectures: 08)

Gene Cloning, DNA Libraries, Expression Vectors, Prokaryotic (pUC 18 and pUC19, pBR322, Ti plasmid, BAC); Lambda phage, M13 phagemid, Cosmid; Eukaryotic Vectors (YAC). Preparation of expression cassettes, Site-Directed Mutagenesis, Gene knock outs and gene editing.

Unit-V: Biotechnological Applications (Lectures: 05)

Genetic Engineering, Genetically Modified Organisms (GMOs), Living modified organisms, Agricultural Biotechnology, Medical Biotechnology.

Unit-VI: Proteomics and Functional Genomics(Lectures: 05)

Protein Structure and Function, Proteomics Techniques, Functional Genomics Approaches.

Unit-VII: Industrial Biotechnology (Lectures: 05)

Fermentation Processes, Enzyme Technology, Bioprocessing.

Unit-VIII: Plant Tissue (Lectures: 08)

Composition of media; Nutrient and hormone requirements; Totipotency; Organogenesis; Embryogenesis (somatic and zygotic); Protoplast isolation, culture and fusion; Tissue culture applications (micropropagation, androgenesis, virus elimination, secondary metabolite production, haploids, triploids and hybrids; Cryopreservation; Germplasm Conservation).

Unit-IX: Ethical and Social Issues in Biotechnology(Lectures: 03)

Ethical Considerations in Genetic Engineering, Environmental and Societal Impacts, Bio safety Regulations and Guidelines.

PRACTICAL (Lectures: 30)

1. Isolation of genomic DNA..
2. Amplification by PCR method and visualization of gel doc..
3. Use of restriction enzymes RFLP..
4. Handling of biological data base from proteomic and genomic data..

RECOMMENDED BOOKS:

1. Lewines, Gene XI.
2. T. A Brown, Genome.
3. Alberts *et al*, Molecular Biology of the Cell
4. J D Watson, Molecular biology of the Gene
5. Primrose and Twyman, Principles of Gene Manipulation and Genomics.
6. Reinhard Renneberg, Biotechnology for Beginners.

COURSE NAME: NATURAL RESOURCES MANAGEMENT

COURSE CODE: BT - CE - 6334

Total Credits: 4 (Theory: 3 + Practical/Tutorial:1)

THEORY: 3 CREDITS

Total Lectures: 45

COURSE OBJECTIVE:

1. *To understand and classify different types of waste, including solid, liquid, and hazardous waste, and understand the characteristics that define each category.*
2. *To explore and evaluate strategies for waste minimization, including source reduction, reuse, and recycling.*
3. *To understand the principles and processes of recycling different types of materials, and assess the environmental and economic benefits of recycling initiatives.*
4. *To develop the ability to design and implement comprehensive waste management plans for different settings, considering the local context, available infrastructure, and waste generation patterns.*
5. *To understand the importance of waste audits and monitoring in the planning and evaluation of waste management programs*
6. *To explore the potential of converting waste into energy and other valuable resources, emphasizing sustainability and environmental benefits.*
7. *Recognize the importance of biodiversity and the role it plays in ecosystem stability. Identify and assess threats to biodiversity and explore strategies for conservation.*
8. *To understand the legal and regulatory frameworks governing waste management at local, national, and international levels.*
9. *Demonstrate the ability to navigate and comply with regulations, and recognize the role of policies in promoting sustainable waste management practices.*

COURSE LEARNING OUTCOME:

Upon successful completion of the course, students will be able to

- CLO-01:** *Demonstrate an integrated understanding of ecosystem dynamics, recognizing the interconnected relationships among living organisms, their environments, and the services ecosystems provide.*
- CLO-02:** *Evaluate and apply principles of sustainable resource management, demonstrating the ability to balance human needs with the preservation of ecosystems and biodiversity.*
- CLO-03:** *Develop the skills to identify, assess, and implement conservation strategies, with a focus on preserving biodiversity, protecting endangered species, and maintaining ecosystem resilience.*

CLO-04: *Analyze environmental policies and governance structures related to natural resource management, and demonstrate the ability to propose, evaluate, and advocate for effective policies that align with sustainability goals.*

CLO-05: *Understand the importance of involving local communities and stakeholders in decision-making processes related to natural resource management. They will demonstrate the ability to foster collaboration, address conflicts, and integrate diverse perspectives for sustainable outcomes.*

Unit- I: : Introduction to Natural Resource Management(Lectures: 10)

Introduction to Natural Resources, types, and classification of natural resources, importance and role of natural resources in bio economy; Ecology and Ecosystems, Ecosystem structure and function, Human impact on the environment, Environmental issues and challenges, Spatial distribution of natural resources, Environmental Economics, Principles of environmental economics, Valuation of natural resources.

Unit- II: Sustainable Resource Management (Lectures: 07)

Concepts and principles of sustainable development, Sustainable development goals (SDGs), Biodiversity conservation, Threats to biodiversity and conservation strategies, Natural Resource Policy and Law, Legal frameworks for resource management.

Unit- III: Soil Resource Management(Lectures: 07)

Land Utilization (agricultural, pastoral, horticultural, silvicultural); Soil degradation and management. Land Use Planning, Principles of land use planning, Integrated land management, Environmental Impact Assessment (EIA), EIA process and methodologies.

Unit-IV: Water Resource Management (Lectures: 05)

Aquatic ecosystems and their dynamics, Water quality and pollution, Water Resource Policy and Governance, Laws and regulations related to water resources, Water Conservation and Management, Water harvesting and conservation techniques, Hydrology and Watershed Management, hydrological cycle.

Unit-V: Forest Resource Management (Lectures: 12)

Introduction to Forestry, Forest ecosystems and their components, Importance of forests for biodiversity and climate, Forest Conservation and Policy, Forest laws and regulations, Community-based Forest management, Wildlife Management, Conservation of wildlife and their habitats, Human-wildlife conflict resolution, Forest Inventory and Remote Sensing, Techniques for forest inventory..

Unit-VI: Contemporary practices in resource management (Lectures: 04)

SIA, GPS, GIS and remote sensing applications in resource mapping, Participatory Resource Appraisal, Ecological Footprint with emphasis on carbon footprint, Resource Accounting; Waste management.

PRACTICAL (Lectures: 30)

1. GIS and Remote Sensing applications.

2. Creation a map of India embedding the geo location of Gir Forest, Nilgiri, Rani-Garbhangha Reserve Forest, Jim Corbett NP using vector and raster data (Q-GIS).
3. Identification of threats and mitigation strategies the threats at the Ramser site near Guwahati.
4. Water Quality Analysis techniques, Sampling and testing of local water sources.
5. Collection of data on forest cover of specific area.
6. Measurement of dominance of woody species by DBH (diameter at breast height) method.
7. Calculation and analysis of ecological footprint.

RECOMMENDED BOOKS:

1. Vasudevan, N. (2006). Essentials of Environmental Science. Narosa Publishing House, New Delhi.
2. Dwivedi, O.P. India's Environmental Policies, Programmes and Stewardship.
3. Chopra K. R. Development and Environmental Policy in India: The Last few decades.
4. Singh, J. S., Singh, S.P. and Gupta, S. (2006). Ecology, Environment and Resource Conservation. Anamaya Publications, New Delhi.
5. Rogers, P.P., Jalal, K.F. and Boyd, J.A. (2008). An Introduction to Sustainable Development. Prentice Hall of India Private Limited, New Delhi.

COURSE NAME: RECENT TRENDS IN PLANT SCIENCE

COURSE CODE: BT- CE - 6344

Total Credits: 4 (Theory: 3 + Practical/Tutorial:1)

THEORY: 3 CREDITS

Total Lectures: 45

COURSE OBJECTIVE:

1. *Explore emerging research areas: Investigate recent advancements in botanical sciences, including molecular biology, genomics, and bioinformatics, to understand cutting-edge research trends.*
2. *Analyze interdisciplinary connections: Examine the intersection of botany with other disciplines like ecology, biotechnology, and climate science to explore holistic approaches to plant study.*
3. *Foster innovation: Encourage critical thinking and creativity to address contemporary challenges in plant biology, such as climate change, food security, and sustainable agriculture, through novel research methodologies and solutions*

COURSE LEARNING OUTCOME:

- CLO-01:** *In-depth Understanding: Gain a comprehensive understanding of recent advancements in botanical sciences, spanning molecular biology, genomics, and bioinformatics, enhancing knowledge of cutting-edge research methodologies and techniques.*
- CLO-02:** *Interdisciplinary Connections: Explore the interdisciplinary nature of botany, analyzing its connections with ecology, biotechnology, and climate science, fostering a holistic perspective on plant biology and its implications for global challenges.*
- CLO-03:** *Critical Thinking Skills: Develop critical thinking skills to evaluate and integrate complex scientific information from diverse sources, fostering creativity and innovation in addressing contemporary issues in botany.*
- CLO-04:** *Research Proficiency: Acquire proficiency in conducting research, including experimental design, data analysis, and interpretation, enabling contribution to scientific advancements in botany.*
- CLO-05:** *Communication Abilities: Enhance communication skills to effectively disseminate research findings and engage in interdisciplinary dialogues, promoting collaboration and knowledge exchange within the scientific community.*
- CLO-06:** *Ethical Awareness: Recognize and adhere to ethical standards in botanical research and applications, emphasizing integrity, transparency, and responsible conduct in scientific inquiry.*
- CLO-07:** *Professional Development: Foster a passion for lifelong learning and engagement with current trends and advancements in botany, preparing for future careers in academia, industry, or research institutions.*

Unit- I: Role of Plants and Microbes in Ecosystem Restoration (Lectures: 07)

Hours Brief account of remediation technologies: bioremediation, phytoremediation (phytoextraction, rhizofiltration, phytovolatilization, phytostabilization etc); Role of associations of Grasses-AMF, Legumes-Rhizobium in restoring degraded land/ mined out areas; Role of macrophytes in wetland restoration; Role of green spaces including parklands and avenue plantations in amelioration of air quality.

Unit- II: National and International Initiatives of Natural Resources(Lectures: 04)

Natural resource management as National (BDA) and international policies (CBD), International Solar Alliance; Ramsar Convention; Basel Convention; Carbon Neutral Goals; Netzero Coalition; Clean Development Mechanism; CAMPA (Compensatory Afforestation Fund Management and Planning Authority); Carbon Credits; REDD+ project, Renewable Energy Certificate. Convention Biological Diversity (CBT) and Biodiversity (BD) Act.

Unit- III: Spectrophotometry(Lectures: 04)

Principles and applications of UV, Visible and IR spectrophotometry.

Unit- IV: Techniques for detection and analysis of nucleic acids and proteins(Lectures: 09)

PCR – design of PCR primers, enzymes used for PCR, cloning of PCR products; DNA polymorphism and its applications (RFLP, AFLP, SSR, SNPs); RNA isolation and analysis, cDNA synthesis and qRT-PCR; Extraction of proteins, PAGE (Native and denaturing); Blotting and hybridization techniques: Southern (Radioactive and Non-radioactive), Northern and Western; DNA sequencing – Sanger's dideoxy sequencing; ELISA.

Unit-V: Climate change and Forest (Lectures: 08)

Carbon Sequestration, Climate change institution and governance; IPCC, UNF, CCC – Conference of Partis (COP); Kyoto Protocol- Emission Trading, Join implementations, Global warming and its effect in Coral Ecosystem; Mycorrhizae in forest ecosystem restoration.

Unit-VI: Biostatistics(Lectures: 07)

Statistics, data, population, samples, parameters; Representation of Data: Tabular, Graphical; Measures of central tendency: Arithmetic mean, mode, median; Measures of dispersion: Range, mean deviation, variation, standard deviation; Chi-square test for goodness of fit.

Unit-VII: Computational Biology(Lectures: 06)

Computer assisted drug design- concept, methods and practical approaches. Diagrammatic, graphical and tabular representations of data; measures of central tendency, dispersion, skewness and kurtosis. Basic concepts of hypothesis testing, two kinds of error, level significance, p value, t-Test.

PRACTICAL (Lectures: 30)

1. Project (any one of the following): a. Rainwater harvesting (site visit) b. Ecological restoration (site visit) c. Energy audit d. Seed germination and seedling growth in garden and contaminated soils e. Composting f. Any other g. Field visit/s to any degraded ecosystem (landfill, polluted water body, invaded forest) or any ongoing restoration project site.

2. Isolation of chloroplasts by differential centrifugation.
3. Gene identification by using GenBank (NCBI), Sequence alignment and construction of phylogenetic tree by using tools (BLAST, MEGA, Bioedit).

RECOMMENDED BOOKS:

1. K.V. Krishnamurthy, Recent Trends in Botany.
2. Indian Council of Agricultural Research (ICAR), Advances in Botany Research in India.
3. Matthias Lang and Adelino da Silva, Trends in Botany
4. Frontiers Media SA, Frontiers in Plant Science.

PAPER CODE: BT-CE-7414
PAPER NAME: RESEARCH METHODOLOGY
Total credits= 4 (Theory – 3 and Practical - 1)

Objectives of the Course:

- Develop foundational knowledge of research methodology, ethics, and integrity.
- Enable students to identify research problems, design experiments, and apply statistical tools for data analysis.
- Train students in good laboratory practices, safety protocols, teamwork, and knowledge sharing.
- Introduce literature search, scientific writing, plagiarism detection, and ethical publication practices.
- Prepare students for scientific communication through abstracts, posters, oral presentations, and conference participation.

Course Learning Outcomes (CLOs)

CLO 1: Understand principles of research methodology, research ethics, integrity, and plagiarism detection.

CLO 2: Identify research problems, conduct literature reviews, and design experimental/observational research.

CLO 3: Apply good laboratory practices, safety protocols, teamwork, and promote knowledge sharing.

CLO 4: Analyze and present data using statistical tools, prepare abstracts/posters, and communicate research effectively.

1. Theory:

UNIT I: Introduction to Research Methodology

Lectures: 4

Meaning, objectives, and importance of research; Types of research: basic, applied, descriptive, experimental, and interdisciplinary; Scientific methods and types of reasoning: Induction, Deduction, Abduction; Research hypothesis and formulation of research questions.

UNIT II: Research Ethics, Integrity and Plagiarism

Lectures: 6

Research and publication ethics; Academic misconduct and research malpractices. Plagiarism- Definition, significance, types; Plagiarism detection tools and interpretation of similarity index; Analysis of real/plausible plagiarism cases; Identification of ethical breaches; Corrective rewriting and ethical compliance. Use of AI in Research: Responsible use of AI tools; Prompt engineering for academic purposes; Ethical boundaries and limitations of AI-assisted research.

UNIT III: Research Problem Identification and Research Design**Lectures: 7**

Identification of research area and topic selection; Literature review: sources, search strategies, and databases; Research gap identification; Formulation of objectives and research questions; Critical evaluation of feasibility: time, cost, effort vs outcome; Research design and planning: Experimental, observational, survey, and field-based designs; Serendipity in research.

UNIT IV: Laboratory Practices, Safety, and Good Research Conduct**Lectures: 8**

General Laboratory Safety and Accident Prevention: General safety and accident prevention guidelines; Good personnel safety practices; Laboratory safety practices: Do's and Don'ts; Different Biosafety levels of laboratory, Fire safety principles and fire-handling methods; Safe handling of chemicals and biological materials; Understanding Material Safety Data Sheet (MSDS); Storage, indexing, and labelling of chemicals and materials; Disposal of chemical, biological, and laboratory wastes; First aid procedures; Awareness of Institutional Safety Committee and emergency contacts. Good Laboratory Practice (GLP): Principles of GLP; Laboratory code of conduct; Lab bench cooperation and teamwork; Promoting scientific discussion and knowledge sharing in laboratories and academic environments.

UNIT V: Data Analysis and Statistical Tools**Lectures: 7**

Data Handling and Analysis: Types of data and data collection methods; Sampling techniques and research design; Data processing, tabulation, and interpretation; Measures of central tendency: Mean, Median, Mode; Measures of dispersion (introductory): Variance, Standard Deviation, Coefficient of Variance; Tests of significance: t-test, Chi-square test, ANOVA (conceptual understanding only); Correlation and regression (basic concepts); Data analysis using MS Excel. Data Presentation: Graph preparation using MS Excel; Bar diagrams, line graphs, pie charts, scatter plots; Flow diagrams, Venn diagrams, heat maps (introductory).

UNIT VI: Scientific Writing and Communication**Lectures: 9**

Importance of academic writing; Structure of research papers and review articles; Abstract writing; Citation and referencing; Reference styles: APA, Vancouver, Harvard (overview), Reference styles of high-impact journals (Nature, Science); Journal indexing, impact factor, and UGC-CARE list; Ethical publication practices; PowerPoint presentation skills; Web-meeting etiquette and scientific communication; Official email correspondence and letter writing; Library access and academic databases.

UNIT VII: Research Culture, Journals and Teamwork**Lectures: 4**

Lab bench cooperation, teamwork, peer discussions, collective responsibility, knowledge sharing, high-impact journals (Nature, Science), journals in botany, manuscript preparation, journal guidelines, submission steps, peer-review awareness, conference participation, abstract and poster preparation, oral presentation skills.

2. Practical

1. Basics of Data Analysis Using MS Excel: Basic statistics: mean, median, mode, variance, standard deviation.
2. Application of t-Test Using MS Excel: Solving biological data problems, Interpretation of statistical output.
3. Graph Preparation and Data Presentation Using MS Excel: Bar graphs, line graphs, scatter plots, pie charts, and Interpretation of graphs.
4. Literature search and reading scientific papers: Identify relevant research papers from online databases (Google Scholar, PubMed, Scopus, ResearchGate); Practice reading abstracts, identifying objectives, methods, and results.
5. Conference Preparation – Part 1: Write a mock abstract (200–250 words) based on a research paper. Summarize a paper in a short paragraph.
6. Conference Preparation – Part 2: Design a poster layout (mock) using PowerPoint or Canvas.
7. Conference Preparation – Part 3: Presentation of the poster (5 min) in small groups.
8. Plagiarism Detection and Ethical Assessment: Checking a given document using plagiarism detection software, identifying types of plagiarism.
9. Reference and Citation Practice: Format references in APA, Vancouver, Harvard, and one journal-specific style; Include books, journal articles, and online sources.
10. Identification of Laboratory Hazards and Risk Zones.

Suggested Readings:

1. Kothari C.R. (2004) Research Methodology: Methods and Techniques. 2nd Edition, New Age International Publishers, New Delhi.
2. Pandey M.,(2018) Research Methodology - Himalaya Publishing House Pvt. Ltd., “Ramdoot”, Dr. Bhalerao Marg, Girgaon, Mumbai - 400004.
3. Pandey P and Pandey M.M., (2015) Research Methodology: Tools and Techniques Bridge Center Buzau, Al. Marghiloman 245.
4. Narayana P.S., Varalakshmi D. and Pullaiah T. (2021) Research Methodology in Plant Science (2nd Ed.), Scientific Publishers.

Paper Code: BT-CE-7424
PAPER NAME: MICROBIOLOGY and PLANT PATHOLOGY
Total credits= 4 (Theory - 3 & Practical - 1)

Objectives of the Course

- To gain knowledge about microbial interactions, bioremediation, bio-fertilizers and biocontrol of plant diseases and about soil metagenomics.
- To know the industrial utilization of microbes and their products
- To gain knowledge of genetic engineering and microbial biotechnology.
- To know the practical knowledge about plant disease and their management.
- To know the importance of biological controls of disease, quarantine and seed certification.

Course Learning Outcomes (CLOs) :

CLO 1. Knowledge on Microbial interactions, bioremediation, biofertilizers and biocontrol of plant diseases.

CLO 2. Knowledge on soil microbes, soil metagenomics

CLO 3. Knowledge on Industrial production of organic acids, antibiotics, ethanol, vitamins and amino acids

CLO 4. Microbial genetics, tools and techniques of genetic engineering and microbial biotechnology

CLO 5. Knowledge on plant disease, symptoms of fungal, bacterial and viral diseases.

CLO 6. Knowledge on different defense mechanism of plants against disease, air, soil and seed born diseases

CLO 7. Biological controls of disease, quarantine and seed certification

1. Theory

Unit-I: Microbial diversity

Lectures: 5

‘Concept, modern branches and Landmark in the history of microbiology, ICN for virus, bacteria and other microbes, microbiome concept, ecological significance of microbes, Future prospect of microbiology.

Unit-II: Microbial techniques

Lectures: 5

Sterilization techniques, Stain and Staining technique, Polyphasic microbial identification, Population estimation (direct spore count method), Pure culture and visualization techniques, culture preservation and maintenance, taxonomic and functional characterization of microbes.

Unit-III: Microbial genetics & Microbial Physiology**Lectures: 7**

Mode of reproduction, Genetic recombination, Microbial mutation and Evolution, Para-sexuality, Mode of nutrition, Growth conditions, Microbial control and nutritional requirements, different metabolic pathways (respiratory and photosynthetic).

Unit IV: Bacteria**Lectures: 8**

Classification of bacteria according to Berger's Manual of Determinative Bacteriology. Ultra structure of bacteria and archaea (cell wall, flagella, fimbriae, pilli, slime layer, S-layers; cell membrane; mesosomes, ribosomes, cytoplasmic inclusion bodies and nucleoid). Bacterial nutrition and growth. Genetic recombination and transformation.

Unit IV: Viruses**Lectures: 5**

General properties of viruses; viral genomes; Plant viruses– replication, transmission and interaction with host plants.

Phage biology: features and economic importance; natural mechanisms and transgenic strategies for virus resistance, relevance to Indian agriculture.

Unit-V: Plant Pathology**Lectures: 5**

Principles of plant pathology, Seed pathology: Storage and field fungi; mechanism of pathogenesis, symptomatology and epidemiology, diseases forecasting, host defence mechanism, causal organism and etiology of certain important plant diseases occurred in NE India

Unit-VI: Plant Immunology**Lectures: 5**

Innate and acquired immunity, antibodies, cells and tissues of the immune system, immune diseases, serological reactions and sero-diagnostics, cancer biology.

Unit-VI: Applied microbiology**Lectures: 5**

Application of microbes in the field of agriculture, fermented foods and dairy products, industry and bio-waste management.

2. Practical:

1. Isolation and pure culture of microbes from soil, air and water.
2. Identification and characterization of isolated pure cultures.
3. Identification and characterization of gram positive and gram negative bacteria.
4. Effect of physical and chemical factors on growth of microbes.
5. Study of plant pathogenic fungi, bacterial and viral diseased specimens occurred in NE India (symptoms, causal organism and their morphological & reproductive characters).
6. Spore measurement and camera lucida diagram.

Suggested Reading:

1. Maloy S.R., Cronan J.E. and Freifelder D.(1994). *Microbial Genetics*, 2nd edition. Jones & Bartlett Publishers, USA.
2. Pelczar M.J., Chan E.C.S and Krieg N.R. (1997). *Microbiology: An Application Based Approach*, 5th edition. Tata McGraw-Hill, India.
3. Whitman W.B., Goodfellow M., Kämpfer P., Busse H.-J., Trujillo M.E., Ludwig W. and Suzuki K. (2012) *Bergey's Manual of Systematic Bacteriology*, Springer-Verlag, New York.
4. Singh R.S. (2021) *Introduction to Principles of Plant Pathology*, MedTech Science Press.
5. Sharma P.D. (2013) *Plant Pathology*. Fingerprint.
6. Sharma P and Kumar P (2021) *Basics of Immunology*, IP Innovative Publication Pvt. Ltd.

Paper Code: BT-CE-7434
PAPER NAME: LOWER CRYPTOGRAMS (ALGAE AND FUNGI)
Total credits= 4 (Theory - 3 & Practical - 1)

Objectives of the Course

- To know about the biodiversity of lower cryptogams – Algae and Fungi.
- To understand the diversity in form, structure and reproduction and the diverse habitats algal and fungal flora.
- To develop theoretical knowledge and technical skills in fundamental of Phycology and mycology
- To realize the economic, ecological and biotechnological potentialities of these groups

Course Learning Outcomes (CLOs):

- CLO 1. The course will increase the understanding of the students about the diversity, classification, structure, and growth of lower cryptogams- algae and fungi.
- CLO 2. It will also develop theoretical knowledge and technical skills in fundamental of Phycology and mycology.
- CLO 3. Students will realize the heterogeneity and polyphyletic nature of both algae and fungi as a group. They will also be apprised of their diversity in form, structure and reproduction and the diverse habitats of fungi.
- CLO 4. Students will realize the vast economic, ecological and biotechnological project and realized potential of these groups.

1. Theory

Unit I: Concept of Lower Cryptogams

Lectures: 2

1. Occurrence and Habitat diversity, Distinguishing characters, and similarities and differences between algae and fungi; their differences with higher cryptogams.

Unit II: Introduction to Diversity of Algae

Lectures: 16

1. Recent trends in the classification, Classification of algae according to Parker (1982) upto class. Role of pigments, reserve food, cell wall, chloroplast and eyespot, flagella in classification of algae.
2. Diversity of algal groups:
 - a) **Cyanophyta:** Pigmentation, cell structure, heterocyst and akinete development, chromatic adaptation, thallus organization and reproduction
 - b) **Glaucophyta:** General Characters; Significance in evolution of Chloroplasts

- c) Viridiplantae (Green Algae and related lineages): Distinguishing Character, thallus organization and reproduction of Chlorophyta, General Characters of Dinophyta, Xanthophyta, Chrysophyta, Bacillariophyta, Pyrrophyta, Euglenophyta, Eustigmatophyta, Prasinophyta and Prochlorophyta.
 - d) Phaeophyta: General characters in brief. Alternation of generation in Phaeophyta and post-fertilization development
 - e) Rhodophyta: General Characters, alternation of generation, post-fertilization changes and site of meiosis in Rhodophyta
3. Algae as evolutionary lineage and role in evolution of land plants Reproductive strategies and evolution of life cycles in algae (Haplontic, diplontic, and haplodiplontic cycles).
 4. Introduction to advances in molecular systematics and phylogenetics of algae. Concept of **Archaeplastida**.

Unit III: Applied aspect of Algae

Lectures: 4

Algae in diverse habitats and their role as primary producer in global carbon cycle, eutrophication, and their environmental impact algal blooms and Phycoviruses. Algae as biofactories: production of bioactive compounds, biofuels, bioplastics, phycocolloids and sustainable resource utilization

Unit IV: Introduction to Fungal diversity and systematics

Lectures: 20

General characteristics and cell structure of fungi, recent trends in classification and phylogeny of major groups and their interrelationships. Different mode of reproduction, parasexuality and degeneration of sex in fungi.

- a) General characters of **Myxomycotina**, Distinguishing character of Plasmodiophorales, thallus structure, reproductive bodies and Life cycle pattern with reference to *Pysarum sp.*
- b) General characters of **Mastigomycotina**, Distinguishing character of Chytridiales, Blastocladales, Saprolegniales and Peronosporales; thallus structure, reproductive bodies and Life cycle pattern with reference to *Plasmopara sp.*
- c) General characters of **Zygomycotina**. Distinguishing character of Mucorales and Entomophthorales; thallus structure, reproductive bodies, heterothallism and Life cycle pattern with reference to *Mucor sp.*
- d) General characters of **Ascomycotina**. Distinguishing character of Endomycetales, Protomycetales, Taphrinales, Erysiphales, Eurotiales, Sphaeriales, Helotiales, Phacidiales and Pezizales; thallus structure, reproductive bodies, structure of asci, Types of ascocarps, heterothallism and Life cycle pattern with reference to *Eurotium sp.*
- e) General characters of **Basidiomycotina**. Distinguishing character of Uredinales, Ustilaginales, Lycoperdales, Nidulariales, Sclerodermatales, Phallales, Agaricales, Aphyllophorales,

Tremellales and Auriculariales; thallus structure, reproductive bodies, Types and Structure of basidia and basidiocarps and Life cycle pattern with reference to *Puccinia sp.*

- f) General characters of **Deuteromycotina**. Distinguishing character of Melanconiales, Moniliales and Mycelia sterilia; Thallus structure, fructifications, Types of conidia.

Unit-V: Lichen

Lectures: 3

Classification and nomenclature, structure and reproduction of lichen, mechanism of phycobiont and mycobiont interaction, lichen as ecological indicator.

2. Practical:

1. Study of thallus organization and reproductive structures of each group of algae with the help of suitable representatives locally available.
2. Culture of algae.
3. Study of morphological and reproductive features of fungi representing every group of fungi studied in theory.
4. Isolation and identification of fungi from different parts of a plant.
5. To determine the density of given sporesuspension using a haemocytometer.
6. Study of morphological and anatomical features of each lichens group with the help of locally available species.

Suggested Readings:

1. Kumar A. and Kumar A. (2015) Textbook of Algae, Vikas Publishing House.
2. Hoek C. van den, Mann D. G. and Jahns H. M. (1995). *Algae: An Introduction to Phycology*. Cambridge: Cambridge University Press.
3. Mallick P. and Chatterjee S. (2010). *Textbook of Algae*. New Delhi: PHI Learning Pvt. Ltd.
4. Webster J. and Weber R. W. S. (2007). *Introduction to Fungi* (3rd ed.). Cambridge: Cambridge University Press.
5. Mehrotra R. S. and Aneja K. R. (2003). *An Introduction to Mycology*. New Delhi: New Age International Publishers.
6. Shukla A. C. (Ed.) (2018). *Applied Mycology: Entrepreneurship with Fungi (Fungal Biology)*. New Delhi: Springer Nature.

Paper Code: BT-CE-7444
PAPER NAME: HIGHER CRYPTOGRAMS AND LOWER PHENEROGAMS
Total credits= 4 (Theory - 3 & Practical - 1)

Objectives of the Course

- To know about the biodiversity of higher cryptogams – Bryophytes and Pteridophytes and lower phenerogams i.e. Gymnosperms.
- To understand the early land habit of plants with the evolutionary adaptation in respect to form, structure and reproductive characters.
- To realize the economic and ecological importance of these groups

Course Learning Outcomes (CLOs):

- CLO 1.** The organ formation occurred in the early land plants that resulted in the diversity of species of “bryophytes”, “pteridophytes” and “gymnosperms”.
- CLO 2.** The strategies for conduction of water and photosynthesis in land plants.
- CLO 3.** The reproductive strategies and breeding systems in plants through lineage of bryophytes, pteridophytes and gymnosperms.
- CLO 4.** The ecological and economic importance of bryophytes, pteridophytes and gymnosperms that help to understand their role in ecosystem functioning.

1. Theory :

Unit I: Land Plant

Lectures: 2

Vegetative and Reproductive innovations in land plants. Evolutionary Changes in life cycle patterns in Bryophytes, Pteridophytes and Gymnosperms.

Unit II: Systematics of Bryophytes

Lectures: 14

- a) Origin of Bryophytes. Classification of Bryophytes up to orders by G.M. Smith 1955; Peristome structure and its significance in the classification of Mosses.
- b) Distinguishing features, Comparative morphology, anatomy, phylogeny & evolutionary tendencies of the following orders with their affinities. Hepaticae- Marchantiales, Jungermannias, Metzerales and Calobryales. Anthocerotae -Anthocerotales. Musci - Polytrichales.
- c) Evolution of gametophytes & sporophytes in Bryophytes.
- d) Economic importance of Bryophytes.

- e) Bryophytes as site indicators; Role of Bryophytes in Ecosystem Dynamics and in global carbon budget, Bryogeography and conservation of bryophytes

Unit III: Pteridophytes

Lectures: 15

- a) Classification of Pteridophytes (Takhtajan, 1964).
- b) Origin of Pteridophytes. Early vascular plants: Rhyniophyta, Trimerophytophyta and Zosterophyllophyta
- c) Meristem organization and organ diversity in Pteridophytes. Comparative account of gametophyte and sporophyte of *Lycopodium sp*, *Selaginella sp*, *Isoetes sp*, *Equisetum sp*, *Marsilea sp* and *Pteris sp*.
- d) Brief account of the range of vegetative structure and reproduction in Ferns.
- e) Telome concept, apogamy and apospory, heterospory and seed habit, Evolution of stele with reference to *Lycopodium*.
- f) Economic importance of Pteridophytes.
- g) Plant sub stratum relationship, Growth Forms and life strategies. Biogeography, Diversity of Ferns-anecological perspective, Gametophyte ecology, Nutrient ecology.

Unit III: Gymnosperms

Lectures: 14

- a) Classification of Gymnosperms. Origin of gymnosperms and its evolutionary relationship with other land plants.
- b) Kinds of fossils, process of fossilization.
- c) General account of Glossopteridaceae.
- d) Comparative study reproductive structure of Coniferales (Pinaceae, Cupressaceae, Araucariaceae, Podocarpaceae, Cephalotaxaceae, Taxodiaceae), Taxales and Gnetales (Gnetaceae, Ephedraceae and Welwitschiaceae).
- e) Economic importance of Gymnosperms.
- f) Evolution of Pollination mechanism in Gymnosperms; Impact of coniferous forest on human life.

2. Practical:

- 1. Comparison of simple and complex thalli through anatomical sections of one example each of Hepaticae, Anthocerotae and Musci.
- 2. Morphology and anatomy of gametophyte of Polytrichaceae member to see the lamellae and special conducting cells and nematodontous peristome.
- 3. Comparison of various leafy liverworts to compare the leaf modifications for water retention, trigones and oil bodies (with photographs)

4. Section of rhizome and petiole of comm only available fern species. Section through sori to study the morphology of sporangia and spores. *Salvinia sp* morphology and anatomy of leaf and rhizome.
5. Herbarium specimen of unique fern species to study the soral patterns.
6. Prepare permanent slide of Study anatomy of stem and leaf of *Thuja sp*.
7. Study of anatomy of *Ginkgo biloba* from permanent slides.

Suggested Readings:

1. Schofield W. B. (1985). *Introduction to Bryology*. New York: Macmillan Publishing Company. ISBN 0029496608.
2. Vanderpoorten A. and Goffinet B. (2009). *Introduction to Bryophytes*. Cambridge: Cambridge University Press. ISBN 978-0-521-70073-3.
3. Goffinet B. and Shaw A. J. (Eds.) (2008). *Bryophyte Biology* (second Ed.). Cambridge: Cambridge University Press. ISBN 978-0-521-69322-6.
4. Dyer A. F. (1979). *Experimental Biology of Ferns*. London: Academic Press.
5. Ranker T. A. and Haufler C. H. (2008). *Biology and Evolution of Ferns and Lycophytes*. Cambridge: Cambridge University Press.
6. Mehltreter K., Walker L. R. and Sharpe J. M. (2010). *Fern Ecology*. Cambridge: Cambridge University Press.
7. Bhatnagar S. P. and Moitra A. (1996). *Gymnosperms*. New Delhi: New Age International (P) Limited.

Paper Code: BT-CE-7454
PAPER NAME: ADVANCED PLANT SYSTEMATICS
Total credits= 4 (Theory - 3 & Practical - 1)

Objectives of the Course:

- To understand the various aspects of plant nomenclature and classification.
- To understand the classical and modern trends of Angiosperm taxonomy.
- To understand the salient features of angiosperm families with special reference to sexual Characters.
- To understand the various modern practical aspects of plant systematics.

Course Learning Outcomes (CLOs):

CLO1. Explain the principles, concepts, and historical development of plant classification systems.

CLO2. Apply the International Code of Nomenclature (ICN) and construct taxonomic keys and descriptions.

CLO3. Evaluate morphological, anatomical, cytological, and molecular data as taxonomic evidence.

CLO4. Interpret phylogenetic trees using molecular sequence data and bioinformatic tools.

CLO5. Identify and classify angiosperm families based on diagnostic characteristics.

CLO6. Demonstrate field and herbarium techniques for plant collection, preservation, and documentation.

CLO7. Assess the role of systematics in biodiversity conservation, ecology, and applied plant sciences.

1. Theory:

Unit I: Principles of Systematics

Lectures: 2

Scope and importance of plant systematics; Species concepts (biological, morphological, phylogenetic, and evolutionary); Historical development of classification: Artificial, Natural, Phylogenetic, Phenetic, and Cladistic approaches.

Unit II: Systems of Classification

Lectures: 4

Major contributions of Theophrastus, Bauhin, Tournefort, Linnaeus, Adanson, de Candolle, Bessey, Hutchinson, Takhtajan and Cronquist. Major historical classification systems: Bentham & Hooker, Comparative account of modern system – Engler & Prantl, Hutchinson, Takhtajan. Modern system - APG IV, 2016: Principles, updates, and rationale. Significance of molecular data in redefining family relationships.

Unit III: Botanical Nomenclature and Taxonomic Procedures Lectures: 9

International Code of Nomenclature (ICN): Development of Botanical Code, Principles, Names of taxa according to rank, Typification, Author Citation, Principle of Priority, Valid Publication, Conservation & Rejection of names. Names of hybrids and cultivated plants. Unified Biological Nomenclature.

Taxonomic literature-Floras, e-Flora, Manuals, Monographs, Icons, Journals. Construction of dichotomous keys and taxonomic descriptions. Use of herbaria and digital databases (Index Herbariorum, IPNI, POWO, Tropicos, BHL).

Unit IV: Sources of Taxonomic Evidence

Lectures: 6

Morphological, anatomical, palynological, cytological, embryological, and phytochemical evidence. Numerical taxonomy and cluster analysis (basic concept).

Unit V: Molecular Systematics and Phylogenetics

Lectures: 8

Barcoding concept; standard barcode markers: nrDNA, cpDNA, and mtDNA; and databases (BOLD, GenBank). Molecular phylogenetic principles: sequence alignment, evolutionary models, parsimony, maximum likelihood, Bayesian methods. Interpreting phylogenetic trees and evolutionary relationships.

Unit VI: Terminology and Angiosperm Families

Lectures: 12

Descriptive Terminologies covering terms from habits up to fruits. General characteristics; Evolutionary history; Basalangio sperms and Magnoliids; Basal monocots; Petaloid monocots; Commelinids; Basaleudicots and Caryophyllids; Rosids; Asterids.

Unit VII: Floristics, Herbarium, and Applied Systematics

Lectures: 4

Field inventory, collection, preservation, and curation of herbarium specimens. Role of herbaria and botanical gardens. Floristic diversity and endemism in India. Systematics in biodiversity conservation. Application in the authentication of medicinal and economically important plants.

2. Practical:

1. Description, illustration and identification of at least 10 families
2. Construction of dichotomous keys.
3. Collection, pressing, drying, poisoning, and mounting of specimens (minimum 15), submit with field notebook.
4. Field trip to study plants in their natural vegetation and submission of report.
5. Visit to any major Indian herbarium or botanical garden or research institute for specimen study.
6. Sequence retrieval from GenBank, alignment, and tree construction using MEGA software.
7. Use of Barcode database for plant identification.

Suggested Readings:

1. **Raven P. H., Evert R. F. and Eichhorn S. E. (1992).***Biology of Plants*. New York: W. H. Freeman and Company.
2. **Singh G. (2012).***Plant Systematics: Theory and Practice* (3rd ed.). New Delhi: Oxford & IBH Publishing Co. Pvt. Ltd.
3. **Simpson M. G. (2006).***Plant Systematics*. San Diego, CA: Elsevier Academic Press.
4. **Weising K., Nybom H., Pfenninger M., Wolff K. and Kahl G. (2005).***DNA Fingerprinting in Plants: Principles, Methods and Applications* (second Ed.). Boca Raton: CRC Press.
<https://doi.org/10.1201/9781420040043>
5. **Lawrence G. H. M. (1951).***Taxonomy of Vascular Plants*. New York: Macmillan.

Paper Code: BT-CE-8414
PAPER NAME: PLANT PHYSIOLOGY AND BIOCHEMISTRY
Total credits= 4 (Theory - 3 & Practical - 1)

Objective of the Course:

- To understand the basic principles of plant physiology.
- To know the physiological background for comprehend energy and nutrient utilization through the process of photosynthesis, respiration, and metabolism.
- To analyse the plant hormones and their roles in growth, development, and stress responses.
- Apply physiological insights to enhance crop yield, quality, and stress management.

Course Learning Outcome (CLOs):

CLO 1. Knowledge on structure and function of membranes and biomolecules.

CLO 2. Knowledge on biosynthesis, storage, breakdown, transport, physiological effects and mechanism of action of plant hormones.

CLO 3. Practical knowledge on extraction and estimation of proteins, carbohydrate, phenolics and chloroplast pigments.

CLO 4. Knowledge on mechanism phytochrome and sensory photobiology. .

1. Theory:

Unit I: Water Relation

Lectures:3

Properties of water, distribution of water in tissues and cells, measurement of cellular water.

Unit II: Transport of water and solutes

Lectures:12

Transport of water and solutes: Uptake of water, comparison of xylem and phloem transports, molecular mechanism of phloem loading and unloading, passive and active transports, soil-plant-atmosphere continuum. Apoplastic and symplastic transport mechanisms, Structure of Unit membrane; role of aquaporins and transporter proteins, structure-function relationship of inward and outward ion channels, dual action of ATPases/pumps and modulation of their activity.

Unit III: Intracellular Transport

Lectures:10

Structure of Endoplasmicreticulum, translocation of secretory proteins across ER membrane, insertion of protein into ER membrane, protein folding and processing. Organization of Golgi apparatus, protein glycosylation, protein sorting and export from Golgi, the vesicular transport mechanism Nuclear envelope, nuclear pore complex, trafficking between nucleus and cytoplasm Structure and genome organization of Mitochondria, protein import and mitochondrial assembly Structure and genome organization of Chloroplast, import and sorting of chloroplast proteins

Unit IV: Phytohormones Biosynthesis, Signalling and Stress Responses Lectures: 6

Concept of phytohormones as chemical messengers, techniques for detection and quantification of phytohormones, classical approaches and use of mutants in understanding phytohormones actions, phytohormones under biotic and abiotic stresses, synthetic regulatory compounds and their diverse uses.

Unit V: Physiology of photomorphogenesis and flowering Lectures: 8

Structure, function and mechanisms of action of phytochromes, cryptochromes and phototropins; scotomorphogenesis and photo-morphogenesis. Flowering as a multi-organ function, floral induction, evolution and development. Regulation of flowering by light and temperature and role of circadian rhythm.

Unit VI: Sensory photobiology Lectures: 6

Discovery of phytochromes and cryptochromes and their photochemical and biochemical properties, photo-physiology of light induced responses. Cellular localisation, molecular mechanism of action of photo-morphogenetic receptors, signalling and gene expression.

Practical:

1. Extraction of proteins from plant materials and estimation by Lowry's method using BSA standard curve.
2. Isolation of protein from plant samples and electrophoresis by SDS-PAGE.
3. Extraction of carbohydrates from plant materials and estimation by spectrometry.
4. Extraction of oil/fat from plant materials.
5. Extraction of chloroplast pigments and quantitative estimation.
6. Quantitative estimation of chlorophyll a, b, carotenoids, anthocyanins, and Measurement of Photosynthesis.
7. Staining of mitochondria by Janus Green B
8. Estimation of lipid peroxidation

Suggested Readings:

1. Verma S. K. and Verma M. (2015). *A Textbook of Plant Physiology, Biochemistry and Biotechnology*. New Delhi: S. Chand Publishing.
2. Malik C. P. and Srivastava A. K. (2002). *Textbook of Plant Physiology*. New Delhi: Kalyani Publishers.
3. Peirce G. J. (1903). *A Textbook of Plant Physiology*. New York: Henry Holt and Company.
4. Bhatla S. C. and Lal M. A. (2018). *Plant Physiology, Development and Metabolism*. Singapore: Springer Nature.

Paper Code: BT-CE-8424
PAPER NAME: PLANT ECOLOGY AND RESOURCE MANAGEMENT
Total credits= 4 (Theory - 3 & Practical - 1)

Objectives of the Course:

- To obtain knowledge of environment and various component ecology.
- To understand and apply various management principles environmental issues, biodiversity and conservation aspects.
- To understand and application of sustainable utilization of plant resources.
- To obtain about the knowledge of phytogeography.

Course Learning Outcomes (CLOs):

CLO1. Students will be able to obtain knowledge of environment and various component ecology.

CLO 2. Students will be able to understand and apply various management principles environmental issues, biodiversity and conservation aspects.

CLO 3. Students will be able to obtained knowledge and applied aspects of various environmental management policies.

CLO 4. Students will be able to obtain knowledge and sustainable utilization of plant resources.

CLO 5. Students will be able to obtain knowledge about phytogeography.

1. Theory:

Unit I: Introduction

Lectures: 3

The Environment- physical and biotic; Definition, principle and scope of ecology, ecological factors. Concept of habitat and niche resource partitioning; character displacement.

Unit II: Population, Community and Ecosystem

Lectures: 8

Characteristics of a population; population growth curves; population regulation; life history strategies (r and K selection). Community structure and attributes; levels of species diversity and its measurement; edges and ecotones. Methods of studying plant communities. Ecological succession- types; mechanisms; changes involved in succession; concept of climax. Ecosystem- types; structure; function; energy flow and mineral cycling (C, N, P & S).

Unit III: Biodiversity

Lectures: 4

Concept, components and types; importance of biodiversity conservation, Principles and practices, different approaches for biodiversity conservation-In-situ and ex- situ conservation.

Unit IV: Environmental Issues and Polices

Lectures: 12

Environmental issues and Environmental Laws – Climate changes, Global warming, Greenhouse effect, Ozone depletion, Acid rain and their impact and management for biodiversity, agriculture and human being. Human-wildlife conflict in India with reference to Northeast India. Assessment

and management of environmental issues in Northeast India. EPA, Air Act, Water Act, Wildlife Protection Act, Forest Conservation Act, International Agreements on environmental issues, Kyoto Protocol and Rights of tribal communities on biodiversity, Carbon sequestration.

Unit V: Resources management

Lectures: 12

Origin, evolution, botany, cultivation and uses of (i) Food & Beverage (ii) Fiber & Oil (iii) Medicinal and Aromatic plants (iv) Bamboo and Cane; important timber-yielding plants and NTFPs. Green revolution: Benefits and adverse consequences, innovations for meeting world food demands, GMO, INM, IPM.

Unit VI: Phytogeography

Lectures: 6

Dynamic phytogeography and its basic principles, theories and hypotheses, centre of origin of cultivated plants, plant migration and theory of tolerance, age and area hypothesis, concept of endemism, mega centres of endemism in India, endemic plants of India with special reference to Northeast India.

2. Practical:

1. Estimation of above ground and below ground biomass from unit area.
2. Effect of biotic disturbances on botanical composition.
3. Study of similarity between plant communities using index of similarity and dissimilarity.
4. Study on effects of effluents/contaminants on plant growth.
5. Field study report and to plot Biosphere Reserves/ Ramsar sites/ National Parks/Wildlife Sanctuaries located in different biogeographical zones of India in general and NE India in particular.
6. Morphological and anatomical studies on economically important plants / part (s) of cotton, jute, tea, bay leaf, *Rauvolfia*, tulsi.

Suggested Readings:

1. **Kumar P. and Mina U. (2014).** *Fundamentals of Ecology and Environment*. New Delhi: Pearson India Education Services Pvt. Ltd.
2. **Joshi N. and Joshi P. C. (2009).** *A Textbook of Ecology and Environment*. Mumbai: Himalaya Publishing House.
3. **Vashishtha A. and Johari S. (2011).** *Contemporary Environmental Issues and Challenges*. New Delhi: Bloomsbury Publishing India.
4. **Rangarajan M. (2007).** *Environmental Issues in India: A Reader*. New Delhi: Pearson India.
5. **Laladhas K. P., Oommen V. and Sudhakaran P. R. (2015).** *Biodiversity Conservation: Challenges for the Future*. Sharjah: Bentham eBooks.
6. **Arumugam N. and Kumaresan V. (2014).** *Plant Ecology and Phytogeography*. New Delhi: Saras Publication.

Paper Code: BT-CE-8434
PAPER NAME: MOLECULAR BIOLOGY
Total credits= 4 (Theory - 3 & Practical - 1)

Objectives of the Course:

- To provide a comprehensive knowledge of the principles and concepts of molecular biology, genetics, and biochemistry of plants.
- To develop practical skills of different biotechnological techniques through hands-on laboratory exercises and experiments.
- To familiarize students with the diverse applications of biotechnology in various sectors, including agriculture, pharmaceuticals, healthcare, and environmental science.
- To enhance critical thinking skills by challenging students to analyze and solve biotechnological problems and their future technological developments.

Course Learning Outcomes (CLOs):

CLO 1. Understand the molecular mechanisms of DNA replication, repair, transcription, and translation.

CLO 2. Explore gene regulation in prokaryotes and eukaryotes.

CLO 3 Analyze experimental techniques used in molecular biology.

CLO 4. Appreciate the application of molecular biology in research and medicine.

1. Theory:

Unit I: Introduction to Molecular Biology

Lectures: 5

History and scope of molecular biology, Central Dogma of Molecular Biology. Overview of nucleic acids: DNA and RNA.

Unit II: DNA Structure and Replication

Lectures: 8

DNA structure and properties. Types of DNA (A, B, Z forms). DNA replication: enzymes involved (DNA polymerases, helicases, ligases). Prokaryotic vs. eukaryotic replication. Replication origin and fork; semi-conservative model.

Unit III: DNA Repair and Recombination

Lectures: 7

Types of mutations. DNA repair mechanisms: mismatch repair, base/nucleotide excision repair. Homologous recombination and non-homologous end joining. Mobile genetic elements and transposons.

Unit IV: Transcription and RNA Processing

Lectures: 6

Prokaryotic and eukaryotic transcription mechanisms. RNA polymerases and promoter elements. Post-transcriptional modifications: capping, polyadenylation, splicing. RNA editing and transport.

Unit V: Translation and Protein Targeting**Lectures: 4**

Genetic code and tRNA structure. Ribosomes and translation mechanism. Post-translational modifications. Protein sorting and trafficking.

Unit VI: Regulation of Gene Expression**Lectures: 5**

Operon concept: *Lac* and *Trp* operons. Eukaryotic gene regulation: enhancers, silencers, transcription factors. Epigenetics: DNA methylation and histone modification. Non-coding RNAs: miRNA, siRNA, lncRNA.

Unit VII: Techniques in Molecular Biology**Lectures: 5**

Nucleic acid isolation and quantification. PCR, RT-PCR, qPCR. Gel electrophoresis, blotting techniques (Southern, Northern, Western). Cloning, plasmids, and recombinant DNA technology. CRISPR-Cas9 and Genome editing: Tools and techniques, applications and regulations.

Unit VIII: Applications and Future Directions**Lectures: 5**

Molecular diagnostics and therapy. Genomics and transcriptomics. Molecular basis of diseases (e.g., cancer, genetic disorders). Ethical issues in molecular biology.

2. Practical:

1. To separate proteins based on their molecular weight using SDS-PAGE.
2. DNA Isolation
3. To separate DNA fragments based on their size using agarose gel electrophoresis.
4. To quantify DNA in agarose gels using a gel documentation system.
5. To design and construct a plasmid for genetic manipulation.

Suggested Readings:

1. Watson J. D., Baker T. A., Bell S. P., Gann A., Levine M. and Losick R. (2014). *Molecular Biology of the Gene* (7th ed.). Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
2. Lodish H., Berk A., Kaiser C. A., Krieger M., Bretscher A., Ploegh H., Amon A. and Scott M. P. (2016). *Molecular Cell Biology* (8th ed.). New York: W. H. Freeman and Company.
3. Brown T. A. (2016). *Genome* (4th ed.). New York: Garland Science.
4. Alberts B., Johnson A., Lewis J., Morgan D., Raff M., Roberts K. and Walter P. (2015). *Molecular Biology of the Cell* (6th ed.). New York: Garland Science.
5. Lewin B. (2008). *Genes IX*. Sudbury, MA: Jones and Bartlett Publishers.
6. Primrose S. B. and Twyman R. M. (2006). *Principles of Gene Manipulation and Genomics* (7th ed.). Oxford: Blackwell Publishing.
7. Sambrook J. and Russell D. W. (2001). *Molecular Cloning: A Laboratory Manual* (3rd ed.). Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.

8. Maniatis T., Fritsch E. F. and Sambrook J. (1982). *Molecular Cloning: A Laboratory Manual*. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
9. Bio-Rad Laboratories (2018). *Gel Doc™ System User Manual: DNA Quantification and Visualization*. Hercules, CA: Bio-Rad Laboratories.

Paper Code: BT-CE-8444
PAPER NAME: CYTOGENETICS AND PLANT BREEDING
Total credits= 4 (Theory - 3 & Practical - 1)

Objectives of the Course:

- To understand the basic principles of classical genetics and genetic variation.
- To develop proficiency in genetic analysis techniques, such as Punnett squares, pedigree analysis, and genetic crosses.
- To understand the goals and objectives of plant breeding, including improving yield, quality, resistance variety and adaptation to specific environments.
- To learn breeding methods such as hybridization, selection, and hybrid vigor to develop improved plant varieties.

Course Learning Outcomes (CLOs):

- CLO 1. Students will be able to obtain knowledge of structure, function and aberration of chromosomes.
- CLO 2. Students will be able to understand and apply principles of plant breeding
- CLO 3. Students will be able to interpret the phylogenetic relationship
- CLO 4. Students will be acquainted with practical knowledge of behaviour of chromosomes.
- CLO 5. Students will be able to establish connections between cytogenetics and plant breeding to understand how genetic principles drive plant improvement and biodiversity.

1. Theory:

Unit I: Cytology and Chromosome biology

Lectures: 12

Comparative Structure of DNA, chromatin and chromosome, centromeres and telomeres, significance of telomere, specialized chromosomes, euchromatin and heterochromatin, cell cycle and its regulation and control, apoptosis, necrosis, autophagy.

Unit II: Genome architecture and pattern of inheritance

Lectures: 12

Genome size and C-value paradox, cot curve, DNA packaging, unique and repetitive DNA, linkage, recombination and crossing over, tetrad analysis, linkage mapping, mapping with molecular markers in plants, and bacteria, sex-linked inheritance, cytoplasmic inheritance.

Unit III: Prokaryotic gene regulation and molecular basis of mutation

Lectures: 3

Operon system for lactose, tryptophan and arabinose metabolism; Molecular basis of mutation, spontaneous, reverse and suppressor mutations

Unit IV: Inborn error in metabolism

Lectures: 2

Genetic diseases and overview of the metabolic basis of inherited diseases.

Unit V: Methods of Plant Breeding and Genetic improvement of Traits Lectures: 14

Principle of plant breeding; distant hybridization, barrier to distance hybridization, techniques for distant hybridization; back Cross methods of plant breeding; breeding for quantitative characters, handling of quantitative data, environmental effect on quantitative characters, estimation of heritability and genetic advance. Modern approaches of plant breeding techniques.

Unit VI: Seed certification and Quality assurance

Lectures: 2

Seed certification: Procedure and significance, Seed quality assurance and recent development

2. Practical:

1. Study of chromosome behaviour in mitosis using onion root tips.
2. Study of chromosome behaviour in meiosis using onion flower buds.
3. Chromosome anomalies in *Tradescantia* bud.
4. Principle, techniques and procedure of emasculation

Suggested Readings:

1. Shukla R. S. and Chandel P. S. (2000). *Cytogenetics, Evolution and Plant Breeding*. New Delhi: S. Chand and Company.
2. Gupta P. K. (2009). *Cytology, Genetics, Evolution and Plant Breeding*. Meerut: Rastogi Publications.
3. Pawar N. S. and Jain D. S. (2003). *A Textbook of Genetics, Plant Breeding and Evolution*. New Delhi: Kalyani Publishers.
4. Singh B. D. (2010). *Plant Breeding: Principles and Methods* (8th ed.). New Delhi: Kalyani Publishers.
5. Singh P. (2005). *Plant Breeding*. New Delhi: Kalyani Publishers.
6. Dewari G. P. (2004). *Cytogenetics, Plant Breeding and Evolution*. New Delhi: S. Chand and Company.
7. Salinas B. (2014). *Plant Cytogenetics: Breeding and Evolution*. New York: Nova Science Publishers.
8. **Agarwal R. L. (2013).** *Seed Technology*. New Delhi: Oxford & IBH Publishing Co. Pvt. Ltd.

PAPER CODE: BT-CE-8454

PAPER NAME: BIODIVERSITY CONSERVATION AND TRADITIONAL KNOWLEDGE

Total credits= 4 (Theory - 3 & Practical - 1)

Objective of the Course:

- To develop practical and theoretical knowledge of the conservation of biodiversity and traditional knowledge.
- To know about different national and international policies and acts for biodiversity conservation.
- To understand the IPR and its effectiveness.
- To understand the importance of Traditional Knowledge and its safeguard.

Course Learning Outcomes (CLOs):

CLO1. Students will be able to obtain knowledge on conservation and management of biodiversity

CLO 2. Students will be able to understand and apply various management principles Ex-situ and In-situ conservation.

CLO 3. Students will be acquainted with practical knowledge of various aspects of Ethnobotany.

CLO 4. Students will be able to know about the traditional knowledge; it's relevance in present day context.

1. Theory:

Unit I: Biodiversity

Lectures: 5

Concept, components and types; importance of biodiversity conservation, Different approaches for biodiversity conservation, Biodiversity Act and Access Benefit sharing.

Unit II: Strategies for conservation I

Lectures: 10

In-situ conservation: international efforts and Indian initiatives, protected regions for conservation of biodiversity. RET Plants of Northeast India and their conservation initiatives.

Unit III: Strategies for conservation II

Lectures: 10

Ex-situ conservation : Principles and practices; botanical gardens, gene banks, seed banks, *in-vitro* repositories, cryobanks; National Bureau of Plant Genetic Resources (NBPGR), Indian Council of Agricultural Research (ICAR) and their conservation efforts.

Unit IV: IPR

Lectures: 8

Principles of IPR and Patent law, patent application procedure, Trade Mark, Copyright, Enforcement of IPR, Information Technology related IPR, Computer software and IPR, Biotechnology and IPR, protection of plant varieties, geographical indicators, farmers right, resource rights.

Unit V: Ethnobotany**Lectures: 7**

Introduction to ethnobotany, Historical approach of ethnobotany in context to Indian ancient literatures, Branches of ethnobotany and its interdisciplinary approaches, Principle and methods of ethnobotanical research, future prospect of ethnobotany.

Unit VI: Traditional Knowledge**Lectures: 5**

Concept & types of Traditional Knowledge, TKDL, Holders Protection, need for a Sui-Generis regime, TK vs modern knowledge, digital library, biopiracy & bioprospecting.

2. Practical:

Project Work: A project work involving field survey, data collection and analysis of data. Report submission and presentation during practical examination.

Suggested Readings:

1. Meerabai M. and Pullaiah T. (2014). *Plant Biodiversity Conservation and Management*. New Delhi: Regency Publications.
2. Shankar U., Rawat G. S. and Rai I. D. (2011). *Plant Biodiversity and Conservation*. New Delhi: Daya Publishing House.
3. Frankel O. H., Brown A. H. D. and Burdon J. J. (1995). *The Conservation of Plant Biodiversity*. Cambridge: Cambridge University Press.
4. Kumar H. D. and Sharma A. (2009). *Plant Biotechnology and Biodiversity Conservation*. New Delhi: Oxford & IBH Publishing Co. Pvt. Ltd.
5. Wadehra B. L. (2004). *Law Relating to Intellectual Property*. New Delhi: Universal Law Publishing Co.
6. Narayanan P. (2017). *Intellectual Property Law* (5th ed.). New Delhi: Eastern Law House.
7. Jha A. (2010). *Traditional Knowledge System in India*. New Delhi: Atlantic Publishers and Distributors.
8. Sengupta N. (2003). *Traditional Knowledge in Modern India*. New Delhi: Oxford University Press.

MINOR

Programme Specific Outcome of Bachelor of Science –Botany Minor

PSO No.	Name	Outcome
PSO-1	Importance of plants and their functions (<i>BTL: Remember, Understanding</i>)	To develop a conceptual understanding of principles and importance of Botany. Students will be able to understand and explain different specializations of Botany such as systematics, evolution, ecology, developmental biology, physiology, biochemistry, plant interactions with microbes and insects, morphology, anatomy, reproduction, genetics, cell and molecular biology of plants.
PSO-2	Laboratory Skills (<i>BTL: Application, Evaluate</i>)	Acquire practical skills in laboratory settings, including microscopy, experimental design, and data analysis. Students are also familiarized with the use of bioinformatics tools and databases and in the application of statistics to biological data. Students will be trained in various analytical techniques of plant biology, use of plants as industrial resources or as support system for human livelihood and will be well versed with the use of transgenic technologies for both basic and applied research in plants.
PSO-3	Development of Research Mindset (<i>BTL: Create</i>)	Plan and execute field investigation, collect, analyze and interpret data using appropriate methods including appropriate IT and accurately report the findings of the field investigation. The will be able to identify and analyze various issues prevailing in the societies, like, socio-political, socio-economic, socio-religious, ethnic issues, health issues in bio-cultural context, ethno botanical, ethno medicine, environmental issues, etc.
PSO-4	Applied Botany (<i>BTL: Apply</i>)	Demonstrate a thorough understanding of the human past with special emphasis on prehistoric and proto historic phase of the past and documentation of prehistoric implements for collection and preservation in museums.
PSO-5	Communication Skills (<i>BTL: Apply</i>)	Be motivated for further higher studies and research in different sub-disciplines of anthropology.
PSO-6	Closeness with nature (<i>BTL: Evaluate</i>)	Students will be eligible in diverse fields in research organization, government services, education sector, human resources, public services, hospitality, industries, corporate sectors, entrepreneur, business, tourism industry, media and Non-Governmental organization.
PSO-7	Continuous Learning (<i>BTL: Create</i>)	The primary ethics of the subject is to ensure appreciation of human diversity and it helps to analyze critically the issues that are relevant in contemporary society.

LIST OF COURSES:

Semester	Course Name	Course Code
1	Biodiversity (Microbes, Algae, Fungi and Archegoniate)	BT – MN – 1114
2	Plant Ecology and Taxonomy	BT – MN – 2114
3	Biomolecules and Cell Biology	BT – MN – 3214
4	Plant Physiology and Metabolism	BT – MN – 4214
5	Plant Anatomy, Embryology and Economic Botany	BT – MN – 5214
6	Plant Breeding and Biotechnology	BT – MN – 6214
7	Environmental Issues and Applied Botany	BT – MN – 7414
8	Biodiversity Conservation and Traditional Knowledge	BT – MN – 8414

Course Learning Outcome (CLO)

Semester	Course Name & Code	Course Learning Outcome (CLO)	
1	Biodiversity (Microbes, Algae, Fungi and Archegoniate) BT – MN – 1114	CLO - 01	Combination of theoretical and practical components of this course will provide comprehensive information and insight into the fascinating world of microbes and plants.
		CLO - 02	Hand on training will help students learn use of the microscope, mounting, section cutting and staining techniques for the study of plant materials.
		CLO - 03	Making drawing in practical records will enhance understanding morphology and structural details and related functional aspects in diverse plant groups.
		CLO - 04	This paper is both informative and interesting and will enable student to learn about biodiversity not only as plant or nature lover but also for higher academic pursuits, particularly in the field of biological sciences, environment and biodiversity conservation. .
2	Plant Ecology and Taxonomy BT – MN – 2114	CLO - 01	Student would have understanding of various ecological parameters of plant in nature pertaining to influencing ecological factors and their analysis of practical datas on individual, population, community and ecosystem level along with their relationships.
		CLO - 02	Student also would have understanding about basic knowledge of plant taxonomy with the modern taxonomic approaches.
		CLO - 03	Practical knowledge of the course material will develop the skill of identification and classification of plant diversity and characterization of angiospermic families along with their phyto geographical analysis.
3	Biomolecules and Cell Biology BT – MN – 3214	CLO-01	Students will be able to obtain knowledge of structure, classification, and physicochemical properties of different biomolecules.
		CLO-02	Students will be able to know about the detail structure, properties, and functions of a cell and its components.
		CLO-03	Students will be acquainted with practical knowledge of properties of cell and cell membranes, Nucleic acid, and microscopy of the plant cell.
		CLO - 04	Students will be able to identify various biomolecules in the laboratory by qualitative tests of biomolecules.

4	Plant Physiology and Metabolism BT – MN – 4214	CLO-01	At the end of the course the student will understand the fundamental concepts of plant physiology and metabolism and know the role of water, hormones, and light in plant growth and development.
		CLO-02	At the end of the course the student will understand the role of mineral in plants growth and their deficiency symptoms.
		CLO-03	At the end of the course the student will understand the conduction of substances within the plant body- cell to cell conduction as well as movement through the entire plant body.
		CLO-04	At the end of the course the student will know in detail the conduction of the absorption and conduction of water in plant body and understand the role of hormones in plant growth and development.
		CLO-05	At the end of the course the student will know the application of hormones in growth, morphogenesis, flowering, germination and senescence of plant and also examine the commercial applications of growth regulators.
		CLO-06	At the end of the course the student will know the basic mechanisms of carbon utilization (photosynthesis, respiration) and nitrogen utilization (nitrate and ammonia assimilation) in plants.
		CLO-07	At the end of the course the student will understand the response of plants to different stress condition and develop practical skills in plant physiology and metabolism
5	Plant Anatomy, Embryology and Economic Botany BT – MN –5214	CLO-01	Students are expected to gain theoretical knowledge and acquire basic skills on the plant anatomy, embryology with special reference to Angiosperms. Students are also expected to gain theoretical knowledge to explore the basic utilitarian aspects of plants. Upon completion of the course, the students will be able to illustrate the structure, types, organization of various cells, tissues and organs of plant body.
		CLO-02	Students are expected to gain theoretical knowledge and acquire basic skills on the plant anatomy, embryology with special reference to Angiosperms. Students are also expected to gain theoretical knowledge to explore the basic utilitarian aspects of plants. Upon completion of the course, the students will be able to relate plant anatomy and embryology of angiosperms with other fields of botany.
		CLO-03	Students are expected to gain theoretical knowledge and acquire basic skills on the plant anatomy, embryology with special reference to Angiosperms. Students are also expected to gain theoretical knowledge to explore the basic utilitarian aspects of plants. Upon completion of

			the course, the students will be able to Combine classical utilitarian aspects of plant with modern molecular organization of plants.
5	Plant Anatomy, Embryology and Economic Botany BT – MN – 5214	CLO - 04	Students are expected to gain theoretical knowledge and acquire basic skills on the plant anatomy, embryology with special reference to Angiosperms. Students are also expected to gain theoretical knowledge to explore the basic utilitarian aspects of plants. Upon completion of the course, the students will be able to Learn various advanced tools to study plant anatomy and embryology.
6	Plant Breeding and Biotechnology BT – MN – 6214	CLO-01	After completing this course, students will be able to understand fundamental concepts of centers of origin of crop plants and explain diversity, acclimatization, plant introduction, and domestication.
		CLO-02	After completing this course, students will be able to gain knowledge on plant tissue culture and the basic molecular techniques used in biotechnology.
		CLO-03	After completing this course, students will be able to Differentiate between types of molecular markers (RAPD, AFLP, SSR, SNP) and apply molecular markers in marker-assisted selection (MAS) for crop improvement.
		CLO-04	After completing this course, students will be able to Identify major biotechnology institutes and companies in India. They will be able to explain applications of DNA recombinant technology in agriculture and medicine.
		CLO-05	After completing this course, students will be able to apply plant tissue culture techniques by understanding the composition of media and nutrient requirements in plant tissue culture.
		CLO-06	After completing this course, students will be able to understand recombinant DNA technology and the role of restriction enzymes. Identify and describe various cloning vectors and gene cloning techniques.
		CLO- 07	After completing this course, students will be able to discuss applications of biotechnology in agriculture, such as pest-resistant and herbicide-resistant plants; Explain the role of transgenics in bioremediation and the production of safer and cheaper medicines; and evaluate biosafety concerns associated with genetically engineered products.
		CLO- 08	After completing this course, students will be able to gain hands-on experience in the preparation of MS medium, in vitro sterilization, and inoculation methods.

7	Environmental Issues and Applied Botany BT – MN – 7414	CLO - 01	Students will be able to obtain knowledge of environmental issues and various applied aspects of botany.
		CLO - 02	Students will be able to understand and apply various management principles environmental issues.
		CLO - 03	Students will be acquainted with practical knowledge of various applied aspects of botany.
		CLO - 04	Students will be able to establish various biological skill based entrepreneurial establishments.
8	Biodiversity Conservation and Traditional Knowledge BT – MN – 8414	CLO - 01	Students will be able to obtain knowledge on conservation and management of biodiversity
		CLO - 02	Students will be able to understand and apply various management principles Ex-situ and In-situ conservation.
		CLO - 03	Students will be acquainted with practical knowledge of various aspects of Ethnobotany.
		CLO - 04	Students will be able to know about the traditional knowledge; it's relevance in present day context.

Mapping of Programme Outcome (PO) and Course Learning Outcome (CLO):

Attributes: Co-relation Levels

“1” : Minimum Co-relation

“2” : Moderate Co-relation

“3” : Maximum Co-relation

“-” : No Co-relation

Course Code	CLO	Programme Outcome (SPO)										
		SPO-1	SPO-2	SPO-3	SPO-4	SPO-5	SPO-6	SPO-7	SPO-8	SPO-9	SPO-10	SPO-11
BT-MN-1114	CLO-1	1	2	1	1	2	2	2	2	3	2	2
	CLO-2	1	1	1	1	2	2	2	2	3	2	2
	CLO - 3	1	-	2	-	-	-	-	-	-	-	-
	CLO - 4	1	-	-	-	-	-	-	2	-	-	-
BT-MN-2114	CLO-1	3	3	2	1		3				2	3
	CLO-2	3	3	3	2		3				2	3
	CLO - 3	3	3	2	1		3				2	3
BT-MN-3214	CLO-1	1	3	2	2	3	3	2	2	3	2	2
	CLO-2	1	2	2	2	3	3	2	2	3	2	2
	CLO - 3	1	2	1	1	2	2	2	2	3	2	2
	CLO - 4	1	1	1	1	2	2	2	2	3	2	2
BT-MN-4214	CLO-1	1	-	2	-	-	-	-	-	-	-	-
	CLO-2	1	-	-	-	-	-	-	2	-	-	-
	CLO - 3	-	2	-	-	-	-	-	-		-	-
	CLO - 4	-	1	2	3	-	-	-	-	-	-	-
	CLO-5	-	-	-	-	1	-	-	-	-	3	-
	CLO - 6	-	-	-	-	-	-		-	-	-	-
	CLO - 7	-	-	-	-	-	1	-	-	2	3	-
BT-MN-5214	CLO-1	1	-	-	-	-	-	-	-	-	-	-
	CLO-2	1	-	-	-	-	-	-	-	-	-	-
	CLO - 3	-	2	3	-	-	-	-	-	-	-	-
	CLO - 4	-	-	-	1	-	-	-	-	-	-	-
BT-MN-6214	CLO-1	3	1	1		1	1	2	1			1
	CLO-2	3	1	1		1	1	2	1			1
	CLO - 3	3	1	1		1	1	2	1			1
	CLO - 4	1	1	1	2	1	2	2	1		1	1
	CLO-5	1	1	1	2	1	2	2	3	2	1	1
	CLO - 6	1	1	2	3	1	2	2	3	2	3	1
	CLO - 7	1	1	2	3	1	3	3	3	2	3	1
	CLO - 8	1	1	2	3	1	2	2	3	3	3	1

BT-MN-7414	CLO1	3	1	1	1	3	2	3	3	1	2	1
	CLO2	3	3	3	2	2	3	3	3	3	3	2
	CLO3	3	3	2	1	3	3	3	3	3	3	2
	CLO4	3	3	3	3	3	3	3	3	3	3	3
BT-MN-8414	CLO1	3	1	1	1	3	2	3	3	1	2	1
	CLO2	3	3	3	2	2	3	3	3	3	3	2
	CLO3	3	3	2	1	3	3	3	3	3	3	2
	CLO4	3	3	3	3	3	3	3	3	3	3	3

Mapping of Programme Specific Outcome (PSO) and Course Learning Outcome (CLO)

Attributes: Co-relation Levels

“1” : Minimum Co-relation

“2” : Moderate Co-relation

“3” : Maximum Co-relation

“-” : No Co-relation

Course code	CLO	Programme Specific Outcome						
		PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7
BT-MN-1114	CLO-1	1	2	1	1	2	2	2
	CLO-2	1	1	1	1	2	2	2
	CLO - 3	1	-	2	-	-	-	-
	CLO - 4	1	-	-	-	-	-	-
BT-MN-2114	CLO-1	3	3	2	1		3	
	CLO-2	3	3	3	2		3	
	CLO - 3	3	3	2	1		3	
BT-MN-3214	CLO-1	1	3	2	2	2	3	1
	CLO-2	1	3	2	2	2	3	1
	CLO - 3	1	1	1	1	2	2	1
	CLO - 4	1	1	1	1	2	2	1
BT-MN-4214	CLO-1	1	-	-	-	-	-	-
	CLO-2	1	-	-	-	-	-	-
	CLO - 3	-	-	-	-	-	-	-
	CLO - 4	-	2	1	-	-	-	-
	CLO-5	-	-	-	-	1	-	-
	CLO - 6	-	-	-	-	-	-	-
	CLO - 7	-	-	-	-	-	-	1
BT-MN-5214	CLO-1	1	-	-	-	-	-	-
	CLO-2	1	-	3	-	-	-	-
	CLO - 3	-	-	-	1	-	-	-
	CLO - 4	-	1	-	-	-	-	-
BT-MN-6214	CLO-1	3		1	1	1	1	1
	CLO-2	3		1	1	1	1	1
	CLO - 3	3		1	1	1	1	1
	CLO - 4	3		1	1	1	1	1
	CLO-5	3		1	1	1	1	1
	CLO - 6	3		1	2	2		1
	CLO - 7	3	3	2	2	2		2
	CLO - 8	2	3	3	3	2		2

BT-MN-7414	CLO1	3	1	1	2	2	2	3
	CLO2	3	3	3	3	3	3	3
	CLO3	3	3	3	3	3	2	3
	CLO4	3	3	3	3	3	2	3
BT-MN-8414	CLO1	3	1	1	2	2	2	3
	CLO2	3	3	3	3	3	3	3
	CLO3	3	3	3	3	3	2	3
	CLO4	3	3	3	3	3	2	3

COURSE NAME: BIODIVERSITY (Microbes, Algae, Fungi and Archegoniate)

COURSE CODE: BT – MN – 1114

Total Credits: 4 (Theory: 3 + Practical/Tutorial:1)

THEORY: 3 CREDITS

Total Lectures: 45

COURSE OBJECTIVE:

The course includes modules on basic knowledge of the plant kingdom viz. Microbes, Algae, Fungi and Archegoniatae, with the main objective of giving a sense of mooring to the undergraduates.

COURSE LEARNING OUTCOME:

On completion of this course

CLO-01: *Combination of theoretical and practical components of this course will provide comprehensive information and insight into the fascinating world of microbes and plants.*

CLO-02: *Hand on training will help students learn use of the microscope, mounting, section cutting and staining techniques for the study of plant materials.*

CLO-03: *Making drawing in practical records will enhance understanding morphology and structural details and related functional aspects in diverse plant groups.*

CLO-04: *This paper is both informative and interesting and will enable student to learn about biodiversity not only as plant or nature lover but also for higher academic pursuits, particularly in the field of biological sciences, environment and biodiversity conservation.*

Unit- I: Microbes (Lectures: 09)

Viruses: General Structure, DNA virus (T Phase), Lytic and Lysogenic Cycle, RNA virus (TMV). Economic Importance

Bacteria: General Characteristic and Cell structure, Reproduction – Vegetative, Asexual and Recombination (Conjugation, Transformation and Transduction), Economic importance

Unit- II: Algae (Lectures: 09)

General characteristic, Range of thallus organization and reproduction, Classification of algae (F E Fritsch classification), Morphology and life cycles of Nostoc, Chlamydomonas, Vaucheria, and Polysiphonia, Economic importance of algae.

Unit- III: Fungi (Lectures: 09)

General characteristic, nutrition, reproduction and classification (G.C Ainsworth classification). Life cycles of Rhizopus (Zygomycota), Phytophthora (Oomycetes) Penicillium, (Ascomycota), Puccinia Agaricus (Basidiomycota), Symbiosis Association – Lichen. General account and significance of Mycorrhiza.

Unit- IV: Introduction to Archegoniate (Lectures: 02)

Unifying features of archegoniates, Transition to land habit, alternation of generation.

Unit-V: Bryophytes(Lectures: 06)

General characteristic, adaptation of land habit, Classification (upto family), Morphology, anatomy and reproduction of Marchantia, Anthoceros and Polytrichum, Ecology and economic importance of bryophytes with special mention of Sphagnum.

Unit-VI: Pteridophytes(Lectures: 05)

General characteristics, classification, Early land plants – Rhynia and Psilotum. Morphology, anatomy and reproduction of Selaginella, and Pteris. Heterospory and seed habit, Stella revolution.

Unit-VII: Gymnosperms (Lectures: 05)

General characteristics, Classification. Morphology, anatomy and reproduction of Cycas, Pinus and Gnetum, Ecological and economical importance.

PRACTICAL (Lectures: 30)

1. Model of Virus - TPhage; Lytic and Lysogenic Cycle from Photographs.
2. Study of bacterial reproduction–Binary Fission and Conjugation from slides /photographs.
3. Gram staining process.
4. Study of vegetative and reproductive structure of Nostoc, Chlamydomonas and Polysiphonia.
5. Study of vegetative and reproductive structure of Penicillium and Puccinia
6. Study of vegetative and reproductive structure of Marchantia and Polytrichum
7. Study of vegetative and reproductive structure of Selaginella.
8. Study of vegetative and reproductive structure of Cycas and Gnetum

RECOMMENDED BOOKS:

1. Pelczar, M.J. (2001)– Microbiology, 5th Edition, Tata McGraw–Hill Co, New Delhi
2. Sarma, P.D. (2009)–Microbiology, Latest Edition, Rastogi Publication, Meerut.
3. Sahu, D. (2000)–Farming the Ocean: Sea Weeds Cultivation and Utilization. Ara Vali International, New Delhi.
4. Kumar, H.D. (1999)–Introductory Phycology. Affiliated East West Press, Delhi
5. Alexopoulos, C. J.; Mims, C. W.; Blackwell, M. (1996) – Introductory Mycology, J. and Sons, 4th Edition.
6. Vashista, P. C.; Singha, A. K., Kumar, A. (2010) – Pteridophyta, S. Chand, Delhi, India
7. Parihar, N. S. (1991) – An Introduction to Embryophyta, Vol I – Bryophyta, Central Book Depot. Allahabad.
8. Bhatnagar, S. P.; Moitra, A. (1996) – Gymnosperms, New Age International (P) Ltd.

COURSE NAME: PLANT ECOLOGY AND TAXONOMY

COURSE CODE: BT – MN – 2114

Total Credits: 4 (Theory: 3 + Practical/Tutorial:1)

THEORY: 3 CREDITS

Total Lectures: 45

COURSE OBJECTIVE:

The main objective of study plant ecology is to examine the relationship of plants with the physical and biotic environment. Plant Taxonomy is the science of discovering, identifying, describing, classifying and naming plants. The main objective of plant taxonomy is to identify characteristics of undiscovered species by comparing with known species, to specify characteristics of recently discovered species, to arrange them in respective “taxa” after looking at their similarities and to give them specific name.

COURSE LEARNING OUTCOME:

On completion of this course

- CLO-01:** *Student would have understanding of various ecological parameters of plant in nature pertaining to influencing ecological factors and their analysis of practical data on individual, population, community and ecosystem level along with their relationships.*
- CLO-02:** *Student also would have understanding about basic knowledge of plant taxonomy with the modern taxonomic approaches.*
- CLO-03:** *Practical knowledge of the course material will develop the skill of identification and classification of plant diversity and characterization of angiospermic families along with their phyto geographical analysis.*

Unit- I: Ecological Factor(Lectures: 08)

Soil: Origin, formation, composition, of soil profile., Water: State of water in the environment, precipitation types. Light and Temperature : Variation, optimal and limiting factors; Shelford Law of Tolerance. Adaptation of Hydrophytes and Xerophytes. Biological indicators.

Unit- II: Plant Communities(Lectures: 04)

Characters; Eco tone and Edge Effect; Succession; Processes and Types.

Unit- III: Ecosystem(Lectures: 08)

Structure; Energy flow trophic organisation; Food chains and Food webs, Ecological Pyramids, Production and Productivity; Biogeochemical Cycle, Carbon, Nitrogen and Phosphorus Cycles

Unit- IV: Phytogeography(Lectures: 02)

Principle of Bio-geographical Zones; Endemism.

Unit-V: Introduction to Plant Taxonomy(Lectures: 02)

Aim and objective of Plant Taxonomy. Identification, Classification and Nomenclature.

Unit-VI: Identification(Lectures: 04)

Function of Herbarium, Important Herbaria and Botanical Gardens of the world and India; Documentation: Flora, Kyes–Single access and Multi assess.

Unit-VII: Modern Trends of Taxonomy(Lectures: 05)

Taxonomy in relation to Palynology, Cytology, Phytochemistry and Molecular data.

Unit-VIII: Botanical Nomenclature(Lectures: 04)

Principles and Rules (ICBN): Ranks and Names; Binomial system, Typification, Authorcitation, Valid Publication, Rejection of names, Principle of Priority and its Limitation.

Unit-IX: Taxonomic Classification (Lectures: 02)

Types of classification; Bentham and Hooker system of classification.

Unit-X: Angiospermic families (Lectures: 02)

Poaceae, Orchidaceae, Magnoliceae, Solanaceae, Lamiaceae and Asteraceae.

PRACTICAL (Lectures: 30)

1. Study of instruments use to measure micro climatic variables –Thermometer, Anemometer, Hygrometer and Lux meter.
2. Study of morphological adaptation of hydrophytes and xerophytes.
3. Determination minimal quadrates size for the study of herbaceous vegetation.
4. Study of vegetative and floral characters of Solanaceae, Lamiaceae, Asteraceae and Orchidaceae.
5. Collection, processing, drying and preparation of a Herbarium of a wild herbaceous plant species.

RECOMMENDED BOOKS:

1. Kormondy, E. J. (1996)–Concept of Ecology, 4th Edition, Prentice Hall, USA.
2. Sharma, P.D. (2010)– Ecology and Enviornment, 8th Edition, Rastogi Publication, Meerut, India.
3. Singh, G. (2012)– Plant Systematics: Theory and Practice, 3rd Edition, Oxford & IBH Publishing Co Pvt Ltd, New Delhi
4. Pandey, B.P. (2018)– A Text Book of Botany: Angiosperms, S Chand Publishing.

COURSE NAME: BIOMOLECULES AND CELL BIOLOGY

COURSE CODE: BT - MN - 3214

Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)

THEORY: 3 CREDITS

Total Lectures: 45

COURSE OBJECTIVE:

1. *To accommodate the widening horizons of the Botany discipline*
2. *To reflect about the dynamism of cell biology and biomolecules*
3. *To understand the properties, functions and roles of different molecules.*
4. *To reveal the relationship between the structure and function of various biomolecules at the chemical level.*
5. *Hands-on approach and laboratory techniques by performing different related experiments*

COURSE LEARNING OUTCOME:

- CLO-01:** *Students will be able to obtain knowledge of structure, classification, and properties of physicochemical different biomolecules.*
- CLO-02:** *Students will be able to know about the detail structure, properties, and functions of a cell and its components.*
- CLO-03:** *Students will be acquainted with practical knowledge of properties of cell and cell membranes, Nucleic acid, and microscopy of the plant cell.*
- CLO-04:** *Students will be able to identify various biomolecules in the laboratory by qualitative tests of biomolecules.*

Unit- I: Introduction to Biomolecules(Lectures: 03)

Definition of biomolecules, Types of biomolecules, Types of chemical bonds holding cellular biomolecules.

Unit- II: Water(Lectures: 03)

Structure and properties.

Unit- III: Carbohydrates (Lectures: 03)

Structure and classification.

Unit- IV: Lipids and Fatty Acid(Lectures: 04)

Classification, Types and functions.

Unit-V: Amino acids and Protein(Lectures: 05)

Structure and functions.

Unit-VI: Nucleic Acids(Lectures: 06)

Nitrogenous bases, Nucleotides, Types and functions of nucleic acids, Structure of B type of DNA.

Unit-VII: Enzymes (Lectures: 04)

Classification, structure and functions.

Unit-VIII: Introduction to cell(Lectures: 06)

Cell as a unit of structure and function; Characteristics of prokaryotic and eukaryotic cells, Cell cycle, Mitosis and meiosis.

Unit-IX: Cell wall and plasma membrane(Lectures: 05)

Chemistry, Structure and function of Plant cell wall, Cytoskeleton, Membrane structure and functions, Fluid mosaic model.

Unit-X: Cell organelles(Lectures: 06)

Nucleus, Ribosome, Chloroplast, Mitochondria, Peroxisomes, Endoplasmic Reticulum, Golgi Apparatus, and Lysosomes

PRACTICAL (Lectures: 30)

1. Qualitative tests for carbohydrates, reducing sugars, proteins.
2. Study of plant cell structure with the help of epidermal peel mount of Onion.
3. Demonstration of the phenomenon of protoplasmic streaming in *Hydrilla*.
4. Study different stages of mitosis.

RECOMMENDED BOOKS:

1. Berg JM, Tymoczko JL and Stryer L (2011) Biochemistry, W.H. Freeman and Company.
2. Campbell MK (2012) Biochemistry, 7th Edition. Published by Cengage Learning.
3. Campbell PN, Smith AD (2011) Biochemistry Illustrated, 4th Edition, Published by Churchill Livingstone.
4. Cooper GM, Hausman RE (2009) The Cell: A Molecular Approach. 5th edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.
5. Hardin J, Becker G, Skliensmith LJ (2012) Becker's World of the Cell, Pearson Education Inc. U.S.A. 8th Edition.
6. Karp G (2010) Cell Biology, John Wiley & Sons, U.S.A. 6th Edition
7. Nelson DL, Cox MM (2008) Lehninger Principles of Biochemistry, 5th Edition, W.H. Freeman and Company.

COURSE NAME: PLANT PHYSIOLOGY AND METABOLISM

COURSE CODE: BT - MN - 4214

Total Credits: 4 (Theory: 3 + Practical/Tutorial:1)

THEORY: 3 CREDITS

Total Lectures: 45

COURSE OBJECTIVE:

The learning objectives of this course are as follows:

- 1. Comprehend the physiological processes that occur in plants, including the role of water, minerals, hormones, and light in plant growth and development.*
- 2. Acquaint the basic biochemical mechanisms of plants, including photosynthesis, respiration, nitrogen metabolism, and chemical regulation of growth and development.*
- 3. Develop skill of practical analysis of plant physiological processes.*

COURSE LEARNING OUTCOME:

At the end of the course the student will:

- CLO-01:** *Understand the fundamental concepts of plant physiology and metabolism and know the role of water, hormones, and light in plant growth and development.*
- CLO-02:** *Understand the role of mineral in plants growth and their deficiency symptoms.*
- CLO-03:** *Understand the conduction of substances within the plant body- cell to cell conduction as well as movement through the entire plant body.*
- CLO-04:** *Know in detail the conduction of the absorption and conduction of water in plant body and understand the role of hormones in plant growth and development.*
- CLO-05:** *Know the application of hormones in growth, morphogenesis, flowering, germination and senescence of plant and examine the commercial applications of growth regulators.*
- CLO-06:** *Know the basic mechanisms of carbon utilization (photosynthesis, respiration) and nitrogen utilization (nitrate and ammonia assimilation) in plants.*
- CLO-07:** *Understand the response of plants to different stress condition and develop practical skills in plant physiology and metabolism*

Unit- I: Plant-water relations (Lectures: 07)

Water potential and its components, pathway of water movement-symplast, apoplast and aquaporins, root pressure, guttation, ascent of sap-cohesion tension theory, transpiration and its significance, factors affecting transpiration, anti-transparent. Mechanism of stomatal movement.

Unit- II: Mineral Nutrition (Lectures: 04)

Essential and beneficial elements, macro- and micro-elements, criteria for essentiality, roles of essential elements and their deficiency symptoms, chelating agents.

Unit- III: Nutrient uptake (Lectures: 05)

Transport of ions across cell membrane, passive absorption, simple and facilitated diffusion (carrier and channel proteins), Fick's law, active absorption, proton ATPase pump, electrochemical gradient, ion flux, uniport, co-transport (symport, antiport)

Unit- IV: Translocation in Phloem (Lectures: 04)

Composition of phloem sap, girdling experiments, Pressure Flow Model, source-sink relationship, phloem loading and unloading.

Unit-V: Plant growth regulators(Lectures: 05)

Role of hormones in plant growth and development. Chemical nature (chemical formula and precursor), physiological roles and applications of Auxins, Gibberellins, Cytokinins, Abscissic Acid, Ethylene; Other growth regulators - Jasmonic Acid, Brassinosteroids, Nitric Oxide. Commercial applications of growth regulators, Growth retardant and its usefulness.

Unit-VI: Enzymes(Lectures: 04)

Structure and properties; Mechanism of enzyme action and enzyme inhibition.

Unit-VII: Photosynthesis(Lectures: 07)

Historical contributions of Blackman, Emerson, and Hill, Photosynthetic pigments (chlorophyll-a and b, xanthophyll, carotene), Photosystem I and II, reaction center, antenna molecules, Electron transport and mechanism of ATP synthesis (Chemiosmotic mechanism), C3 pathway, C4 and CAM plants (in brief), Photorespiration.

Unit-VIII: Respiration(Lectures: 04)

Glycolysis, Anaerobic respiration, TCA cycle, Oxidative phosphorylation, Glyoxylate cycle, RQ.

Unit-IX: Nitrogen Metabolism(Lectures: 01)

Biological nitrogen fixation: Definition and types, Role of nitrogenase enzyme, Nitrate and ammonia assimilation (basic concept).

Unit-X: Seed Dormancy(Lectures: 02)

Types; Causes and Methods of breaking seed dormancy.

Unit-XI: Physiology of Senescence and Ageing(Lectures: 02)

Senescence and Ageing.

PRACTICAL (Lectures: 30)

1. Determination of osmotic potential of plant cell sap by plasmolytic method.
2. Determination of water potential of potato tuber cells by weight method.
3. Calculation of stomatal index and stomatal frequency from the two surfaces of leaves of a mesophyte and xerophyte.
4. To study the effect of different concentrations of ABA on stomatal closure.
5. Effect of carbon dioxide concentration on the rate of photosynthesis.

RECOMMENDED BOOKS:

1. Nelson, D.L., Cox, M.M. (2017). *Lehninger Principle of Biochemistry*, 7th edition. New York, NY: W.H. Freeman, Macmillan learning.
2. Taiz, L., Zeiger, E., Moller, I. M. & Murphy, A. 2018. *Plant Physiology and Development*, International 6th edn, Oxford University Press, Sinauer Associates, New York, USA.
3. Hopkins, W.G., Huner, N. (2008). *Introduction of Plant Physiology*, 4th edition. New Jearsey, U.S.: John Wiley and sons.
4. Jones, R., Ougham, H., Thomas, H., Waaland, S. (2013). *The molecular life of plants*. Chichester, England: Wiley-Blackwel Buchanan, B.B., Gruissem, W. and Jones, R.L. (2015). *Biochemistry and Molecular Biology of Plants*, 2nd edition. New Jearsey, U.S.: Wiley Blackwell.
5. Kochhar, S.L. & Gujral, S.K. 2020. *Plant Physiology: Theory and Applications*, 2nd Edition. Cambridge University Press, UK
6. Bhatla, S.C., Lal, M.A. (2018). *Plant Physiology, Development and Metabolism*. Singapore: Springer.

**COURSE NAME: PLANT ANATOMY, EMBRYOLOGY AND
ECONOMIC BOTANY**

COURSE CODE: BT - MN - 5214

Total Credits: 4 (Theory: 3 + Practical/Tutorial:1)

THEORY: 3 CREDITS

Total Lectures: 45

COURSE OBJECTIVE:

To enable the students

- 1. To understand the various aspects of plant anatomy Embryology and Economic Botany.*
- 2. To understand the application of plant anatomical knowledge and angiospermic plants in utilitarian aspects of resource management.*
- 3. To understand the salient features of plant anatomy and embryology of angiosperms with special reference to plant taxonomy.*

COURSE LEARNING OUTCOME:

Students are expected to gain theoretical knowledge and acquire basic skills on the plant anatomy, embryology with special reference to Angiosperms. Students are also expected to gain theoretical knowledge to explore the basic utilitarian aspects of plants. Upon completion of the course, the students will be able to:

- CLO-01:** *Illustrate the structure, types, organization of various cells, tissues and organs of plant body.*
- CLO-02:** *Relate plant anatomy and embryology of angiosperms with other fields of botany.*
- CLO-03:** *Combine classical utilitarian aspects of plant with modern molecular organization of plants.*
- CLO-04:** *Learn various advanced tools to study plant anatomy and embryology.*

Unit- I: Introduction and Organization of Plant Body (Lectures: 03)

Organization of plant body - Types of Cells, Tissues and Tissue systems.

Unit- II: Apical Meristems(Lectures: 04)

Organizational theories of Shoot and Root Apex. Primary structure stem, root and leaves of dicot and monocot..

Unit- III: Vascular Cambium and Wood(Lectures: 05)

Structure, Function and seasonal activity of Cambium. Secondary Growth in Stem and root of dicot and monocot. Dendrochronology.

Unit- IV: Adaptive and Protective Systems (Lectures: 03)

Hairs and Trichomes. Anatomical Adaptation of Xerophytes and Hydrophytes.

Unit-V: Reproductive Development(Lectures: 12)

Introduction and Interdisciplinary approaches of Embryology and its application. Genetic and molecular aspect of flower development. Structure and Significance of Anther and Anther wall. Micro sporogenesis and Micro gametogenesis. Pollen Wall Structure and NPC System. Structure and Types of ovules. Mega sporogenesis and Mega gametogenesis (*Polygonum* type). Organization and Structure of Embryo sac; Pollination – Type Adaption and significance.

Unit-VI: Fertilization, Embryo and Seeds(Lectures: 03)

Double fertilization. General pattern of development of dicot and monocot embryo and endosperm. Seed – Structure, Type and dispersal mechanisms..

Unit-VII: Origin and Cultivation of Commercially Importance Plants (Lectures: 15)

Centres of Origin with reference to Vavilov's work. Evaluation of new crops. Importance of germplasm diversity in food security. Morphology, processing and uses of Rice, Wheat, Sugarcane. Clove, Black Pepper, Tea, Coffee, Jute and Cotton.

PRACTICAL (Lectures: 30)

1. Work out of Experiment.

- (i). Dissection, description, preparation of temporary / permanent slides of primary cells, root and stem apices, secondary growth of dicot and monocot stems, adaptations of hydrophyte and xerophyte
- (ii) Study and preparation of temporary slides or from permanent slides of anther, ovules and endosperms.
- (iii) Study of morphology, useful part and active ingredients of rice, wheat, sugar cane, clove, black pepper, tea, coffee, jute and cotton..

2. Spot Identification :

Plant specimens (fresh specimens, permanent slides or photographs) of Anatomy, Embryology and Economic Botany included in the theory syllabus.

RECOMMENDED BOOKS:

1. Pandey, B. P. Plant Anatomy, S Chand.
2. Sinha, S. K. A Text Book of Plant Anatomy, Bames and Noble.
3. Ragland, A and Arumugam, N. Fundamentals of Plant Anatomy and Microtechniques, Saras Publication.
4. Lersten, N. R. Flowering Plant Embryology, Blackwell Publishing.
5. Shukla, R. N. Embryology Concept and Application, Goodreads.
6. Rane, G. M. Plant Embryology, Prashant Publications.
7. Rathor, J. S. Textbook of Economic Botany, Indian Books and Periodicals.
8. Pandey, B. P. Economic Botany, S Chand.
9. Sarma, O. P. Economic Botany (Plants and Human Welfare), Progati Edition.

COURSE NAME: PLANT BREEDING AND BIOTECHNOLOGY

COURSE CODE: BT - MN - 6214

Total Credits: 4 (Theory: 3 + Practical/Tutorial:1)

THEORY: 3 CREDITS

Total Lectures: 45

COURSE OBJECTIVE:

1. *To provide students with a comprehensive understanding of advanced principles and techniques in plant breeding and biotechnology.*
2. *Students will explore the genetic basis of plant breeding methods, the application of molecular markers, and the integration of biotechnological tools in crop improvement.*
3. *Practical sessions will reinforce theoretical knowledge through hands-on experience with essential laboratory techniques in plant tissue culture, recombinant DNA technology, and molecular biology.*

COURSE LEARNING OUTCOME:

After completing this course, students will be able to

- CLO-01:** *Understand fundamental concepts of centers of origin of crop plants and explain diversity, acclimatization, plant introduction, and domestication.*
- CLO-02:** *Gain knowledge on plant tissue culture and the basic molecular techniques used in biotechnology.*
- CLO-03:** *Differentiate between types of molecular markers (RAPD, AFLP, SSR, SNP) and apply molecular markers in marker-assisted selection (MAS) for crop improvement.*
- CLO-04:** *Identify major biotechnology institutes and companies in India. They will be able to explain applications of DNA recombinant technology in agriculture and medicine.*
- CLO-05:** *Apply plant tissue culture techniques by understanding the composition of media and nutrient requirements in plant tissue culture.*
- CLO-06:** *Understand recombinant DNA technology and the role of restriction enzymes. Identify and describe various cloning vectors and gene cloning techniques.*
- CLO-07:** *Discuss applications of biotechnology in agriculture, such as pest-resistant and herbicide-resistant plants; Explain the role of transgenics in bioremediation and the production of safer and cheaper medicines; and evaluate biosafety concerns associated with genetically engineered products*
- CLO-08:** *Gain hands-on experience in the preparation of MS medium, in vitro sterilization, and inoculation methods.*

Unit- I: Introduction to Plant Breeding (Lectures: 03)

Objectives of plant breeding; Centre of origin of crop plants and diversity, acclimatization, plant introduction and domestication of crops.

Unit- II: Principles and breeding methods I(Lectures: 05)

Selection- mass selection, pure line selection and clonal selection, genetic basis of selection methods; Hybridization- Procedure of hybridization, back & test cross method, inter generic, inter specific, inter varietal hybridization with examples; Hybrid Vigor.

Unit- III: Principles and breeding methods II(Lectures: 06)

Heterosis; Inbreeding depression (genetic basis); Mutation breeding methods and achievements in India; Breeding for biotic and abiotic resistance; Male sterility; Polyploidy and its significance in evolution of new species

Unit- IV: Molecular markers in plant breeding (Lectures: 05)

Types of molecular markers (RAPD, AFLP, SSR, SNP); Marker-assisted selection (MAS) in plant breeding; Applications of molecular markers in crop improvement.

Unit-V: Basic Biotechnology (Lectures: 03)

Scope and branches of Biotechnology, Major Biotechnology institutes and companies in India, applications of DNA recombinant technology in agriculture and medicines, transgenic plants.

Unit-VI: Plant Tissue Culture (Lectures: 08)

Composition of media; Nutrient and hormone requirements; Totipotency; Organogenesis; Embryogenesis (somatic and zygotic); Protoplast isolation, culture and fusion; Tissue culture applications (micro propagation, androgenesis, virus elimination, secondary metabolite production, haploids, triploids and hybrids; Cryopreservation; Germplasm Conservation).

Unit-VII: Recombinant DNA Technology (Lectures: 06)

Recombinant DNA technology, restriction enzymes (Types I-IV), Cloning Vectors: Prokaryotic (pUC 18 and pUC19, pBR322, Ti plasmid, BAC); Lambda phage, M13 phagemid, Cosmid; Eukaryotic Vectors (YAC)., DNA libraries, Gene cloning and PCR.

Unit-VIII: Applications of Biotechnology (Lectures: 09)

Pest resistant (Bt-cotton); herbicide resistant plants (RoundUp Ready soybean); Transgenic crops with improved quality traits (Flavr Savr tomato, Golden rice); Role of transgenics in bioremediation (Superbug); Safer and cheaper medicines by Biotechnology (e.g. insulin, tPA, and Blood clotting factor); edible vaccines; Genetically Engineered Products– Human Growth Hormone; Humulin; Biosafety concerns

PRACTICAL (Lectures: 30)

1. Preparation of MS medium.
2. Demonstration of *in vitro* sterilization and inoculation methods using leaf.
3. Study of anther, embryo and endosperm culture, micro propagation, somatic embryogenesis & artificial seeds through photographs.

4. Study of Emasculation in plants.
5. Study of genetic engineering techniques (photographs): FISH, DNA Fingerprinting, Gene gun, Ti plasmid, Bt cotton, Golden rice, Savrflavr tomato.
6. Study of molecular techniques: PCR, Blotting techniques, AGE and PAGE.

RECOMMENDED BOOKS:

1. Bhojwani, S.S. and Razdan, M.K., (1996). Plant Tissue Culture: Theory and Practice. Elsevier Science Amsterdam. The Netherlands.
2. Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington.
3. Stewart, C.N. Jr. (2008). Plant Biotechnology & Genetics: Principles, Techniques and Applications. John Wiley & Sons Inc. U.S.A
4. Chaudhury, R. C. (1989). Introduction to Plant Breeding, Oxford and IBH publishing PVT. LTD.
5. Gupta, P. K (2009), Biotechnology and Genomics, Rastogi Publications.
6. Singh, B. D. (2016) Plant Breeding: Principles and Methods. Kalyani Publishers.

COURSE NAME: ENVIRONMENTAL ISSUES AND APPLIED BOTANY

COURSE CODE: BT-MN-7414

Total Credits: 4 (Theory: 3 + Practical/Tutorial:1)

THEORY: 3 CREDITS

Total Lectures: 45

COURSE OBJECTIVE:

1. *To obtain knowledge of different environmental issues.*
2. *To understand and its application of various management principles, acts and policies towards the environmental issues.*
3. *To acquaint with practical knowledge of various applied aspects of Botany and development of biological skill based entrepreneurial establishments.*

COURSE LEARNING OUTCOME:

- CLO-01:** *Students will be able to obtain knowledge of environmental issues and various applied aspects of botany.*
- CLO-02:** *Students will be able to understand and apply various management principles environmental issues.*
- CLO-03:** *Students will be acquainted with practical knowledge of various applied aspects of botany.*
- CLO-04:** *Students will be able to establish various biological skill based entrepreneurial establishments.*

Unit- I: Environmental Pollution(Lectures: 15)

Environmental pollution: sources of air, soil and water pollution, parameters to assess the pollution level, effects of pollution on plants and ecosystems and pollution abatement; global environmental change: climate change: greenhouse gases (CO₂, CH₄, N₂O, CFCs: sources, trends and role), consequences of climate change, ozone depletion. Environmental Protection and Biodiversity Acts, Wildlife Protection Act, Forest Conservation Act, International Agreements on environmental issues, Kyoto Protocol and Rights of tribal communities on biodiversity.

Unit- II: Environmental Issues(Lectures: 08)

Human impacts on forest ecosystems; soil erosion and its control; shifting cultivation and its ecological implications; coal mining problem of northeast India; eco-restoration of degraded ecosystems; environmental impact assessment (EIA). Human-wildlife conflict in India with reference to Northeast India.

Unit- III: General account of Microbial Applications (Lectures: 07)

General account about the microbes used as Bio-fertilizer and Bio-pesticide. Characteristic features, isolation, identification and mass multiplication of *Rhizobium sp*, *Azospirillum sp*,

Azotobacter sp., Cyanobacteria (blue green algae), and *Anabaena azollae*, Mushroom cultivation.

Unit- IV: Agricultural Application(Lectures: 10)

Nitrogen fixation, factors affecting growth, blue green algae and *Azolla sp* in rice cultivation. Mycorrhizal association, types of mycorrhizal association, taxonomy, occurrence and distribution, phosphorus nutrition, growth and yield – colonization of AM – isolation and inoculum production of VAM, and its influence on growth and yield of crop plants.

Unit-V: Organic Farming(Lectures: 05)

Green manuring and organic fertilizers, pesticides and herbicides. Recycling of biodegradable municipal, agricultural and Industrial wastes – bio-compost making methods, types and method of vermicomposting – field application and cultural practices

PRACTICAL (Lectures: 30)

1. Estimation of above ground and below ground biomass from unit area.
2. Demonstration of mushroom cultivation.
3. To plot Biosphere Reserves/ Ramsar sites/ National Parks/Wildlife Sanctuaries located in different biogeographical zones of India in NE India.
4. Study of Mycorrhizae for specimens (Supplied / Photograph)
5. To study the practical aspect of vermicomposting.

RECOMMENDED BOOKS:

1. Kumar P. and Mina U. (2014).*Fundamentals of Ecology and Environment*. New Delhi: Pearson India Education Services Pvt. Ltd.
2. Joshi N. and Joshi P. C. (2009).*A Textbook of Ecology and Environment*. Mumbai: Himalaya Publishing House.
3. Gaur R., Mehrotra S. and Pandey R. R. (2010).*Microbial Applications*. New Delhi: I. K. International Publishing House Pvt. Ltd
4. Mallick P. and Chatterjee S. (2010).*Textbook of Algae*. New Delhi: PHI Learning Pvt. Ltd
5. Shukla A. C. (Ed.) (2018).*Applied Mycology: Entrepreneurship with Fungi (Fungal Biology)*. New Delhi: Springer Nature
6. Agrihortico Cpl (2016).*Organic Farming: A Simple Guide for Beginners*. New Delhi: Agrihortico Publications.
7. Shukla P. K. (2013).*Organic Farming: Principles, Methods and Practices*. New Delhi: YKing Books.

COURSE NAME: BIODIVERSITY CONSERVATION AND TRADITIONAL KNOWLEDGE

COURSE CODE: BT-MN-8414

Total Credits: 4 (Theory: 3 + Practical/Tutorial:1)

THEORY: 3 CREDITS

Total Lectures: 45

COURSE OBJECTIVE:

1. *To develop practical and theoretical knowledge of the conservation of biodiversity and traditional knowledge.*
2. *To know about different national and international policies and acts for biodiversity conservation.*
3. *To understand the IPR and its effectiveness.*
4. *To understand the importance of Traditional Knowledge and its safeguard.*

COURSE LEARNING OUTCOME:

- CLO-01:** *Students will be able to obtain knowledge on conservation and management of biodiversity.*
- CLO-02:** *Students will be able to understand and apply various management principles Exsitu and In-situ conservation.*
- CLO-03:** *Students will be acquainted with practical knowledge of various aspects of Ethno botany.*
- CLO-04:** *Students will be able to know about the traditional knowledge; it's relevance in present day context.*

Unit- I: Biodiversity (Lectures: 05)

Concept, components and types; importance of biodiversity conservation, Different approaches for biodiversity conservation, Biodiversity Act and Access Benefit sharing.

Unit- II: Strategies for conservation I (Lectures: 10)

In-situ conservation: international efforts and Indian initiatives, protected regions for conservation of biodiversity. RET Plants of Northeast India and their conservation initiatives.

Unit- III: Strategies for conservation II (Lectures: 10)

Ex-situ conservation: Principles and practices; botanical gardens, gene banks, seed banks, *in-vitro* repositories, cryobanks; National Bureau of Plant Genetic Resources (NBPGR), Indian Council of Agricultural Research (ICAR) and their conservation efforts

Unit- IV: IPR (Lectures: 08)

Principles of IPR and Patent law, patent application procedure, Trade Mark, Copyright, Enforcement of IPR, Information Technology related IPR, Computer software and IPR, Biotechnology and IPR, protection of plant varieties, geographical indicators, farmers right,

resource rights.

Unit-V: Ethnobotany(Lectures: 07)

Introduction to ethnobotany, Historical approach of ethnobotany in context to Indian ancient literatures, Branches of ethnobotany and its interdisciplinary approaches, Principle and methods of ethnobotanical research, future prospect of ethnobotany.

Unit-VI: Traditional Knowledge(Lectures: 05)

Concept & types of Traditional Knowledge, TKDL, Holders Protection, need for a Sui-Generis regime, TK vs modern knowledge, digital library, biopiracy & bioprospecting.

PRACTICAL (Lectures: 30)

1. Demonstration of seed storage and viability testing.
2. Demonstrate the patent application procedure.
3. Study of the locally available 10 herbal medicinal plant.
4. Identification and documentation of RET plants of Northeast India
5. Study of examples of TKDL entries and holders' protection.

RECOMMENDED BOOKS:

1. Meerabai M. and Pullaiah T. (2014). *Plant Biodiversity Conservation and Management*. New Delhi: Regency Publications.
2. Shankar U., Rawat G. S. and Rai I. D. (2011). *Plant Biodiversity and Conservation*. New Delhi: Daya Publishing House.
3. Frankel O. H., Brown A. H. D. and Burdon J. J. (1995). *The Conservation of Plant Biodiversity*. Cambridge: Cambridge University Press
4. Kumar H. D. and Sharma A. (2009). *Plant Biotechnology and Biodiversity Conservation*. New Delhi: Oxford & IBH Publishing Co. Pvt. Ltd
5. Wadehra B. L. (2004). *Law Relating to Intellectual Property*. New Delhi: Universal Law Publishing Co
6. Narayanan P. (2017). *Intellectual Property Law* (5th ed.). New Delhi: Eastern Law House.
7. Jha A. (2010). *Traditional Knowledge System in India*. New Delhi: Atlantic Publishers and Distributors.
8. Sengupta N. (2003). *Traditional Knowledge in Modern India*. New Delhi: Oxford University Press.

SKILL ENHANCEMENT COURSE (SEC)

Programme Specific Outcome of Bachelor of Science–Botany (Skill Enhancement Course)

PSO No.	Name	Outcome
PSO–1	Importance of plants and their functions (BTL: Remember, Understanding)	To develop a conceptual understanding of principles and importance of Botany. Students will be able to understand and explain different specializations of Botany such as systematics, evolution, ecology, developmental biology, physiology, biochemistry, plant interactions with microbes and insects, morphology, anatomy, reproduction, genetics, cell and molecular biology of plants.
PSO–2	Laboratory Skills (BTL: Application, Evaluate)	Acquire practical skills in laboratory settings, including microscopy, experimental design, and data analysis. Students are also familiarized with the use of bioinformatics tools and databases and in the application of statistics to biological data. Students will be trained in various analytical techniques of plant biology, use of plants as industrial resources or as support system for human livelihood and will be well versed with the use of transgenic technologies for both basic and applied research in plants.
PSO–3	Communication Skills (BTL: Apply)	Be motivated for further higher studies and research in different sub-disciplines of anthropology.
PSO–4	Closeness with nature (BTL: Evaluate)	Students will be eligible in diverse fields in research organization, government services, education sector, human resources, public services, hospitality, industries, corporate sectors, entrepreneur, business, tourism industry, media and Non-Governmental organization.
PSO–5	Continuous Learning (BTL: Create)	The primary ethics of the subject is to ensure appreciation of human diversity and it helps to analyze critically the issues that are relevant in contemporary society.

Basic Syllabus Structure of SEC

Semester	Course Name	Course code
1	Gardening	BT – SE – 1113
2	Floriculture and Interior Decoration with Indoor Plants	BT – SE – 2113
3	Value added Horticultural Product and Nursery Development	BT – SE – 3213

Course Learning Outcome – Skill Enhancement Course (SEC)

Semester	Course Name & Code	Course Learning Outcome(CLO)	
1	Gardening BT-SE-1113	CLO-01	After completing the course students will get service career opportunities which include such jobs as floral designers, groundskeepers, landscape designers, architects and horticultural therapists.
		CLO-02	Professional qualification combined with an inclination towards gardening and such other activities produces efficient floriculturists as well as horticulturists and landscaping professionals..
2	Floriculture and Interior Decoration with Indoor Plants BT-SE-2113	CLO-01	A course work on floriculture and interior decoration with indoor plants would equip the participants to join the floriculture field as farm/estate managers, plantation experts, supervisors and project coordinators etc.
		CLO-02	It would qualify the candidates to join in the marketing of floriculture products and develop technique of interior decoration with indoor plants for different ventures is emerging as a potential segment of this course.
		CLO-03	Besides research and teaching are some other avenues of employment in the field.
3	Value added Horticultural Product and Nursery DevelopmentBT-SE- 3213	CLO-01	Product Diversification: Students will gain expertise in producing a range of value-added horticultural products such as jams, juices, and dried fruits, enhancing their ability to meet diverse consumer demands and capitalize on market opportunities.
		CLO-02	Nursery Management Proficiency: Through hands-on training, students will develop skills in nursery development, plant propagation, and management practices, enabling them to establish and maintain successful horticultural nurseries.
		CLO-03	Entrepreneurial Skills: Students will acquire entrepreneurial acumen, including market analysis, business planning, and marketing strategies, empowering them to establish and manage profitable horticultural ventures.
		CLO-04	Sustainable Practices: Understanding sustainable horticultural practices, students will be able to integrate principles of environmental stewardship and resource conservation into their production and management processes.
		CLO-05	Industry Collaboration: Through industry partnerships and practical experiences, students will cultivate professional networks and collaboration opportunities, enhancing their readiness for employment or entrepreneurship in the horticultural sector

Mapping of Course Learning Outcome and Programme Outcome

Course Code	CLO	PROGRAMME OUTCOME										
		SPO-1	SPO-2	SPO-3	SPO-4	SPO-5	SPO-6	SPO-7	SPO-8	SPO-9	SPO-10	SPO-11
BT-SE-1113	CLO1	3	1	2	3	-	3	-	-	-	2	3
	CLO 2	-	-	1	3	-	3	-	-	-	2	3
BT-SE-2113	CLO1	-	2	-	3	-	3	-	-	-	2	3
	CLO 2	3	1	2	3	-	3	-	-	-	2	3
	CLO 3	-	2	-	3	-	3	-	-	-	2	3
BT-SE-3213	CLO1	-	-	-	-	-	2	-	-	1	-	-
	CLO 2	-	-	-	-	-	-	-	-	1	-	3
	CLO 3	-	-	-	-	-	-	-	-	1	-	-
	CLO 4	-	-	-	-	-	-	-	1	-	-	2
	CLO 5	-	-	-	-	-	-	2	-	-	1	-

Mapping of Course Learning Outcome and Programme Specific Outcome

Course code	CLO	Programme Specific Outcome (PSO)				
		PSO-1	PSO-2	PSO-3	PSO-4	PSO-5
BT-SE-1113	CLO 1	3	2	3	3	3
	CLO 2	3	2	2	1	3
BT-SE-2113	CLO 1	3	1	-	3	3
	CLO 2	-	-	-	1	-
	CLO 3	-	-	2	1	-
BT-SE-3213	CLO 1	-	-	-	1	-
	CLO 2	-	-	2	1	-
	CLO 3	-	1	-	-	-
	CLO 4	-	1	-	-	2
	CLO 5	-	-	-	1	-

COURSE NAME: GARDENING

COURSE CODE: BT–SE–1113

Total Credits: 3 (Theory: 2 + Project/Practical/Tutorial:1)

THEORY: 2 CREDITS

Total Lectures: 30

COURSE OBJECTIVE:

A course work on gardening would equip the students to join the horticultural field as farm /estate management, plantation experts, supervisors and project coordinators etc. Besides research and teaching aspects, it would qualify the students to join as consultant of projects, landscape architect etc. with proper training. One can also work as entrepreneur and offer employment to others.

COURSE LEARNING OUTCOME:

CLO-01: *After completing the course students will get service career opportunities which include such jobs as floral designers, groundskeepers, landscape designers, architects and horticultural therapists.*

CLO-02: *After completing the course students will acquire professional qualification combined with an inclination towards gardening and such other activities produces efficient floriculturists as well as horticultureists and landscaping professionals.*

Unit- I: Introduction (Lectures: 06)

Definition of Gardening, History, Types, Features and Component of gardening

Unit- II: Technique of Gardening(Lectures: 05)

Planning and Layout for different types of gardens.

Unit- III: Preparation of Propagules(Lectures: 06)

Sowing, raising of seeds and seedlings; Types and Process of vegetative propagations.

Unit- IV: Management of Garden (Lectures: 09)

Gardening operations: Soil laying, Manuring, Watering, Management of pests and diseases and Harvesting.

Unit-V: Prospect of Gardening (Lectures: 04)

Future prospects and values of gardening.

PRACTICAL / PROJECT (Lectures: 30)

1. Project/Field work based on the syllabus of theory course.

RECOMMENDED BOOKS:

1. Bose, T.K. and Mukherjee, D. (1972) – Gardening in India, Oxford and IBH Publishing Co. New Delhi.
2. Edmond Musser and Andres – Fundamentals of Horticulture, Mc Graw Hill Book Co. New Delhi.
3. Johnson, H. Principles of Gardening: The Practice of the Gardener's Art.

COURSE NAME: GARDENING

COURSE CODE: BT–SE–2113

Total Credits: 3 (Theory: 2 + Project/Practical/Tutorial:1)

THEORY: 2 CREDITS

Total Lectures: 30

COURSE OBJECTIVE:

There has been a great improvement of the quality of life, leading to a well balanced demand and supply of flowers. As a result, floriculture has blossomed into a viable business segment. So the main objective is in promotion of the floriculture trade leading to development of nursery, seed and bulb production, micro propagation of flowering plants like orchids, silviculture and extraction of essential oils. Thus it would involve with cultivation of ornamental flowers and crops from the time of planting to the time of harvesting..

COURSE LEARNING OUTCOME:

CLO-01: *A course work on floriculture and interior decoration with indoor plants would equip the participants to join the floriculture field as farm/estate managers, plantation experts, supervisors and project coordinators etc.*

CLO-02: *It would qualify the candidates to join in the marketing of floriculture products and develop technique of interior decoration with indoor plants for different ventures is emerging as a potential segment of this course.*

CLO-03: *Besides research and teaching are some other avenues of employment in the field*

Unit- I: Introduction (Lectures: 05)

Definition of Floriculture, History, Importance and scope of floriculture.

Unit- II: Management(Lectures: 05)

Nursery Management and routine garden operations and Green House.

Unit- III: Types and Technique (Lectures: 010)

Principle, Features and Management of Interior Decorations; Landscaping gardening of Public Places, Highways and Educational Institutions.

Unit- IV: Ornamental Plants(Lectures: 05)

Different types of ornamental plants and their utilization, Indoor Plants, Potted Plants, Hydroponics and Bonsai.

Unit-V: Commercial Floriculture (Lectures: 06)

Production and Packaging of flowers; Methods and importance of Flower arrangement. Market potentialities of floriculture.

PRACTICAL / PROJECT (Lectures: 30)

1. Project/Field work based on the syllabus of theory course.

RECOMMENDED BOOKS:

1. Randhowa, G.S. and Mukhopadhyay, A. (1986)–Floriculture in India, Allied Publishers.
2. Balaji, S. Kulkarni (2016)–Floriculture and Land scapping, Agro India Publication.
3. Roy, A. Larson (1992)-Introduction to Floriculture, 2nd Edition, Academic Press.

**COURSE NAME: VALUE ADDED HORTICULTURAL PRODUCT AND
NURSERY DEVELOPMENT**

COURSE CODE: BT-SE-3213

Total Credits: 3 (Theory: 2 + Practical/Tutorial:1)

THEORY: 3 CREDITS

Total Lectures: 30

COURSE OBJECTIVE:

The course objectives are as follows:

1. *Diversified Product Portfolio: Introduce students to various value-added horticultural products like jams, juices, and essential oils, broadening their understanding of horticultural entrepreneurship.*
2. *Nursery Development Skills: Equip students with skills in nursery management, propagation techniques, and plant breeding to foster sustainable horticultural practices and support industry growth.*
3. *Market Analysis: Provide insights into market trends, consumer preferences, and marketing strategies for horticultural products, enabling students to develop viable business plans and enhance market competitiveness.*

COURSE LEARNING OUTCOME:

- CLO-01:** *Product Diversification: Students will gain expertise in producing a range of value-added horticultural products such as jams, juices, and dried fruits, enhancing their ability to meet diverse consumer demands and capitalize on market opportunities.*
- CLO-02:** *Nursery Management Proficiency: Through hands-on training, students will develop skills in nursery development, plant propagation, and management practices, enabling them to establish and maintain successful horticultural nurseries.*
- CLO-03:** *Entrepreneurial Skills: Students will acquire entrepreneurial acumen, including market analysis, business planning, and marketing strategies, empowering them to establish and manage profitable horticultural ventures.*
- CLO-04:** *Sustainable Practices: Understanding sustainable horticultural practices, students will be able to integrate principles of environmental stewardship and resource conservation into their production and management processes.*
- CLO-05:** *Industry Collaboration: Through industry partnerships and practical experiences, students will cultivate professional networks and collaboration opportunities, enhancing their readiness for employment or entrepreneurship in the horticultural sector.*

Unit- I: Introduction to Value-Added Horticultural Products(Lectures: 02)

Overview of value-added products in horticulture. Importance and market potential of value-added products.

Unit- II: Product Development Techniques(Lectures: 02)

Processing methods for value addition such as preservation (Class I and Class II), fermentation, extraction. Quality control measures and standards for product development. Specific Product Lines.

Unit- III: Exploration of various value-added products and Marketing(Lectures: 13)

Production of various value-added such as jams, jellies, pickles, sauces, and beverages. Market research methodologies to identify consumer preferences and trends. Analysis of market opportunities and challenges for horticultural products. Business Planning and Entrepreneurship: Basics of business planning, including feasibility studies and financial projections. Entrepreneurial skills development, including marketing, branding, and distribution strategies.

Unit- IV: Nursery Infrastructure Planning and Layout Design(Lectures: 06)

Techniques for plant propagation, including seed sowing, grafting, and cutting propagation. Nursery management practices, including irrigation, pest control, and disease management.

Unit-V: Genetics for Nursery Development (Lectures: 02)

Selection criteria for superior cultivars and varieties.

Unit-VI: Fundamentals of Plant Breeding(Lectures: 04)

Sustainable Practices and Environmental Management.

PRACTICAL (Lectures: 30)

1. Industry Visits and Guest Lectures :
 - i) Field trips to horticultural enterprises and processing facilities.
 - ii) Guest lectures by industry experts to provide insights into current trends and best practices
2. Practical Training and Project Work
 - i) Hands-on training sessions in product development, nursery management, and business planning.
 - ii) Project work or internships to apply theoretical knowledge in real-world settings and gain practical experience.
 - iii) Hands-on training in product formulation, packaging, and labeling.

RECOMMENDED BOOKS:

1. Indian Council of Agricultural Research (ICAR), Handbook of Horticulture.
2. S.S. Sindhu and R.K. Pathak, Propagation of Horticultural Crops.
3. R.K. Pathak and S.S. Sindhu, Nursery Management for Horticultural Crops
4. Richard N. Artica, Introduction to Horticulture.
5. Michael A. Dirr and Charles W, The Reference Manual of Woody Plant Propagation
6. Christopher Lloyd, The Well-Tempered Garden.
7. Bruce Macdonald, Practical Woody Plant Propagation for Nursery Growers.
8. George Acquaah, Horticulture: Principles and Practices.

INTER-DISCIPLINARY COURSE (IDC)

Programme Specific Outcome of Bachelor of Science–Botany (IDC)

PSO No.	Name	Outcome
PSO–1	Importance of plants and their functions (<i>BTL: Remember, Understanding</i>)	To develop a conceptual understanding of principles and importance of Botany. Students will be able to understand and explain different specializations of Botany such as systematics, evolution, ecology, developmental biology, physiology, biochemistry, plant interactions with microbes and insects, morphology, anatomy, reproduction, genetics, cell and molecular biology of plants.
PSO–2	Communication Skills (<i>BTL: Apply</i>)	Be motivated for further higher studies and research in different sub-disciplines of anthropology.
PSO–3	Closeness with nature (<i>BTL: Evaluate</i>)	Students will be eligible in diverse fields in research organization, government services, education sector, human resources, public services, hospitality, industries, corporate sectors, entrepreneur, business, tourism industry, media and Non-Governmental organization.
PSO–4	Continuous Learning (<i>BTL: Create</i>)	The primary ethics of the subject is to ensure appreciation of human diversity and it helps to analyze critically the issues that are relevant in contemporary society.

Basic Syllabus Structure of IDC

Semester	Course Name	Course Code
1	Plant Biodiversity	BT-ID-1113
2	Plants and Human Welfare	BT-ID-2113
3	Nursery and Gardening	BT-ID-3213

Course Learning Outcome (CLO)

Semester	Course Name & Code	Course Learning Outcome (CLO)	
1	Plant Biodiversity BT-ID-1113	CLO-01	After completing the course, the student will learn about biodiversity not only as plant or nature lover but also for higher academic pursuits, particularly in the field of biological sciences, environment and biodiversity conservation.
2	Plants and Human Welfare BT-ID-2113	CLO-01	This paper will enable student to learn about importance of plants and human welfare.
		CLO-02	They will also learn about microbes, different types of forest and forest products.
		CLO-03	They will also gain knowledge about mushroom technology together with knowledge of medicinal plants.
3	Nursery and Gardening BT-ID-3213	CLO-01	Students will demonstrate proficiency in establishing and managing horticultural nurseries, including site selection, layout planning, infrastructure development, and inventory management.
		CLO-02	They will acquire knowledge of nursery business operations, including financial management, marketing strategies, and customer relations, preparing them for entrepreneurship or employment in the nursery industry
		CLO-03	Through practical training, students will master various plant propagation techniques, including seeding, grafting, cutting propagation, and tissue culture, enabling them to produce a diverse range of healthy and vigorous plant stock. They will understand the principles of seed germination, root development, and plant growth, allowing them to propagate plants efficiently and sustainably..
		CLO-04	Students will develop practical gardening skills, including soil preparation, planting techniques, watering practices, fertilization methods, and integrated pest management strategies.
		CLO-05	They will learn to design and maintain ornamental gardens, vegetable plots, and landscape features, enhancing their ability to create aesthetically pleasing and environmentally sustainable outdoor spaces.
		CLO-06	They will gain knowledge of plant nutrition, disease identification, and pest control measures, enabling them to maintain plant health and vitality in nursery and garden settings. They will learn to diagnose common plant problems and implement appropriate remedies, promoting the long-term health and productivity of plants under their care.
		CLO-07	They will develop an understanding of sustainable gardening practices, including water conservation, organic gardening methods, and habitat creation for wildlife. They will appreciate the ecological benefits of gardening, such as biodiversity conservation, soil erosion control, and carbon sequestration, fostering a sense of environmental stewardship

Mapping of Course Learning Outcome (CLO) and Programme Outcome (PO)

Course Code	CLO	Programme Outcome (PO)										
		SPO-1	SPO-2	SPO-3	SPO-4	SPO-5	SPO-6	SPO-7	SPO-8	SPO-9	SPO-10	SPO-11
BT-ID-1113	CLO - 1	-	-	1	-	-	-	-	-	-	-	-
BT-ID-2113	CLO - 1	-	-	-	-	-	1	-	-	-	-	-
	CLO - 2	-	-	-	1	2	-	-	-	-	-	-
	CLO - 3	3	3	3	3	-	3	-	-	-	3	3
BT-ID-3213	CLO - 1	-	-	1	-	-	-	-	-	-	-	-
	CLO - 2	-	-	-	-	-	1	-	-	-	-	-
	CLO - 3	-	-	-	1	2	-	-	-	-	-	-
	CLO - 4	-	-	-	2	-	-	-	-	1	-	-
	CLO - 5	-	-	1	2	-	-	-	3	-	-	-
	CLO - 6	1	2	-	-	-	-	-	-	-	-	-
	CLO - 7	1	-	-	-	-	-	-	2	-	-	3

Mapping of Course Learning Outcome (CLO) and Programme Specific Outcome (PSO)

Course Code	CLO	Programme Specific Outcome (PSO)			
		PSO-1	PSO-2	PSO-3	PSO-4
BT-ID-1113	CLO-1	1	2	-	3
BT-ID-2113	CLO-1	-	-	-	1
	CLO - 2	-	1	2	-
	CLO - 3	3	2	2	1
BT-ID-3213	CLO-1	1	2	-	3
	CLO - 2	-	-	-	1
	CLO - 3	-	1	2	-
	CLO-4	-	1	-	-
	CLO - 5	-	1	-	-
	CLO - 6	1	-	-	-
	CLO-7	-	-	-	1

COURSE NAME: PLANT BIODIVERSITY

COURSE CODE: BT – ID – 1113

Total Credits: 3 (Theory: 3)

THEORY: 3 CREDITS

Total Lectures: 45

COURSE OBJECTIVE:

This course will provide comprehensive information and insight into the fascinating world of biodiversity. A proper orientation for the students that would make them own up responsibility for conservation of our exploited and threatened biological natural resources.

COURSE LEARNING OUTCOME:

CLO-01: *After completing the course, the student will learn about biodiversity not only as plant or nature lover but also for higher academic pursuits, particularly in the field of biological sciences, environment and biodiversity conservation.*

Unit- I: Introduction of Biodiversity (Lectures: 06)

Definition, history, objectives, type and interdisciplinary approaches of Plant Biodiversity.

Unit- II: Function of Biodiversity (Lectures: 06)

Human and Societal need – food and nutrition security, energy, medicine and pharmaceutical development and fresh air and water.

Unit- III: Challenges for Biodiversity (Lectures: 13)

Climate change, Pollution-air, water and land, destruction of habitat, invasive of exotic species, over exploitation of natural environment. Afforestation

Unit- IV: Sustainable development and Conservation of Biodiversity (Lectures: 13)

Concept, threats and principle of sustainable development. Causes of unsustainability. Social forestry, Ex-situ and In-situ conservation, deforestation, traditional approaches of plant conservation.

Unit-V: National and International legal aspects of Biodiversity (Lectures: 07)

History, frame work of laws policies and projects of biodiversity conservation in regional, national and international basis. Importance of National Green Tribunal (NGT).

RECOMMENDED BOOKS:

1. Krishnamurty, K.V.(2018)–An Advanced textbook on biodiversity: Principles and Practice Oxford & IBH Publishing Co. Pvt Ltd, New Delhi.
2. Hosetty, B.B. and Ramakrishnan, S.(2016)–Biodiversity: Concept and Conservation, Aavishkar Publishers, Distributors, Jaipur, India.
3. Das, B.K. and Banerjee, A. (Edited) (2014)–biodiversity Conservation in India, Concept Publishing Company Pvt. Ltd.

COURSE NAME: PLANTS AND HUMAN WELFARE

COURSE CODE: BT – ID – 2113

Total Credits: 3 (Theory: 3)

THEORY: 3 CREDITS

Total Lectures: 45

COURSE OBJECTIVE:

This course will provide comprehensive information and insight into the importance of Plants and Human Welfare. It would give the students exposure on how such concepts like herbal technologies that are present and maintained in traditional knowledge systems and how they helps in human welfare.

COURSE LEARNING OUTCOME:

CLO-01: *This paper will enable student to learn about importance of plants and human welfare.*

CLO-02: *The students will also learn about microbes, different types of forest and forest products*

CLO-03: *The students will also gain knowledge about mushroom technology together with knowledge of medicinal plants*

Unit- I: Microbes and Industrial Importance (Lectures: 10)

Introduction, Microbes (Bacteria and Yeast) in diary technology, medicine, bakery, brewery industries.

Unit- II: Forest and Forest Products (Lectures: 05)

Type of forest, timber, paper, essential oils and other natural products yielding plants.

Unit- III: Mushroom–Technology, Production and Marketing (Lectures: 09)

Introduction and economic importance, spawn culture, cultivation of mushroom, and harvesting, storage of mushrooms and processing

Unit- IV: Practical Utilizations of Crop and Medicinal Plants (Lectures: 13)

Harvesting and post harvesting processes of different agricultural crops. Extraction processes of alkaloids, flavonoids for medicine manufacturing.

Unit-V: Ethno-Botany and Traditional Indigenous Knowledge (Lectures: 08)

Definition, aim, objectives and Interdisciplinary approaches of ethno botany, importance of traditional knowledge, IPR relating traditional knowledge.

RECOMMENDED BOOKS:

1. Pelczar, M.J. (2001)– Microbiology, 5th Edition, Tata McGraw–Hill Co, New Delhi.
2. Verma, V. (2019)-Text Book of Economic Botany.
3. Alam, A (2021) – A Text Book of Economic Botany and Ethnobotany, I. K. International Publishing House Pvt. Ltd.
4. Agarwal, A., Sharma, Y.P. and Jangra, E.(2021)–A Text Book on Mushroom.
5. Cultivation: Theory and Practice, Newrays Publishing House.

COURSE NAME: NURSERY AND GARDENING

COURSE CODE: BT – ID – 3213

Total Credits: 3 (Theory: 3)

THEORY: 3 CREDITS

Total Lectures: 45

COURSE OBJECTIVE:

1. *Nursery Establishment: Develop skills in setting up and managing a horticultural nursery, including site selection, infrastructure development, and inventory management.*
2. *Plant Propagation Techniques: Learn various propagation methods such as seeding, grafting, and cutting propagation to produce healthy and high-quality plants.*
3. *Gardening Basics: Understand principles of gardening, including soil preparation, planting, watering, fertilizing, and pest management, to create and maintain attractive and healthy garden spaces.*

COURSE LEARNING OUTCOME:

- CLO-01:** *Students will demonstrate proficiency in establishing and managing horticultural nurseries, including site selection, layout planning, infrastructure development, and inventory management.*
- CLO-02:** *They will acquire knowledge of nursery business operations, including financial management, marketing strategies, and customer relations, preparing them for entrepreneurship or employment in the nursery industry*
- CLO-03:** *Through practical training, students will master various plant propagation techniques, including seeding, grafting, cutting propagation, and tissue culture, enabling them to produce a diverse range of healthy and vigorous plant stock. They will understand the principles of seed germination, root development, and plant growth, allowing them to propagate plants efficiently and sustainably.*
- CLO-04:** *Students will develop practical gardening skills, including soil preparation, planting techniques, watering practices, fertilization methods, and integrated pest management strategies*
- CLO-05:** *They will learn to design and maintain ornamental gardens, vegetable plots, and landscape features, enhancing their ability to create aesthetically pleasing and environmentally sustainable outdoor spaces*
- CLO-06:** *Students will gain knowledge of plant nutrition, disease identification, and pest control measures, enabling them to maintain plant health and vitality in nursery and garden settings. They will learn to diagnose common plant problems and implement appropriate remedies, promoting the long-term health and productivity of plants under their care.*

CLO-07: *Students will develop an understanding of sustainable gardening practices, including water conservation, organic gardening methods, and habitat creation for wildlife. They will appreciate the ecological benefits of gardening, such as biodiversity conservation, soil erosion control, and carbon sequestration, fostering a sense of environmental stewardship and responsibility*

Unit- I: Introduction to Horticulture(Lectures: 02)

Introduction to the scope and significance of nursery management and gardening in horticultural sciences.

Unit- II: Nursery Establishment and Management(Lectures: 06)

Site selection criteria for nursery establishment, including soil type, topography, and climate considerations. Planning and layout design of nursery infrastructure, including greenhouse construction, shade structures, and irrigation systems. Inventory management techniques for plant stock, including record-keeping, labeling, and inventory control.

Unit- III: Plant Propagation Techniques (Lectures: 06)

Principles and methods of seed propagation, including seed dormancy, germination, and seedling production. Techniques for vegetative propagation, such as grafting, budding, cutting propagation, and tissue culture.

Unit- IV: Development, Planning and Management of Nursery(Lectures: 10)

Selection of plant species for nursery production, considering market demand, climatic suitability, and economic feasibility. Nursery production schedules and planning for seasonal and perennial crops, including propagation cycles and production timelines. Nursery crop management practices, including fertilization, irrigation, pest and disease management, and weed control. Soil preparation techniques for gardening, including soil testing, amendment, and improvement strategies. Planting techniques for ornamental and vegetable gardens, including spacing, depth, and planting arrangements. Watering practices and irrigation methods for efficient water management in gardens.

Unit-V: Gardening (Lectures: 06)

Principles of garden design, including layout, focal points, balance, and harmony in landscape composition. Landscape planning considerations, including site analysis, functional zoning, and aesthetic elements.

Unit-VI: Integrated Pest Management (IPM) in Horticulture(Lectures: 04)

Concepts of environmental sustainability in horticultural practices, including water conservation, soil health, and biodiversity conservation. Sustainable gardening practices, including organic gardening methods, composting, and mulching for soil fertility and health. Role of horticulture in environmental conservation and ecosystem services, including carbon sequestration, habitat creation, and urban greening initiatives.

Unit-VII: Professional Skills and Career Development(Lectures: 06)

Development of professional skills, including communication, teamwork, problem-solving, and leadership skills in horticultural contexts. Career opportunities in nursery management, garden design, landscape architecture, horticultural therapy, and sustainable agriculture

Unit-VIII: Ethical and Legal Considerations in Horticulture (Lectures: 05)

Ethical considerations in horticultural practices, including plant conservation, biodiversity preservation, and ethical sourcing of plant material. Legal regulations and standards governing nursery and garden operations, including plant quarantine laws, pesticide regulations, and intellectual property rights. Awareness of ethical and legal responsibilities in horticultural professions, including adherence to industry standards, codes of conduct, and professional ethics

RECOMMENDED BOOKS:

1. Dr. N. Armstrong, Indian Gardening and Planting.
2. C.P. Khare, Indian Medicinal Plants: An Illustrated Dictionary.
3. Pradip Krishen, The Gardener's Guide to Indian Plants.
4. Michael A. Dirr, Manual of Woody Landscape Plants: Their Identification, Characteristics, Culture, Propagation and Uses.
5. Christopher Lloyd, The Well-Tempered Garden.
6. Eliot Coleman, The New Organic Grower: A Master's Manual of Tools and Techniques for the Home and Market Gardener.

CERTIFICATE COURSE NAME: MUSHROOM PRODUCTION TECHNOLOGY

Total Credits: 3 (Theory: 3)

THEORY: 3 CREDITS

Total Lectures: 45

COURSE OBJECTIVE:

1. *Enabling students to identify edible and poisonous mushrooms.*
2. *Hands on training for preparation of mushroom production at home on small scale basis.*
3. *Providing exposure to students to experts mainly Counsel on Mushroom Farming*
4. *Provide an edge to students to self employment and income generation.*

Unit- I: Introduction (Lectures: 04)

Introduction to the scope and significance of nursery management and gardening in horticultural sciences.

Unit- II: Morphology of Mushroom (Lectures: 04)

Vegetative, anatomical and reproductive characters of Button mushroom (*Agaricus bispora*), Paddy straw mushroom (*Volvariella volvea*) and Oyster mushroom (*Pleurotus suiorcaju*). Differentiation of edible and poisonous mushroom.

Unit- III: Economic Importance of Mushroom (Lectures: 03)

Nutritional profile of different type of mushrooms, Health benefits, medicinal and therapeutic values and antitumor effect of mushroom. Market potentiality of mushroom in local, regional and national aspects.

Unit- IV: Principles and Techniques of Mushroom Production (Lectures: 04)

Structure and Construction of various mushroom production houses. Prepreparation stage – Collection, Storage, Cutting and Sterilization techniques of straw; Collection and Storage of Spawn. Composition technology and preparation of beds. Spawn seeding and making mushroom begs. Conditions for spawn germinate. Cultivation process of Paddy straw mushroom and Oyster mushroom. Various challenges and problems of mushroom cultivation: Management strategies for mushroom diseases, pest and nematode incidence.

Harvesting and Post Harvesting Technique - Preservation technique special refences to freezing, dry freezing and dry packaging

Unit-V: Practical Aspect for Mushroom Production(Lectures: 15)

- i) Practical Aspect for Mushroom Production.
- ii) Study of various sterilization technique, mushroom house preparation, straw collection and cutting, mushroom beg preparation, various harvesting techniques.
- ii) Training / Workshop and Intuitional Visit / Field Visit.

Unit-VI: Integrated Pest Management (IPM) in Horticulture(Lectures: 04)

Concepts of environmental sustainability in horticultural practices, including water conservation, soil health, and biodiversity conservation. Sustainable gardening practices, including organic gardening methods, composting, and mulching for soil fertility and health. Role of horticulture in environmental conservation and ecosystem services, including carbon sequestration, habitat creation, and urban greening initiatives.

Unit-VII: : Professional Skills and Career Development(Lectures: 06)

Development of professional skills, including communication, teamwork, problem-solving, and leadership skills in horticultural contexts. Career opportunities in nursery management, garden design, landscape architecture, horticultural therapy, and sustainable agriculture

Unit-VIII: Ethical and Legal Considerations in Horticulture (Lectures: 05)

Ethical considerations in horticultural practices, including plant conservation, biodiversity preservation, and ethical sourcing of plant material. Legal regulations and standards governing nursery and garden operations, including plant quarantine laws, pesticide regulations, and intellectual property rights. Awareness of ethical and legal responsibilities in horticultural professions, including adherence to industry standards, codes of conduct, and professional ethics