

LEARNING OUTCOME BASED EDUCATION

Botany Department, 2020

Introduction –

Botany Department has framed this Learning Outcome Based Education draft keeping in mind its vision which is to impart knowledge centered, skill based, research and application oriented quality education to students for facing future challenges. Every course in this Programme gives deep knowledge of the subject as well as skills, which makes the student undertake research projects and thereby apply the gained experience in facing the challenges. This programme exposes the student to various facets of Botany and appraises student's knowledge of fundamental basis of all living organisms (Plant and Microbes) as well as applying the same in sustainable usage of resources for the quality human survival on planet earth and protect environment with the help of technology.

Objective/Aim of B. Sc. Programme in Botany-

Vision: To impart knowledge centred skill based research and application oriented quality education to students for facing future challenges.

Mission: The Department of Botany, Parvatibai Chowgule College aims to build up basic foundations amongst students for skill development in the field of Plant Sciences. To achieve this, the Department offers core and elective courses that provide theoretical and practical component.

Our students get basic trainings in microbiology, plant physiology, plant tissue culture, plant drug technology, mycology, cosmetology, horticulture and field ecology methods during their practical hours itself. Some conventional papers like diversity of plants, Systematics of angiospermic plants, plant anatomy and embryology strengthen their knowledge in Botany.

Graduate Attributes: Following are the Graduate attributes of Botany student

GA-1:	Analytical approach	Think, identify, analyse situations and attempt to develop solutions that meet the specified goals and may assist in sustainable development of the environment.
GA-2:	Application oriented	Efficiently use IT tools in their daily activities of communication, academics and recognize professional ethics
GA-3:	Communication, entrepreneurial and team skills	Function effectively at various levels, communicate, team work and build entrepreneurial skills.
GA-4	Research Aptitude	Understand basic research methods, analyse, apply, interpret and derive rational conclusions.

Qualification descriptors and Course Learning Objectives (CLOs): Of all courses of the department.

Sr. No.	Course Code	Course Title	Course Outcomes
1.	BOT-I.C-1	Plant diversity	<p>Upon successful completion of the course, students will be able to</p> <p>CO 1: State, describe and explain the characters and evolutionary aspects of different plant groups of lower plants.</p> <p>CO 2: Define, Describe, correlate and compare the lower plant groups and fossils.</p> <p>CO 3: Position a given lower plant as per the classification studied.</p> <p>CO4: Sketch the morphology and anatomy of selected lower plants.</p>
2.	BOT-I.C-2	Cell Biology & Biomolecules	<p>Upon successful completion of the course, students will be able to:</p> <p>CO1: Recognize, classify cell, and explain cell theory, evolution and biogenesis.</p> <p>CO2: Define, describe, classify and explain cytoskeleton, cell organelle, biomolecules.</p> <p>CO3: Define, describe, compare, explain, and illustrate cell wall and plasma membrane.</p> <p>CO4: Predict and interpret the importance of cell organelles and biomolecules in cell functioning.</p>
3.	BOT-II.C-3	Plant Anatomy and Embryology	<p>Upon successful completion of the course, students will be able to:</p> <p>CO1: Define, describe and explain the basic plant anatomical and embryological features.</p> <p>CO2: Compare the interrelatedness of organ-systems and their functions.</p> <p>CO3: Examine the features through histological techniques.</p> <p>CO4: Define, describe, explain, compare theories in organization of tissues.</p>
4.	BOT-II. C-4	Microbiology	<p>Upon successful completion of the course, students will be able to:</p> <p>CO1 : Appraise the students to the fundamental basis of all living organisms (Plant and Microbes)</p> <p>CO2 : Relate interaction of microbes with plant and the environment.</p> <p>CO3 : Describe, demonstrate and Assess methods of microbial preparation.</p> <p>CO4 :Understand applications of the microbes in food, agriculture and industry with sustainable usage of resources for the benefit and human survival.</p>

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5.	BOT-III.C-5	Physiology of Plants	<p>Upon successful completion of the course, students will be able to:</p> <p>CO1: Analyse Physiological processes operational in the plants.</p> <p>CO2: Formulate and design experiments to explain physiological concepts and interpret data.</p> <p>CO3: Estimate and evaluate methods of quantitation of pigments, enzymes and metabolites.</p> <p>CO4: Describe and verify physiological processes through mini projects.</p>
6.	BOT-IV.C-6	Cytogenetics	<p>Upon successful completion of the course, students will be able to:</p> <p>CO1: Restate, apply, analyze and access the fundamentals of genetics</p> <p>CO 2: To discuss, explain and interpret extra nuclear inheritance, Sex linked inheritance and chromosomal aberrations.</p> <p>CO 3: Identify different stages of cell division, to construct chromosome maps.</p> <p>CO 4: Review the effects of mutagens on seed germination.</p>
7.	BOT-V.C-7	Plant Molecular Biology	<p>Upon successful completion of the course, students will be able to:</p> <p>CO1: Outline, memorize and express process of central dogma</p> <p>CO2: Understand molecular basis of life</p> <p>CO3: Estimate and evaluate methods of quantitation of macromolecules</p> <p>CO4: Learn and demonstrate basic molecular techniques of nucleic acid isolation and separation by electrophoresis.</p>
8.	BOT-VI.C-8	Plant Genetic Engineering	<p>Upon successful completion of the course, students will be able to:</p> <p>CO1: Understand, associate and apply the basic knowledge of tools, genetic markers, techniques of gene sequencing in recombinant DNA technology towards research.</p> <p>CO2: Interpret, analyse, justify a research problem and design an experiment by them.</p> <p>CO3: Compare and assess the different DNA sequencing techniques</p> <p>CO4: To state the Biosafety regulations and assess its procedure and importance.</p>

9.	BOT-III.E-1	Ecology & Conservation	<p>Upon successful completion of the course, students will be able to :</p> <p>CO1: Discuss, explain and review the concept of ecosystem, phytogeography and population ecology.</p> <p>CO2: Analyze and evaluate the pollution scenario of the area and relate the theory in the natural environment and work towards conservation of the environment.</p> <p>CO3: Quantitatively estimate the oxygen and Carbon dioxide from different water samples.</p> <p>CO4: Evaluate and determine minimum area of sampling unit (using quadrant) for the study of local vegetation.</p>
10.	BOT-III.E-2	Systematics of Flowering plants and Phylogeny	<p>Upon successful completion of the course, students will be able to:</p> <p>CO1: Identify, outline, arrange, describe and compare taxa/ families in Botany according to Bentham and Hooker classification with examples.</p> <p>CO2: Examine the characters and outline keys for identification of flowering plants with relevant examples.</p> <p>CO3: Analyse and interpret the phylogenetic trees, cladograms in phylogeny.</p> <p>CO4: To understand the importance of APG classification and biosystematics.</p>
11.	BOT-III.E-3	Enzymes and metabolic pathways	<p>Upon successful completion of the course, students will be able to:</p> <p>CO1: Identify the role of enzymes in various biological processes</p> <p>CO2: Classify the different enzymes based on its structure and function</p> <p>CO3: Understand and extrapolate the various mechanisms of enzyme action</p> <p>CO4: Study application of enzymes in industry.</p>
12.	BOT-III.E-4	Herbal Cosmetology	<p>Upon successful completion of the course, students will be able to:</p> <p>CO 1: Explain the basics of herbal cosmetology, skin, skin types.</p> <p>CO 2: Outline the requirements for making herbal soaps, oils, shampoos, face packs, etc.</p> <p>CO 3: Inculcate the technique of preparation of herbal products.</p> <p>CO 4: Identify and describe the herbs used for cosmetic products and understand the future prospects of Herbal cosmetic industry.</p>

13.	BOT-IV.E-5	Plant Breeding and Biostatistics	<p>Upon successful completion of the course, students will be able to:</p> <p>CO 1: Identify and assess the role of various institutions and certification programmes in plant breeding.</p> <p>CO 2: Describe and compare various techniques in plant breeding</p> <p>CO 3: Employ manual emasculation procedure.</p> <p>CO 4: Calculate mean, median, mode, standard deviation, std. error for provided material.</p>
14.	BOT-IV.E-6	Techniques and Instrumentation in Botany	<p>Upon successful completion of the course, students will be able to:</p> <p>CO 1: Understand, define and explain the principle, instrumentation and working of microscopy and radiobiology techniques used in Botanical research.</p> <p>CO2: Understand the principle, working and applications of centrifugation and spectrophotometry in Botanical research.</p> <p>CO 3: Understand, define the principle, working and applications of chromatography, electrophoresis and molecular techniques.</p> <p>CO 4: Compare and contrast the techniques used in Research fields.</p>
15.	BOT-IV.E-7	Plant pathology	<p>Upon successful completion of the course, students will be able to:</p> <p>CO1: Identify various diseases and its causal agents of economically important plants.</p> <p>CO2: Explain plant pathogen interaction.</p> <p>CO3: Find effective control measures to deal with pathogens.</p> <p>CO4: Isolate, observe and culture plant disease causing pathogens.</p>
16.	BOT-IV.E-8	Algal Biotechnology	<p>Upon successful completion of the course, students will be able to:</p> <p>CO1: Explore bio-resources from algae.</p> <p>CO2: Learn culture techniques for mass culture of algal types.</p> <p>CO3: Use algal resources for industry, agriculture development.</p> <p>CO4: Know the opportunity for start-ups of eco-friendly algal bio fertilizer.</p>
17.	BOT-V.E-9	Bioinformatics	<p>Upon successful completion of the course, students will be able to:</p> <p>CO1: Introduce, explain and explore biological databases through websites (online) and the need of Bioinformatics.</p> <p>CO2: Compare and contrast protein information</p>

			resources and genome information resources, different biological databases and its role in molecular level sequencing CO3: Relate the theoretical knowledge with practical sessions. Enable data handling and analysis. CO4: Define the terminologies, types of biological databases, its applications and compare the homology between different biological species.
18.	BOT-V.E-10	Seed Technology	Upon successful completion of the course, students will be able to: CO 1: Review characteristics of good seeds and their role in germination. CO 2: Know methods of seed testing and understand seed viability. CO 3: Realize the role of seed banks, seed storage units and seed testing organizations. CO 4: Apply knowledge of seed types to the field.
19.	BOT-V.E-11	Plant Drug Technology and Pharmacognosy	Upon successful completion of the course, students will be able to: CO1: Explain, discuss and classify medicinal plants, plant drug and technologies of extraction CO2: Explain and illustrate, biosynthetic pathways, bioassays and working of instruments CO3: Discuss and compare methods of extraction and analysis of phytochemicals. CO4: Apply fundamental knowledge, techniques and skills in plant drug industry, drug discovery and development.
20.	BOT-V.E-12	Organic Farming	Upon successful completion of the course, students will be able to: CO1: understand the need and basics of Organic Farming; create awareness of the social, economic and environmental context for current and future organic agricultural production and management. CO2: Assess the importance of organic foods in today's World. CO3: Analyse and interpret the given problem in components of Organic Farming. CO4: Apply the knowledge in becoming an entrepreneur in Organic Farming to create own business plan.
21.	BOT-VI.E-13	Plant tissue culture	Upon successful completion of the course, students will be able to: CO1: Explain and discuss the general theoretical backgrounds and practical techniques. CO2: Describe, define, explain/ discuss, compare, concept of differentiation and culture types. CO3: Define, describe, explain/ discuss the techniques in PTC in media preparation, sterilization, callus culture and organogenesis

			CO4: Describe, explain, discuss applications in forestry, agriculture, etc.
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22.	BOT- VI.E-14	Horticulture, floriculture and landscaping	Upon successful completion of the course, students will be able to: CO1: Explain the basics of Horticulture, floriculture and landscaping. CO 2: Outline the requirements for building up nurseries, garden, etc. CO 3: Inculcate the technique of vegetative propagation of plants. CO 4: Identify and relate the scope of these fields in building up career.
23.	BOT- VI.E-15	Economic Botany	Upon successful completion of the course, students will be able to: CO1: Identify and classify economically important plants/plant parts. CO2 : Extract valuable plant products of potential market and economic value. CO3 : Describe and create awareness of the uses of natural plant products CO4 : Understand and use plants as an alternative to synthetic and chemical products
24.	BOT- VI.E-16	Applied Mycology	Upon successful completion of the course, students will be able to: CO 1: Describe fungal cultures CO2:Restate Media formulations CO3: Identify the role of fungi in Industry. CO4: Identify the role of fungi in Agriculture.

Programme Learning Outcome (PLOs):

PLO-1	Use of Technology and Problem Analysis and Solutions	Apply appropriate IT tools efficiently in their daily life- professional and personal. Think critically, identify, analyze problems/ situations and further attempt to design/ develop solutions that meet the specified goals
PLO-2	Environment and Sustainability, Ethics and Social responsibility	Be aware of environmental issues and commit towards sustainable development at local/ national and global context. Recognize and understand professional ethics /human values and be responsible.
PLO-3	Individual and Team work, Communication skills and Life Skills.	Function effectively at various levels, capacities and situations. Communicate proficiently (oral and written) as a responsible member of society. Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of domain specific change
PLO-4	Research Aptitude	Understand general research methods and be able to analyse, interpret and derive rational conclusions
PLO-5	Recognize all forms of lower plants (Algae, Fungi, Bryophytes, Pteridophytes), higher plants (Gymnosperm and Angiosperm). Illustrate distinct features of plant kingdom.	
PLO-6	Recognize cell organelles and bio molecules including enzymes, Predict and interpret their significances in cell metabolism/functioning and Pathways.	
PLO-7	Apply physiological mechanism operational in plants, analyse, extract and identify valuable plant products (Primary/ Secondary) with economic potential and health effects.	
PLO-8	Analyse the techniques and working principles of Instruments used in Botanical studies and apply the knowledge in Basic and applied Plant research (Microbiology, Plant Physiology, plant breeding, Fungi, Plant Tissue Culture, Plant Genetic Engineering, Ecology,	

	plant drug technology. etc.).
PLO-9	Analyse applications of online biological databases, data handling.
PLO-10	Appraise student's knowledge in Botany including fundamental basis of all living organisms (Plant and Microbes) and applying the same in sustainable usage of resources for the quality human survival on planet earth and protect environment.

Course Structure: Annexure 1. Three year B.Sc. Degree Course in BOTANY revised w.e.f. June 2020.

Semester	Core		Elective			
I	BOT-I.C-1 Plant diversity	BOT-I.C-2 Cell Biology and Biomolecules	-----	-----	-----	-----
II	BOT-II.C-3 Plant Anatomy and Embryology	BOT-II.C-4 Microbiology	-----	-----	-----	-----
III	BOT-III.C-5 Physiology of Plants		BOT-III.E-1 Ecology and Conservation	BOT-III.E-2 Systematics of flowering plants and Phylogeny	BOT-III.E-3 Enzymes and their metabolic pathways	BOT-III.E-4 Herbal Cosmetology
IV	BOT-IV.C-6 Cytogenetics		BOT-IV.E-5 Plant Breeding and Biostatistics	BOT-IV.E-6 Techniques and Instrumentation in Botany	BOT-IV.E-7 Plant pathology	BOT-IV.E-8 Algal Biotechnology
V	BOT-V.C-7 Plant Molecular Biology		BOT-V.E-9 Bioinformatics	BOT-V.E-10 Seed Technology	BOT-V.E-11 Plant Drug Technology and Pharmacognosy	BOT-V.E-12 Organic Farming
VI	BOT-VI.C-8 Plant Genetic Engineering		BOT-VI.E-13 Plant tissue culture	BOT-VI.E-14 Horticulture, Floriculture and Landscaping	BOT-VI.E-15 Economic Botany	BOT-VI.E-16 Applied Mycology

Course Description: (highlight objectives of all courses in brief)

Plant Diversity BOT-I.C-1	This Course provides knowledge on morphology, structure and importance of the lower group of organisms. Education and awareness about plant diversity, its role in sustainable livelihoods.
Cell biology and Biomolecules BOT-I.C-2	This course will provide a detailed discussion on a wide range of topics in Cell biology & Bio-molecules emphasizing experimental approaches and key experiments that have provided important insights. The course is aimed at conveying an understanding of how cellular structure and function arise as a result of the properties of cellular macromolecules. Emphasis will be on the dynamic nature of cellular organization, structure and function.
Plant anatomy and embryology BOT-II.C-3	This paper deals to understand the plant anatomy and embryology of angiospermic plant. Importance of studying this paper is highlighted reflecting on the current changing needs of the students by providing latest information. Practical component will provide an ample understanding of anatomical and embryological features.
Microbiology BOT-II.C-4	The objective of this course is to familiarize the student with basic concepts that help in understanding of microbial world. The course is aimed to understand microbial survival and distribution, it's relation and interaction with environment and human beings. The laboratory exercises are designed so that students acquire basic and bacteriological skills and are able to successfully use them.
BOT-III.C-5 Physiology of Plants	Relate physiological mechanism of plants and their functioning. Analyze biosynthesis of valuable plant metabolites (primary/secondary) and their role.
BOT-IV.C-6 Cytogenetics	This course will enable the students to understand fundamentals of genetics and evolution
BOT-V.C-7 Plant Molecular Biology	At the end of the course student will able to explain life processes at the sub-cellular and molecular (gene) level and know general principles of gene organization and functions.
BOT-VI.C-8 Plant Genetic Engineering	This course is to develop fundamental knowledge and skills in various aspects of Genetic engineering.
Ecology & Conservation BOT-III.E-1	to provide introductory knowledge on biotic and abiotic environmental factors, pollution and phytogeography with regards to Government regulations towards environmental management with respect to agriculture and food security.

Systematics of Flowering plants and Phylogeny BOT-III.E-2	To study the morphology, Systematics and phylogeny of flowering plants.
Enzymes and metabolic pathways BOT-III.E-3	To understand the importance and mechanisms of enzyme action. The course also discusses about enzymatic regulation & metabolic control of biochemical reactions.
Herbal Cosmetology BOT-III.E-4	To impart knowledge about the different plants that play a very important role in enriching inner health and skin quality.
Plant Breeding and Biostatistics BOT-IV.E-5	To enable the students to learn various techniques in plant breeding with regards to crop productivity.
Techniques and Instrumentation in Botany BOT-IV.E-6	Objective of the course is to impart knowledge of principle, methodology and application of various techniques & instrumentation.
Plant pathology BOT-IV.E-7	Make the students aware of various plant pathogens and their control
Algal Biotechnology BOT-IV.E-8	Provide an understanding of alternate resources of food, fuel and environment.
Bioinformatics BOT-V.E-9	The course will help the students to understand the fundamentals of bioinformatics and tools available.
Seed Technology BOT-V.E-10	Characterize seeds based on their viability, know and apply the theoretical knowledge to conserve the germplasm.
Plant Drug Technology and Pharmacognosy BOT-V.E-11	To enable the students to learn and understand the fundamental knowledge, techniques & skills in plant drug industry, drug discovery and development.
Organic Farming BOT-V.E-12	The course provides knowledge of principles and practices of organic agriculture and its role in sustainable crop production.
Plant tissue culture BOT-VI.E-13	To develop the plant tissue culture skills.
Horticulture, floriculture and landscaping BOT-VI.E-14	To provide entrepreneur opportunities.
Economic Botany BOT-VI.E-15	This course provides knowledge on the value of plants with scientific information and critical thinking to enhance economic botany.
Applied Mycology BOT-VI.E-16	This paper provides knowledge on culture techniques and the applicative aspects of fungi.

Teaching-Learning-Evaluation Pedagogies:

The Department of Botany believes in using the latest teaching learning pedagogies for attaining the course outcomes mentioned above. We focus on using various teaching – learning methods (as mentioned below). The faculties are supported with trainings and workshops on teaching- learning- evaluation pedagogies time to time. The teaching and evaluation pedagogies of the Department of Botany are as follows:

Teaching pedagogies:

- Lecture method
- ICT supplemented teaching.
- Group learning activities
- Case Studies
- Experiential Learning
- Inquiry Based Learning
- Flipped Classroom (Round Robin, Think Pair share etc).
- Field Based studies
- Projects
- Student Seminars
- Group Discussions
- Outdoor Activities
- Lab Experiments
- Project based learning
- Online learning

Evaluation:

- Modes of assessment:
- Written test
- Open book exam (obe)
- Multiple choice questions (mcq)
- Student presentations
- Short -answer questions
- Debate
- Portfolios
- Case study
- Gobbet
- Poster / chart / model
- Practical work
- Assignments
- Review
- Report making
- Quiz
- Making mind maps
- Experiential learning/Field visits

Activities of the Department: (Indirect assessors of attainment of PLOs and attaining Graduate attributes).

In order to attain the Course outcomes (CO), Programme Learning Outcomes (PLOs), the Department of Botany organizes multiple activities for students, teachers (in house and outside participants), general public, etc. The activities of the Department of Botany are as follows:

- Workshops- The Department organizes state and National level workshops on various topics to get hands on training to impart skills to the students, teachers and public. Department also undertake workshops involving entrepreneurial skills. To name some Department has organised workshops on the topics such as Herbal Cosmetology, Oyster Mushroom Cultivation, Kitchen gardening, Plant genetic engineering, Plant Molecular Biology and Bioinformatics etc.
- Industry/ Academic Lecture series- The department organizes guest lecture/ Lecture series for students to update them with practical/field experiences by the resource person. Eg. Plant – animal interaction lecture series, Medicinal values of plants, value of plants in homeopathy, plant molecular biology. We have tie ups with the Goa State Biodiversity Board, Goa Forest Department and State Medicinal Plants Board – Goa, Goa University and so on.
- Seminars- the Department organizes State and National Level seminars on Plant Science.
- Students Presentation/ Team Assignments- The students are given assignments, presentation, poster topics as a mode of continuous assessments. The students are also provided opportunity to present their third year project work at State and National Forums.
- Newsletters: Department publishes four newsletters yearly.

- Exhibition and Plant sale counter: As a part of community outreach programme, the department also organizes medicinal plant exhibition, Green Bazaar / Agri expo, etc.
- Practical lab work- Handling of instruments, Sectioning skills, study of higher plants, Viva answering (communication skill development), Mini projects (For understanding research methodology on their own. i.e. for understanding concepts on their own, analysing the results, reviewing literature etc)

COURSE TITLE: PLANT DIVERSITY (THEORY) W.e.f. June 2020

COURSE CODE: BOT-I.C-1.

MARKS: 100(75 theory + 25 Practical)

CREDITS: 4 (3 theory + 1 Practical)

COURSE DURATION: 45 HOURS

COURSE OBJECTIVES:

This paper provides knowledge on morphology, structure and importance of the lower group of organisms. Education and awareness about plant diversity, its role in sustainable livelihoods.

COURSE OUTCOMES:

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

CO 1: State, describe and explain the characters and evolutionary aspects of different plant groups of lower plants.

CO 2: Define, Describe, correlate and compare the lower plant groups and fossils.

CO 3: Position a given lower plant as per the classification studied.

CO4: Sketch the morphology and anatomy of selected lower plants.

Sr.No.	UNITS, TOPICS AND SUB-TOPICS	Hours
MODULE 1: ALGAE AND FUNGI		15
UNIT I: ALGAE		
1.1	Five kingdom classification	
1.2	Classification of algae (Cyanobacteria, Chlorophyta, Phaeophyta and Rhodophyta) following Lee (1999) upto groups with general characters and examples	
1.3	Endosymbiotic theory: origin of plastids	
1.4	Cyanophyceae: Distribution, systematic position and life cycle of <i>Nostoc</i> and Charophyta: <i>Chara</i>	
UNIT II: FUNGI		
2.1	General characteristics, Classification, economic importance. Systematic position, life history of <i>Puccinia</i> and <i>Penicillium</i>	
MODULE 2: BRYOPHYTES AND PTERIDOPHYTES		15
UNIT III: BRYOPHYTES		
3.1	General characters, brief classification and alternation of	

	generation	
3.2	Study of morphological and anatomical studies and reproductive character of <i>Riccia</i> , <i>Marchantia</i> , <i>Anthoceros</i> and <i>Funaria</i> .	
UNIT IV: PTERIDOPHYTES		
4.1	General characters, brief classification, stellar evolution, alternation of generation.	
4.2	Structure, reproduction, life history and systematic position of <i>Psilotum</i> , <i>Lycopodium</i> and <i>Marsilea</i> .	
MODULE 3: GYMNOSPERMS, PALEOBOTANY, LICHENS AND ECONOMIC IMPORTANCE.		15
UNIT V: GYMNOSPERMS, PALEOBOTANY, LICHENS AND ECONOMIC IMPORTANCE.		
5.1	General characters, brief classification, alternation of generation of Gymnosperms	
5.2	Systematic position, life history of <i>Pinus</i> and <i>Gnetum</i>	
5.3	Fossils and fossilization, importance of fossils (with a mention of Birbal Sahni institute)	
5.4	Lichens: Structure, Ecological and economic importance of lichens	
5.5	Economic importance of Cyanobacteria, algae, fungi, bryophytes, pteridophytes and gymnosperms.	
TOTAL		45

COURSE TITLE: PLANT DIVERSITY (PRACTICAL)

COURSE CODE: BOT-I.C-1

MARKS: 25

CREDITS: 1

PRACTICAL SESSIONS: 15

Sr. No	Module 4: Topics	Practical Sessions
1.	Morphological study of algal and Blue green algal forms: <i>Oscillatoria/Nostoc, Chara, Sargassum, Polysiphonia</i>	03
2.	Morphological study of fungal forms: <i>Puccinia, Penicillium, Albugo and Rhizopus</i>	03
3.	Study of lichens (Permanent slide/ specimen)	01
4.	Study of fossils: (Permanent slide/ specimen)	01
5.	Morphological and anatomical study of: i. Bryophyte (preferably <i>Riccia</i> or <i>Anthoceros</i>) ii. Pteridophyte (preferably <i>Selaginella</i>) iii. Gymnosperm (preferably <i>Cycas</i>)	05
6.	Mini project: Collection and field study of locally available Algae, Bryophytes, Pteridophyte, Gymnosperms and Lichens	02
Total		15

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COURSE TITLE: CELL BIOLOGY AND BIOMOLECULES (THEORY) w.e.f June 2020

COURSE CODE: BOT-I.C-2

MARKS: 100 (75 Theory+ 25 Practicals)

CREDITS: 4 (3 Theory+ 1 Practical)

COURSE DURATION: 45 HOURS

COURSE OBJECTIVES:

This course will provide a detailed discussion on a wide range of topics in Cell biology & Bio-molecules emphasizing experimental approaches and key experiments that have provided important insights. The course is aimed at conveying an understanding of how cellular structure and function arise as a result of the properties of cellular macromolecules. Emphasis will be on the dynamic nature of cellular organization, structure and function.

COURSE OUTCOME:

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

CO 1: Recognise, classify cell, explain cell theory, evolution and biogenesis

CO 2: Define, describe, classify and explain cytoskeleton, cell organelle, biomolecules.

CO 3: Define, describe, compare, explain, illustrate cell wall and plasma membrane

CO 4: Predict and interpret the importance of cell

Sr. No	TOPICS	Hours
Module I: Introduction to Cell, Ultra-structure and Function of Cell Wall and Plasma Membrane		15
1.1	Discovery and basic properties of cells Prokaryotic and Eukaryotic cell; Cell theory	
1.2	Cell evolution and biogenesis	
1.3	Structure and functions of cytoskeleton;	
1.4	Structure and function of Microtubule, Intermediate filaments, Microfilaments	
1.5	Structure and function of cell wall; Chemical composition of cell wall;	
1.6	Extracellular matrix and cell interactions; Gap -Junctions & plasmodesmata	
1.7	Structure and function of plasma membrane; Active and Passive transport of solute (channels & pumps); Cell signaling- molecules and receptors, signaling network.	

Module II: Study of Cell Organelles		15
2.1	Semiautonomy and gene control; Structure & functions of peroxisome, glyoxysome & lysosomes	
2.2	Nucleus and its Organization; Nuclear envelope, nuclear pore complex Nuclear matrix, Chromosomes and chromatin structure	
2.3	Structure and function of ribosome	
2.4	Endomembrane systems- Endoplasmic reticulum and Golgi complex	
2.5		
Module III: BIOCHEMISTRY OF CARBOHYDRATES, LIPIDS AMINO ACIDS AND PROTEINS		15
3.1	Definition & importance of biomolecules; types of bonds in bio- molecules; pH and buffers ; Water as a biological solvent	
3.2	Classification and biological functions of carbohydrates and lipids	
3.3	Classification and biological functions of amino acids and proteins	
		Total 45

COURSE TITLE: CELL BIOLOGY & BIOMOLECULES (PRACTICAL)**COURSE CODE: BOT-I.C-2****MARKS: 25****CREDITS: 1****PRACTICAL SESSIONS: 15**

Sr.No	MODULE IV: TOPICS	PRACTICAL SESSIONS
1.	Study of cell structure in <i>Hydrilla</i> and <i>Tradescantia</i> staminal hairs	1
2.	Examination of prokaryotic cell, eukaryotic cell and cell organelles by EM graphs	1
3.	Preparation of temporary slides to observe different types of cells	2
4.	Staining and Preparation of slides	6
	Cytochemical staining of Nucleus- Acetocarmine Cytochemical staining of polysaccharides- Periodic Acid Schiff's (PAS) Cytochemical staining of Mitochondria – Jannis Green Cytochemical staining of Total proteins –Bromophenol blue Cytochemical staining of Histones – Fast Green	
5.	Determination of pH (of plant extracts) using pH meter	1
6.	Quantitative determination of carbohydrates (Anthrone reagent)	1
7.	Estimation of oil in fatty seeds using (Soxhlet apparatus)	2
8.	Estimation of proteins (Lowry's Method)	1
	Total	15

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COURSE TITLE: PLANT ANATOMY AND EMBRYOLOGY (THEORY)**COURSE CODE: BOT-II. C-3****MARKS: 100 (75 Theory+ 25 Practicals)****CREDITS: 4 (3 Theory+ 1 Practical)****COURSE DURATION: 45 HOURS****COURSE OBJECTIVE:**

This paper deals to understand the plant anatomy and embryology of angiospermic plant. Importance of studying this paper is highlighted reflecting on the current changing needs of the students by providing latest information. Practical component will provide an ample understanding of anatomical and embryological features.

COURSE OUTCOME: Students will be able to:

CO1: Define, describe and explain the basic plant anatomical and embryological features

CO 2: Compare the interrelatedness of organ-systems and their functions

CO 3: Examine the features through histological techniques.

CO 4: Define, describe, explain, and compare theories in organization of tissues

Sr.No.	TOPICS	Hours
MODULE I: SHOOT, ROOT AND LEAF ANATOMY		15
1.1	Organization of Shoot apical meristem	
1.2	Apical cell theory, Histogen theory, Tunica-Corpus theory, Cyto-	
1.3	histological zonation.	
1.4	Organization of root apical meristem	
1.5	Korper-Kappe theory, Quiescent centre.	
1.6	Anatomy of leaf: epidermis, mesophyll and vascular tissue Stomata and its diversity, leaf abscission	
MODULE II: WOOD STRUCTURE		15
2.1	Vascular cambium, Secondary xylem, Xylary elements	
2.2	Secondary phloem, Phloem elements and Periderm	
2.3	Conifer wood, Dicotyledon wood, wood anatomy-TS, TLS, RLS.	

Module III: Reproductive biology, Pollination and fertilization		15
3.1	Floral development: ABC model of flowering	
3.2	Structure and development of male gametophyte- Microsporangium	
3.3	Microsporogenesis& Pollen grains	
3.4	Structure and development female gametophyte – Megasporangium, Megasporogenesis, Forms of ovule-Monosporic, bisporic and Tetrasporic	
3.5	Mechanism of pollination and fertilization- types of pollination, germination of pollen grain, pollen pistil interaction, self- incompatibility	
	Double fertilization, embryo (dicot and monocot) and endosperm formation. General account of Apomixis and Polyembryony	
TOTAL		45

COURSE TITLE: PLANT ANATOMY AND EMBRYOLOGY (PRACTICAL)**COURSE CODE: BOT-II.C-3****MARKS: 25****CREDITS: 1****COURSE DURATION: 15 SESSIONS**

Sr.No.	Module 4: TOPICS	PRACTICAL
1.	Study of simple and complex tissues by using permanent slides/ EM graphs.	2
2.	Microscopic study of wood tissues in T.S, T.L.S. and R.L.S. (Permanent slides) and maceration (Any one species)	3
3.	Study of Meristems, Microsporogenesis and Megasporogenesis through permanent slides	2
4.	Mini Project- Study of diversity in leaf anatomy, stomata and female gametophyte exhibiting self-incompatibility.	3
5.	Embryo and Endosperm with haustoria mounting (<i>Tridax/ Cucurbit</i>).	2
6.	In vitro growth of pollen tube in <i>Portulaca/ Vinca</i> .	1
7.	Pollen studies: Chitaley's method for analysis in <i>Ipomoea, Ocimum, Hibiscus, Acacia auriculiformis</i> and Grass.	2
TOTAL		15

REFERENCES: -

1. Bhojwani, S. S and Bhatnagar, S.P. (2009). *The Embryology of Angiosperms*, New Delhi: Vikas Publishing House Pvt. Ltd.,
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Weblinks:

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2. <http://www.biologydiscussion.com/plants/wood-anatomy-of-some-important-plants-biology/57016>

COURSE TITLE: MICROBIOLOGY (THEORY)

COURSE CODE: BOT- IIC-4

MARKS: 100 (75 Theory+ 25 Practicals)

CREDITS: 4 (3 Theory+ 1 Practical)

COURSE DURATION: 45 HOURS

COURSE OBJECTIVES:

The objective of this course is to familiarize the student with basic concepts that help in understanding of microbial world. The course is aimed to understand microbial survival and distribution, it's relation and interaction with environment and human beings. The laboratory exercises are designed so that students acquire basic and bacteriological skills and are able to successfully use them.

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

CO1 : Appraise the students to the fundamental basis of all living organisms (Plant and Microbes)

CO2 : Relate interaction of microbes with plant and the environment.

CO3 : Describe, demonstrate and Assess methods of microbial preparation.

CO4 : Understand applications of the microbes in food, agriculture and industry with sustainable usage of resources for the benefit and human survival.

Sr.No.	TOPICS	Hours
Module I: Overview of microbial world & development		15
1.1	Developments of microbiology in the twentieth century Microbial taxonomy & phylogeny (archaea, bacteria, fungi, algae, protozoa)	
1.2	Structure & General characteristics of viruses, viroids, Prions, Bacteriophages, TMV & mycoplasma, satellite viruses.	
1.3	Distribution of microbes in the environment (air, soil & water) Scope of microbiology and Microbial diseases	
Module 2: Isolation, characterization, growth of microorganisms & microbial genetics		15
2.1	Control of microbial growth: Biochemical characterization & nutritional types; Sterilization techniques,	
2.2	Preparation of pure cultures; growth factors & growth curve.	
2.3	Staining techniques	
2.4	Bacterial Reproduction: Conjugation, Transformation & transduction;	

2.5	Methods of viral replication (Lytic & Lysogenic mode)	
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Module 3: Application Microbiology		15
3.1	Applications in Environment: Applications of microbes in environment sustenance (microbial degradation of cellulose, hemicelluloses, lignin, biodegradation of hydrocarbons),	
3.2	Applications in Agriculture: Association of plants with cyanobacteria, actinomycetes, fungus; Xenobiotics (biodegradation of pesticides, herbicides; metals, biofuels	
3.3	Applications in Medicine: Microbial antibiotics	
3.4	Applications in Industry: Microbes in Fermentation technology & dairy industry, bioreactors, UASB reactor and tricking filters for waste water treatment.	
		TOTAL
		45

COURSE TITLE: MICROBIOLOGY (PRACTICAL)

COURSE CODE: BOT-II.C-4

MARKS: 25

CREDITS: 1

COURSE DURATION: 15 SESSIONS

Sr.No.	Module 4: Topics	Practical
1	Preparation of culture media for bacteria, pure cultures and aseptic transfer of pure culture	3
2	Staining of microorganisms (Gram staining)	2
3	Measurement of bacterial growth, cell number in a culture (Turbidity, serial dilution & Haemocytometer)	3
4.	Distribution of microorganisms in our environment (Skin, air, water and soil sample)	2
5	Mini Projects: i) Microbiological examination of water ii) Bacteriological testing of milk iii) Fermentation of carbohydrates and wine preparation	5
TOTAL		15

REFERENCES:

1. Aneja, K. R. (2007). *Experiments in Microbiology Plant Pathology & Biotechnology*. 5th ed. New Age International Publishers.
2. Atlas, R. M. (1997). *Principles of Microbiology*. 2nd ed. McGraw-Hill
3. Dubey, R.C & Maheshwari, D.K. (2002). *Practical Microbiology*. New Delhi: S. Chand & Company Ltd.
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8. Prescott, L. M. (2005). *Microbiology*. 6th ed. McGraw-Hill.
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10. Shivkumar, P. K., Joe, M. M. & Sukesh, K. (2010). *An Introduction to Industrial Microbiology*. 1st ed. New Delhi: S. Chand & Company Pvt. Ltd.

COURSE TITLE: PHYSIOLOGY OF PLANTS (THEORY)

COURSE CODE: BOT.III.C-5

MARKS: 100 (75Theory +25 Practical)

CREDITS: 4 (3 Theory +1 Practical)

COURSE DURATION: 45 HOURS

COURSE OBJECTIVE:

Relate physiological mechanism of plants and their functioning.

Analyze biosynthesis of valuable plant metabolites (primary/ secondary) and their role.

COURSE OUTCOME:

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

CO1: Analyse Physiological processes operational in the plants.

CO2: Formulate and design experiments to explain physiological concepts and interpret data.

CO3: Estimate and evaluate methods of quantitation of pigments, enzymes and metabolites.

CO4: Describe and verify physiological processes through mini projects.

Sr. No	UNITS, TOPICS AND SUB-TOPICS	Hours
	MODULE -I: PLANT WATER RELATIONS AND SOLUTE TRANSPORT	15
1.1	Water and its significance to plants	
1.2	Osmotic & water potential of cell	
1.3	Transpiration, stomatal regulation & anti-transpirants	
1.4	Uptake, transport and translocation of water	
1.5	Essentiality of mineral nutrition and its uptake (active, passive and its role on membranes)	
1.6	Transport of organic solutes (source sink relationship)	
	MODULE II: PHOTOSYNTHESIS AND STRESS PHYSIOLOGY	15
2.1	Chloroplast and Light harvesting complexes	
2.2	Z scheme of photosynthesis & Mechanisms of electron transport	
2.3	CO ₂ fixation (C ₃ , C ₄ and CAM pathways)	
2.4	Photoprotective mechanisms (photorespiration)	
2.5	Environmental change and its impact on photosynthesis Responses of plants to abiotic (water, temperature and salt) stresses	
	MODULE III: PLANT GROWTH AND DEVELOPMENT AND SECONDARY METABOLITES	15
3.1	Role of phytochromes & cryptochromes and its functions	
3.2	Plant hormones, transport and physiological functions	
3.3	Photoperiodism and & vernalization	
3.4	Senescence, seed dormancy & germination	
3.5	Biosynthetic pathway of terpenes, phenols and alkaloids and their Functions	
	TOTAL	45

COURSE TITLE: PHYSIOLOGY OF PLANTS (PRACTICALS)**COURSE CODE: BOT.III.C-5****MARKS: 25****CREDITS: 1****PRACTICAL SESSION: 15 (Inclusive of 3 PA)**

Sr. No	TOPICS	PRACTICAL SESSIONS
1	Determination of osmotic potential of plant cell sap by plasmolytic method.	2
2	Determine water potential of given tissue by falling drop/ tissue weight method	2
3.	Chromatographic separation of plant pigments and plant sugars by paper chromatography	3
4	Quantitation of total free amino acids	2
5	Mini Project: 1. Mineral deficiency symptoms in plants 2. Secondary metabolites in plants. 3. Oxygen consumption during respiration 4. Role of Plant hormones in plant growth 5. Starch production during photosynthesis 6. Use of hydroponic technique for plant growth	6
		15

REFERENCES:

1. Harvey J.M. Hou, Najafpour, M. Mahdi., Moore, G. F., Allakhverdiev S. I. (2017) *Photosynthesis: Structures, Mechanisms, and Applications*. NY: Springer Publications.
2. Jordan Smith (2016) *Plant and Crop Physiology*. Syrawood Publishing House.
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CURRENT LITERATURE (JOURNAL ARTICLES):

Plant Physiology, The Plant Cell, Journal of Plant Physiology, Physiologia Plantarum, Plant Physiology and Biochemistry, Postharvest Biology and Technology, Journal of the American Society for Horticultural Science, Nature, Scientific American and Science

COURSE TITLE: ECOLOGY AND CONSERVATION (THEORY) w.e.f June 2021

COURSE CODE: BOT-III.E-1

MARKS: 100 (75 Theory+ 25 Practical)

CREDITS: 4 (3 Theory+ 1 Practical)

COURSE DURATION: 45 HOURS

COURSE OBJECTIVES:

Objective of this paper is to provide introductory knowledge on biotic and abiotic environmental factors, pollution and phytogeography with regards to Government regulations towards environmental management with respect to agriculture and food security.

COURSE OUTCOMES:

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

CO1: Discuss, explain and review the concept of ecosystem, phytogeography and population ecology.

CO2: Analyze and evaluate the pollution scenario of the area and relate the theory in the natural environment and work towards conservation of the environment and its legalities.

CO3: Quantitatively estimate the oxygen and Carbon dioxide from different water samples.

CO4: Evaluate and determine minimum area of sampling unit (using quadrant) for the study of local vegetation.

Sr.No.	UNITS, TOPICS AND SUB-TOPICS	HOURS
Module 1: CONCEPT OF ECOSYSTEM, PHYTOGEOGRAPHY AND POPULATION ECOLOGY		15
1.1	Concept of Ecosystem, Ecological adaptations of plants belonging to following ecological groups: Hydrophytes, Xerophytes and Halophytes. Shelford's law of tolerance; Introduction to Species diversity indices (Simpson's & Shannon-Weiner) of herbaceous vegetation.	
1.2	Phytogeography- plant distribution, theories on plant distribution Endemism, Biomes of the world, and phytogeographical regions of India, biosphere reserves, Forest training institutes, Land bridge theory	
1.3	Population Ecology: Survivorship curves- Type I, Type II, Type III. Population growth: Population growth curves – Carrying capacity K, Exponential growth (J shaped curve) and Logistic growth (S shaped curve).	
MODULE II: ECOLOGICAL FACTORS AND COMMUNITY RELATIONSHIPS		15
2.1	Light - quality, duration, absorption, intensity & effects on plants Temperature-variation due to altitude effects on plants, thermal constant and stratification	
2.2	Water- precipitation, moisture & measurement of rainfall Wind - speed, advantages and damage caused to plants	
2.3		
2.4	Soil- Soil profile, texture, classification and organic matter Community relationships: Biotic interactions, Gaia Hypothesis, Introduction to Optimal foraging theory	
MODULE III: POLLUTION, LAWS AND ORGANISATIONS		15

3.1	Air pollution- polluting gases; ozone depletion, greenhouse effect, global warming, acid rain and smog	
3.2	Water pollution-eutrophication, sewage, industrial waste, heavy metal pollution	
	Soil pollution – chemical pollutants	
3.3	Bioremediation	
3.4	Forest conservation act, Indian forest act, Biodiversity act, western Ghat protection act, Kasthurirangan Act, Gadgil committee report,	
3.5	Mining committee reports, wild life act (recent acts to be studied).	
3.6	Organizations (National & International) working for conservation (NEERI, TERI, MSSRF, IUCN, TRAFFIC)	
	TOTAL	45

COURSE TITLE: ECOLOGY AND CONSERVATION (PRACTICAL)

COURSE CODE: BOT-III.E-1

MARKS: 25

CREDITS: 1

PRACTICAL SESSIONS: 15

Sr. No	Module IV- Topics	Practical Sessions
1.	Study of ecological instruments i.e. lux meter, rain gauge, hygrometer, wet and dry bulb thermometer, maximum and minimum thermometer	02
2.	To study the physical and chemical characters (moisture, texture and pH) of Sand, Loam and Clay.	02
3.	Analysis of different water samples for oxygen and carbon-dioxide content	03
4.	Estimation of total carbonates from soil sample	01
5.	Visual interpretation of remotely sensed image for vegetation types (Land use land cover, NDVI)	01
6.	Anatomical study of Hydrophytes (leaf), Xerophytes (succulents) and Halophytes (leaf)	01
7.	Mini project: To determine minimum area of sampling unit (quadrat) for the study of local community and to determine species diversity index (Simpson's & Shannon-Weiner) of herbaceous vegetation	05
Total		15

REFERENCES:

1. Ambasht, R.S. (1988), *A Text Book of Plant Ecology*. Varanasi: Students Friends Co.
2. P. D. Sharma (2004), *Ecology and environment*. 7th edition, Meerut: Rastogi publications.
3. Jogdand, SN, (1995), *Environmental Biotechnology*. Mumbai: Himalaya Publishing House,
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12. Sangodkar U.M.X and Masur Patil Uma (2018). *Fundamentals in Environmental Biotechnology*, 1st Edition, CinnamonTeal Publishers.
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14. World Wide Fund – India :<https://www.wwfindia.org/>
15. NEERI: <https://www.neeri.res.in/>

16. TRAFFIC:<https://www.worldwildlife.org/initiatives/traffic-the-wildlife-trade-monitoring-network>
17. International Union for conservation of nature: <https://www.iucn.org/>
18. MSSRF- <https://www.mssrf.org/>
19. TERI-<https://www.teriin.org/>

COURSE TITLE: SYSTEMATICS OF FLOWERING PLANTS AND PHYLOGENY**COURSE CODE: BOT-III.E-2****MARKS: 100 (75 Theory + 25 Practical)****CREDITS: 4 (3 Theory +1 Practical)****COURSE OBJECTIVES:**

To study the morphology, systematics and phylogeny of flowering plants.

COURSE OUTCOMES:

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

CO1: Understand the process of Plant Classification, documentation and nomenclature in Plant Systematics. .

CO2: Explain, examine the concept of taxonomic evidences and phylogeny of angiosperms..

CO3: Understand, explain, analyze and interpret the systems of classification, features of families in Systematics of flowering plants. .

CO4: Identify plants with help of Floras, taxonomic keys, prepare Herbarium and construct Cladograms.

	TOPICS	Hours
Module 1: Introduction to Plant classification, Nomenclature		
1.1	Plant classification, nomenclature & biosystematics	15
1.2	Field inventory; Functions of Herbarium; Important herbaria and botanical gardens (India & world), virtual herbarium; e-flora	
1.3	Documentation: Flora, Monographs, Journals; Keys: Single access and Multi-access	
1.4	Principles and rules (ICBN); Ranks and names; Typification, author citation, valid publication	
1.5	Rejection of names, principle of priority and its limitations; Names of hybrids	
Module 2: Concept, Taxonomic evidences and Phylogeny of Angiosperms		15

2.1	Concept of taxa (family, genus, species); Categories and taxonomic hierarchy; species concept (taxonomic, biological, evolutionary).	15 hours
2.2	Evidence from palynology, cytology, phytochemistry and molecular data.	
2.3	Origin & evolution of angiosperms, Co-evolution of angiosperms. Characters; Variations; OTUs, cluster analysis, Phenograms, cladograms (definitions and differences)	

Module 3: Systems of classification; position and diagnostic features of families		15
3.1	Concepts of evolution and phylogeny	
3.2	Major contributions by Linnaeus, Bentham and Hooker, Engler and Prantl; Brief reference of Angiosperm Phylogeny group (APG III) Classification.	
3.3	Annonaceae, Capparidaceae, Brassicaceae, Tiliaceae, Rutaceae, Myrtaceae, Cucurbitaceae, Rubiaceae, Apocyanaceae, Asclepiadaceae, Solanaceae, Verbenaceae, Lamiaceae, Amaranthaceae, Orchidaceae, Araceae, Asteraceae, Zingiberaceae, Commelinaceae, Poaceae.	
	Total:	45

COURSE TITLE: SYSTEMATICS OF FLOWERING PLANTS AND PHYLOGENY**COURSE CODE: BOT-III.E-2****MARKS: 75****CREDITS: 3**

Sr.no	Module 4: Topics	Practical
1	Plant identification using flora book and database	01
2	Preparation of herbarium	01
3	Identification of 15 families mentioned in unit IV (Bentham & Hooker's system) studied in theory from locally available specimens (with floral diagram).	10
4	Use of taxonomic keys and construction of dichotomous keys	01
5	Taxonomic interpretation using pollen of related species	01
6	Construction of Phenogram and Cladogram	01
	Total	15

REFERENCES:

1. Singh, G. (1999). *Plant Systematics: Theory and Practice*. New Delhi: Oxford & IBH Pvt. Ltd.
2. Chopra, G. L. (1985). *Angiosperm (Systematics & Life cycles)*. Jaladhar, India : Pradeep Publications, pp.339-350.
3. Pandey, B. P. (1969). *Taxonomy of Angiosperms*. New Delhi: S. Chand and company Ltd, India, pp.102-105.
4. Subrahmanyam N S (1995). *Modern plant taxonomy*, Vikas publishing house pvt. Ltd.
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6. Mondal, A.K. (2009). *Advanced Plant Taxonomy*, New Delhi: New Central Book Agency Ltd.
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COURSE TITLE: ENZYMES AND THEIR METABOLIC PATHWAYS (THEORY)**COURSE CODE: BOT-III. E-3****MARKS: 100 (75 Theory+ 25 Practicals)****CREDITS: 4 (3 Theory+ 1 Practical)****COURSE DURATION: 45 HOURS****COURSE OBJECTIVES:**

The objective of this course is to understand the importance and mechanisms of enzyme action. The course also discusses about enzymatic regulation & metabolic control of biochemical reactions.

COURSE OUTCOMES: Upon successful completion, the students will be able to

CO1: Identify the role of enzymes in various biological processes

CO2: Classify the different enzymes based on its structure and function

CO3: Understand and extrapolate the various mechanisms of enzyme action

CO4: Study application of enzymes in industry

Sr.No	UNITS, TOPICS AND SUB-TOPICS	Hours
MODULE I: BASIC CONCEPT AND CATALYSIS OF ENZYMES		15
1.1	Classifications & nomenclature (IUB system).	
1.2	Biological role of enzymes; Concept of holoenzymes, apoenzymes, prosthetic group, iso-enzymes, allosteric enzymes and Active sites.	
1.3	Chemical nature of enzymes, Enzyme activity. Characteristics of enzymes (Physico-chemical and biological properties).	
1.4	Role of co-factors (NAD, NADP+, FMN/FAD, Co-enzyme A, Pyridoxyl phosphate and metal ions).	
MODULE II: ENZYME KINETICS		15
2.1	Factors affecting enzyme activity (concentration, substrate, pH, temperature, inhibitors).	
2.2	Michaelis-Menten equation and its significance.	
2.3	Fisher's lock and key model and Koshland (induced fit theory), Arrhenius plot.	
2.4	Enzyme action (competitive, noncompetitive and reversible)	

MODULE III: METABOLIC CONCEPTS OF ENZYMES		15
3.1	Glycolysis, Fate of pyruvate (Lactic acid & alcohol fermentation).	
3.2	Citric acid cycle, Respiratory substrate, Mitochondrial Electron transport, Cytochrome, Alternate oxidase pathway, Glycogen cycle.	
3.3	Biosynthesis and degradation of triglycerides.	
3.4	Pathway for amino acid catabolism (Nitrogenase enzyme complex, NIF and Nod genes).	
TOTAL		45

COURSE TITLE: ENZYMES AND METABOLIC PATHWAYS (PRACTICALS)

COURSE CODE: BOT-III.E-3

MARKS: 25 MARKS

CREDITS: 1

COURSE DURATION: 15 SESSIONS

Sr. No	TOPICS	PRACTICAL SESSIONS
1	Qualitative and quantitative determination for amylase enzyme in the given plant samples.	3
2	Effect of enzyme concentration, temperature, substrate, inhibitors and pH on the activity of α -amylases	5
3	To extract and determine the activity of catalase , lipase and peroxidase enzymes	3
4	<ul style="list-style-type: none"> a. Mini project on role of Nitrogen in plants b. Application of enzymes in industries (dairy/ pharmaceuticals/ sugar/ waste management/ food/ wine) c. Anaerobic respiration in germinating seeds. 	4
TOTAL		15

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COURSE TITLE: HERBAL COSMETOLOGY (THEORY) w.e.f June 2021

COURSE CODE: BOT-III.E-4

MARKS: 100 (75 Theory +25 Practical)

CREDITS: 4 (3 Theory +1 Practical)

COURSE OBJECTIVES:

To impart knowledge about the different plants that play a very important role in enriching inner health and skin quality.

COURSE OUTCOMES:

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

CO 1: Explain the basics of herbal cosmetology, skin, skin types.

CO 2: Outline the requirements for making herbal soaps, oils, shampoos, face packs, etc.

CO 3: Inculcate the technique of preparation of herbal products.

CO 4: Identify and describe the herbs used for cosmetic products and understand the future prospects of Herbal cosmetic industry.

	TOPICS	Hours
Module I: Introduction to Herbal cosmetology		15
1.1	Definition, Collection and processing of herbal material, Natural and artificial drying of herbal material	
1.2	Herbal remedies for holistic health	
	Current status of Herbal Cosmetic Industry in India	
1.3	Introduction Herbal edible churnas beneficial for skin and hair	
	Herbs used in weight loss and weight gain:	
1.4	<ul style="list-style-type: none">• Herbs for weight gain• Herbs for weight loss (For e.g. Ginseng, Cinnamon, Black Pepper, Dandelion, Yashtimadhu, Ashwagandha)	
1.5	Herbs that help in depression and anxiety	
1.6	Future prospects of herbal cosmetic industry	

Module 2: Identification (botanical name and family), description and utilization of following plants with Cosmetic benefits & their cosmetic uses		15
2.1	i) <i>Curcuma longa</i> ii) <i>Aloe vera</i> iii) <i>Azadirachta indica</i> iv) <i>Ocimum sp.</i> v) <i>Moringa sp.</i> vi) <i>Cymbopogon flexuosus</i> vii) <i>Murrayakoenigii</i> viii) <i>Citrus limon</i> ix) <i>Mentha sp.</i> x) <i>Tagetes sp.</i> xi) <i>Musa paradisiaca</i> xii) <i>Rosa sp.</i> xiii) <i>Manjistha</i>	
Module 3: Standardization of raw material and commonly used herbs in the herbal cosmetics		15
3.1	Importance of standardization	
	Physical and chemical methods of standardization	
3.2	Quantitative and qualitative estimation of phyto-constitutes	
	Herbs used in the following cosmetic product:	
3.3	<ul style="list-style-type: none"> • Herbal Shampoo • Herbal Conditioner • Herbal Hair Dye/ Herbal Hair Oil/Hair Cream/Hair Gel, • Herbal Face Mask • Herbal Bath Oil. 	
3.4	Study of protocol for preparation of :	
	<ul style="list-style-type: none"> • Different types of Herbal face masks- for dry skin, oily skin, pigmented skin & wrinkled skin • Special Herbal masks for sensitive skin • Herbal Shampoo 	
	Total	45

COURSE TITLE: HERBAL COSMETOLOGY (PRACTICAL)**COURSE CODE: BOT-III.E-4****MARKS: 25****CREDITS: 1**

Sr. No.	Module 4- Topics	Practical
1.	Herbal face masks for dry skin, oily skin, pigmented skin, wrinkled skin.	02
2.	Preparation of Herbal Shampoo	02
3.	Demostration of Churna preparation	01
4.	Comparison of Herbal products to non-herbal products	01
5.	Visit to an Ayurvedic institute / local ayurvedic clinic.	02
6.	Extraction of plant pigments- <i>Lawsonia inermis</i> (mehndi) and <i>Curcuma longa</i> (turmeric),	02
7.	Mini project : <ul style="list-style-type: none">• Study of herbal products for weight loss and weight gain• Study of various skin and hair care herbal products available in the market.• Study of locally available herbal Churnas.• Local Survey to know about awareness about home remedies for cosmetic purpose.	05
	Total	15

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5. Sharma, O.P. (1998) *Hill's Economic Botany*. New Delhi: Tata McGraw Hill Publishing Company Ltd.
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COURSE TITLE: CYTOGENETICS (THEORY)w.e.f 2021

COURSE CODE:BOT-IV.C-6

MARKS: 100 (75 Theory+ 25 Practicals)

CREDITS: 4 (3 Theory+ 1 Practical)

COURSE DURATION: 45 HOURS

COURSE OBJECTIVES:

This course will enable the students to understand fundamentals of genetics and evolution.

COURSE OUTCOMES: Students will be able to:

CO 1: Restate, apply, analyze and access the fundamentals of genetics

CO 2: To discuss, explain and interpret extra nuclear inheritance, Sex linked inheritance and chromosomal aberrations.

CO 3: Identify different stages of cell division, to construct chromosome maps.

CO 4: Review the effects of mutagens on seed germination.

Sr.No.	TOPICS	HOURS
Module 1: Mendelian Genetics and Linkage		15
Mendelian genetics and principles of inheritance and Multiple allelism		
1.1	Cell cycle- mitosis, meiosis and its significance, Mendel's Laws, backcross and test cross.	
1.2	Allelic and non-allelic interactions, Epistatic interactions	
1.3	Multiple alleles in Drosophila (eye colour), man (blood groups) and plants (self-incompatibility).	
Linkage, Mutations and Molecular basis of mutations		52
1.4	Linkage- Coupling and Repulsion Hypothesis Chromosome maps.	
1.5	Mutations and its types. Types of mutagens.	
1.6	Transitions and transversions; frame shift mutations. DNA repair	

	mechanisms, Applications of mutations	
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Module 2: Extranuclear inheritance and Sex linked inheritance		15
Extranuclear inheritance and Maternal influence		
2.1	Extranuclear inheritance and maternal influence: Kappa particles in <i>Paramecium</i> ; CO ₂ sensitivity in <i>Drosophila</i> ; cytoplasmic inheritance in mitochondria and plastids; Shell coiling in snails; eye colour in flour moth.	
Sex Determination and Sex Linkage		
2.2	Sex Chromosomes, Mechanisms of sex determination; Genic balance mechanism.	
2.3	Sex-linked inheritance- X linked and Y linked inheritance.	
Module 3: Genetic variation due to chromosome structure and number		15
Genetic variation due to chromosome structure and number		
3.1	Chromosomal aberrations – duplications, deletions, inversions and translocation	
3.2	Variations in chromosome number; auto-and allo-polyploidy - types and effects; artificial induction of polyploidy. Auto and allo-polyploid crop species Aneuploid segregations in plants- tetrasomics and nullisomics; triploid and tetraploid plants. Applications of polyploidy	
	TOTAL	45 HOURS

COURSE TITLE: CYTOGENETICS (PRACTICAL)

COURSE CODE:BOT-IV.C-6

MARKS: 25

CREDITS: 1

COURSE DURATION: 15 SESSIONS

Sr. No	MODULE 4: TOPICS	Practical
1.	Study of Mitosis and meiosis using suitable plant material	03
2.	Karyotype analysis and preparation of ideogram	02
3.	Detection of anomalies in cell division using suitable plant material.	02
4.	Study of multiple allelism in blood groups of human beings.	01
5.	Effect of physical and chemical mutagen on seed germination	03
6.	Preparation of chromosome maps from 3-point test cross data and calculation of Interference and coincidence	01
7.	Induction of polyploidy using Colchicine treatment.	02
8.	Study of sex linked inheritance	01
	TOTAL	15 P

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COURSE TITLE: PLANT BREEDING AND BIostatISTICS (THEORY)

COURSE CODE:BOT-IV.E-5

MARKS: 100 (75 Theory+ 25 Practicals)

CREDITS: 4 (3 Theory+ 1 Practical)

COURSE DURATION: 45 HOURS

COURSE OBJECTIVES:

To enable the students to learn various techniques in plant breeding with regards to crop productivity.

COURSE OUTCOMES: Students will be able to:

CO 1: Identify and assess the role of various institutions and certification programmes in plant breeding.

CO 2: Describe and compare various techniques in plant breeding

CO 3: Employ manual emasculation procedure.

CO 4: Calculate mean, median, mode, standard deviation, std. error for provided material.

Sr.No.	TOPICS	HOURS
Module 1: Introduction to Plant breeding, Organisations and Certifications		15
Introduction to Plant breeding and Organizations		
1.1	Introduction, history, objectives, achievements and prospects. Centres of origin of crop plants.	
1.2	Organizations & their mandate–CCARI- ICAR, ICRISAT, IRRI (Indian& International)	
1.3	Plant breeders' & Farmers' Rights, Phytosanitary and Seed Certifications	

Module 2: Hybridisation, Heterosis, Inbreeding Depression and Mutation breeding		15
Hybridisation, Heterosis and Inbreeding Depression		
2.1	Pure line and mass selection	
2.2	Types and Techniques in hybridization Introduction, domestication and acclimatization.	
2.3	Heterosis and inbreeding depression.	
Mutation Breeding; Breeding for stresses.		
2.4	Varieties developed in India through mutation breeding;	
2.5	Limitations of mutation breeding	
Module 3: Biostatistical methods and Genetics of Pathogenicity		15
Biostatistical methods and Genetics of Pathogenicity		
3.1	Introduction to biostatistics: Terms used in biostatistics, types of data, Sampling theories- random sample, sample size determination, precision, data collection, processing and presentation of data: qualitative and quantitative	
3.2	Measures of central tendency: Mean, Median, Mode. Measures of variation: standard deviation, standard error	
3.3	Concept of correlation between two variables and regression line Chi square	
3.4	Physiological races and types. Genetics of pathogenicity; vertical and horizontal resistance & breeding for various biotic stresses in rice/wheat.	
	TOTAL	45

COURSE TITLE: PLANT BREEDING AND BIOSTATISTICS**(PRACTICAL) COURSE CODE: BOT-IV.E-5****MARKS: 25****CREDITS: 1****COURSE DURATION: 15 SESSIONS**

Sr. No	MODULE 4: TOPICS	Practical sessions
1.	Emasculation and bagging of flowers using suitable plant material and Estimation of fruit and seed set in emasculated flowers	03
2.	Correlation of floral structure with pollination system	01
3.	Estimation of pollen fertility (pollen viability) in (any two) locally grown crop species.	02
4.	Study of centres of origin of some important crop plants.	01
5.	Study of soil pH using different soil types & relate it to crops	01
6.	Analysis of data for mean, median & mode, Standard deviation and standard error using suitable plant samples	03
7.	Determination of correlation and regression, Chi square analysis	03
8.	Visit to CCARI- ICAR	01
	TOTAL	15 P

REFERENCES:

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COURSE TITLE: TECHNIQUES & INSTRUMENTATION IN BOTANY (THEORY)

COURSE CODE: BOT-IV.E-6

MARKS: 100 (75 Theory+ 25 Practical)

CREDITS: 4 (3 Theory+ 1 Practical)

COURSE DURATION: 45 HOURS

COURSE OBJECTIVES:

Objective of the course is to impart knowledge of principle, methodology and application of various techniques & instrumentation.

COURSE OUTCOMES:

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

CO 1: To understand, define and explain the principle, instrumentation and working of microscopy and radiobiology techniques used in Botanical research.

CO2: To understand the principle, working and applications of centrifugation and spectrophotometry in Botanical research.

CO 3: To understand, define the principle, working and applications of chromatography, electrophoresis and molecular techniques.

CO 4: To compare and contrast the techniques used in Research fields.

Sr.No	UNITS, TOPICS AND SUB-TOPICS	Hours
	MODULE I: MICROSCOPY AND RADIOBIOLOGY (PRINCIPLE, METHODOLOGY AND APPLICATIONS)	15
1.1	Light microscopy (compound microscopy and Phase contrast microscopy) Fluorescence microscopy	
1.2	Transmission and Scanning electron microscopy (sample preparation for electron microscopy, cryofixation.)	
1.3	Microscopic measurements (Micrometry & cytometry) and photography (micro and macro)	
1.4	Radioactivity and its measurements (Geiger Muller and Scintillation counter	
1.5	and autoradiography)	

MODULE II : CENTRIFUGATION AND SPECTROPHOTOMETRY: PRINCIPLE, METHODOLOGY AND APPLICATIONS		15
2.1	Centrifugation: Low speed, high speed, cooling centrifuges and ultracentrifugation Analytical, preparatory and gradient centrifugation	
2.2	UV visual spectrophotometry	
2.3	Fluorescence spectrophotometry	
2.4	Flame (Atomic absorption) spectrophotometry	
2.5	Mass spectrophotometry	
MODULE III: CHROMATOGRAPHY, ELECTROPHORESIS & MOLECULAR TECHNIQUES: PRINCIPLE, METHODOLOGY AND APPLICATIONS		15
3.1	Adsorption and partition chromatography	
3.2	Column chromatography (isocratic and gradient)	
3.3	High Performance Liquid Chromatography& Gas Chromatography	
3.4	Electrophoresis: Agarose Gel Electrophoresis,Sodium Dodecyl Sulphate- Polyacrylamide Gel Electrophoresis , Iso-Electric Focussing and 2- Dimensional Electrophoresis	
3.5	Polymerase Chain Reaction, Real Time PCR	
	TOTAL	45

COURSE TITLE: TECHNIQUES & INSTRUMENTATION IN BOTANY (PRACTICAL)
COURSE CODE: BOT-IV.E-6
MARKS: 25
CREDITS: 1

SR.NO	Module 4- TOPICS	PRACTICAL
1	Preparation of Molar, Normal and ppm solutions	1
2	Determination of Lambda (λ) max of a given solution Verification of Beer's Law	2
3	Micrometric dimensions (cytometry and micrometry)	2
4	Demonstration of SDS- PAGE/ Agarose gel Electrophoresis	2
5	Preparation of TLC plate and Separation of biomolecules	2
6	Visit to Instrumentation Lab (NIO/College/ Goa University)	1
7.	Demonstration of Flame photometry	1
8	Mini project: Comparison of data of ultra and gradient Centrifugation Microscopy: Analysis of different photo micrographs Photography: To submit a report of macro and micro photography Preparation of column for column chromatography.	4
	Total	15

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4. vlab.amrita.edu,. (2011). Spectrophotometry. Retrieved 12 February 2020, from vlab.amrita.edu/?sub=2&brch=190&sim=338&cnt=1

COURSE TITLE: PLANT PATHOLOGY (THEORY)

COURSE CODE: BOT-IV.E-7

MARKS: 100 (75 Theory+ 25 Practicals)

CREDITS: 4 (3 Theory+ 1 Practical)

COURSE DURATION: 45 HOURS

COURSE OBJECTIVES:

To make the students aware of various plant pathogens and their control.

COURSE OUTCOME:

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

CO1: Identify various diseases and its causal agents of economically important plants.

CO2: Explain plant pathogen interaction.

CO3: Find effective control measures to deal with pathogens.

CO4: Isolate, observe and culture plant disease causing pathogens.

Sr. No	TOPICS	Hours
MODULE I: AN INTRODUCTION AND EPIDEMIOLOGY OF PLANTS DISEASES		15
1.1	History, Definitions and Importance of plant pathology	
1.2	Concepts and types of diseases in plants	
1.3	Biotic causes of plant diseases.	
1.4	Infectious agents (nematodes, protozoans, bacteria, fungi & viruses) Growth, reproduction, survival and dispersal of important plant pathogens	
1.5	Disease triangle	
MODULE II: PLANT DISEASE DEVELOPMENT (PATHOGENESIS) AND MANAGEMENT		15
2.1	Parasitism and pathogenicity	
2.2	Symptomatology	
2.3	Host parasite interaction	
2.4	Recognition concept and infection,	

2.5	Role of enzymes, toxins & growth regulators in pathogenesis	
2.6	Quantitative resistance (Physical, Biological & cultural methods) Biochemical defences (oxidative burst; Phenolics, Phytoalexins, PR proteins, antimicrobial substances and plantibodies), Quarantine measures	
MODULE III: GENETICS OF PLANT DISEASE AND STUDY OF PLANT DISEASES IN INDIA		15
3.1	Altered plant metabolism due to pathogens attack	
3.2	Genetics of resistance ('R' & avr genes, elicitors responses)	
3.3	Signalling and programmed cell death	
3.4	Study of Diseases (Name of disease, pathogen, symptoms and control measures need to be studied) Important diseases (Any 2 of each) of Paddy, Arecanut, Wheat, Banana, Coconut, Sugarcane, Mango and Amaranth/ Raddish	
	TOTAL	45

COURSE TITLE: PLANT PATHOLOGY (PRACTICAL)**COURSE CODE: BOT-IV.E-7****MARKS: 25**

Sr. No	Topics	Practical Sessions	CREDITS: 1 COURSE DURATION: 15 SESSIONS
1	Isolation and culture of fungal and bacterial pathogens.	02	
2.	Demonstration of Koch's postulates	01	
3.	Assay for cellulase /pectinase enzyme from diseased plant	02	
4.	Study of plant diseases with reference to pathogen & symptomology (Viral, Bacterial & Fungal) (any 10 as per theory)	05	
5	Anatomical observations of fungal infected plants (rust, blight, rots)	3	
6	Study of antagonistic behaviour of bacterial pathogens	1	
7.	Visit to Plant Pathology Laboratory (CCARI)	1	
	Total	15	

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1. Agrios, G.N. (2005). *Plant Pathology* (5th ed.). London: Academic Press.
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WEBLINKS

1. <https://www.springer.com/journal/42161>
2. <https://bsppjournals.onlinelibrary.wiley.com/journal/13653059>

COURSE TITLE: ALGAL BIOTECHNOLOGY (THEORY)

COURSE CODE: BOT-IV.E-8

MARKS: 100 (75 Theory+ 25 Practicals)

CREDITS: 4 (3 Theory+ 1 Practical)

COURSE DURATION: 45 HOURS

COURSE OBJECTIVES:

This course provides knowledge on diversity of algal types in Goa and understands the potential significance of algal resources as food, fodder, fuel and environment sustenance

COURSE OUTCOMES: Students will be able to

CO1: Apprise the students to the methods of algal culture techniques.

CO2: Assess, compare and manage algal in water bodies

CO3: Explore algal bio- resources and understand their commercial applications.

CO4: Understand opportunities for start-ups through eco-friendly bio- fertilizer production using algae.

Sr. No	TOPICS	Hours
MODULE I: METHODS OF ALGAL ISOLATION AND CULTURE		15
1.1	Methods of algal isolation	
1.2	Types of algal cultures (synchronous, continuous, mass and "in vitro" culture)	
1.3	Maintenance and growth of algal culture (freshwater and marine algae)	
1.4	Multiplication of economically important algae (Rhodophyta, Phaeophyta, Chlorophyta, Cyanophyta)	
MODULE-II: PHYCOREMEDIATION AND ALGAL POLLUTION		15
2.1	Phycoremediation	
2.2	Sewage disposal and waste treatment, textile and effluent sugar industry	
2.3	Single cell algal protein and phycocolloids	
2.4	Algae as indicator of pollution, aquatic pollution by algae: causes and consequences	
2.5	Eutrophication and its impact on water quality	
2.6	Algae in environmental health, sewage treatment ,	
2.7	Algal Blooms and their control	

Module III: COMMERCIAL APPLICATIONS OF ALGAL TECHNOLOGY		15
3.1	Application of algae in carbon sequestration	
3.2	Application of algae as food and fodder	
3.3	Application of algae in pharmaceutical industries Algae in biofuels	
3.4	Algae as Biofertilizers, application of cyanobacteria in bioplastics	
3.5	Algae as secondary metabolites	
3.6	Applications of algae in entrepreneurship development	
	TOTAL	45

COURSE TITLE: ALGAL BIOTECHNOLOGY (PRACTICALS)

PAPER CODE: BOT-IV.E-8

MARKS: 25

CREDITS:1

COURSE DURATION: 15 SESSIONS

Sr. No	TOPICS	PRACTICALS
1	Survey of market products of algal material	2
2	Visit to NIO and submission of report	2
3	Chromatographic separation of algal pigments (β -carotene containing algal)	2
4	Documentation of various types of algae found in fresh and marine ecosystems of Goa	2
	Mini Projects Isolation and estimation of algal proteins and lipids Culture of algae (Fresh & marine water, one each) Preparation of algal biofertilizer.	7
	Total	15

REFERENCES

- 1 .Becker, S. W. (1994). *Micro Algae Biotechnology and Microbiology*. Cambridge University Press.
2. Ignacimuthu, S. (1996). *Basic Biotechnology*. New Delhi: Tata McGraw Hill Publishing Limited.
4. Tridevi, P. C. (2001). *Algal Biotechnology*. Jaipur: Point Publisher.
5. Venkatraman, G. S. (1972). *Algal Biofertilizers and rice cultivation*. New Delhi: Today and Tomorrows Printers and Publishers.
6. Zajic, J. E. (1970). *Properties and Products of Algae*. New York: Plenum Press.
7. Bold ,H.C. and Wynne ,M.J. (1976). *Introduction to Algae structure and reproduction*. Prentice hall.
8. Presott, G.W. (1970). *How to know freshwater Algae*. W.C. Braun & Co.
9. Desikachary, T.V. (1972). *Taxonomy and Biology of Blue Green Algae*. University of Madras

Articles:

- Aziz M.A. and Ng W.G. (1993). Industrial wastewater treatment using an activated algae-reactor. *Water Sci. Technol.* **28**: 71–76.
- Thomas D.G., Minj N., Mohan N. and Rao P.H. (2016.) Cultivation of microalgae in domestic wastewater for biofuel applications – An upstream approach. *J. Algal Biomass Utln.* **7(1)**: 62-70
- Power, M., Van der Meer, J., Tchelat, R. (1998). Molecular based methods can contribute to assessments of toxological risks and bioremediation strategies. *J. Microbiol. Methods*, **32**: 107 –119.

COURSE TITLE: PLANT MOLECULAR BIOLOGY (THEORY)**COURSE: BOT-V.C-7****MARKS: 100 (75 Theory+25 Practicals)****CREDITS: 4 (3 Theory +1 Practical)****COURSE DURATION: 45 HOURS****COURSE OBJECTIVE**

At the end of the course student will able to explain life processes at the sub-cellular and molecular (gene) level and know general principles of gene organization and functions.

COURSE OUTCOMES

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

CO1: Outline, memorize and express process of central dogma

CO2: Understand molecular basis of life

CO3: Estimate and evaluate methods of quantitation of macromolecules

CO4: Learn and demonstrate basic molecular techniques of nucleic acid isolation and separation by electrophoresis.

Sr. No	UNITS, TOPICS AND SUB-TOPICS	Hours
MODULE-I: NATURE OF GENETIC MATERIAL AND DNA REPLICATION		15
1.1	Characteristics of genetic material, evidences to prove DNA & RNA as genetic material, Watson and Crick's model of DNA; Polymorphism of DNA.	
1.2	Central dogma of molecular biology, Model organism for studying molecular biology; C-value paradox; Chargoff's Law, Franklin's and Wilkin's work	
1.3	General feature of DNA replication (replication eye, replication forks); Types of DNA replication, mechanism of DNA replication in Prokaryotes & in Eukaryotes (Dispersive, Conservative and Semi- conservative); enzymes of replication –DNA Primase; DNA polymerases.	

Module II: DNA DAMAGE AND TRANSCRIPTION		15
2.1	Types of DNA damages and repair (direct reversal of damage, excision repair)	
2.2	Structure and functions of mRNA, tRNA and rRNA	
2.2	Transcription of mRNA in prokaryotes & eukaryotes	
2.3	Post transcriptional event; eukaryotes splicing & processing	
MODULE III: GENE REGULATION, EXPRESSION & TRANSLATION (PROTEIN SYNTHESIS)		15
3.1	Units of gene (Cistron, recon, muton, enhancers, split genes, overlapping genes; transposons and its role in gene structure, promoters & terminators.	
3.2	Gene regulation in prokaryotes (Lac operon concept) & eukaryotes (tryptophan) ; Inducible and repressible mechanism.	
3.3	Secondary structure of mRNA and its functions	
3.4	Mechanism & factors of Translation; RNA polymerases	
3.5	Post translational modifications; Protein targeting	
	Total	45

COURSE TITLE: PLANT MOLECULAR BIOLOGY (PRACTICALS)

COURSE CODE: BOT-V. C-7

MARKS 25

CREDIT 1

COURSE DURATION: 15 SESSIONS (inclusive of 3 PA)

Sr. No	TOPICS	Practical sessions
1	Isolation of plant genomic-DNA	3
2	Quantification of DNA by DPA method.	2
3	Isolation and estimation of RNA from plant tissue(orcinol method).	2
4	Preparation of Agarose gel and running of DNA	3
5	Demonstration of DNA amplification by PCR	3
6	Mini Project 1. Spooling of DNA from different plant samples	2
	Total	15

REFERENCES:

1. Gupta P.K. (2018) *Molecular Biology*. Rastogi Publications.
2. Alberts Bruce, Johnson A. Lewis Julian., Raff Martin., Roberts Keith., and Walter Paul (2002). *Molecular Biology of the Cell*. 4th edition. New York: Garland Publishing, Inc.
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4. Pal, J.K. and Ghaskadabi S.S. (2008) *Fundamentals of Molecular Biology*. Oxford.
5. James D. Watson (2007). *Molecular Biology of the Gene* (6th Edition) by, Tania A. Baker, Stephen P. Bell, and Alexander Gann.
6. Kleinsmith L.J and Kish V.M (1995). *Principles of Cell and Molecular Biology* (2nd Edition). New York: Happer Collins College Publishers.
7. Lehninger (2008). *Principles of Biochemistry* by David L. Nelson and Michael M.
8. Dube, R.C. (2008). *A Text Book of Biotechnology*. New Delhi: S. Chand pub.
9. Lewin B. (2000). *Genes VII*. New York: Oxford University Press.
10. Buchanan B.B, Gruissem W. and Jones R.L (2000). *Biochemistry and Molecular biology*.
11. Johnson Charlotte (2009) *Plant molecular biology*. Oxford Book company.
12. David Freifelder (1983) Jones & Bartlett publishers. *Molecular biology*. 2nd Ed. Reprint 1993. Narosa Publishing House.

COURSE TITLE: BIOINFORMATICS (THEORY)**COURSECODE: BOT-V.E-9****MARKS: 100 (75 Theory +25 Practical)****CREDITS: 4 (3Theory +1 Practical)****COURSE OBJECTIVES:**

The course will help the students to understand the fundamentals of bioinformatics and tools available.

COURSE OUTCOMES:

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

CO1: Introduce, explain and explore biological databases through websites (online) and the need of Bioinformatics.

CO2: Compare and contrast protein information resources and genome information resources, different biological databases and its role in molecular level sequencing

CO3: Relate the theoretical knowledge with practical sessions. Enable data handling and analysis.

CO4: Define the terminologies, types of biological databases, its applications and compare the homology between different biological species.

	TOPICS	Hours
MODULE 1: INTRODUCTION TO BIOINFORMATICS AND INFORMATION NETWORKS		
1.1	Introduction to bio-informatics, The biological sequence / structure deficit.	15
1.2	Genome projects, Pattern recognition and prediction, Levels of protein structure, Ramachandran Plot	
1.3	Role of Chaperons, Sequence analysis.	
1.4	Fields Related to Bioinformatics: Computational Biology, Genomics, Proteomics, Pharmacogenomics, Cheminformatics, Medical Informatics, Importance of Bioinformatics.	
1.5	Internet and the facilities available on it, computational biology, What is World Wide Web, Web browsers and Web Addresses. The National Centre for Biotechnology Information- NCBI, MMDb The European Molecular Biology Network- EMBnet Bioinformatics programme in India- BTISNet, BPI-2004, BOLD (Bar code of life database)	

MODULE 2: INTRODUCTION TO BIOLOGICAL DATABASES AND SEQUENCE ALIGNMENT METHODS.		15
2.1	Introduction To Biological Database : GenBank, EMBL, SwissProt, PROSITE, EC-ENZYME, PDB, GDB, OMIM,PIR-PSD.	15
2.2	Introduction and comparison of Homology, Analogy, Orthology And Paralogy. Alignment based methods and Hybrid method. Comparison of Computer Prediction Algorithms	
2.3	Introduction to pairwise and multiple sequence alignment; Comparison of sequences; Global alignment: The Needleman and Wunsch algorithm; Database interrogation, Alphabet and complexity; Pairwise database searching.	
2.4	BLAST; Databases of Multiple Alignments, Clustal Omega	
MODULE 3: PROTEIN AND GENOME INFORMATION RESOURCES		15
3.1	Introduction to Protein information resources, Primary Sequence Databases, Composite protein sequence databases, Secondary databases, Composite protein pattern databases; Structure classification databases.	15
3.2	Introduction to genome information resources, DNA sequence databases, Specialised genomic resources, ORF (Open Reading Frame Finder), TIGR Genome Resources ,Genome comparison, Genome Annotation, Microarray image analysis	
	Total	45

COURSE TITLE: BIOINFORMATICS

COURSE CODE: BOT-V.E-9

MARKS: 25

CREDITS: 1

SR. NO	Module 4- TOPICS	PRACTICAL
	Biological databases and exploring various websites- NCBI, PUBMED and GenBank databases	3
	To explore EBI server and searching EMBL	2
	Exploring and querying UniProt KB	1
	Pairwise global alignment of protein and DNA using Needleman- Wunsch algorithm.	2
	Obtaining sequences for Pairwise alignment and to interpret the results to study the homology between the sequences.	2
	Database searching using different versions of BLAST and FASTA and Derivation of relationships of query sequences.	2
	Use of Clustal Omega for multiple sequence alignment	1

	MINI PROJECTS Drug designing Construction of phylogenetic trees/cladogram (comparison between different organisms)	2
	TOTAL	15

REFERENCES:

1. Attwood, D. J., Parry Smith D.J. and Phukan, S. (2011). *Introduction to Bioinformatics*. Pearson education.
2. Ignacimuthu, S. (2005). *Basic Bioinformatics*. Narosa PublishingHouse
3. Khan, I. A. and Khanum, A. (2003). *Fundamentals of Bioinformatics* –Ukaaz publications.
4. Mani, K. and Vijayaraj, K.A. (2002). *Bioinformatics for Beginners*. Aparnaa Publication.
5. Murthy, C. S. V. (2004). *Bioinformatics*. Himalaya Publishing House.

Web Resources

1. <http://genes.mit.edu/GENSCAN.html>
2. <http://vmoc.museophile.org> ComputerHistory
3. <http://www.clcbio.com/index>
4. <http://www.genome.jp>
5. <http://www.genome.jp/dbget/LinkDB>
6. <http://www.ncbi.nlm.nih.gov/Structure/CN3D/cn3d.shtml>
7. <http://www.softberry.com/berry>
8. <http://www.studentworkzone.com/>
9. www.ebi.ac.uk
10. www.fgc.edu/support/office2000
11. www.learnthenet.com WebPrimer
12. www.clustawomega.org
13. www.embl.org

Research article:

1. Antre R.V *et al.*, Computer aided Drug Design: An Innovative Tool for Modeling, Open Journal of Medicinal Chemistry, 2012,2,pp139-148.
2. Surabhi et al, Computer aided drug designs: An overview, Journal of Drug Delivery and Therapeutics, 2018; 8(5);pp504-509. Available at <http://jddtonline.info>

Drug Design Softwares:

1. ArgusLab- <https://www.arguslab.com>
2. Schrodinger- <https://www.schrodinger.com/>
3. VlifeMDSTM- <https://vlifesciences.com/>
4. Accelrys
5. SYBYL
6. AutoDock- <https://autodock.scripps.edu/>
7. FlexX- <https://www.biosolveit.de/FlexX>
8. Vakser Lab
9. Ligplot: <https://www.ebi.ac.uk/thornton-srv/software/LIGPLOT/>
10. LiganScout- <https://www.intelligand.com>

COURSE TITLE: SEED TECHNOLOGY (THEORY)**COURSE CODE: BOT-V. E-10****MARKS: 100 (75 Theory+ 25 Practical)****CREDITS: 4 (3 Theory+ 1 Practical)****COURSE DURATION: 45 HOURS****COURSE OBJECTIVE:**

Characterize seeds based on their viability, know and apply the theoretical knowledge to conserve the germplasm.

COURSE OUTCOMES:

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

CO 1: Review characteristics of good seeds and their role in germination.

CO 2: Know methods of seed testing and understand seed viability.

CO 3: Realize the role of seed banks, seed storage units and seed testing organizations.

CO 4: Apply knowledge of seed types to the field.

Sr. No	UNITS, TOPICS AND SUB-TOPICS	Hours
Module-I: PRINCIPLES OF SEED TECHNOLOGY AND SEED TESTING ORGANIZATIONS		15
1.1	Concepts and role of seed technology; Seed definition; types of seed (breeders seed, foundation seed, and certified seed); characteristics of good seeds. National seed corporation.	
1.2	International seed testing association ; central and state seed testing laboratory; Role of ICRISAT AND ICAR; Procedure, Equipments for seed testing; and importance of seed testing	
Module II: PLANT BREEDING IN RELATION TO SEED TECHNOLOGY		15
2.1	Maintenance of breeders seed methods in self and cross fertilized crops. Development trial and release of seed variety	
2.2	Germplasm and its conservation, seed banks and types of seed collections; Use of heterosis in crop improvement	
Module III: SEED PROTECTION, PROCESSING AND STORAGE		15
3.1	Importance of epidemic and seed borne diseases; Factors affecting seed infection	
3.2	Control of Seed borne pathogens; Pest problems and their treatment during storage	
3.3	Methods of seed drying and their advantages; Chemicals and equipments for seed treatments; Concept of seed marketing; Forecasting of seed.	
Total		45



COURSE TITLE: SEED TECHNOLOGY (PRACTICALS)**COURSE CODE: BOT-V.E-10****MARKS: 25****CREDITS: 1****DURATION: 15 SESSIONS (inclusive of 3 PA)**

Sr. No	TOPICS	Practical sessions
1	Physical and chemical properties of seed	3
2	Structure of dicot and monocot seeds from various plant species	3
3	To test seed viability (2,3,5-triphenyl tetrazolium chloride test)	2
4	Mini Projects Breaking of seed dormancy methods (chemical, hormone & 1. temperature) 2. Seeds and diseases 3. Seed moisture and germination 4. Preparation of seed balls	6
5	Visit to ICRISAT/ seed tech plant and report submission	1
	Total	15

REFERENCES:

1. Agrawal (2005). *Seed Technology*. New Delhi: Oxford and IBH Publishing Co. Pvt. Ltd.
2. Pandey (2010). *A text book of Botany*. New Delhi: S. Chand and Company Ltd.
3. Reddy (2008). *Principles of crop production*. New Delhi: Kalyani Publishers.
4. Santra and Chatterjee (2007). *College Botany*. Kolkata: New Central Book Agency (P) Ltd..
5. Umaraniet. A.L. (2006). *Experimental Seed Science and Technology*. Jodhpur: Agrobios.
6. Dutta (1983). *A Class book of Botany*. Calcutta: Oxford University Press.

COURSE TITLE: PLANT DRUG TECHNOLOGY AND PHARMACOGNOSY (THEORY)

COURSE CODE: BOT-V.E-11

MARKS: 100(75 Theory+ 25 Practicals)

CREDITS: 4 (3 Theory+ 1 Practical)

COURSE DURATION: 45 HOURS

COURSE OBJECTIVES:

To enable the students to learn and understand the fundamental knowledge, techniques & skills in plant drug industry, drug discovery and development.

COURSE OUTCOMES:

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

CO 1: Explain, discuss and classify medicinal plants, plant drug and technology

CO 2: Explain and illustrate, biosynthetic pathways, bioassays and working of instruments

CO 3: Discuss and compare methods of extraction and analysis of phytochemicals.

CO4: Apply fundamental knowledge, techniques and skills in plant drug industry, drug discovery and development.

SR. NO.	TOPICS	HOURS
	MODULE I: INTRODUCTION	15
1.1	Introduction to plant drug technology and Pharmacognosy	
1.2	Classification of drugs: morphological, chemical and pharmacological.	
1.3	Identification of marker compounds in the formulations. Bioassays, Fingerprint and identification of plant drugs.	
1.4	Biosynthesis of alkaloids. Metabolic pathways of selected plants (from <i>Ocimum sanctum</i> and <i>Rauwolfia</i>).	
	MODULE II: CULTIVATION, COLLECTION AND CONSTITUENTS	15
2.1	ROOTS/ RHIZOME: <i>Rauwolfia</i> and <i>Curcuma</i>	
2.2	LEAVES: <i>Adathoda</i> and <i>Ocimum</i>	
2.3	SEEDS: Fenugreek and Nutmeg	
2.4	FRUITS: Coriander and Senna pod	
2.5	FLOWERS: Clove and Rose	
	MODULE III: PHYTOCHEMICALS (EXTRACTION AND ANALYSIS)	15
3.1	Extraction methods and principles. Traditional and modern techniques	
3.2	Methods of Characterization: NMR,MS,UV-Vis, GC-MS, LC-MS	
3.3	Analysis of Pigments, Phenolics, Flavonoids and Alkaloids.	
	TOTAL	45

COURSE TITLE: PLANT DRUG TECHNOLOGY AND PHARMACOGNOSY (PRACTICAL)
COURSE CODE: BOT-V.E-11
MARKS: 25
CREDITS: 1
PRACTICAL SESSIONS: 15

Sr. No.	MODULE IV: TOPICS	Practical
1.	Isolation of alkaloids and Phenolics	02
2.	Test for alkaloids: Mayer's, Wagner's, Dragendorffs' reagent	01
3.	Disc diffusion for antimicrobial assay	02
4.	MIC evaluation for antimicrobial assay	02
5.	Anatomical study of <i>Nux vomica</i> seeds, Ginger, Citronella leaf, Senna leaf & its medicinal properties	04
6.	Histochemical tests for Oils And Fats – Castor seed/ <i>Eucalyptus</i> Citrus	01
7.	Microchemical test of Arum / <i>Colocasia</i> leaves for observation of Calcium oxalate crystals.	01
8.	Mini project Adulteration of crude drugs	02
	TOTAL	15

REFERENCES:

- Gokhale, S.B. & Kokate, C.K. (2009). *Pharmacognosy*. Maharashtra: Nirali Prakashan.
- Khandelwal, K. R. (2008). *Practical Pharmacognosy*. Maharashtra: Nirali Prakashan.
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- Kumar, G. S., & Jayaveera, K. N. (2014). *A Textbook of Pharmacognosy and Phytochemistry*. New Delhi: S. Chand & Company Pvt. Ltd.
- McCreath, S. B., & Delgoda, R. (2017). *Pharmacognosy: Fundamentals, Applications and Strategies*. Amsterdam: Mica Haley.
- Shah, B., & Seth, A. (2010). *Textbook of Pharmacognosy and Phytochemistry*. New Delhi: Elsevier Health Sciences.
- What is Pharmacognosy*. (2020, February 12). Retrieved from www.pharmacognosy.com: <https://pharmacognosy.com/pharmacognosy-consulting-firm/>

14. *Pharmacognosy*. (2020, February 12). Retrieved from www.phytojournal.com: <http://www.phytojournal.com/pharmacognosy>

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COURSE TITLE: ORGANIC FARMING (THEORY)

COURSE CODE: BOT-V.E-12

MARKS: 100 (75 Theory +25 Practical)

CREDITS: 4 (3Theory +1 Practical)

COURSE DURATION: 45 HOURS

COURSE OBJECTIVES:

The course provides knowledge of principles and practices of organic agriculture and its role in sustainable crop production.

COURSE OUTCOMES:

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

CO 1: To understand the need and basics of Organic Farming, create awareness of the social, economic and environmental context for current and future organic agricultural production and management.

CO 2: Assess the importance of organic foods in today's World.

CO 3: Analyse and interpret the given problem in components of Organic Farming.

CO 4: Apply the knowledge in becoming an entrepreneur in Organic Farming to create own business plan.

Sr.No.	UNITS, TOPICS AND SUB-TOPICS	HOURS
	MODULE 1: Concept of Organic farming, compost, manures and its application.	15
1.1	Introduction: Farming, organic farming, concept and development of organic farming. Principles of organic farming, Types of organic farming. Needs and benefits of organic farming. Agencies and institutions related to organic agriculture. Farm components for an organic farm	

1.2	<p>Manure application: Composted vs. uncomposted manure</p> <p>Composting- principles, stages, types and factors</p> <p>Composting methods, Vermicomposting</p> <p>Bio-fertilizers, M.I., F.I.M., Neem cake, Mulching, Elley farming, Bioinoculation</p>	
MODULE II: Soils, Soil Fertility Management and fertilizers		15
2.1	Soil types and Soil tillage	
2.2	Factors affecting soil fertility and productivity	
2.3		
2.4	Land preparation	
2.5		
2.6	Water management for good soil, Commercial fertilizers, composition	
	Residual effects and fertilizer use efficiency	
	Foliar application and its concept	
MODULE III: Organic plant protection, Seed Certification and Entrepreneurship Development		15
3.1	Plant protection- cultural and mechanical	
	Plant protection- bio pesticide and bio control agents.	
3.2	Allelopathic methods of weed control.	
	Certification of organically produces seeds.	
3.3	Entrepreneurship – Concept, characteristics, approaches, need for entrepreneurship in Organic farming	
3.4	Popularization of organic farming.	
3.5	Marketing of organic produce.	
	National and international scenario of organic farming	
3.6		
	TOTAL	45

COURSE TITLE: ORGANIC FARMING (PRACTICAL)**COURSE CODE: BOT-V.E-12****MARKS: 25****CREDITS: 1****PRACTICAL SESSIONS: 15**

Sr. No	Module IV- Topics	Practical sessions
	Comparative analysis of pH, EC, organic C, total N, available N, P, K and S from organic and inorganic data (obtained data).	01
	Survey of weeds in crop fields (Organic v/s inorganic farming)	01
	Study of soil types.	01
	Observation of Mycorrhizae	01
	Study of bio pesticide (Neem cake)	01
	Study of Mulching	01
	Study of nitrogen fixing bacteria in leguminous plants	01
	Visit to an organic farm	02
	Mini project: Preparation of Compost/ vermi-compost Effect of various manures on plant growth. Study of recycling of farm waste.	06
Total		15

REFERENCES:

1. Chakraverty, A. (1991). *Post-harvest technology of cereal, pulses and oil seeds*. Oxford: IBH Publishing Co. Pvt Ltd.
2. Deshmukh, S.N. (2012). *Organic Farming: Principles, Prospects and Problems*, India: Agrobios Publishers.
3. Gehlot, D. (2010). *Organic Farming: Components and Management*, India: Agrobios Publishers.
4. Gupta, O.P. (2010). *Modern weed management*. Agrobios Publishers.
5. Israelsen, O.W. and Hansen, V.E. (2015). *Irrigation Principles and Practices*. John Wiley & Sons Inc.
6. Kanwar, J.S. (1978). *Soil Fertility, Theory and Practice*. Indian Council of Agricultural Research Publication.
7. Palaniappan, S.P. and Annadurai, K.A. (2010). *Organic Farming: Theory and Practice*. Indian Council of Agricultural Research, Scientific Publishers Journals Dept.
8. Rao, V.S. (2000). *Principles of Weed science*. Taylor & Francis Publishers.
9. Reddy, T.Y. and SankarReddi, G. H. (2015). *Principles of Agronomy*. Kalyani Publishers.
10. Sadhu, A.N. and Singh, A. (2014). *Fundamentals of Agricultural Economics*. Himalaya Publishing House.

11. Saraswat, V.N., Bhan, V. M. and Yaduraju, N.T. (2003). *Weed management* - (ICAR), Indian Council of Agricultural Research Publication.
12. Sharma, A.K. (2002). *A hand book of Organic Farming*. Agrobios Publishers.
13. Singh, B. D. (2006). *Plant Breeding Principles and Methods*. Kalyani Publishers.
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15. Yawalkar, K. S., Agrawal, J.P. and Bokde, S. (1962). *Manures and Fertilizers*. Agri-Horticulture Publishing House.
16. *Introduction to Organic Farming*. (n.d.). Retrieved February 13, 2020, from <http://agritech.tnau.ac.in/>: <http://agritech.tnau.ac.in/>
17. Reddy, J. (2017, February 19). *Organic Agriculture Information Guide*. Retrieved February 13, 2020, from AgriFarming: <https://www.agrifarming.in/organic-agriculture>.

COURSE TITLE: PLANT GENETIC ENGINEERING

COURSE CODE: BOT- VI.C-8

MARKS: 100 (75 Theory +25 Practical)

CREDITS: 4 (3Theory +1 Practical)

COURSE DURATION: 45 HOURS

COURSE OBJECTIVES: This course is to develop fundamental knowledge and skills in various aspects of Genetic engineering.

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

CO1: Understand, associate and apply the basic knowledge of tools in plant genetic engineering.

CO2: Interpret, analyze and understand the techniques in plant genetic engineering.

CO3: Apply the knowledge of plant genetic engineering in various fields.

CO4: State the Biosafety regulations and assess its procedure and importance.

Sr.No	TOPICS	Hours
Module 1: Tools in Recombinant DNA technology		15
1.1	Introduction to Recombinant DNA technology, DNA cloning-cell based and cell free.	
1.2	Enzymes- Importance in plant genetic engineering, Nucleases: Exo and endonucleases; Types I, II, III and Nomenclature. DNA ligases. DNA modifying enzymes, Factors affecting enzyme activation.	
1.3	DNA ligation, transformation, selection of transformed bacteria-antibiotic selection.	
1.4	Vectors- Key features, advantages and disadvantages. Prokaryotic vectors - plasmids, cosmids, Lambda phage. Eukaryotic vectors-	
1.5	Bacterial Artificial Chromosome, Yeast Artificial Chromosome. DNA Isolation and sequencing (Sanger & Coulson, Maxam & Gilbert).	

Module 2 : Techniques in Recombinant DNA technology		15
2.1	Methods of Gene transfer: Indirect and Direct methods of gene transfer. Indirect method: Agrobacterium mediated gene transfer- T-DNA, Ti plasmid and Ri plasmid derived vector systems. T-DNA transfer.	
2.2	Direct methods of gene transfer: Physical and Chemical.	
2.3	Selection of transformants; selectable marker (Antibiotic resistant markers, herbicide resistant markers) and reporter genes (Luciferase, GUS, GFP).	
2.4	Gene Cloning: Construction of genomic and cDNA libraries, screening of DNA libraries; complementation, colony hybridization; Southern, Northern and Western blotting; ELISA, CRISPR-Cas9.	
2.5	Polymerase Chain Reaction, Techniques of DNA fingerprinting (RFLP, RAPD, AFLP)	

Module 3: Gene transfer methods in plants, Biosafety and Applications of Genetic Engineering		15
3.1	Applications in Agriculture: Transgenic crops with improved quality traits: FLAVR SAVR Tomato, Golden rice, Bt cotton, herbicide resistant plants.	
3.2	Applications in Environment: Role of transgenics in bioremediation Mycoremediation, Phytoremediation, and Waste management(UASB reactor), Remediation of Xenobiotic compounds Molecular techniques in Phytoremediation	
3.3	Applications in Industries: Edible vaccines; Industrial enzymes (Protease, Lipase); Genetically Engineered Products – Human Growth Hormone; Humulin; Superweeds	
3.4	Bioethics and Biosafety: Intellectual Property Rights, Genetic engineering and Public issues. Biosafety regulations	
3.5		
		45

COURSE TITLE: PLANT GENETIC ENGINEERING (PRACTICAL)

COURSE CODE: BOT- VI.C-8

MARKS: 25

CREDITS: 1

Practical Sessions: 15

Sr. No	Module4: Topics	Practical
1	DNA isolation by CTAB/(any other) method	02
2.	Estimation of DNA	02
3.	Agarose Gel Electrophoresis	02
4.	Restriction digestionof DNA	02
5	Sequence reading – Sanger method/Maxam Gilbert method – problem	02
6	<i>Agrobacterium tumefaciens</i> -mediated plant transformation. (Virtual Library)	01
7	Small scale plasmid preparation from <i>E. coli</i>	03
8	Visit to a leading biotechnology institute and Report making.	01
	Total	15

REFERENCES:

1. Brown, T. A., (2006). *Gene cloning and DNA analysis An Introduction*. UK: Blackwell scientific publishers.
2. Chawla, H.S. (2000). *Introduction to Plant Biotechnology*. New Delhi: CRC Press.
3. Dovstekel (2005). *Microarray Bioinformatics*. UK: Cambridge University press.
4. Dubey, R.C. (2014). *Introduction to Plant Biotechnology*. New Delhi: S. Chand & Co.
5. Ignacimuthu, S. (1997). *Plant Biotechnology*. New Hampshire: Science Publishers.
6. Purohit, S.S. (2003). *Agricultural Biotechnology*. New Delhi: Agrobios.
7. Sobti, R.C & Pachauri, S.S. (2009). *Essentials of Biotechnology*. New Delhi: Ane Books.
8. Gupta, P. K. (1996). *Elements of Biotechnology*. Meerut: Rastogi Publications.
9. Lewin, B. (2004). *Genes VIII*. UK: Oxford University Press.
10. Primrose, S. B, Twyman, R. M. & Old R. W. (2001). *Principles of gene manipulation: An Introduction to genetic engineering*, 6th ed. UK: Blackwell scientific publishers. Smith, J.E. (2005). *Biotechnology*. UK: Cambridge University press.
11. Wilson, K. & Walker, J. (2008). *Principles and Techniques of Biochemistry and*

Weblinks and Article References:

1. Thomson, J. (2011). Genetic Engineering Of Plants. <https://www.semanticscholar.org/paper/GENETIC-ENGINEERING-OF-PLANTS-Thomson/e34c54c3c16d50c5180df80dd6b8993fc23851c6>.
2. <https://ndl.iitkgp.ac.in/>
3. Hsu, P. D., Lander, E. S., & Zhang, F. (2014). Development and applications of CRISPR-Cas9 for genome engineering. *Cell*, 157(6), 1262-1278.
4. Ran, F. A., Hsu, P. D., Wright, J., Agarwala, V., Scott, D. A., & Zhang, F. (2013). Genome engineering using the CRISPR-Cas9 system. *Nature protocols*, 8(11), 2281-2308.
5. Mathur, R. (2018). Genetic engineering and biosafety in the use of genetically modified foods. *IJASRM*, 2018(I), 76-82.
6. Cahoon, E. B. (2003). Genetic enhancement of soybean oil for industrial uses: prospects and challenges. *AgBioForum*, 6(1&2): 11-13.

COURSE TITLE: PLANT TISSUE CULTURE

COURSE CODE: BOT-VI.E-13

MARKS: 100 (75 Theory +25 Practical)

CREDITS: 4 (3Theory +1 Practical)

COURSE DURATION: 45 HOURS

COURSE OBJECTIVES: To develop the plant tissue culture skills.

COURSE OUTCOME: Upon successful completion, the students will be able to:

CO 1: Explain and discuss the general theoretical backgrounds and practical techniques

CO 2: Describe, define, explain/ discuss, compare, concept of differentiation and culture types.

CO 3: Define, describe, explain/ discuss, techniques in PTC in media preparation, sterilisation, callus culture and organogenesis

CO 4: Describe, explain, discuss applications in forestry, agriculture etc.

Sr.No	TOPICS	Hours
MODULE – I: INTRODUCTION AND DIFFERENTIATION		15
1.1	Scope and history of plant tissue culture, Laboratory organization.	
1.2	Culture techniques – Sterilization methods of glasswares, explant preparation, sterilization, media composition and preparation.	
1.3	Cellular differentiation and totipotency; effect of growth regulators on differentiation.	
MODULE – II: CULTURE TYPES AND TECHNIQUES IN TISSUE		15
2.1	Cell culture types- callus, single cell and suspension culture	
2.2	Organogenesis and embryogenesis; Somaclonal variation; meristem Micropropagation, Germplasm conservation; Isolation and regeneration of protoplasm; Somatic hybridization, Synthetic seeds, Cryopreservation, secondary metabolite production.	
MODULE- III: APPLICATION OF PLANT TISSUE CULTURE		15
3.1	Horticulture	
3.2	Agriculture	
3.3	Forestry	

TOTAL	45
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COURSE TITLE: PLANT TISSUE CULTURE (Practical)

COURSE CODE: BOT-VI.E-13

MARKS: 25

CREDITS: 1

COURSE DURATION: 15 SESSIONS

Sr. No	MODULE 4: Topics	Practical sessions
1	Preparation of MS Medium; Sterilization techniques	03
2	Embryo culture of maize	02
3	Callus induction and its morphological studies	04
4	Sub-culturing callus for rooting and shooting	03
5	Enzymatic Isolation of plant protoplast	01
6	Synthetic seed production	01
7	Visit to Plant tissue culture unit	01
	TOTAL	15

REFERENCES:

1. Bhojwani, S.S. (1990). *Plant Tissue Culture: Applications and Limitations*. USA: Elsevier Science Publishers.
2. Kumar, U. (1999). *Methods in Plant Tissue Culture*. Jodhpur: Agrobios.
3. Razdan, M. K. (2002). *Introduction to Plant Tissue Culture*. New Delhi: Oxford & IBH Publishing Co. Pvt. Ltd.
4. Satyanarayana U. (2013). *Biotechnology*. New Delhi: Books and allied (P) Ltd.
5. Vasil, I.K. and Thorpe, T.A. 1994. *Plant Cell and Tissue Culture*. Netherlands: Kluwer Academic Publishers.

COURSE TITLE: HORTICULTURE, FLORICULTURE AND LANDSCAPING (THEORY)

COURSE CODE: BOT-VI.E-14

MARKS: 100 (75 Theory+ 25 Practical)

CREDITS: 4 (3 Theory+ 1 Practical)

COURSE DURATION: 45 HOURS

COURSE OBJECTIVES:

To provide entrepreneur opportunities.

COURSE OUTCOMES:

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

CO 1: To explain the basics of Horticulture, floriculture and landscaping.

CO 2: To outline the requirements for building up nurseries, garden, etc.

CO 3: To inculcate the technique of vegetative propagation of plants.

CO 4: To identify and relate the scope of these fields in building up career.

	TOPICS	Hours
Module I: Introduction to Horticulture		
1.1	Definition and importance; scope of Pomoculture, Olericulture, Floriculture	15
1.2	Fertilizers: inorganic, Organic – biofertilizers: vermin composting, green manure, algal culture, FYM.	
1.3	Pots & potting:– Earthen, Fibre, Polythene bags, Potting mixture, Potting, Re-potting, Top dressing.	
1.4	Irrigation:- Surface, Sprinkle, Drip and Gravity irrigation	
1.5	Use of plant growth regulators in horticulture: Induction of rooting, flowering, fruit set, fruit development and control of fruit crops.	

Module II: Introduction to Floriculture and Propagation methods		15
2.1	Knowledge of annual, biennials and perennials with reference to ornamental flowers.	
2.2	Cultivation of commercial flowers – Rose, Jasmine, Chrysanthemum., Crossandra& Orchid	
2.3	Nursery maintenance; Cut flowers ; flower arrangements (including Ikebana); improving shelf life of cut flowers. Green house, Poly house, Moist chamber, Net frame	
2.4	Sexual methods (seed propagation) – Definition, Merits and Demerits, Criteria for selection of seeds.	
2.5	Asexual (Vegetative) propagation – Definition, and types- Cutting (root, stem, leaf), Layering (simple, air), Grafting (Whip, Approach) and Budding (T, patch), Stock –scion relationship in important horticultural crops.	
Module III: Introduction to Landscaping		15
3.1	Types of garden: Formal, informal and kitchen garden. Locations in the garden- edges, hedges, fence, lawn, flower beds,	
3.2	Avenue, water garden (with two examples of each). Focal point. Auto CAD in garden designing	
3.3	National parks, Botanical gardens, water garden, rockery plants, Bonsai techniques, Hydroponics.	
3.4	Lawn making: type of lawn grasses and maintenance. Plants suitable for hedges. Aftercare: Weeding, top dressing methods of pruning and topiary	
	Total	45 hours

COURSE TITLE: HORTICULTURE, FLORICULTURE AND LANDSCAPING**COURSE CODE: BOT-VI.E-14****MARKS: 25****CREDITS: 1****PRACTICAL SESSIONS: 15 (Inclusive of 3 PA)**

Sr. No.	Module 4- Topics	Practical
1.	Preparation of nursery bed and polybag filling	01
2.	Preparation of potting mixture – Potting, repotting.	02
3.	Field work in cutting, grafting, budding, layering	02
4.	Garden designing using Auto CAD software/any app	01
5.	Familiarizing gardening tools and implements	01
6.	Preparation of organic compost& vermicompost	02
7.	Establishment of vegetable garden using organic compost & vermi-compost	03
8.	Flower arrangement	01
9.	Visit to nurseries, gardens and Report.	01
10	Improving the shelf life of cut flowers using chemicals	01
	Total	15

REFERENCES:

1. Swarup V. (1997). *Ornamental horticulture*. NewDelhi: MaMillan India Limited.
2. Randhava, G.S, (1973). *Ornamental horticultural in India*. New Delhi: Today and Tomorrow Printers and Publishers.
3. Trivedi TP (2007). *Ornamental horticultural in India*. Indian Council of Agricultural Research NewDelhi.
4. Nayak, K.C. *South Indian fruits and their culture*. P.L. Madras: Varadaraj & Co.
5. Edment Senn Andrews (1994). *Fundamentals of Horticulture*. New Delhi: Tata McGraw Hill Publishing Co. Ltd.
6. Richard B. *Pruning, Training & Topiary*. Lorenz Books.
7. Oldfield, S. *Botanic Garden*. UK: New Holland Publishers Ltd.
8. Alan Titchmarshs gardening guides (1984), Lawns, Hamlyn.
9. Alan Titchmarshs gardening guides (1984), Bush Roses, Hamlyn.
10. Alan Titchmarshs gardening guides (1984), Climbing Plants, Hamlyn.

Web links:

1. http://agritech.tnau.ac.in/horticulture/horti_index.html
2. http://agritech.tnau.ac.in/horticulture/horti_flower%20crops.html
3. http://agritech.tnau.ac.in/horticulture/horti_nursery%20techniques.html

COURSE TITLE: ECONOMIC BOTANY (THEORY)

COURSE CODE: BOT-VI. E-15

MARKS: 100 (75 Theory+ 25 Practicals)

CREDITS: 4 (3 Theory+ 1 Practical)

COURSE DURATION: 45 HOURS

COURSE OBJECTIVES:

This course provides knowledge on the value of plants with scientific information and critical thinking to enhance economic botany.

COURSE OUTCOMES: Students will be able to

CO1: Identify and classify economically important plants/plant parts.

CO2 : Extract valuable plant products of potential market and economic value.

CO3 : Describe and create awareness of the uses of natural plant products

CO4 : Understand and use plants as an alternative to synthetic and chemical products

Sr. No	TOPICS	Hours
Module 1: Origin of Cultivated Plants (Centres of Origin, Cereals & legumes)		15
1.1	Centres of origin: Concept, Vavilov's work, examples of major plant introductions; evolution of new crops/ varieties; crop domestication, NRRI, CFTRI, SBRI	
1.2	Genetic diversity and its loss, Importance of germplasm	
1.3	Cereals: Wheat, Rice (local varieties) and Millets (any one)	
1.4	Legumes: Chick pea, Cow pea and one fodder legumes	
Module 2: Sources of sugars & Starch, Oils & Fats, Drugs & Natural Rubber		15
2.1	Sugar & Starch sources: Sugarcane ; Potato & Dioscorea	
2.2	Fat and Oil sources: Groundnut, Coconut, Soybean and; extraction and applications of essential oils, Eucalyptus and mustard oils	
2.3	Therapeutic and habit-forming drugs: <i>Cinchona</i> , <i>Cannabis</i> ; Tobacco (Morphology, processing, uses and health hazards)	

2.4	Tapping, processing and uses of <i>Hevea brasiliensis</i>	
Module 3: Classification, general description and uses of Spices, & beverages, Fruit and Nuts, Fibers and Timber Plants		15
3.1	Spices & condiments: Clove, Black pepper, cinnamon, turmeric	
3.2	Beverages: Tea & Coffee	
3.3	Fruits: Mango, Cashew & Jackfruit	
3.4	Fibers: Coconut, cotton & Jute.	
3.5	General account of Timber Plants: Teak and Matti	
		45

COURSE TITLE: ECONOMIC BOTANY (PRACTICAL)

COURSE CODE: BOT-VI.E-15

MARKS: 25

CREDITS: 1

COURSE DURATION: 15 SESSIONS

Sr. No	TOPICS	Practical Sessions
1	Morphological and Microscopic study of cereal and legumes seeds (rice and groundnut)	04
2	Study of essential oil yielding plants (Coconut, Eucalyptus, Citrus)	02
3	Mini Projects: i. Essential oil from plant sources ii. Analysis of starch content from plant sources(fruits, rhizome, tubers) iii. Analysis of plants for drugs, alkaloids and dyes iv. Fibers from plants v. Study of local fruits and spices	07
4	Visit to a Spice Farm/ Rubber Plantation/ economically important plant farm	02
Total		15

REFERENCES:

1. Kochhar, S.L. (2012). *Economic Botany in Tropics*. New Delhi: MacMillan & Co.
2. Wickens, G.E. (2001). *Economic Botany: Principles & Practices*. Netherlands: Kluwer Academic Publishers.
3. Chrispeels, M. J. and Sadava, D. E. (1994) *Plants, Genes and Agriculture*. Jones & Bartlett Publishers.
4. Subrahmanyam, N. S. and Sambamurty, A.V.S.S. (2008). *A textbook of Modern economic Botany*. New Delhi: CBS Publishers & Distributors.
5. Pandey, B. P. (2015). *Economic Botany*. New Delhi: S. Chand & Company.

COURSE TITLE: APPLIED MYCOLOGY (THEORY)

COURSE CODE: BOT-VI.E-16

MARKS: 100 (75 Theory +25 Practical)

CREDITS: 4 (3 Theory +1 Practical)

COURSE OBJECTIVES:

This paper provides knowledge on culture techniques and the applicative aspects of fungi.

COURSE OUTCOMES: The students be able to:

CO 1: Describe fungal cultures

CO2: Restate Media formulations

CO3: Identify the role of fungi in Industry.

CO4: Identify the role of fungi in Agriculture.

Sr.No.	TOPICS	Hours
Module 1: Introduction and Fungal Culture studies		15
INTRODUCTION		
1.1	General account of fungi. Microscopic structure, Chemical composition and understanding of fungal cell wall	
1.2	Environmental factors influencing fungal growth	
STUDIES OF FUNGAL CULTURE		
1.3	Introduction to culture collections, Culture Media formulations and types of media used in mycology. Culture databases.	
1.4	Various techniques for pure culture isolation and maximum recovery from different habitats (Soil, Litter, Water, Dung) Baiting, moist-chamber and particle-plating techniques	
1.5	Isolation of pure cultures and maintenance.	
1.6	Study of colony characters and growth patterns	
1.7	Fungal gene banks- Culture Collection Centres.	
Module 2: Industrial Mycology		15
INDUSTRIAL MYCOLOGY		
2.1	Role of fungi in biotechnology	
2.2	Applications of fungi in food industry <ul style="list-style-type: none">• Flavour and texture	

	<ul style="list-style-type: none"> • Fermentation and baking • Organic acids (Preferably Citric acid) • Enzymes (Preferably Cellulases and Pectinases) Mycoproteins– SCP (Yeast)	
2.3	Endophytic fungi and its industrial applications.	
Module 3: Fungi in Agriculture, medicine and recent mycological advances.		15
FUNGI IN AGRICULTURE		
3.1	Fungi as biofertilizers (Preferably <i>Trichoderma</i>) Fungi as biocontrol agents- Mycofungicides, Mycoherbicides, Mycoinsecticides	
3.2	Mycorrhizae and its role	
3.3	Medical mycology - Secondary metabolites- Pharmaceutical preparations from fungi, antibiotics from fungi. (Preferably <i>Penicillium</i> and <i>Ganoderma</i>)	
MUSHROOM CULTIVATION & RECENT ADVANCES IN MYCOTECHNOLOGY		
3.4	Mushroom cultivation techniques: Oyster and Button mushrooms.	
3.5	Applications of PCR and other molecular techniques in mycology, Mycoinformatics, Mycoremediation	
		TOTAL: 45 Hours

COURSE TITLE: APPLIED MYCOLOGY (PRACTICAL)

COURSE CODE: BOT-VI.E-16

PRACTICAL SESSIONS: 15

CREDITS: 1

Sr. No.	MODULE 4: TOPICS	Practicals
1.	Isolation and preparation of pure culture from a mixed culture plate on solid medium.	02
2.	Preparation of moist chamber and incubation of fungi	01
3.	Particle dilution plating for fungi	01
4.	Isolation of endophytic fungi from plant leaves	01
5.	Study of effect of incubation temperatures and pH on fungal growth	02
6.	Colorimetric estimation of cellulase and amylase produced by fungi	02
7.	Production of Citric acid (using <i>Aspergillus</i>) in broth and testing for its presence.	02
8.	Mushroom cultivation- Oyster mushrooms and its protein estimation	03
9.	Understanding structures of fungal enzymes using Bioinformatics tools.	01
TOTAL		15

REFERENCES:

1. Aneja, K. R. (2007). *Experiments in Microbiology Plant Pathology & Biotechnology*. (5th ed.) New Delhi: New Age International Publishers.
2. Bhat, D. J. (2010). *Fascinating Microfungi (Hyphomycetes) of Western Ghats – India*. First edition., Goa: Broadway Book Centre.
3. Powar, C.B. and Dagainawala, H.F. (1982). *General Microbiology–Volume II*. Mumbai: Himalaya Publishing house.
4. Prescott, L. M. (2005). *Microbiology*. 6th ed., New Delhi: Mc Graw-Hill.
5. Shivkumar, P.K., Joe, M.M. & Sukesh K. (2010). *An Introduction to Industrial Microbiology*. (1st ed.). New Delhi: S. Chand& Company Pvt. Ltd.
6. Trivedi, P.S. and Pandey, S.N. (2009). *A Textbook of Botany*. Volume I. New Delhi: Vikas Publishing House Pvt Limited.

COURSE TITLE: BASICS IN HORTICULTURE (THEORY)
SKILL ENHANCEMENT COURSE
MARKS: 100
CREDITS: 4

COURSE OBJECTIVES:
 To provide entrepreneur opportunities.

COURSE OUTCOMES:
 Upon successful completion of the course, students will be able to:
 CO 1: Explain the basics of Horticulture, floriculture and landscaping
 CO 2: Outline the requirements for building up nurseries, garden, etc.
 CO3: Inculcate the technique of vegetative propagation of plants.
 CO 4: Identify and relate the scope of these fields in building up career

Sr.No	Topics	Hours
Module I: Tools and Techniques in Horticulture, floriculture		15
1.1	Theory sessions: Definition and importance; Pomoculture, Olericulture, Floriculture. Fertilizers: inorganic, Organic – biofertilizers: vermicomposting, green manure, algal culture, FYM. Knowledge of annual, biennials and perennials with reference to ornamental flowers Irrigation:- Surface, Sprinkle, Drip and Gravity irrigation Introduction to Green house, Poly house, Moist chamber, Net frame, Introduction to Hydroponics.	
1.2	Practice sessions: Local visits to nurseries, home gardens to know about different pots and its potting system Preparation of potting mixture – Potting, repotting Preparation of organic compost &vermicompost Familiarizing gardening tools and implements Improving the shelf life of cut flowers using chemicals Study of Hydroponics Local visit to an established green house/polyhouse and report making.	

Module II: Propagation Methods		15
2.1	<p>Theory sessions:</p> <p>Introduction to sexual methods (seed propagation) – Definition, Merits and Demerits, Criteria for selection of seeds.</p> <p>Asexual (Vegetative) propagation – Definition, and types- Cutting (root, stem, leaf), Layering (simple, air), Grafting (Whip, Approach) and Budding (T, patch), Stock –scion relationship in important horticultural crops.</p> <p>Use of plant growth regulators in horticulture</p> <p>Practice sessions:</p>	
2.2	<p>Field work in cutting, grafting, budding, layering</p> <p>To design experiments for induction of rooting, flowering, fruit set, fruit development and control of fruit crops</p> <p>To study the cultivation practices of local commercial flowers</p> <p>Field work in Nursery management; Cut flowers; to improve shelf life of cut flowers.</p> <p>Visit to a local florist for learning different forms of flower-arrangement and live tutorials in classroom on various examples of flower arrangement all around the world.</p>	
Module III: Landscaping		15
3.1	<p>Theory sessions:</p> <p>Types of garden: Formal, informal and kitchen garden</p> <p>Locations in the garden- edges, hedges, fence, lawn, flower beds, Avenue, water garden (with two examples of each). Focal point.</p> <p>Auto CAD in garden designing. Bonsai techniques</p>	
3.2	<p>Practice session:</p> <p>Visit to local gardens and giving comparative account of types of garden</p> <p>Listing of plants used for edges, fence, lawn, flower beds, water gardens, etc.</p> <p>Visit to a botanical gardens/ water garden</p> <p>To learn different styles of Bonsai techniques</p> <p>Lawn making: type of lawn grasses and maintenance. Plants suitable for hedges.</p> <p>Aftercare: Weeding, top dressing methods of pruning and topiary</p> <p>Garden designing using (preferably Auto CAD) software</p>	

Module 4: Applications of Horticulture, Floriculture and Landscaping		15
4.1	Theory sessions: Entrepreneurship skills, Invited lecture by Guests (Spice Farm owner, Ecotourism sector, Organic farmer/ Organic products outlet owner, Nursery manager/ Landscaper, Krishivigyan Kendra, Agriculture dept, Forest Dept, etc) Latest schemes in horticulture, floriculture, agriculture in Goa.	
4.2	Practice sessions: Preparation of garden design (area of the campus) Innovative ideas for beautification of the campus and preparation of the same. Establishment of vegetable garden using organic compost &vermi-compost	
	Total	60

REFERENCES:

1. Swarup V. (1997). *Ornamental horticulture*. New Delhi: MacMillan India Limited.
2. Randhava, G.S, (1973) – *Ornamental horticultural in India* New Delhi: Today and Tomorrow Printers and Publishers.
3. Trivedi TP (2007). *Ornamental horticultural in India*. New Delhi: Indian Council of Agricultural Research.
4. Nayak, K.C. *South Indian fruits and their culture*. Madras: P.L. Varadaraj & Co. ,& Lingichetti Street.
5. Edment Senn Andrews (1994) *Fundamentals of Horticulture*. New Delhi: Tata McGraw Hill Publishing Co., Ltd.

Web-link

1. http://agritech.tnau.ac.in/horticulture/horti_index.html

Parvatibai Chowgule College of Arts & Science
(Autonomous)
Margao –Goa
Department of Botany

Certificate course in Herbal Cosmetology

SYLLABUS

Sr.no	Topics	Time (hour)
1	Introduction to herbal cosmetology.	1
2	Concept of Skin, skin types and metabolism.	2
3	Ayurvedic guidelines about diet and nutrition for healthy skin and hair.	2
4	Hair and its types,	1
5	Hair growth and metabolism in body.	2
6	Ayurvedic management of hairfall, dandruff and premature greying.	2
7	Benefits of tulsi, neem, <i>Aloevera</i> , fenugreek seeds, ragietc in herbal Cosmetology.	2
8	Scope of herbal cosmetology	1
9	Assignment	3
10	Written exam	2
11	Practical exam	2
	Total	20

Sr.no	Practicals	Sessions
1	Preparation of herbal soaps and lipbalms.	2
2	Preparation of herbal oil, shampoos etc	2
3	Preparation of facepacks, body massage powder etc	2
4	Practice sessions- skin products	2
5	Practice sessions- hair products	2
	Total	10

Learning Outcome Matrix : (Templates attached as annexures):

Matrix -1: Mapping activities to the PLOs (single document for entire programme).

Matrix -2: Mapping PLOs to CLOs (course wise).

Matrix-3: Mapping Teaching –Learning Pedagogies to PLOs and CLOs (Course wise).

Matrix-4: Mapping Assessment modes to PLOs and CLOs (Course wise)

	Workshops and training programmes	✓	✓	✓	✓	✓	✓	✓	✓
	Exhibition and plant sale counter	✓	✓	✓	✓	✓		✓	✓
	Lecture series	✓	✓	✓	✓	✓	✓	✓	✓
	Field visits	✓	✓	✓	✓	✓	✓	✓	✓

MATRIX -2 (Course-wise)

MAPPING OF PROGRAMME LEARNING OUTCOME TO COURSE LEARNING OUTCOMES

<p>MATRIX -2 (Course-wise)</p> <p>MAPPING OF PROGRAMME LEARNING OUTCOME TO COURSE LEARNING OUTCOMES</p> <p>Programme: B. Sc. Botany</p> <p>Type of Course: (GEC/SEC/DSE/Core)</p> <p>Course Code: BOT-I.C-1</p> <p>Course Title: Plant diversity</p> <p>(use if linked, if not linked)</p>								
PLOs CLOs	PLO-1: Use of Technology, Problem Analysis and Solutions	PLO-2: Environment Sustainability & Ethics	PLO -3: Individual and Team work, Communication & Life Skills	PLO-4: Research Aptitude & Social responsibility	PLO-5: Recognize plant groups, cell types and cell organelles	PLO-6: Analyse techniques and instrumentation in botanical studies	PLO-7: Understand adaptations and mechanisms in microbes and plants	PLO-8: Appraise students with knowledge of applied botany
1	✓	✓	✓	✓	✓	X	X	X
2	✓	✓	✓	✓	✓	X	X	X
3	✓	✓	✓	✓	✓	X	X	X
4	✓	✓	✓	✓	✓	X	X	X

MATRIX -2 (*Course-wise*)
 MAPPING OF PROGRAMME LEARNING OUTCOME TO COURSE LEARNING OUTCOMES

Programme: BSc Botany
 Type of Course: (*GEC/SEC/DSE/Core*)

Course Code: BOT-VI.C-8
Course Title: Plant Genetic Engineering

(use *if linked,* *if not linked*)

PLOs CLOs	PLO-1: Use of Technology, Problem Analysis and Solutions	PLO-2 : Environment Sustainability & Ethics	PLO -3: Individual and Team work, Communicationa & Life Skills	PLO-4: Research Aptitude & Social responsibility	PLO-5: Recognize plant groups, cell types and cell organelles	PLO-6 Analyse techniques and instrumentation in botanical studies	PLO-7: Understand adaptations and mechanisms in microbes and plants	PLO-8: Appraise students with knowledge of applied botany
1	✓	✓	✓	✓	✓	✓	✓	✓
2	✓	✓	✓	✓	✓	✓	x	✓
3	✓	✓	✓	✓	✓	✓	✓	✓
4	✓	✓	✓	✓	x	x	x	✓

MATRIX -2 (Course-wise)
 MAPPING OF PROGRAMME LEARNING OUTCOME TO COURSE LEARNING OUTCOMES

Programme: BSc Botany
 Type of Course: (GEC/SEC/DSE/Core)

Course Code: BOT-IV.E-5
Course Title: Plant Breeding and Biostatistics

(use if linked, if not linked)

PLOs CLOs	PLO-1: Use of Technology, Problem Analysis and Solutions	PLO-2 : Environment Sustainability & Ethics	PLO -3: Individual and Team work, Communicationa & Life Skills	PLO-4: Research Aptitude & Social responsibility	PLO-5: Recognize plant groups, cell types and cell organelles	PLO-6 Analyse techniques and instrumentation in botanical studies	PLO-7: Understand adaptations and mechanisms in microbes and plants	PLO-8: Appraise students with knowledge of applied botany
1	✓	✓	✓	✓	✓	✓	✓	✓
2	✓	✓	✓	✓	✓	✓	✓	✓
3	✓	✓	✓	✓	✓	✓	✓	✓
4	✓	✓	✓	✓	x	✓	✓	✓

MATRIX -2 (Course-wise)
MAPPING OF PROGRAMME LEARNING OUTCOME TO COURSE LEARNING OUTCOMES

Programme: BSc Botany
Type of Course: (GEC/SEC/DSE/Core)

Course Code: BOT-V.E-9
Course Title: Bioinformatics

(use *if linked*, *if not linked*)

PLOs CLOs	PLO-1: Use of Technology, Problem Analysis and Solutions	PLO-2 : Environment Sustainability & Ethics	PLO -3: Individual and Team work, Communicationa & Life Skills	PLO-4: Research Aptitude & Social responsibility	PLO-5: Recognize plant groups, cell types and cell organelles	PLO-6 Analyse techniques and instrumentation in botanical studies	PLO-7: Understand adaptations and mechanisms in microbes and plants	PLO-8: Appraise students with knowledge of applied botany
1	✓	✓	✓	✓	✓	✓	✓	✓
2	✓	✓	✓	✓	✓	✓	✓	✓
3	✓	✓	✓	✓	x	✓	x	✓
4	✓	✓	✓	✓	x	✓	x	✓
5	✓	✓	✓	✓	✓	✓	✓	✓
6	✓	✓	✓	✓	x	✓	x	✓

MATRIX -2 (*Course-wise*)
 MAPPING OF PROGRAMME LEARNING OUTCOME TO COURSE LEARNING OUTCOMES

Programme: BSc Botany
 Type of Course: (*GEC/SEC/DSE/Core*)

Course Code: BOT-V.E-12
Course Title: Organic Farming

(use *if linked,* *if not linked*)

PLOs CLOs	PLO-1: Use of Technology, Problem Analysis and Solutions	PLO-2 : Environment Sustainability & Ethics	PLO -3: Individual and Team work, Communicationa & Life Skills	PLO-4: Research Aptitude & Social responsibility	PLO-5: Recognize plant groups, cell types and cell organelles	PLO-6 Analyse techniques and instrumentation in botanical studies	PLO-7: Understand adaptations and mechanisms in microbes and plants	PLO-8: Appraise students with knowledge of applied botany
1	✓	✓	✓	✓	x	✓	✓	✓
2	✓	✓	✓	✓	X	X	X	✓
3	✓	✓	✓	✓	X	✓	✓	✓
4	✓	✓	✓	✓	x	X	X	✓

MATRIX -2 (Course-wise)
 MAPPING OF PROGRAMME LEARNING OUTCOME TO COURSE LEARNING OUTCOMES

Programme: BSc Botany
 Type of Course: (GEC/SEC/DSE/Core)

Course Code: BOT-VI.E-14

Course Title: Horticulture, Floriculture and Landscaping

(use if linked, if not linked)

PLOs CLOs	PLO-1: Use of Technology, Problem Analysis and Solutions	PLO-2 : Environment Sustainability & Ethics	PLO -3: Individual and Team work, Communicationa & Life Skills	PLO-4: Research Aptitude & Social responsibility	PLO-5: Recognize plant groups, cell types and cell organelles	PLO-6 Analyse techniques and instrumentation in botanical studies	PLO-7: Understand adaptations and mechanisms in microbes and plants	PLO-8: Appraise students with knowledge of applied botany
1	✓	✓	✓	✓	✓	✓	✓	✓
2	✓	✓	✓	✓	✓	✓	✓	✓
3	✓	✓	✓	✓	✓	✓	x	✓
4	✓	✓	✓	✓	x	x	x	✓

MATRIX 3 (Course wise)
MAPPING TEACHING METHODS/PEDAGOGIES TO CLOs AND PLOs
PROGRAMME: B.Sc. Botany
Course: Plant Diversity
(use if linked, if not linked and if mode not used)

Level of Blooms Taxonomy (1-6)	T-L-E modes	CLO-1	CLO2	CLO 3	CLO 4	CLO5	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO 8
	Traditional Lecture Method	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Interactive Lecture Method	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Group Discussion	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Debate	x	x	X	x	x	x	x	x	x	x	x	x	X
	Experiential Learning	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Out-door Experiments	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Laboratory Work	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	POGIL	x	x	X	x	x	x	x	x	x	x	x	x	X
	Flipped Classroom	x	x	X	x	x	x	x	x	x	x	x	x	X
	Field Based studies	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Problem Based Learning	x	x	X	x	x	x	x	x	x	x	x	x	X
	Project based Learning	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Blooms Taxonomy: 1-Remembering, 2-Understanding, 3-Applying, 4-Analysing, 5-Evaluating, 6-Creating

MATRIX 3 (Course wise)
MAPPING TEACHING METHODS/PEDAGOGIES TO CLOs AND PLOs
PROGRAMME: B.Sc. Botany
Course: _Cell biology and Biomolecules
(use if linked, if not linked and if mode not used)

Level of Blooms Taxonomy (1-6)	T-L-E modes	CLO-1	CLO2	CLO 3	CLO 4	CLO5	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO 8
	Traditional Lecture Method	✓	✓	✓	✓	-	✓	✓	✓	✓	✓	✓	✓	✓
	Interactive Lecture Method	✓	✓	✓	✓	-	✓	✓	✓	✓	✓	✓	✓	✓
	Group Discussion	x	x	X	✓	-	✓	✓	✓	✓	✓	✓	✓	✓
	Debate	x	x	X	x	-	x	x	x	x	x	X	X	X
	Experiential Learning	x	x	X	x	-	x	x	x	x	x	x	x	X
	Out-door Experiments	x	x	X	x	-	x	x	x	x	x	x	x	X
	Laboratory Work	✓	✓	✓	✓	-	✓	✓	✓	✓	✓	✓	✓	✓
	POGIL	x	x	X	x	-	x	x	x	x	X	X	X	X
	Flipped Classroom	x	x	X	x	-	x	x	x	X	X	X	X	x
	Field Based studies	x	x	X	x	-	x	x	✓	✓	x	✓	✓	✓
	Problem Based Learning	x	x	X	x	-	x	x	X	X	X	X	X	x
	Project based Learning	x	x	X	x	-	✓	✓	✓	✓	✓	✓	✓	✓

Blooms Taxonomy: 1-Remembering, 2-Understanding, 3-Applying, 4-Analysing, 5-Evaluating, 6-Creating

MATRIX 3 (Course wise)
MAPPING TEACHING METHODS/PEDAGOGIES TO CLOs AND PLOs
PROGRAMME: BSc _

Course: BOT-II. C-4Microbiology_____

(use if linked, if not linked and if mode not used)

Level of Blooms Taxonomy (1-6)	T-L-E modes	CLO-1	CLO2	CLO 3	CLO 4	CLO5	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO 8
	Traditional Lecture Method	✓	✓				✓	✓	✓	✓	✓	✓	✓	✓
	Interactive Lecture Method	✓	✓				✓	✓	✓	✓	✓	✓	✓	✓
	Group Discussion	✓	✓				✓	✓	✓	✓	✓	✓	✓	✓
	Debate													
	Experiential Learning	✓	✓				✓	✓	✓	✓	✓	✓	✓	✓
	Out-door Experiments	✓	✓				✓	✓	✓	✓	✓	✓	✓	✓
	Laboratory Work	✓	✓				✓	✓	✓	✓	✓	✓	✓	✓
	POGIL													
	Flipped Classroom		✓				✓	✓	✓	✓	✓	✓	✓	✓
	Field Based studies	✓	✓				✓	✓	✓	✓	✓	✓	✓	✓
	Problem Based Learning													
	Project based Learning	✓	✓				✓	✓	✓	✓	✓	✓	✓	✓

Blooms Taxonomy: 1-Remembering, 2-Understanding, 3-Applying, 4-Analysing, 5-Evaluating, 6-Creating

MATRIX 3 (Course wise)
MAPPING TEACHING METHODS/PEDAGOGIES TO CLOs AND PLOs
PROGRAMME: BSc. _____

Course: BOT-III.C-5Physiology OF Plants

(use if linked, if not linked and if mode not used)

Level of Blooms Taxonomy (1-6)	T-L-E modes	CLO-1	CLO2	CLO 3	CLO 4	CLO5	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO 8
	Traditional Lecture Method	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
	Interactive Lecture Method	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
	Group Discussion	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
	Debate													
	Experiential Learning	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
	Out-door Experiments	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
	Laboratory Work	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
	POGIL													
	Flipped Classroom													
	Field Based studies	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
	Problem Based Learning	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
	Project based Learning	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓

Blooms Taxonomy: 1-Remembering, 2-Understanding, 3-Applying, 4-Analysing, 5-Evaluating, 6-Creating

MATRIX 3 (Course wise)
MAPPING TEACHING METHODS/PEDAGOGIES TO CLOs AND PLOs
PROGRAMME: _____ B.Sc. Botany _____
Course: _Systematics of flowering plants and phylogeny _____
(use if linked, if not linked and if mode not used)

MATRIX 3 (Course wise)
MAPPING TEACHING METHODS/PEDAGOGIES TO CLOs AND PLOs
PROGRAMME: B.Sc. Botany
Course: _Ecology and Conservation
(use if linked, if not linked and if mode not used)

Level of Blooms Taxonomy (1-6)	T-L-E modes	CLO-1	CLO2	CLO 3	CLO 4	CLO5	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO 8
	Traditional Lecture Method	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Interactive Lecture Method	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Group Discussion	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Debate	x	x	x	x	x	x	x	x	x	x	x	x	x
	Experiential Learning	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Out-door Experiments	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Laboratory Work	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	POGIL	x	x	x	x	x	x	x	x	x	x	x	x	x
	Flipped Classroom	x	x	x	x	x	x	x	x	x	x	x	x	x
	Field Based studies	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Problem Based Learning	x	x	x	x	x	x	x	x	x	x	x	x	x
	Project based Learning	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Blooms Taxonomy: 1-Remembering, 2-Understanding, 3-Applying, 4-Analysing, 5-Evaluating, 6-Creating

Level	T-L-E modes	C L O -1	CLO2	CLO 3	CLO 4	CLO5	PLO-1:	PLO-2 :	PLO -3:	PLO-4:	PLO- 5:	PLO-6	PLO-7:	PLO- 8:
	Traditional Lecture Method	✓	✓	✓	✓	-	✓	✓	✓	✓	✓	✓	✓	✓
	Interactive Lecture Method	✓	✓	✓	✓	-	✓	✓	✓	✓	X	✓	✓	✓
	Group Discussion	-	-	-	-	-	-	-	-	-	-	-	-	-
	Debate	-	-	-	-	-	-	-	-	-	-	-	-	-
	Experiential Learning	-	-	-	-	-	-	-	-	-	-	-	-	-
	Out-door Experiments	✓	✓	✓	✓	-	✓	✓	✓	✓	✓	✓	✓	✓
	Laboratory Work	✓	✓	✓	✓	-	✓	✓	✓	✓	✓	✓	✓	✓
	POGIL	-	-	-	-	-	-	-	-	-	-	-	-	-
	Flipped Classroom	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Field Based studies	-	-	-	-	-	-	-	-	-	-	-	-	-
	Problem Based Learning	-	-	-	-	-	-	-	-	-	-	-	-	-
	Project based Learning	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Blooms Taxonomy: 1-Remembering, 2-Understanding, 3-Applying, 4-Analysing, 5-Evaluating, 6-Creating</i>														

MATRIX 3 (Course wise)
MAPPING TEACHING METHODS/PEDAGOGIES TO CLOs AND PLOs
PROGRAMME: _____ B.Sc. Botany _____
Course: _Herbal cosmetology_____
(use if linked, if not linked and if mode not used)

Level	T-L-E modes	CL O-1	CL O2	CLO 3	CLO 4	CLO5	PLO-1:	PLO-2 :	PLO -3:	PLO-4:	PLO-5:	PLO-6	PLO-7:	PLO-8:
	Traditional Lecture Method	✓	✓	✓	✓	-	✓	✓	✓	✓	✓	✓	✓	✓
	Interactive Lecture Method	✓	✓	✓	✓	-	✓	✓	✓	✓	X	✓	✓	✓
	Group Discussion	✓	✓	✓	✓	-	✓	✓	✓	✓	✓	✓	✓	✓
	Debate	-	-	-	-	-	-	-	-	-	-	-	-	-
	Experiential Learning	-	-	-	-	-	-	-	-	-	-	-	-	-
	Out-door Experiments	-	-	-	-	-	-	-	-	-	-	-	-	-
	Laboratory Work	✓	✓	✓	✓	-	✓	✓	✓	✓	✓	✓	✓	✓
	POGIL	-	-	-	-	-	-	-	-	-	-	-	-	-
	Flipped Classroom	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Field Based studies	-	-	-	-	-	-	-	-	-	-	-	-	-
	Problem Based Learning	-	-	-	-	-	-	-	-	-	-	-	-	-
	Project based Learning	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Blooms Taxonomy: 1-Remembering, 2-Understanding, 3-Applying, 4-Analysing, 5-Evaluating, 6-Creating

MATRIX 3 (Course wise)
MAPPING TEACHING METHODS/PEDAGOGIES TO CLOs AND PLOs
PROGRAMME: B.Sc. Botany
Course: _Cytogenetics
 (use if linked, if not linked and if mode not used)

Level of Blooms Taxonomy (1-6)	T-L-E modes	CLO-1	CLO2	CLO 3	CLO 4	CLO5	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO 8
	Traditional Lecture Method	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Interactive Lecture Method	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Group Discussion	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Debate	x	x	x	x	x	x	x	x	x	x	x	x	x
	Experiential Learning	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Out-door Experiments	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Laboratory Work	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	POGIL	x	x	x	x	x	x	x	x	x	x	x	x	x
	Flipped Classroom	x	x	x	x	x	x	x	x	x	x	x	x	x
	Field Based studies	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Problem Based Learning	x	x	x	x	x	x	x	x	x	x	x	x	x
	Project based Learning	x	x	X	x	x	x	x	x	x	x	x	x	x

Blooms Taxonomy: 1-Remembering, 2-Understanding, 3-Applying, 4-Analysing, 5-Evaluating, 6-Creating

MATRIX 3 (Course wise)
MAPPING TEACHING METHODS/PEDAGOGIES TO CLOs AND PLOs
PROGRAMME: B.Sc. Botany
Course: _Plant Breeding and Biostatistics
 (use if linked, if not linked and if mode not used)

Level of Blooms Taxonomy (1-6)	T-L-E modes	CLO-1	CLO2	CLO 3	CLO 4	CLO5	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO 8
	Traditional Lecture Method	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Interactive Lecture Method	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Group Discussion	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Debate	x	x	X	x	x	x	x	x	x	x	x	x	x
	Experiential Learning	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Out-door Experiments	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Laboratory Work	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	POGIL	x	x	X	x	x	x	x	x	x	x	x	x	X
	Flipped Classroom	x	x	X	x	x	x	x	x	x	x	x	x	X
	Field Based studies	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Problem Based Learning	x	x	X	x	x	x	x	x	x	x	x	x	X
	Project based Learning	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Blooms Taxonomy: 1-Remembering, 2-Understanding, 3-Applying, 4-Analysing, 5-Evaluating, 6-Creating

Blooms Taxonomy: 1-Remembering, 2-Understanding, 3-Applying, 4-Analysing, 5-Evaluating, 6-Creating

MATRIX 3 (Course wise) MAPPING TEACHING METHODS/PEDAGOGIES TO CLOs AND PLOs PROGRAMME: BSc _____ Course: __BOT-V.C-7Plant Molecular biology _____														
<i>(use if linked, if not linked and if mode not used)</i>														
Level of Blooms Taxonomy (1-6)	T-L-E modes	CLO-1	CLO2	CLO 3	CLO 4	CLO5	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO 8
	Traditional Lecture Method	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
	Interactive Lecture Method	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
	Group Discussion	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
	Debate						✓	✓	✓	✓	✓	✓	✓	✓
	Experiential Learning	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
	Out-door Experiments	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
	Laboratory Work	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
	POGIL													
	Flipped Classroom													
	Field Based studies	✓	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓
	Problem Based Learning	✓	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓
	Project based Learning	✓	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓

Blooms Taxonomy: 1-Remembering, 2-Understanding, 3-Applying, 4-Analysing, 5-Evaluating, 6-Creating

MATRIX 3 (Course wise)
MAPPING TEACHING METHODS/PEDAGOGIES TO CLOs AND PLOs
PROGRAMME: B.Sc. Botany
Course: Bioinformatics
(use if linked, if not linked and if mode not used)

Level of Blooms Taxonomy (1-6)	T-L-E modes	CLO-1	CLO2	CLO 3	CLO 4	CLO5	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO 8
	Traditional Lecture Method	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Interactive Lecture Method	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Group Discussion	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Debate	x	x	x	x	x	x	x	x	x	x	x	x	X
	Experiential Learning	x	x	x	x	x	x	x	x	x	x	x	x	X
	Out-door Experiments	x	x	x	x	x	x	x	x	x	x	x	x	X
	Laboratory Work	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	POGIL	x	x	x	x	x	x	x	x	x	x	x	x	X
	Flipped Classroom	x	x	x	x	x	x	x	x	x	x	x	x	X
	Field Based studies	x	x	x	x	x	x	x	x	x	x	x	x	x
	Problem Based Learning	x	x	x	x	x	x	x	x	x	x	x	x	X
	Project based Learning	x	x	x	x	x	x	x	x	x	x	x	x	X

Blooms Taxonomy: 1-Remembering, 2-Understanding, 3-Applying, 4-Analysing, 5-Evaluating, 6-Creating

	Lecture Method													
	Interactive Lecture Method	✓	✓	✓	-	-	✓	✓	✓	✓	✓	✓	✓	✓
	Group Discussion	✓	✓	✓	-	-	✓	✓	✓	✓	✓	✓	✓	✓
	Debate	x	x	x	-	-	x	x	x	x	x	x	x	X
	Experiential Learning	✓	✓	✓	-	-	✓	✓	✓	✓	✓	✓	✓	✓
	Out-door Experiments	✓	✓	✓	-	-	✓	✓	✓	✓	✓	✓	✓	✓
	Laboratory Work	✓	✓	✓	-	-	✓	✓	✓	✓	✓	✓	✓	✓
	POGIL	x	x	x	-	-	x	x	x	x	x	x	x	X

MATRIX 3 (Course wise)
MAPPING TEACHING METHODS/PEDAGOGIES TO CLOs AND PLOs
PROGRAMME: _____ B.Sc. Botany _____
Course: _Organic farming _____
(use if linked, if not linked and if mode not used)

	Flipped Classroom	x	x	x	-	-	x	x	x	x	x	x	x	X
	Field Based studies	✓	✓	✓	-	-	✓	✓	✓	✓	✓	✓	✓	✓
	Problem Based Learning	x	x	x	-	-	x	x	x	x	x	x	x	X
	Project based Learning	✓	✓	✓	-	-	✓	✓	✓	✓	✓	✓	✓	✓
<i>Blooms Taxonomy: 1-Remembering, 2-Understanding, 3-Applying, 4-Analysing, 5-Evaluating, 6-Creating</i>														

Level of Blooms Taxonomy (1-6)	T-L-E modes	CLO-1	CLO2	CLO 3	CLO 4	CLO5	PLO-1:	PLO-2 :	PLO -3:	PLO-4:	PLO-5:	PLO-6	PLO-7:	PLO-8:
	Traditional Lecture Method	✓	✓	✓	✓	-	✓	✓	✓	✓	✓	✓	✓	✓
	Interactive Lecture Method	✓	✓	✓	✓	-	✓	✓	✓	✓	✓	✓	✓	✓
	Group Discussion	✓	✓	✓	✓	-	✓	✓	✓	✓	✓	✓	✓	✓
	Debate	✓	✓	✓	✓	-	✓	✓	✓	✓	✓	✓	✓	✓
	Experiential Learning	✓	✓	✓	✓	-	✓	✓	✓	✓	✓	✓	✓	✓
	Out-door Experiments	✓	✓	✓	✓	-	✓	✓	✓	✓	✓	✓	✓	✓
	Laboratory Work	✓	✓	✓	✓	-	✓	✓	✓	✓	✓	✓	✓	✓
	POGIL	-	-	-	-	-	-	-	-	-	-	-	-	-
	Flipped Classroom	✓	✓	✓	✓	-	✓	✓	✓	✓	✓	✓	✓	✓
	Field Based studies	-	-	-	-	-	-	-	-	-	-	-	-	-
	Problem Based Learning	-	-	-	-	-	-	-	-	-	-	-	-	-
	Project based Learning	-	-	-	-	-	-	-	-	-	-	-	-	-

Blooms Taxonomy: 1-Remembering, 2-Understanding, 3-Applying, 4-Analysing, 5-Evaluating, 6-Creating

	Work													
	POGIL	x	x	x	x	x	x	x	x	x	x	x	x	X
	Flipped Classroom	x	x	x	x	x	x	x	x	x	x	x	x	X
	Field Based studies	x	x	x	x	x	x	x	x	x	x	x	x	X
	Problem Based Learning	x	x	x	x	x	x	x	x	x	x	x	x	X
	Project based Learning	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
<i>Blooms Taxonomy: 1-Remembering, 2-Understanding, 3-Applying, 4-Analysing, 5-Evaluating, 6-Creating</i>														

MATRIX 3 (Course wise)
MAPPING TEACHING METHODS/PEDAGOGIES TO CLOs AND PLOs
PROGRAMME: B.Sc. Botany
Course: Horticulture Floriculture and Landscaping
(use if linked, if not linked and if mode not used)

Level of Blooms Taxonomy (1-6)	T-L-E modes	CLO-1	CLO2	CLO 3	CLO 4	CLO5	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO 8
	Traditional Lecture Method	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Interactive Lecture Method	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Group Discussion	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Debate	x	x	x	x	x	x	x	x	x	x	x	x	X
	Experiential Learning	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Out-door Experiments	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Laboratory Work	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	POGIL	x	x	x	x	x	x	x	x	x	x	x	x	X
	Flipped Classroom	x	x	x	x	x	x	x	x	x	x	x	x	X
	Field Based studies	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Problem Based Learning	x	x	x	x	x	x	x	x	x	x	x	x	X
	Project based Learning	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Blooms Taxonomy: 1-Remembering, 2-Understanding, 3-Applying, 4-Analysing, 5-Evaluating, 6-Creating

	Project based Learning	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
Blooms Taxonomy: 1-Remembering, 2-Understanding, 3-Applying, 4-Analysing, 5-Evaluating, 6-Creating														
MATRIX 4 (Course wise) MAPPING ASSESSMENT MODES TO CLOs AND PLOs PROGRAMME: B.Sc. Botany Course: Plant Diversity <i>(use if linked, if not linked and if mode not used)</i>														
Level of Blooms Taxonomy (1-6)	T-L-E modes	CLO-1	CLO2	CLO 3	CLO 4	CLO5	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO 8
	Problem Based Learning	x	x	x	x	x	x	x	x	x	x	x	x	X
	Project based Learning	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Student Seminars	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Case Studies	x	x	x	x	x	x	x	x	x	x	x	x	X
	Student Presentation	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Gobbet	x	x	x	x	x	x	x	x	x	x	x	x	X
	Assignments	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Open Book Exam	x	x	x	x	x	x	x	x	x	x	x	x	X
	SAQ	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	MCQ	x	x	x	x	x	x	x	x	x	x	x	x	X
													
Blooms Taxonomy: 1-Remembering, 2-Understanding, 3-Applying, 4-Analysing, 5-Evaluating, 6-Creating														

	Open Book Exam	x	x	x	x	x	x	x	x	x	x	x	x	X
	SAQ	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	MCQ	x	x	x	x	x	x	x	x	x	x	x	x	X
													
<i>Blooms Taxonomy: 1-Remembering, 2-Understanding, 3-Applying, 4-Analysing, 5-Evaluating, 6-Creating</i>														

	MCQ	x	x	x	x	x	x	x	x	x	x	x	x	x	X
														
<i>Blooms Taxonomy: 1-Remembering, 2-Understanding, 3-Applying, 4-Analysing, 5-Evaluating, 6-Creating</i>															

	Gobbet	x	x	x	x	x	x	x	x	x	x	x	x	X
	Assignments	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Open Book Exam	x	x	x	x	x	x	x	x	x	x	x	x	X
	SAQ	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	MCQ	x	x	x	x	x	x	x	x	x	x	x	x	X
													
Blooms Taxonomy: 1-Remembering, 2-Understanding, 3-Applying, 4-Analysing, 5-Evaluating, 6-Creating														

MATRIX 4 (Course wise)														
MAPPING ASSESSMENT MODES TO CLOs AND PLOs														
PROGRAMME: _____ B.Sc Botany _____														
Course: <u>Organic farming</u>														
<i>(use if linked, if not linked and if mode not used)</i>														
Level of Blooms Taxonomy (1-6)	T-L-E modes	CLO-1	CLO2	CLO 3	CLO 4	CLO5	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO 8
	Problem Based Learning	-	-	-	-	-	-	-	-	-	-	-	-	-
	Project based Learning		-	-	-	-	-	-	-	-	-	-	-	-
	Student Seminars	✓	✓	✓	✓	-	✓	✓	✓	✓	✓	✓	✓	✓
	Case Studies	✓	✓	✓	✓	-	✓	✓	✓	✓	✓	✓	✓	✓

Student Presentation	√	√	√	√	-	√	√	√	√	√	√	√	√	√
Gobbet	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Assignments	√	√	√	√	-	√	√	√	√	√	√	√	√	√
Open Book Exam	√	√	√	√	-	√	√	√	√	√	√	√	√	√
SAQ	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MCQ	-	-	-	-	-	-	-	-	-	-	-	-	-	-
.....														

Blooms Taxonomy: 1-Remembering, 2-Understanding, 3-Applying, 4-Analysing, 5-Evaluating, 6-Creating

MATRIX 4 (Course wise)**MAPPING ASSESSMENT MODES TO CLOs AND PLOs****PROGRAMME: B.Sc. Botany****Course: Plant tissue culture**

(use if linked, if not linked and if mode not used)

Level of Blooms Taxonomy (1-6)	T-L-E modes	CLO-1	CLO2	CLO 3	CLO 4	CLO5	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO 8
	Problem Based Learning	x	x	x	x	x	x	x	x	x	x	x	x	x
	Project based Learning	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Student Seminars	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Case Studies	x	x	x	x	x	x	x	x	x	x	x	x	x
	Student Presentation	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Gobbet	x	x	x	x	x	x	x	x	x	x	x	x	x
	Assignments	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Open Book Exam	x	x	x	x	x	x	x	x	x	x	x	x	x
	SAQ	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	MCQ	x	x	x	x	x	x	x	x	x	x	x	x	x
													

Blooms Taxonomy: 1-Remembering, 2-Understanding, 3-Applying, 4-Analysing, 5-Evaluating, 6-Creating

MATRIX 4 (Course wise)

MAPPING ASSESSMENT MODES TO CLOs AND PLOs

PROGRAMME: B.Sc. Botany

Course: Horticulture Floriculture and Landscaping

(use if linked, if not linked and if mode not used)

Level of Blooms Taxonomy (1-6)	T-L-E modes	CLO-1	CLO2	CLO 3	CLO 4	CLO5	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO 8
	Problem Based Learning	x	x	x	x	x	x	x	x	x	x	x	x	x
	Project based Learning	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Student Seminars	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Case Studies	x	x	x	x	x	x	x	x	x	x	x	x	x
	Student Presentation	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Gobbet	x	x	x	x	x	x	x	x	x	x	x	x	x
	Assignments	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Open Book Exam	x	x	x	x	x	x	x	x	x	x	x	x	x
	SAQ	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	MCQ	x	x	x	x	x	x	x	x	x	x	x	x	x
													

Blooms Taxonomy: 1-Remembering, 2-Understanding, 3-Applying, 4-Analysing, 5-Evaluating, 6-Creating

MATRIX 4 (Course wise)

MAPPING ASSESSMENT MODES TO CLOs AND PLOs

PROGRAMME: B.Sc.

Course: BOT-VI.E-15 Economic Botany

(use if linked, if not linked and if mode not used)

Level of Blooms Taxonomy (1-6)	T-L-E modes	CLO-1	CLO2	CLO 3	CLO 4	CLO5	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO 8
	Problem Based Learning													
	Project based Learning	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
	Student Seminars	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
	Case Studies													
	Student Presentation	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
	Gobbet													
	Assignments	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
	Open Book Exam													
	SAQ	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
	MCQ													
													

Blooms Taxonomy: 1-Remembering, 2-Understanding, 3-Applying, 4-Analysing, 5-Evaluating, 6-Creating

