



CARMEL COLLEGE OF ARTS, SCIENCE & COMMERCE FOR WOMEN NUVEM - GOA

PROGRAMME OUTCOMES

The B.Sc. Programme, Carmel College of Arts, Science and Commerce for Women, Nuvem, Goa endeavors to achieve the following outcomes.

PO1: Attribute: **KNOWLEDGE:** Inculcate in our learners a quest for knowledge and an understanding of fundamental concepts and scientific principles related to various phenomena in daily life.

PO2: Attribute: **CRITICAL THINKING:** Acquire practical skills in handling scientific instruments and other experimental analysis, observational and problem-solving skills and draw logical inferences from scientific experiments. Teach learners the skills required for critical thinking.

PO3: Attribute: **RESEARCH:** To encourage a sense of curiosity and foster a research culture amidst fraternity and students.

PO4: Attribute: **SUSTAINABLE DEVELOPMENT:** Have an interdisciplinary approach and provide solutions for sustainable development.

PO5: Attribute: **COMMUNICATION SKILLS:** Have good communication skills which help in expressing ideas and views clearly and effectively.

PO6: Attribute: **LIFE LONG LEARNING:** Encourage a receptive mindset for lifelong learning.

PO7: Attribute: **SOCIETY:** To groom an eco-conscious and ethical society.

DEPARTMENT OF BOTANY PROGRAMME SPECIFIC OUTCOMES

On completion of the undergraduate B.Sc. Botany Degree Programme, the student will be able to:

PSO1: Attribute: **KNOWLEDGE:** Explain the fundamental concepts and demonstrate required practical skills in Plant Sciences.

PSO2: Attribute: **CRITICAL THINKING:** Identify, analyze and think critically and creatively to solve problems related to agriculture, environment, social welfare and other allied branches of Botany.

PSO3: Attribute: **RESEARCH AND COMMUNICATION SKILLS:** Identify the scientific problems, communicate ideas proficiently and develop solutions to benefit the society/ for the efficient functioning of the society.

PSO4: Attribute: **SUSTAINABLE DEVELOPMENT AND SOCIAL RESPONSIBILITY:** Inculcate an attitude of eco-consciousness to foster sustainable development for the benefit of the environment and society.

PSO5: Attribute: **LIFELONG LEARNING:** Demonstrate the knowledge of Botany in real-life situations to be competitive and self-reliant for entrepreneurial opportunities with an attitude of lifelong learning for the new developments in a broad context.

B. Sc. Botany Programme

Programme Structure for Semester I to VI – Bachelor of Science in Botany										
Semester	Major -Core	Minor	MC	AEC	SEC	I	D	VAC	Total Credits	Exit
I	BOT-101 Fundamentals of Botany (3T+1P)	BOT-112 Plants in Everyday Life (3T+1P)	BOT-133 Kitchen Gardening (3T)	(2T)	BOT-142 Nursery and Gardening (1T+2P)					
II				(2T)						BOT-162 Floriculture (1T+3P)
III	BOT-200 Diversity of Microbes and Non-flowering plants (3T+1P) BOT-201 Plant Physiology (3T+1P)	BOT-211 Plant-Animal Interactions (3T+1P)	BOT-231 Plant Propagation Methods (3T)	(2T)	BOT-241 Herbal Technology (1T+2P)					

IV	BOT-202 Anatomy and Reproductive Biology of Flowering Plants (3T+1P) BOT-203 Cell Biology and Plant Biochemistry (3T+1P) BOT-204 Biofertilizers (3T+1P) BOT-205 Palynology (1T+1P)	BOT-221 Techniques in Floral Arrangement (2T+2P) [VET]								BOT-261 Organic farming (1+3)
V	BOT-300 Plant Taxonomy and Phylogeny (3T+1P) BOT-301 Cytogenetics and Plant Breeding (3T+1P) BOT-302 Microbiology and Plant Pathology (3T+1P) BOT-303 Field Botany (1T+1P)	BOT-321 Mushroom Cultivation Technology (3T+1P) [VET]				BOT-361 Internship- (2)				

VI	BOT-304 Plant Tissue Culture (3T+1P)									
	BOT-305 Plant Ecology and Phytogeography (3T+1P)	BOT-322 Post-harvest Technology of Fruits and Vegetables (3T+1P) [VET]							20	
	BOT-306 Molecular Biology and Genetic Engineering (3T+1P)									
	BOT-307 Minor Project (4)									

Major [Disciplinary/Interdisciplinary Major (Core)]; Minor (Disciplinary/Interdisciplinary Minors); MC (Multidisciplinary Courses); VET (Vocational Education and Training); AEC (Ability Enhancement Courses); I/D (Internship/Apprenticeship/Dissertation); VAC (Value Added Courses).

SEMESTER I & II

Major (Core)

Name of the Programme : B. Sc. (Botany)
Course Code : BOT-101
Title of the Course : Fundamentals of Botany
Number of Credits : 4 (3 Theory + 1 Practical)
Effective from AY : 2026-27 (Revised)

Prerequisites for the course:	Basic knowledge of Biology.	
Course Objective(s):	This course aims to: 1. Provide a fundamental understanding of plant diversity, evolution, classification and life processes. 2. Develop knowledge of morphology, anatomy, tissues, and physiological responses of flowering plants. 3. Introduce modern advancements in plant science, including AI, remote sensing, GIS, biofortification, synthetic biology, and biofuels. 4. Impart practical skills in plant identification, observation, experimentation and analysis through laboratory experiments, field visits and hands-on training with scientific instruments and digital tools, fostering scientific inquiry and environmental awareness.	
Content:	Theory:	45 hours
	Module 1: Introduction to plant kingdom and life processes. Fundamental notions of plants: Relation of plants to man; interdisciplinary links of Botany to other sciences; definition and importance of different branches of Botany (Phycology, Mycology, Systematic Botany, Cytology, Anatomy, Morphology, Embryology, Biochemistry, Physiology, Genetics, Ecology, Phytogeography, Economic Botany, Ethnobotany and Paleobotany). Evolutionary history of plants: Evolution of plants on geological time scale; Fossil formation process, types of fossils – Impression, Compression, Petrification and Amber. Classification of plant kingdom: Seven kingdom classification of life; characteristic features of the plant kingdom and plant groups (Algae, Fungi, Bryophytes, Pteridophytes, Gymnosperms and Angiosperms). Life processes: Definition, brief process and significance of osmosis, imbibition, diffusion, transpiration, photosynthesis and respiration.	15 hours
	Module 2: Morphology of flowering plants, tissues and plant responses. Morphology of flowering plants: Root: Characteristics, functions, types (tap root and adventitious root); modifications of tap root for storage (fusiform, conical, napiform); modifications of adventitious roots for storage (tuberous, fasciculated, nodulated) and other modifications (prop, stilt, parasitic, breathing, epiphytic	15 hours

	and clinging roots). Stem: Characteristics, functions and types – aerial (caudex, decurrent, twiner, tendril, thorn, phylloclade); sub-aerial (runner, sucker, offset, stolon); underground (rhizome, bulb, corm, tuber). Leaf: Characteristics, structure and functions; types (simple, compound); phyllotaxy (alternate, opposite, whorled); shape (linear, lanceolate, elliptical, ovate, cordate, sagittate); apex (acute, obtuse, acuminate); margin (entire, wavy, serrate), venation (reticulate, parallel). Inflorescence: Characteristics, types – cymose (monochasial, bichasial) and racemose (raceme, panicle, spike, spadix, catkin, umbel, capitulum). Flower: Whorls and their functions, symmetry, aestivation. Fruit: Definition and types – simple (dry {achenial – achene, caryopsis, nut, and capsular – legume, follicle, capsule} and fleshy {berry, pome, drupe}), aggregate (eaterio of berries and eaterio of follicles) and multiple (sorosis, syconus). Seed: Parts of a seed, types (endospermic and non-endospermic), structure of dicot and monocot embryo, seed dispersal mechanisms, germination (hypogeal and epigeal). Tissues in plants: Types, position and functions of meristems; position and functions of simple tissues (parenchyma, collenchyma, sclerenchyma) and complex tissues (xylem and phloem). Plant responses: Tropic responses in plants (phototropism, geotropism, chemotropism, hydrotropism and thigmotropism); leaf movements (nyctinasty and seismonasty).	
	Module 3: Recent technologies in plant science and instrumentation. Recent technologies in plant science: Artificial intelligence in agriculture; role of remote sensing and GIS; sensor-based crop monitoring; plant identification apps – Google Lens. Plants and food security: Global food challenges; food demand and nutritional security; underutilized crops; biofortification. Future perspectives in plant science: Plant synthetic biology; biofuels from plants (biodiesel – <i>Jatropha curcas</i>, ethanol – <i>Saccharum officinarum</i>, algal biofuel – <i>Chlorella vulgaris</i>). Instrumentation: Principle and applications – microscopy, spectrophotometer, centrifuge, laminar air flow unit, orbital shaker, pH meter and autoclave.	15 hours
	Practical:	30 hours
	1. Study of different types of fossils.	2 hours
	2. Study of different types of stem and root.	2 hours
	3. Study of different characters of leaves with respect to types, phyllotaxy, shape, apex, margin and venation.	2 hours

	4. Study of whorls of a flower, types of inflorescence and fruits.	2 hours
	5. a. Demonstration of epigeal and hypogeal seed germination. b. Study of effect of UV light on germinating seeds.	2 hours
	6. Study of types of meristems, simple and complex tissues using permanent slides.	2 hours
	7. a. Demonstration of phototropism and geotropism in plants. b. Demonstration of nyctinasty and seismonasty in plants.	2 hours
	8. a. Comparison of oxygen evolution during photosynthesis in bright light and diffused light by inverted funnel method. b. Comparison of carbon dioxide evolution during respiration at room temperature and RT+10°C in germinating seeds using phenol red indicator.	4 hours
	9. a. Study of plasmolysis in <i>Rheo</i> leaf cells using sucrose solution. b. Study of imbibition in seeds.	2 hours
	10. Study of basic instruments used for preparation of culture media and inoculation of seeds (demonstration).	2 hours
	11. Understanding the use of Agribuddy App (or similar agriculture apps) for farm planning and crop management.	2 hours
	12. Visit to research institution. / Field visit to observe the plant diversity (Algae, Bryophytes, Pteridophytes, Gymnosperms and Angiosperms) and identification of any two plant species using Google Lens or similar app.	6 hours
Pedagogy:	Lectures, tutorials, presentations, demonstrations, assignments, use of multimedia, hands-on experiments and field visit.	
References/ Readings:	Arnold, CA (2018). An Introduction to Paleobotany. Surjeet Publications, Delhi. Basu, D, Mandal, A and Sinha, A (2021). 101 Mobile Applications in Agriculture: A ready reckoner. New Delhi Publishers, India. Bhojwani, SS, Bhatnagar, SP and Dantu, PK (2015). The Embryology of Angiosperms. 6th edition. Vikas Publishing House Pvt. Ltd., New Delhi. Gangulee, SC, Das, KS, Dutta, CD and Kar, AK (1968). College Botany Vol. I, II and III. New Central Book Agency, Kolkata. Jain, VK (2017). Fundamentals of Plant Physiology. 19th edition. S. Chand Company Ltd., New Delhi. Mahajan, M and Katak, S (2025). Biological Invasions in India: Impacts and Management. India: MoEFCC. Pandey, A (2009). Handbook of Plant-based Biofuels. CRC Press, U.S. Pandey, A, Chauhan, B, Singh, MP, Ansari, MJ, Shukla, D, Shukla, K, and Husain, M (2024). Botany Lab Essentials. Book Saga Publications. Sambamurthy, AVSS (2006). A Textbook of Bryophytes, Pteridophytes, Gymnosperms and Paleobotany. I.K. International Publication, New Delhi. Sharma, VK (1991). Techniques in Microscopy and Cell Biology. Tata McGraw-Hill, New Delhi. Sharma, A, Biswas, A, Singh, A, Rana, O and Rath, V (2026).	

	Multimodal Artificial Intelligence in Precision Agriculture: Practices, Challenges and Applications. CRC Press, US. 12. Singh, G (2012). Plant Systematics. Theory and Practice. 3rd edition. Oxford & IBH Pvt. Ltd., New Delhi. 13. Steward, WM (2010). Paleobotany and the Evolution of Plants. Cambridge University Press, Cambridge. 14. Surwase, S, Deshmukh, P, Kadu, P and Singh, SK (2025). Foundations and Applications of Remote Sensing and GIS. BP International Publishers, India. 15. Tiwari, MK, Devi, MP, Gupta, P, Salam, P, Kumar, R and Devi, YS (2026). Underutilized Crops: Towards Nutritional Security and Climate Resilience. CRC Press, US.											
Course Outcomes:	On completion of this course, students will be able to: CO1: Recall the diversity of plant life, basic biological processes, plant structures, adaptive responses, modern botanical advancements and laboratory tools. CO2: Explain evolutionary trends, structural organization, functional activities of plants, technological interventions in agriculture, and principles of scientific instruments. CO3: Apply concepts of plant biology and emerging technologies to interpret observations, solve basic botanical problems and perform laboratory-based tasks. CO4: Analyze and evaluate plant systems and technological innovations to address issues related to sustainability, food security and future developments in plant science.											
PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	1	1	1	0	2	1	3	1	1	1	2
CO2	3	2	1	2	0	2	1	3	2	1	2	2
CO3	2	3	2	2	1	2	1	3	3	2	2	2
CO4	2	3	2	3	1	3	2	2	3	3	3	3

Minor

Name of the Programme : B. Sc. (Botany)
Course Code : BOT-112
Title of the Course : Plants in Everyday Life
Number of Credits : 4 (3 Theory + 1 Practical)
Effective from AY : 2026-27 (Revised)

Prerequisites for the course:	Basic knowledge of Biology.	
Course Objective(s):	This course aims to: 1. Familiarize students with the importance of plants in daily life, traditional practices, environmental management and sustainable resource utilization using modern plant-based technologies. 2. Identify economically important plants and their uses in value-added plant products. 3. Impart hands-on training in plant identification, preparation of herbal and eco-friendly products, extraction techniques, laboratory testing, and field-based study of local plant resources.	
Content:	Theory:	45 hours
	Module 1: Plant services in everyday life. Plants and society: Introduction to Botany; plant resources, uses and applications in everyday life. Ethnobotany in local festivals / rituals (any two); role of traditional knowledge in conservation. Role of plants: Phytoremediation (definition and types: phytoextraction, phytostabilization, rhizodegradation, phytovolatilization, rhizofiltration); lichens as pollution indicators. Plant nutrient cycling – litter decomposition and organic manures. Basics of plant morphology for identification: Roots (tap, adventitious); stem (aerial, underground); leaf (parts of the leaf; phyllotaxy – alternate, opposite, whorled; types – compound, simple; venation – parallel, reticulate); inflorescence (cymose, racemose); whorls of flower; fruits (simple, aggregate, multiple). Modern plant sciences: Definition, technique and applications of hydroponics and aeroponics; precision farming – concept and its applications in sustainable food production.	15 hours
	Module 2: Plant resources and utilization. Common wild plants: Unique features and uses of the following: Hirda (<i>Terminalia chebula</i>), Matti (<i>Terminalia elliptica</i>), Bhillo mad (<i>Caryota urens</i>), Chunna (<i>Ziziphus rugosa</i>) and Kanna (<i>Carissa carandas</i>). Grandma's herbal pouch: Unique features, plant parts used and medicinal importance of the following: Tulsi (<i>Ocimum sanctum</i>), Adulsa (<i>Adhatoda vasica</i>), Aale (<i>Zingiber officinale</i>), Halad (<i>Curcuma longa</i>), Kirayte	15 hours

	(<i>Andrographis paniculata</i>), Ganjan (<i>Cymbopogon citratus</i>), Ottalao (<i>Coleus aromaticus</i>) and Punarnava (<i>Boerhaavia diffusa</i>). Essential crop plants used in daily life: Unique feature, parts used and uses of the following: - Cereals: Rice, wheat - Milletts: Ragi, jowar - Legumes: Bengal gram, green gram - Cash crops: Cashew, sugarcane - Plantation crops: Banana, mango - Essential oils / edible oils: <i>Eucalyptus</i>, coconut - Tuber crops: Potato, sweet potato - Vegetable crops: Radish, lady's finger - Spices: Nutmeg, black pepper - Timber: Teak (Sailo), rose wood (Shisham)	
	Module 3: Utilization of plants in value added products. Herbal based hair dye: Preparation of hair dye using different ingredients (Henna, Bhringaraj, <i>Hibiscus</i>, Amla) and their role; method of application. Herbal cosmetics and aromatics: Introduction and scope; extraction methods – maceration, infusion, decoction, distillation and tinctures. Role of plants as cleansers (neem, cucumber), scrubs (marigold, orange peel), wash (rose – face wash; <i>Hibiscus</i>, amla – hair wash), packs (sandalwood, turmeric) and creams (rose, jasmine). Types of herbal preparations – powder, poultice, ointments, tablets, syrup, balms, capsules and creams. Paper industry: Raw materials used, manufacturing process and kinds of paper. Beverages: Processing of tea and coffee. Eco-friendly use of plant parts: Arecanut spathe, banana fresh leaves, Kumyo leaves (<i>Carex arborea</i>), jackfruit leaves and bamboo culm. Fibres: Processing and uses of coir, banana and sisal.	15 hours
	Practical:	30 hours
	1. Demonstration of decomposition of leaf litter to prepare organic manure.	4 hours
	2. Setting up a hydroponic unit to grow any one vegetable (demonstration).	2 hours
	3. Identification of common wild plants (any two); plants from Grandma's herbal pouch (any two); cereals, millets, legumes, cash crops, plantation crops, essential oils, edible oils, tuber crops, vegetable crops, spices and timbers (any one plant from each category).	4 hours
	4. a. Preparation of decoction of kirayte leaves. b. Extraction of gel from <i>Aloe vera</i> .	2 hours

	5. Extraction of essential oil from lemon grass / <i>Eucalyptus</i> leaves by distillation.	2 hours
	6. Extraction and cleaning of sisal fibre.	2 hours
	7. Preparation of herbal hair dye.	2 hours
	8. Preparation of plant-based Holi colours (solid and liquid) using turmeric and beetroot.	2 hours
	9. Preparation of handmade paper from waste paper.	2 hours
	10. Comparison of starch grains in tubers of potato and sweet potato using histochemical test.	2 hours
	11. Field visit to study local flora and use of mobile app (iNaturalist or PlantNet or similar app) to identify any 10 plants.	6 hours
Pedagogy:	Lectures, tutorials, presentations, demonstrations, assignments, use of multimedia, hands-on experiments and field visit.	
References/ Readings:	1. Billings, S and Collingwood, S (2013). The Big book of home remedies. Lulu.com publisher. 2. Buckley, C (2020). Plant Magic: Herbalism in Real Life. Roost Books Publishers, New York. 3. Hill, AF (1952). Economic Botany: A Textbook of Useful Plants and Plant Products. McGraw Hill Publishing Company Ltd., New Delhi. 4. Kochhar, SL (2012). Economic Botany in the Tropics. MacMillan India Ltd., New Delhi. 5. Purohit, SS and Vyas, SP (2008). Medicinal Plant Cultivation: A Scientific Approach. Agrobios, India. 6. Rao, RS (1985-1986). Flora of Goa, Diu, Daman & Nagar-Haveli. Volume I and II. Botanical Survey of India, New Delhi. 7. Raviv, M, Leith, JH and Bar-Tal, A (2019). Soilless Culture: Theory and Practice. 2nd edition. Academic Press, New York. 8. Reddy, TY and Shankara Reddy, GH (2026). Principles of Agronomy. Kalyani Publishers, New Delhi. 9. Sambamurty, AVSS and Subramanyam, NS (1989). A Textbook of Economic Botany. Wiley Eastern Ltd., New Delhi. 10. Sen, S (2009). Economic Botany. NCBA Publishers, New Delhi. 11. Shailesh, R (2019). Everyday Ayurveda: The complete book of Ayurvedic home remedies. Notion Press, India. 12. Singh V, Pande, PC and Jain, DK (2009). A Text Book of Economic Botany. Rastogi Publications, Uttar Pradesh. 13. Trivedi, PC (2006). Medicinal Plants: Ethnobotanical Approach. Agrobios, India. 14. Upadhyay, R (2023). Botany for B.Sc. students, Economic Botany, Ethnomedicine and phytochemistry/Commercial Botany and phytochemical Analysis. S. Chand and Company Ltd. Publishers, India. 15. Wickens, GE (2001). Economic Botany: Principles & Practices. Springer, Netherlands.	

Course Outcomes:	On completion of this course, students will be able to: CO1: Recall the significance of plants in daily life, environmental management, traditional practices, plant resources, and value-added products. CO2: Explain plant-based services, morphological features for plant recognition, resource utilization, and preparation of plant-derived products. CO3: Apply knowledge of plant resources, sustainable cultivation practices, and herbal products for healthy and sustainable living. CO4: Analyze and evaluate the role of plants in sustainability, healthcare, food security, and value addition for societal well-being.											
PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	1	1	2	0	2	2	3	1	1	2	2
CO2	3	2	1	2	1	2	2	3	2	1	2	2
CO3	2	3	2	3	1	3	3	3	3	2	3	3
CO4	2	3	2	3	2	3	3	2	3	3	3	3

Multidisciplinary Course (MC)**Name of the Programme : B. Sc. (Botany)****Course Code : BOT-133****Title of the Course : Kitchen Gardening****Number of Credits : 3 Theory****Effective from AY : 2026-27 (Revised)**

Prerequisites for the course:	Basic knowledge of plants.	
Course Objective(s):	This course aims to: 1. Provide students with an understanding of the principles and practices of kitchen gardening. 2. Introduce concepts of soil preparation, organic nutrient management, sustainable pest and disease control, and cultivation of different plants for kitchen gardens. 3. Emphasize crop planning, intercropping, crop rotation, pollination strategies, and seasonal scheduling to promote sustainable food production, resource efficiency and household nutritional security.	
Content:	Theory:	45 hours
	Module 1: Introduction to kitchen garden, nursery management for vegetable crops and routine operations. Kitchen garden: Concept and importance; planning and layout of kitchen garden; indoor/urban kitchen gardening (terrace or balcony spaces); tools and implements; compost pit. Routine operations in kitchen garden: Irrigation methods and scheduling; cropping patterns, spacing of crops; mulching, earthing up; pinching, pruning; plant supports (stakes, trellis, moss/coir sticks); manuring; harvesting; seeds and tuber collection. Nursery management: Objectives of a nursery; types (beds, seedling trays, etc.); site preparation; soil preparation. Seed sowing: Seed quality and viability; breaking seed dormancy; seed treatment (biological and chemical); methods of seed sowing (line sowing, broadcasting). Nursery care: Managing micro-climate; hardening-off seedlings; transplanting and reducing transplant shock.	15 hours
	Module 2: Soil preparation, organic manures, pest and disease management. Soil preparation: Soil types (sand, loam, clay); basic soil testing and soil amendments; improving soil structure; primary and secondary tillage; bed preparation (raised, flat, basin). Organic manures: Benefits and application methods of organic manures (panchagavya, jeevamrit, beej amrit solution, compost, fish manure, bone meal, farm yard manure, vermicompost, wood ash, oil-cake, green manure).	15 hours

	Pest and disease management: Common garden pests – sucking insects (mealy bugs, aphids, white flies), biting and chewing insects (caterpillars, beetles, grasshoppers), borers, ants, slugs and snails, rodents. Plant protection measures – biocontrol agents, bio-pesticides, pheromones, trap crops. Common diseases of vegetable plants, symptoms and control measures (damping-off, powdery mildew, yellow vein mosaic). Weed control methods; soil solarization.	
	Module 3: Plants for kitchen garden and planning kitchen garden activities. Plants for kitchen garden: Classification of annual vegetables on the basis of planting season. General cultivation practices followed for: - Leafy greens: Red amaranth, spinach. - Fruiting vegetables: Okra, tomato. - Gourds: Cucumber, little gourd (<i>tendli</i>). - Tubers and roots: Sweet potato, radish. - Beans: Cluster beans, long beans (<i>virvil</i>). - Perennials: Drumstick, banana. - Medicinal herbs: Ginger, lemon grass. - Microgreens. Intercropping plants; crop rotation; companion plants; pollinator attracting plants; artificial pollination for increasing yield. Planning kitchen garden activities: Importance of a kitchen gardening planner; monthly vegetable growing operations as per the season (time of sowing, successional sowing, transplanting). Preparation of a yearly diary of kitchen gardening activities.	15 hours
Pedagogy:	Lectures, tutorials, presentations, assignments, live specimens, herbarium specimens and use of multimedia.	
References/ Readings:	1. Agrawal, PK (1993). Hand Book of Seed Technology. Department of Agriculture and Cooperation, National Seed Corporation Ltd., New Delhi. 2. Alphonso, N (2004). Home Gardening. Agriculture Officers' Association, Panaji, Goa. 3. Bailey, LH (2009). Manual of Gardening. Srishti Book Distributors, New Delhi. 4. Biles, RE (2003). The Complete Book of Gardening. Biotech Books, Delhi. 5. Bose, TK and Mukherjee, D (1972). Gardening in India. Oxford & IBH Publishing Co., New Delhi. 6. Karant, A (2013). Seed Technology. Black Prints India INC., New Delhi. 7. Rao, KM (2005). Textbook of Horticulture. 2nd edition. Macmillan India Limited, New Delhi. 8. Rao, PS (2016). Vegetable Crops Production. Sonali Publications, New Delhi.	

	9. Sheela, VL (2011). Horticulture. MJP Publications, Chennai. 10. Sud, RK and Kumar, S (2004). Herbs: Culinary, Medicinal, Aromatic. Pawan Kumar Scientific Publishers, Jodhpur. 11. Sutton, M (1997). The Culture of Vegetables and Flowers from Seeds and Roots. Ambey Publications, New Delhi. 12. Trivedi, PP (1987). Home Gardening. Indian Council of Agricultural Research, New Delhi. 13. Zingare, AK (2013). A Manual of Gardening. Satyam Publishers & Distributors, Jaipur.											
Course Outcomes:	On completion of this course, students will be able to: CO1: Recall the principles of kitchen gardening, nursery practices, soil management, plant protection measures, and cultivation requirements of commonly grown garden plants. CO2: Explain the significance of nursery management, routine garden operations, organic inputs, pest and disease control strategies, and seasonal planning in kitchen gardening. CO3: Outline the principles of nursery management, routine gardening activities, organic nutrient management, pest and disease control, and seasonal scheduling in kitchen gardens. CO4: Apply appropriate techniques for raising nurseries, preparing soil, managing crops, and scheduling kitchen garden activities for productive cultivation.											
PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	2	3	2	3	3	3	2	2	3	3
CO2	3	3	3	3	2	3	3	3	3	3	3	3
CO3	3	3	3	3	2	3	3	3	3	3	3	3
CO4	3	3	3	3	2	3	3	3	3	3	3	3

Skill Enhancement Course (SEC)**Name of the Programme : B. Sc. (Botany)****Course Code : BOT-142****Title of the Course : Nursery and Gardening****Number of Credits : 3 (1 Theory + 2 Practical)****Effective from AY : 2026-27 (Revised)**

Prerequisites for the course:	Basic knowledge of Biology.	
Course Objective(s):	This course aims to: 1. Increase the understanding about the different types of gardens, their features and routine operations in nursery management and gardening. 2. Impart skills in designing a plant nursery, different types of gardens, cultivation practices to be followed in operating a plant nursery and garden.	
Content:	Theory:	15 hours
	Module 1: Plant nursery, gardens and their management. Introduction: Definition, objectives and scope of a plant nursery and garden. Plant nursery layout, infrastructure, planning and seasonal activities; marketing challenges. Types of gardens and their design: Indoor garden (gardening in window boxes, tubs, troughs, trays and hanging baskets; vertical garden; terrarium; bonsai) and outdoor garden (landscape, avenue plantation, park, rock garden, water garden, terrace garden and kitchen garden). Features of a garden (fence, hedge, edge, steps, drives and paths; arches, pergolas, lawns, carpet bed, flower bed, shrubbery, border, topiary, plant supports, garden adornments). Nursery and Garden management: Preparation of soil, methods of breaking seed dormancy, planting (direct seeding and transplanting), hardening, irrigation, manuring, staking, pinching, pruning and defoliation; management of pests and diseases.	15 hours
	Practical:	60 hours
	1. Preparation of a layout sketch of a plant nursery.	2 hours
	2. Preparation of layout sketches of any 2 types of gardens.	4 hours
	3. Familiarization with various tools, implements and plant supports.	2 hours
	4. Identification and description of any 2 plants used for avenues, hedges, flower beds, lawns, ornamental shrubs, rock garden, water garden and indoor garden.	4 hours
	5. Raising of any 2 seedlings in seed trays, preparation of potting mix, transplanting of seedlings in pots and bags; care and maintenance of plants till flowering/maturity.	6 hours
	6. Treatment of seeds of coriander or other suitable seeds to break dormancy and to find germination percentage of treated seeds.	2 hours

	7. Propagation of plants by cutting, layering, budding, grafting, runners, suckers, corms, bulbs, bulbils and tubers.	6 hours
	8. Preparation of a coir stick/coir basket.	2 hours
	9. Preparation of a garden in window boxes, troughs and trays (any 2).	4 hours
	10. Preparation of a terrarium.	2 hours
	11. Preparation/creation of a vertical garden and its after care.	4 hours
	12. Preparation of potting medium and cultivation of different types of potted plants (foliage, succulent, anthurium and orchid).	4 hours
	13. Demonstration of cultivation of house plants and after care of upright and climbing plants.	4 hours
	14. Cultivation of any 3 vegetables in the College Botanical Garden (red amaranth, cluster beans, cucurbits, chillies, lady's finger, ginger and tomato).	6 hours
	15. Preparation of compost.	4 hours
	16. Field visit to a plant nursery or landscape garden.	4 hours
Pedagogy:	Lectures, tutorials, presentations, demonstrations, assignments, use of multimedia, participatory learning, hands-on experiments and field visit.	
References/ Readings:	1. Acquaah, G (2019). Horticulture: Principles and Practices. 4th edition. Pearson India Education Services Pvt. Ltd., India. 2. Agrawal, PK (1993). Hand Book of Seed Technology. Department of Agriculture and Cooperation, National Seed Corporation Ltd., New Delhi. 3. Alphonso, N (2004). Home Gardening. Agriculture Officers' Association, Panaji, Goa. 4. Bose, TK and Mukherjee, D (1972). Gardening in India. Oxford & IBH Publishing Co., New Delhi. 5. Courtier, J and Clarke, G (1997). Indoor Plants: The Essential Guide to Choosing and Caring for Houseplants. Reader's Digest, New York. 6. Edmond, JB, Musser, AM and Andrews, FS (1957). Fundamentals of Horticulture. McGraw Hill Book Co., New Delhi. 7. Janick, J (1979). Horticultural Science. 3rd edition. W.H. Freeman & Co., San Francisco, USA. 8. Kumar, N (1997). Introduction to Horticulture. Rajalakshmi Publications, Nagercoil. 9. Randhawa, GS and Mukhopadhyay, A (1986). Floriculture in India. Allied Publishers Limited, New Delhi. 10. Rao, KM (2005). Textbook of Horticulture. 2nd edition. MacMillan India Limited, New Delhi. 11. Rao, PS (2016). Vegetable Crops Production. Sonali Publications, New Delhi. 12. Sandhu, MK (1989). Plant Propagation. Wiley Eastern Ltd., Bangalore. 13. Stevenson, V (1984). Plants and Flowers in the Home. Treasure Press, London. 14. Trivedi, PP (1987). Home Gardening. Indian Council of Agricultural	

	Research, New Delhi. 15. Zingare, AK (2013). A Manual of Gardening. Satyam Publishers & Distributors, Jaipur.											
Course Outcomes:	On completion of this course, students will be able to: CO1: Recall the principles of plant nursery establishment, garden types, garden features, and routine horticultural practices. CO2: Explain the planning, design, management, and maintenance requirements of nurseries and gardens. CO3: Describe the principles involved in the planning, design, management, and maintenance of nurseries and gardens. CO4: Apply appropriate techniques for nursery operations, plant propagation, garden development, and plant care practices.											
PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	1	1	1	1	2	2	3	1	1	1	2
CO2	3	2	2	3	2	2	3	3	3	2	3	2
CO3	3	2	2	3	2	2	3	3	3	2	3	2
CO4	3	3	2	3	2	3	3	3	3	2	3	3

Exit Course

Name of the Programme : B. Sc. (Botany)
Course Code : BOT-162
Title of the Course : Floriculture
Number of Credits : 4 (1 Theory + 3 Practical)
Effective from AY : 2026-27 (Revised)

Prerequisites for the course:	Basic knowledge of Biology.	
Course Objective(s):	This course aims to: 1. To provide knowledge in nursery bed preparation, use of various methods of plant propagation, use of garden implements, cultivation methods, care and harvesting of flowers and plant parts in floriculture. 2. To impart practical skills in garden operations, plant propagation, designing floral arrangements and marketing of flowers.	
Content:	Theory:	15 hours
	Module 1: Floriculture: Scope, routine garden operations, propagation and commercial aspects. Scope and future of floriculture: Scope of floriculture; global trends and importance. Future of floriculture as an industry in Goa and government initiatives (SCHEMES). Routine garden operations and propagation: Different garden tools and their operation. Preparation of nursery beds, sowing of seeds, soil sterilization, planting and transplanting; pricking, pinching, defoliation and mulching. Role of plant growth regulators (auxins, gibberellins, cytokinins, ABA and florigen), fertilizers and manures. Types of grafting, layering, cutting and budding of ornamental plants. Commercial aspects of floriculture: Different styles and types of flower arrangements. Preparation of floral bouquets, floral rangoli, garlands, crown, wreaths, baskets and dry flower arrangements.	15 hours
	Practical:	90 hours
	1. Ornamental garden planting plan/design.	2 hours
	2. Garden implements and their operation; plant supports.	4 hours
	3. a. Identification and description of plants based on types and shapes: flowers (any 5); cut greens (any 5); cacti (any 2); water plants (any 2); lawns (any 2). b. Decorative plants according to their shapes (upright – <i>Sansiviera</i> , bushy – <i>Dieffenbachia</i> , trailing – <i>Chlorophytum</i> , climbing – <i>Monstera</i> , standard – <i>Ficus benjamina</i> , architectural – <i>Chamaerops</i> /palms, ball – Cacti, rosette – <i>Haworthia</i> , <i>Echeveria</i>).	10 hours
	4. Soil preparation and sterilization.	2 hours
	5. Preparation of different types of nursery beds (flat beds, raised beds, ridges and furrows, basin) and pots.	4 hours
	6. Methods of vegetative propagation: Grafting, layering, cuttings, offsets, budding.	6 hours

	7. Handling and propagation of bulbs, bulbils, tubers, suckers, runners and corms.	4 hours
	8. Cultivation of plants based on substrates and maintenance of the same till flowering/maturity: Coconut husk/coco peat: Orchids and Anthuriums. Soil: Cultivation of flowering / foliage / water / cacti / succulent plants (1 of each category).	14 hours
	9. Aesthetic grouping of plants in open and container gardens.	4 hours
	10. Garden operations: Mulching, pricking, topping, trimming and training, feeding and repotting.	6 hours
	11. Harvesting, packing of cut flowers – packaging material (polythene, butter paper, brown paper, newspaper, corrugated cardboard); storage conditions (room temperature, refrigeration, water).	6 hours
	12. Prolonging shelf-life of cut flowers (any two).	2 hours
	13. Identification of plant diseases and pests (Insects, Fungi, Bacteria, Virus and Mycoplasma).	6 hours
	14. Methods of drying plant materials (air-drying, desiccants, sand, microwave/oven).	4 hours
	15. Styles of flower arrangements: Garlands (any 2); bouquets (any 2); crown (any 1); wreath (any 1); basket (any 1); flower swag (any 1), Ikebana (any 1), dry flower arrangement (any 1).	10 hours
	16. Field visit to an orchidarium / flowering plant polyhouse / nursery / landscaped public place.	6 hours
Pedagogy:	Lectures, tutorials, presentations, demonstrations, assignments, use of multimedia, participatory learning, hands-on experiments and field visit.	
References/ Readings:	1. Database Floriculture and Seeds (apeda.gov.in). 2. Gorer, R (1978). The Growth of Gardens. Faber and Faber, London. 3. Gupta, J and Dubey, RK (2018). Factors Affecting Post-Harvest Life of Flower Crops. International Journal of Current Microbiology and Applied Sciences (7) 548-557. 4. Hall, DA (2002). Fertilizers and Manures. Biotech Books, Delhi. 5. Hartman, HT and Kester, DF (1976). Plant Propagation: Principles and Practices. Prentice & Hall of India, New Delhi. 6. Knee, M (2000). Selection of biocides for use in floral preservatives. Postharvest Biology and Technology (18): 227-34. 7. Publications of Directorate of Agriculture, Govt. of Goa and ICAR, Old Goa. 8. Randhawa, GS and Mukhopadhyay, A (1986). Floriculture in India. Allied Publishers, India. 9. Singh, K, Singh, R, Kumar, R and Chawla, N (2010). Effect of harvesting stages and BAP on post storage keeping quality of cut stems of Chrysanthemum (<i>Dendranthema grandiflora</i>). Journal of Ornamental Horticulture (13): 233-236. 10. Swarup, V (1997). Ornamental Horticulture. MacMillan India Ltd., UK.	

Course Outcomes:	On completion of this course, students will be able to: CO1: Recall the scope of floriculture, garden operations, propagation methods, plant growth regulators, and floral decorative practices. CO2: Explain the principles of nursery management, routine horticultural operations, plant propagation techniques, and the significance of floriculture in the ornamental plant industry. CO3: Outline the key aspects of nursery management, common horticultural practices, plant propagation, and the contribution of floriculture to the ornamental plant sector. CO4: Apply appropriate floricultural practices for raising ornamental plants, carrying out propagation, and preparing floral arrangements and decorations.											
PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	1	1	3	1	3	3	3	3	2	3	3
CO2	3	2	1	3	2	3	3	3	3	2	3	3
CO3	3	3	2	3	2	3	3	3	3	3	3	3
CO4	3	3	3	3	2	3	3	3	3	3	3	3

SEMESTER III

Disciplinary/Interdisciplinary Major (Core)

Name of the Programme : B. Sc. (Botany)

Course Code : BOT-200

Title of the Course : Diversity of Microbes and Non-flowering Plants

Number of Credits : 4 (3 Theory + 1 Practical)

Effective from AY : 2024-25

Prerequisites for the course:	Basic knowledge of microbes and plant groups.	
Course Objectives:	This course aims to: 1. Familiarize students with diverse groups of microbes and non-flowering plants. 2. Provide the ability to identify and classify microbes and non-flowering plant groups. 3. Impart knowledge of the morphology, life cycle, reproduction and economic importance of various microbes and non-flowering plants.	
Content:	Theory:	45 hours
	Module 1: Viruses, Bacteria and Fungi Viruses: General structure, characteristics, origin and evolution; major groups (DNA viruses, RNA viruses and retroviruses); general account of replication; characteristics of virus-like particles (viroids, virusoids and prions). Bacteria: General characteristics of eubacteria and archaebacteria; shapes and arrangement of bacteria; ultrastructure of bacterial cell; cell structure and morphology of cyanobacteria; binary fission; genetic recombination (conjugation, transformation and transduction); economic importance. Fungi: General characteristics; Ainsworth's classification; morphological features of <i>Mucor</i> , <i>Aspergillus</i> , <i>Agaricus</i> and <i>Saccharomyces</i> ; reproduction (asexual, sexual and parasexual); ecological and economic importance of fungi; general characteristics, types and significance of symbiotic fungal associations (lichens and mycorrhizae).	15 hours
	Module 2: Algae and Bryophytes Algae: General characteristics; range of thallus structure; Smith's classification; life cycle patterns (haplontic, diplontic, isomorphic, heteromorphic, haplobiontic and diplobiontic); methods of reproduction; morphological features of <i>Nostoc</i> , <i>Spirogyra</i> , <i>Sargassum</i> and <i>Polysiphonia</i> ; ecological and economic importance. Bryophytes: General characteristics; Smith's classification; alternation of generations; methods of reproduction; morphological features of <i>Riccia</i> , <i>Anthoceros</i> and <i>Funaria</i> ; ecological and economic importance.	15 hours
	Module 3: Pteridophytes and Gymnosperms	15 hours

	Pteridophytes: General characteristics; Smith's classification; alternation of generations; morphology of early land plants (<i>Cooksonia</i> and <i>Rhynia</i>); morphological features and reproductive structures of <i>Psilotum</i>, <i>Selaginella</i>, <i>Equisetum</i> and <i>Pteris</i>; heterospory and seed habit; stelar evolution; ecological and economic importance. Gymnosperms: General characteristics and life cycle; Coulter and Chamberlain's classification; morphological features and reproductive structures of <i>Cycas</i>, <i>Pinus</i> and <i>Gnetum</i>; ecological and economic importance.	
	Practical:	30 hours
	1. Study of viruses (T-Phage, TMV) and bacteria using electron micrographs.	2 hours
	2. Study of bacteria by monochrome staining and Gram staining techniques.	4 hours
	3. Study of asexual and sexual stages of <i>Mucor</i> and <i>Aspergillus</i> (temporary mounts / permanent slides).	4 hours
	4. Study of <i>Agaricus</i> basidiocarp (button and mature stage); cross-section through gills to locate basidiospores.	2 hours
	5. Study of different types of lichen thalli (crustose, foliose and fruticose).	2 hours
	a. Study of endomycorrhizae using trypan blue staining method. b. Study of ectomycorrhizae (permanent slides or photographs).	2 hours
	7. Morphology of thallus and reproductive structures of <i>Nostoc</i> , <i>Spirogyra</i> , <i>Sargassum</i> and <i>Polysiphonia</i> (fresh or preserved specimens / permanent slides).	2 hours
	8. Morphology of thallus and sporophyte of <i>Riccia</i> , <i>Anthoceros</i> and <i>Funaria</i> (fresh or preserved specimens / permanent slides).	4 hours
	9. Morphology and reproductive structures of <i>Psilotum</i> , <i>Equisetum</i> and <i>Pteris</i> (fresh or preserved specimens / permanent slides).	2 hours
	10. Morphology of <i>Selaginella</i> and L.S. of its strobilus.	2 hours
	11. Morphology and reproductive structures (male and female cones) of <i>Cycas</i> , <i>Pinus</i> and <i>Gnetum</i> (fresh / preserved specimens).	4 hours
Pedagogy:	Lectures, use of multimedia, assignments, presentations, hands-on experiments and demonstrations.	
References/ Readings:	1. Alexopoulos, CJ, Mims, CW and Blackwell, M (1996). Introductory Mycology. 4th edition. John Wiley and Sons (Asia), Singapore. 2. Bhatnagar, SP and Moitra, A (1996). Gymnosperms. New Age International (P.) Ltd., New Delhi. 3. Das, K (2023). Microbes and Plant Diversity. Mahaveer Publications, Assam. 4. Kumar, HD (1999). Introductory Phycology. 2nd edition. Affiliated East-West Press Pvt. Ltd., New Delhi.	

	5. Kushwaha, AK (2020). Fungi, Viruses, Bacteria and Mycoplasma. Lambert Academic Publishing, U.K. 6. Pandey, BP (2017). Botany for Degree Students: Biodiversity. S. Chand and Company Ltd., New Delhi. 7. Parihar, NS (1991). An Introduction to Embryophyta. Volume I: Bryophyta. Central Book Depot, Allahabad. 8. Rashid, A (1998). An Introduction to Bryophyta. Vikas Publishing House Pvt. Ltd., Noida. 9. Santra, SC (2015). Practical Botany. Volume 1. New Central Book Agency (P.) Ltd., Kolkata. 10. Sethi, IK and Walia, SK (2011). Text Book of Fungi and their Allies. MacMillan Publishers Pvt. Ltd., New Delhi. 11. Sharma, OP (2011). Series on Diversity of Microbes and Cryptogams: Algae. McGraw Hill Education India Pvt. Ltd., Chennai. 12. Sharma, OP (2011). Series on Diversity of Microbes and Cryptogams: Fungi and Allied Microbes. McGraw Hill Education India Pvt. Ltd., Chennai. 13. Sharma, OP (2014). Series on Diversity of Microbes and Cryptogams: Bryophyta. McGraw Hill Education India Pvt. Ltd., Chennai. 14. Singh, V, Pande, PC and Jain, DK (2019). A Textbook of Botany - Archegoniate (Bryophyta, Pteridophyta, Gymnosperms and Palaeobotany). Rastogi Publications, Meerut. 15. Smith, GM (1955). Cryptogamic Botany. Volume I: Algae and Fungi. 2nd edition. McGraw-Hill, New York. 16. Smith, GM (1955). Cryptogamic Botany. Volume II: Bryophytes and Pteridophytes. 2nd edition. McGraw-Hill, New York. 17. Tortora, GJ, Funke, BR and Case, CL (2010). Microbiology: An Introduction. 10th edition. Pearson Benjamin Cummings, U.S.A. 18. Vashishta, BR and Sinha, AK (2011). Botany for Degree Students: Bryophyta. S. Chand and Company Pvt. Ltd., New Delhi. 19. Vashishta, BR and Sinha, AK (2014). Botany for Degree Students: Fungi. S. Chand and Company Pvt. Ltd., New Delhi. 20. Vashishta, PC, Sinha, AK and Kumar, A (2006). Botany for Degree Students: Gymnosperms. S. Chand and Company Pvt. Ltd., New Delhi. 21. Vashishta, PC, Sinha, AK and Kumar, A (2010). Botany for Degree Students: Pteridophyta. S. Chand and Company Pvt. Ltd., New Delhi.											
Course Outcomes:	On completion of this course, students will be able to: 1. Identify and classify microbes and non-flowering plants based on their characteristic features. 2. Compare and contrast the morphological features within and between the groups for a comprehensive understanding of the basis of their classification. 3. Examine the life cycle and methods of reproduction of microbes and non-flowering plant groups. 4. Appraise the economic importance of microbes and non-flowering plants.											
PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	2	1	1	3	1	3	2	1	1	3
CO2	3	3	2	1	1	3	1	3	3	1	1	3
CO3	3	2	2	1	1	3	1	3	2	1	1	3
CO4	3	3	2	2	1	3	2	3	3	1	2	3

Disciplinary/Interdisciplinary Major (Core)

Name of the Programme : B. Sc. (Botany)
Course Code : BOT-201
Title of the Course : Plant Physiology
Number of Credits : 4 (3 Theory + 1 Practical)
Effective from AY : 2024-25

Prerequisites for the course:	Basic knowledge of Biology.	
Course Objectives:	This course aims to: 1. Develop an understanding of the physiological processes occurring in plants and their responses. 2. Enable the analysis of plant responses to various factors and understand their effects on physiological processes. 3. Impart practical skills essential for planning and executing research in plant physiology and allied fields.	
Content:	Theory:	45 hours
	Module 1: Transport of water, inorganic and organic solutes Plant water relations: Water potential and its components; water transport through xylem (ascent of sap); transpiration and its significance; factors affecting transpiration; root pressure and guttation. Mineral nutrition: Criteria for determining essentiality of elements; macronutrients and micronutrients; role and deficiency symptoms of essential elements; nutrient uptake and transport across the membrane (ion channels, carriers and pumps). Translocation in phloem: Translocation of organic solutes; composition of phloem sap; path of translocation (girdling experiment); mechanism of translocation of organic solutes (Pressure Flow Model); phloem loading and unloading; assimilate partitioning.	15 hours
	Module 2: Plant metabolism Photosynthesis: Structure of photosynthetic apparatus; photosynthetic pigments (chlorophyll a, chlorophyll b, carotenoids, phaeophytins and phycobillins). Light reaction: Photosystems and harvesting of light; electron transport pathways (cyclic and non-cyclic); mechanism of ATP synthesis (photophosphorylation). Dark reaction: C ₃ , C ₄ and CAM pathways of carbon fixation. Mechanism of photorespiration. Respiration: Glycolysis, TCA cycle, oxidative phosphorylation, Pentose Phosphate Pathway; anaerobic respiration.	15 hours
	Module 3: Nitrogen metabolism, phytohormones and plant responses Nitrogen metabolism: Biological nitrogen fixation; assimilation of nitrate and ammonia. Phytohormones: Discovery and physiological roles of auxins, gibberellins, cytokinins, abscisic acid and ethylene.	15 hours

	Plant responses to light, temperature and stress: Discovery and role of phytochrome and cryptochrome; responses of red and far-red light on photomorphogenesis; technique, mechanism and applications of vernalization. Plant responses to stress (drought, salt, metals and radiations).	
	Practical:	30 hours
	1. Determination of osmotic potential of plant cell sap by plasmolytic method.	2 hours
	2. Study of the effect of environmental factors (light and wind) on transpiration using excised twig.	2 hours
	3. Calculation of stomatal index and stomatal frequency of a mesophyte and a xerophyte.	4 hours
	4. Qualitative tests to detect mineral nutrients in plants (any four).	2 hours
	5. Separation of chlorophyll pigments by paper chromatography.	2 hours
	6. Demonstration of Hill's reaction.	2 hours
	7. Comparison of anatomical features of C ₃ and C ₄ plants.	2 hours
	8. Determination of chlorophyll a, chlorophyll b and total chlorophyll content in shade and sun plants.	2 hours
	9. Determination of oxygen evolution during photosynthesis in aquatic plants by titrimetric method.	2 hours
	10. Study of photo-oxidation of photosynthetic pigments.	2 hours
	11. Comparative study of rate of respiration in any two parts of a plant.	2 hours
	12. Determination of Q ₁₀ of germinating seeds.	2 hours
	13. Study of bacteria from root nodule suspension by Gram staining technique.	2 hours
	14. Study of the effect of auxins on rooting.	2 hours
Pedagogy:	Lectures, use of multimedia, tutorials, assignments, presentations, hands-on experiments, demonstrations and team-based learning.	
References/ Readings:	1. Bajracharya, D (1999). Experiments in Plant Physiology - A Laboratory Manual. Narosa Publishing House, New Delhi. 2. Evert, RF (2012). Raven Biology of Plants. International Edition. 8th edition. Palgrave Macmillan, U.K. 3. Hopkins, WG and Huner, NP (2009). Introduction to Plant Physiology. 4th edition. John Wiley & Sons, U.S.A. 4. Jain, VK (2022). Fundamentals of Plant Physiology. S. Chand and Company, Delhi. 5. Kochar, SL and Gujral, SK (2020). Plant Physiology: Theory and Applications. Cambridge University Press India Private Limited, New Delhi. 6. Pandey, SN and Sinha, BK (2006). Plant Physiology. Vikas Publication House, New Delhi. 7. Sinha, R (2015). Modern Plant Physiology. Narosa Publishing House, New Delhi. 8. Taiz, L, Zeiger, E, Moller, IM and Murphy, A (2015). Plant Physiology	

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Disciplinary/Interdisciplinary Minor**Name of the Programme : B. Sc. (Botany)****Course Code : BOT-211****Title of the Course : Plant-Animal Interactions****Number of Credits : 4 (3 Theory + 1 Practical)****Effective from AY : 2024-25**

Prerequisites for the course:	Basic knowledge of Biology.	
Course Objectives:	This course aims to: 1. Enable students to explore the diversity and understand the mechanism of interactions between plants and animals. 2. Assess the outcome of the interactions at population, community and ecosystem level.	
Content:	Theory:	45 hours
	Module 1: Plant-animal interactions – an evolutionary approach Interdependence of plants and animals: Plants as producers, animals as consumers, interdependence of plants and animals for survival; overview of plant-animal interactions; evolutionary perspective of plant-animal interactions; evolution and coevolution of plants and animals, species interactions and the evolution of biodiversity. Diversity of plant-animal interactions: Parasitism, mutualism, antagonism, commensalism, competition; multi-trophic level interaction; the sensory biology of the interaction between plants and animals - vision, chemoreception, olfaction and multimodal signaling; energetics of plant-animal interactions.	15 hours
	Module 2: Pollination and dispersal biology Pollination biology: Plant reproductive biology; pollination types, cross-pollination and its significance; pollinator groups; pollination syndromes; floral adaptation to different pollinators (insects, birds, mammals); floral attractants, types and significance; types of pollinator rewards. Fruits, seeds and their dispersers: Adaptations in plants for dispersal (fruit chemistry, palatability, fruit size, seed coat structure, secondary metabolites in fruits and seeds); fruit and seed dispersers; adaptations in dispersers (external and internal).	15 hours
	Module 3: Defense mechanism, plant-ant interactions and future perspectives in plant-animal interactions Defense mechanism of plants: Plant crypsis, aposematism and mimicry, plant herbivore interaction; animal response to plant defense mechanism; sensory aspects of carnivorous plants, trap mechanisms; benefits of carnivory. Plant-ant interactions: Plants as ant food; pollination by ants; leaf-cutting and seed-harvesting ants; effect of harvesters on vegetation; ants as primary and secondary seed dispersers.	15 hours

	Future perspectives in plant-animal interactions: Impact of invasive plants and GM crops on native plant-animal interactions; climate change, habitat loss, fragmentation, pesticide use, hunting and breakdown of plant-animal interactions; impact on community, diversity, productivity and livelihood.	
	Practical:	30 hours
	1. Study of plant-animal interactions – parasitism, mutualism, antagonism, commensalism, competition (campus visit / videos / photographs).	4 hours
	2. Study of floral adaptation to different pollinators (insects, birds and mammals).	4 hours
	3. Study of morphological adaptations in plants for fruit and seed dispersal.	2 hours
	4. Study of morphological adaptations in animals for fruit and seed dispersal.	2 hours
	5. Isolation of nectar from flowers and detection of sugars using Benedict's reagent.	2 hours
	6. Detection of the presence of osmophores in flowers (orchid / jasmine / or any other suitable flower).	2 hours
	7. Microscopic observation of plant galls.	2 hours
	8. Plant defenses against herbivores (videos / photographs).	2 hours
	9. Study of traps - snap, flypaper, bladder, lobster pot, pitfall - in carnivorous plants (fresh specimens / videos / photographs).	4 hours
	10. Study of fig-wasp mutualism (field visit / videos).	2 hours
	11. Field visits to observe plant-animal interactions, pollinators and dispersers.	4 hours
Pedagogy:	Lectures, use of multimedia, tutorials, assignments, presentations, hands-on experiments, demonstrations, team-based learning and field visit.	
References/ Readings:	1. Abrahamson, WG (1989). Plant-animal Interactions. McGraw-Hill Book Company, N.Y. 2. Crawley, MJ (1986). Plant Ecology. Blackwell Scientific Publications, Oxford, U.K. 3. Del-Claro, K and Torezan-Silingardi, HM (2021). Plant-Animal Interactions: Source of Biodiversity. Springer Nature, Switzerland. 4. Herrera, CM and Pellmyr, O (2009). Plant Animal Interactions: An Evolutionary Approach. John Wiley & Sons, U.K. 5. Rico-Gray, V and Oliveira, PS (2007). The Ecology and Evolution of Ant-Plant Interactions. University of Chicago Press, U.S. 6. Schaefer, MH and Ruxton, GD (2011). Plant-Animal Communication. Oxford University Press, U.K. 7. Simcha, LY (2016). Defensive (anti-herbivory) Coloration in Land Plants: Anti-herbivory Plant Coloration and Morphology. Springer, Switzerland. 8. Traveset, A and Richardson, DM (2020). Plant Invasions - The Role of Biotic Interactions. CABI, Wallingford, U.K. 9. Walker, T (2020). Pollination: The Enduring Relationship between Plant	

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Multidisciplinary Course (MC)

Name of the Programme : B. Sc. (Botany)
Course Code : BOT-231
Title of the Course : Plant Propagation Methods
Number of Credits : 3 Theory
Effective from AY : 2024-25

Prerequisites for the course:	Basic knowledge of gardening.	
Course Objectives:	This course aims to: 1. Impart knowledge of the basic structures, tools and media used in plant propagation. 2. Familiarize students with various methods employed to propagate plants.	
Content:	Theory:	45 hours
	Module 1: Basics of plant propagation General aspects of plant propagation: History, scope and its importance; plant life cycle; vegetative/asexual and sexual methods of propagation - definition, objectives, advantages and disadvantages. Propagation structures and tools: Mist chamber, humidifiers, green house, polyhouse, glass house, lath house, cold frames and hot beds. Garden tools for plant propagation. Media for propagation: Organic and inorganic media used for propagation of plants. Garden operation: Preparation of beds, soil sterilization, planting, transplanting and hardening. Field visit to a plant nursery to observe propagation practices and preparation of field report.	15 hours
	Module 2: Natural methods of plant propagation Natural plant propagation: Concept, types, advantages and disadvantages. Vegetative/asexual structures in natural propagation: Runners, stolons, offsets, suckers, crowns, bulbs, bulbils, corms, tubers and rhizomes. Sexual structures in natural plant propagation: Seed; parts of a seed; seed germination; types of seed germination (epigeal and hypogeal); factors controlling germination of seeds – light, age, maturity, dormancy and viability. Apomictic seeds and polyembryony. Field visit in the college campus to observe natural ways of plant propagation and preparation of field report.	15 hours
	Module 3: Artificial methods of plant propagation Artificial plant propagation: Concept, types, advantages and disadvantages. Artificial methods using vegetative/asexual structures: Propagation by cuttings - concept, principle, advantages and disadvantages; types of cuttings (stem, root and leaf). Factors	15 hours

	influencing rooting of cuttings; use of plant growth regulators in rooting of cuttings. Propagation by layering - concept, principle, advantages and disadvantages; types of layering (simple, mound, compound, air). Propagation by budding - concept, principle, advantages and disadvantages; types of budding (shield/T and patch). Propagation by grafting - concept, principle, advantages and disadvantages; types of grafting (inarching, side and splice). Propagation by tissue culture/micro-propagation - concept and applications. Artificial methods using sexual structures: Artificial methods of breaking seed dormancy - mechanical (scarification), hot water treatment, soaking in water. Synthetic seeds - basic concept and applications.											
Pedagogy:	Lectures, use of multimedia, assignments, presentations, videos and field visit.											
References/ Readings:	1. Hartman, HT, Kester, DE, Davies, Jr. FT and Geneve, PL (2015). Plant Propagation: Principles and Practices. Prentice Hall of India Private Limited, New Delhi. 2. Krishnan, PR (2014). Plant Nursery Management: Principles and Practices. Central Arid Zone Research Institute (ICAR), Jodhpur. 3. Rajan, S and Markose, BL (2007). Propagation of Horticultural Crops. New India Publishing Agency – NIPA, India. 4. Randhawa, GS and Mukhopadhyay, A (1986). Floriculture in India. Allied Publishers Limited, India. 5. Rao, KM (2005). Textbook of Horticulture. 2nd edition. Macmillan India Limited, New Delhi. 6. Sadhu, MK (1996). Plant Propagation. New Age International Publishers, New Delhi. 7. Sheela, VL (2011). Horticulture. MJP Publications, Chennai. 8. Tarai, RK, Naik, B, Sahoo, AI and Mandal, P (2020). Plant Propagation and Nursery Management. New India Publishing Agency, New Delhi.											
Course Outcomes:	On completion of this course, students will be able to: 1. Recall various plant propagation structures, tools and their utilization. 2. Understand the advantages and disadvantages of vegetative / asexual and sexual plant propagation methods. 3. Apply techniques to break seed dormancy. 4. Appraise vegetative/asexual and sexual plant propagation techniques.											
PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	1	1	2	1	3	2	3	1	2	1	3
CO2	3	2	2	2	2	2	2	3	2	2	2	2
CO3	3	3	3	2	1	3	2	3	3	2	2	3
CO4	3	3	3	2	2	3	2	3	3	2	2	3

Skills Enhancement Course (SEC)

Name of the Programme : B. Sc. (Botany)
Course Code : BOT-241
Title of the Course : Herbal Technology
Number of Credits : 3 (1 Theory + 2 Practical)
Effective from AY : 2024-25

Prerequisites for the course:	Basic knowledge of plants.	
Course Objectives:	This course aims to: 1. Impart knowledge on the use of medicinal and aromatic plants in the manufacture of herbal drugs, cosmeceuticals and nutraceuticals. 2. Focus on developing entrepreneurial skills by imparting hands-on training in the preparation of herbal products.	
Content:	Theory:	15 hours
	Module 1: Herbal technology for industrially important products and formulations Introduction: Importance of herbal medicines, brief account of methods of collection and processing (drying, garbling, packing and storage) of herbal raw materials. Methods of preparation of crude herbal extracts and drug evaluation: Brief account of decoction, maceration, infusion, hot continuous extraction, distillation and supercritical fluid extraction. Brief account of drug evaluation using morphological, microscopic, chemical, physical and biological methods; quality control of herbal drugs. Drug adulteration - deliberate and indeliberate adulteration; types of adulterants. Herbal cosmeceuticals and nutraceuticals: Herbal plants used in cosmetic formulations for skin care - cream, lotion and sunscreen; hair care - oil, shampoo, conditioner and dye; oral care - toothpaste and mouthwash (any two plants for each product and its formulation). Herbal excipients - significance of substances of natural origin as excipients (binding agents, colourants, diluents, emulsifying agents, flavours and sweetening agents) - any two examples for each type. Aromatherapy - study of various oils used in aromatherapy with special reference to its applications in inhalation, local application and bath. Herbal nutraceuticals and their health benefits; culinary uses of any five herbs. Herbal product-based industries and institutions: Contribution of Dabur Ltd., Himalaya Wellness Company and Vicco Labs; Central Institute of Medicinal and Aromatic Plants (CIMAP) and National Medicinal Plants Board (NMPB); role of Traditional Knowledge Digital Library (TKDL).	15 hours
	Practical:	60 hours
	1. Study of biological source, organoleptic characters, chemical	10 hours

	constituents and medicinal uses of the following plants: <i>Allium sativum</i> , <i>Andrographis paniculata</i> , <i>Bixa orellana</i> , <i>Boerhavia diffusa</i> , <i>Catharanthus roseus</i> , <i>Centella asiatica</i> , <i>Garcinia indica</i> , <i>Hemidesmus indicus</i> , <i>Justicia adhatoda</i> , <i>Ocimum sanctum</i> , <i>Phyllanthus emblica</i> , <i>Piper longum</i> , <i>Rauwolfia serpentina</i> , <i>Saraca indica</i> and <i>Tinospora cordifolia</i> (fresh specimens or photographs).	
	2. Study of organoleptic and microscopic characters, chemical constituents and medicinal uses of the following herbs: <i>Aloe vera</i> - leaf, <i>Coriandrum sativum</i> - fruit, <i>Curcuma longa</i> - rhizome, <i>Cymbopogon citratus</i> - leaf, <i>Drimys indica</i> - bulb scale and <i>Zingiber officinale</i> - rhizome (fresh specimens).	6 hours
	3. Preparation of herbal decoction for common cold (demonstration).	2 hours
	4. Preparation of lemon grass or mint tea/infusion (demonstration).	2 hours
	5. Microscopic evaluation and chemical tests (Metanil yellow test and chalk powder test) to detect adulteration of turmeric powder.	2 hours
	6. Preparation of herbal cream (demonstration).	2 hours
	7. Preparation of herbal lotion (demonstration).	2 hours
	8. Preparation of herbal soap (demonstration).	4 hours
	9. Preparation of herbal lip balm (demonstration).	2 hours
	10. Preparation of rose water (demonstration).	2 hours
	11. Preparation of herbal hair oil (demonstration).	2 hours
	12. Preparation of herbal shampoo (demonstration).	2 hours
	13. Preparation of herbal hair dye (demonstration).	2 hours
	14. Preparation of herbal mouthwash (demonstration).	2 hours
	15. Identification of chemical characters of herbal excipients: Acacia, agar, starch and tragacanth.	4 hours
	16. Preparation of herbal infused oils for inhalation, massage oil for local application and bath salts (demonstration).	2 hours
	17. Preparation of coriander chutney or any other herbal dish (demonstration).	2 hours
	18. Oral presentation and submission of a herbal plant grown by the student.	6 hours
	19. Field visit to herbal industry / medicinal plant garden.	4 hours
Pedagogy:	Lectures, use of multimedia, tutorials, assignments, presentations, hands-on experiments, demonstrations, field visit and team-based learning.	
References/ Readings:	1. Agarwal, SS and Paridhavi, M (2012). Herbal Drug Technology. 2nd edition. Universities Press (India) Private Limited, Hyderabad. 2. Gokhale, SB and Kokate, CK (2017). Practical Pharmacognosy. 18th edition. Nirali Prakashan, Pune. 3. Handa, P (1982). Herbal Beauty Care. Orient Paperbacks, Delhi. 4. Kalia, AN (2005). Textbook of Industrial Pharmacognosy. CBS Publishers & Distributors Pvt. Ltd., New Delhi.	

5. **Kapoor, S** (2000). Khana Khazana. Popular Prakashan Pvt. Ltd., Mumbai.
6. **Kar, A** (2003). Pharmacognosy and Pharmacobiotechnology. 2nd edition. New Age International (P.) Limited, New Delhi.
7. **Khandelwal, KR** (2002). Practical Pharmacognosy: Techniques and Experiments. 9th edition. Nirali Prakashan, Pune.
8. **Kokate, CK, Purohit, AP and Gokhale, SB** (2015). Pharmacognosy. 51st edition. Nirali Prakashan, Pune.
9. **Kumar, NC** (1993). An Introduction to Medical Botany and Pharmacognosy. Emkay Publications, Delhi.
10. **Kumaresan, V** (2015). Herbal Biotechnology and Pharmacognosy. Saras Publication, Tamil Nadu.
11. **Mendonsa, G** (2007). The Best of Goan Cooking. UBS Publishers Distributors Pvt. Ltd., New Delhi.
12. **Miller, L and Miller, B** (1998). Ayurveda and Aromatherapy: The Earth Essential Guide to Ancient Wisdom and Modern Healing. Lotus Press, United States.
13. **Prasad, N** (2020). Biodiversity: Herbal Medicine. Random Publications, New Delhi.
14. **Qadry, JS** (2014). A Textbook of Pharmacognosy. 17th edition. CBS Publishers & Distributors Pvt. Ltd., New Delhi.
15. **Rosaline, A** (2011). Pharmacognosy. MJP Publishers, Chennai.
16. **Shah, B and Seth, AK** (2010). Textbook of Pharmacognosy and Phytochemistry. Elsevier India Private Limited, New Delhi.
17. **Shirsat, MK, Dwivedi, J, Khathuriya, R and Wadhwa, AA** (2017). Handbook of Pharmacognosy. Success Publications, Pune.
18. **Trease, EC and Evans, WC** (2009). Pharmacognosy. 16th edition. W.B. Saunders Co. Ltd., London.
19. **Unnisa, A and Sahoo, SK** (2015). A Textbook of Industrial Pharmacognosy. Professional Publications, Hyderabad.
20. **Vimaladevi, M** (2015). Textbook of Herbal Cosmetics. CBS Publishers & Distributors Pvt. Ltd., New Delhi.

Course Outcomes:

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

1. Recall the importance of medicinal and aromatic plants for preparation of herbal medicines.
2. Describe the methods for preparation of crude herbal extracts and drug evaluation.
3. Apply the acquired knowledge and skills to prepare herbal products.
4. Analyse the use of herbal plants for preparation of cosmeceuticals and nutraceuticals.

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SEMESTER IV

Disciplinary/Interdisciplinary Major (Core)

Name of the Programme : B. Sc. (Botany)

Course Code : BOT-202

Title of the Course : **Anatomy and Reproductive Biology of Flowering Plants**

Number of Credits : 4 (3 Theory + 1 Practical)

Effective from AY : 2024-25

Prerequisites for the course:	Basic knowledge of Botany.	
Course Objectives:	This course aims to: 1. Provide knowledge of tissue systems, primary structure, secondary growth and wood anatomy. 2. Impart theoretical and practical understanding of the process of sexual reproduction leading to seed production in flowering plants.	
Content:	Theory:	45 hours
	Module 1: Tissue systems and primary structure Meristematic tissues: Characteristics and functions; classification based on position; root and shoot apical meristems (Histogen theory and Tunica-Corpus theory). Concept of tissue system: Dermal tissue, ground tissue and vascular tissue; types of vascular bundles; epidermal appendages, stomatal type; secretory structures. Primary structure: Anatomy of root, stem and leaf in monocots and dicots; nodal anatomy; root-stem transition.	15 hours
	Module 2: Secondary growth and wood anatomy Secondary growth: Normal secondary growth in dicot stem and root; anomalous secondary growth in stems of <i>Boerhavia</i> and <i>Dracaena</i> ; structure and functions of periderm, rhytidome and lenticels; activity of vascular cambium; secondary xylem; secondary phloem. Wood anatomy: Ring porous and diffuse porous wood; tyloses; heartwood and sapwood; tension wood; dendrochronology and other applications of plant anatomy.	15 hours
	Module 3: Reproductive biology of flowering plants Male and female reproductive structures: Structure of anther (microsporangium); development of anther and formation of pollen grains (microsporogenesis); anther wall; development of male gametophyte. Structure and parts of the ovule (megasporeangium); types of ovules; megasporogenesis and development of female gametophyte (embryo sac); types of embryo sacs - monosporic (<i>Polygonum</i> type), bisporic (<i>Allium</i> type) and tetrasporic (<i>Peperomia</i> type); ultrastructure of mature embryo sac. Pollination, fertilization and seed structure: Mechanism of self- and cross-pollination (types, adaptations and significance); pollen-pistil interaction; double fertilization and its significance. Structure of dicot and monocot embryo; endosperm types and	15 hours

	functions. Structure of mature seed; endospermous seed; fruit and seed dispersal and its significance.	
	Practical:	30 hours
	1. Study of root and shoot apical meristems (permanent slides/photographs).	2 hours
	2. Maceration of wood to study xylem elements.	2 hours
	3. Study of primary structure: a. Stems of <i>Helianthus annuus</i> / <i>Eupatorium odoratum</i> and <i>Oryza sativa</i> / <i>Zea mays</i> . b. Roots of <i>Helianthus annuus</i> / <i>Eupatorium odoratum</i> and <i>Oryza sativa</i> / <i>Zea mays</i> .	4 hours
	4. Study of multiple epidermis and cystoliths in leaves of <i>Ficus</i> sp. and buliform cells in leaves of <i>Zea mays</i> .	2 hours
	5. Normal secondary growth in dicot stem (<i>Helianthus annuus</i> / <i>Eupatorium odoratum</i>).	2 hours
	6. Anomalous secondary growth in the stems of <i>Boerhavia</i> and <i>Dracaena</i> (fresh or preserved specimens).	4 hours
	7. Study of epidermal appendages and stomatal types (any 5 types - fresh specimens/permanent slides).	4 hours
	8. Study of structure of young and mature anther (permanent slides/photographs).	2 hours
	9. Study of structure and types of ovules: orthotropous, anatropous, circinotropous, amphitropous/ campylotropous (permanent slides/photographs).	2 hours
	10. Temporary mount of stigma to observe germinating pollen grains (petunia/datura or any other suitable flower).	2 hours
	11. Study of pollination types and dispersal mechanisms of fruits/seeds (any 4 types - fresh or preserved specimens/ photographs).	4 hours
Pedagogy:	Lectures, use of multimedia, assignments, presentations and hands-on experiments.	
References/ Readings:	1. Arthur, JE and MacDaniels, LH (1977). An Introduction to Plant Anatomy. 2nd edition. Tata McGraw-Hill Publishing Company Ltd., New Delhi. 2. Bhojwani, SS and Bhatnagar, SP (2011). Embryology of Angiosperms. 5th edition. Vikas Publication House Pvt. Ltd., New Delhi. 3. Bhojwani, SS, Bhatnagar, SP and Dantu, PK (2015). Embryology of Angiosperms. 6th edition. Vikas Publishing House Pvt. Ltd., Noida. 4. Chandurkar, PJ (1983). Plant Anatomy. Oxford & IBH, New Delhi. 5. Dickson, WC (2000). Integrated Plant Anatomy. Academic Press, Cambridge, U.K. 6. Esau, K (1977). Anatomy of Seed Plants. 2nd edition. Wiley Eastern Pvt. Ltd., New Delhi. 7. Fahn, A (1990). Plant Anatomy. 4th edition. Pergamon Press, U.K. 8. Johansen, DA (1990). Plant Embryology. Waltham Mass, U.S.A. 9. Maheswari, P (1982). Introduction to the Embryology of Angiosperms.	

	Tata McGraw Hill Inc., New Delhi. 10. Mishra, BK (2017). Anatomy of Angiosperms. Kalyani Publishers, New Delhi. 11. Mishra, BK (2017). Reproductive Biology of Angiosperms. Kalyani Publishers, New Delhi. 12. Pandey, BP (2014). Plant Anatomy. S. Chand & Company Pvt. Ltd., New Delhi. 13. Pandey, BP (2015). A Text Book of Botany: Angiosperms – Taxonomy, Anatomy, Embryology & Economic Botany. S. Chand and Company Pvt. Ltd., New Delhi. 14. Pandey, SN and Chadha, A (1993). A Textbook of Botany: Plant Anatomy and Economic Botany. Vol. III. Vikas Publishing House Pvt. Ltd., New Delhi. 15. Santra, SC, Chatterjee, TP and Das, AP (2006). College Botany Practical. Volume I. New Central Book Agency (P.) Limited, Kolkata. 16. Singh, V, Pandey, PC and Jain, DK (2017). Reproductive Biology of Angiosperms. Rastogi Publications, Meerut.											
Course Outcomes:	On completion of this course, students will be able to: 1. Recall the characteristic features of meristems, tissue systems and sexual reproductive structures in plants. 2. Understand the differences between primary and secondary structures in flowering plants and explain development of reproductive structures, significance of pollination and seed dispersal. 3. Illustrate various structures in anatomy and reproductive biology and apply the knowledge of embryology in seed production. 4. Analyse the characteristics of wood and applications of plant anatomy in different fields.											
PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	1	1	1	2	1	1	3	1	1	1	1
CO2	3	3	2	1	2	1	1	3	3	2	2	1
CO3	3	3	3	3	1	2	2	3	3	3	2	2
CO4	3	3	3	2	1	2	2	3	3	2	2	2

Disciplinary/Interdisciplinary Major (Core)**Name of the Programme : B. Sc. (Botany)****Course Code : BOT-203****Title of the Course : Cell Biology and Plant Biochemistry****Number of Credits : 4 (3 Theory + 1 Practical)****Effective from AY : 2024-25**

Prerequisites for the course:	Basic knowledge of Biology.	
Course Objectives:	This course aims to: 1. Provide an overview of structure of the cell and subcellular components and their functions. 2. Enhance knowledge of classification, structure and functions of biomolecules. 3. Impart skills to study properties of biomolecules and to estimate their quantities for bio-analytical research.	
Content:	Theory:	45 hours
	Module 1: Cell and subcellular components Cell theory, ultrastructure of prokaryotic (eubacteria) and eukaryotic (plant) cell. Cell wall – chemical composition, structure and functions. Cell membrane – chemical composition, structure (Fluid Mosaic Model) and functions; cell membrane fluidity. Nucleus – structure (nuclear envelope, nucleoplasm, chromatin – euchromatin and heterochromatin, nucleolus) and functions. Plastids – types of plastids; morphology, structure and functions of chloroplast. Mitochondria – structure and functions. Ribosomes – structure of prokaryotic and eukaryotic ribosomes and their functions. Endoplasmic reticulum – types, structure and functions. Golgi apparatus – structure and functions. Cytoskeleton – structure and functions of microtubules, microfilaments and intermediate filaments. Other subcellular components – structure and functions of lysosomes, peroxisomes and glyoxysomes.	15 hours
	Module 2: Biomolecules Carbohydrates: Classification and biological role of carbohydrates; structure and properties of monosaccharides (glucose and fructose), oligosaccharides (sucrose and maltose) and polysaccharides (starch and cellulose); synthesis and degradation of starch in plants. Amino acids: Classification, structure, properties and biological role of amino acids; transamination. Proteins: Classification; structure (primary, secondary, tertiary and quaternary); properties and biological role. Lipids: Classification and biological role of lipids; properties and structure of triglycerides; synthesis of fatty acids; synthesis and	15 hours

	breakdown of triglycerides; β -oxidation of fatty acids. Nucleic acids: Structure of nucleotides; Watson & Crick's model of DNA, forms of DNA; types of RNA, structure of tRNA.	
	Module 3: Vitamins, enzymes and secondary metabolites Vitamins: Classification of vitamins; properties, occurrence, functions and deficiency symptoms of vitamins A, B complex, C, D, E and K. Enzymes: Nomenclature, classification, importance and physico-chemical properties of enzymes; structure of enzyme molecule; isoenzymes; mechanism of enzyme action (lock and key hypothesis, induced-fit theory); Michaelis-Menten equation; enzyme specificity; enzyme inhibition; factors affecting enzyme activity. Secondary metabolites: Broad classification of secondary metabolites; properties and functions of terpenoids, phenolics and alkaloids.	15 hours
	Practical:	30 hours
	1. a. Study of prokaryotic and eukaryotic cells and sub-cellular components with the help of electron micrographs. b. Study of structure of DNA and RNA with the help of models/images.	2 hours
	2. Study of starch grains of wheat and potato using I_2KI reagent.	2 hours
	3. Localization of lipids using Sudan III reagent.	2 hours
	4. Histochemical tests for detection of cellulose and lignin in plant sections.	2 hours
	5. Qualitative tests for biomolecules - carbohydrates, proteins and lipids (any one test for each).	2 hours
	6. Extraction and estimation of total sugars using phenol-sulphuric acid reagent.	4 hours
	7. Extraction and estimation of reducing sugars by Nelson-Somogyi method.	4 hours
	8. Extraction and estimation of amino acids using ninhydrin reagent.	4 hours
	9. Extraction and estimation of ascorbic acid by titrimetric method.	4 hours
	10. Determination and comparison of acid value of fresh and rancid fat samples by titrimetric method.	2 hours
	11. Effect of substrate concentration on the activity of amylase enzyme.	2 hours
Pedagogy:	Lectures, tutorials, presentations, demonstrations, assignments, use of multimedia and hands-on experiments.	
References/ Readings:	1. Becker, WM, Kleinsmith, LJ, Hardin, J and Bertoni, GP (2009). The World of the Cell. 7 th edition. Pearson Benjamin Cummings Publishing, U.S.A. 2. Berg, JM, Tymoczko, JL and Stryer, L (2011). Biochemistry. WH Freeman and Company, New York.	

	3. Boyer, R (2001). Modern Experimental Biochemistry. 3rd edition. Pearson Education, Singapore. 4. Campbell, MK (2012). Biochemistry. 7th edition. Cengage Learning, Boston. 5. Gupta, PK (1999). A Text Book of Cell and Molecular Biology. Rastogi Publications, Meerut, U.P. 6. Jain, JL, Jain, S and Jain, N (2007). Elementary Biochemistry. 3rd edition. S. Chand and Company Ltd., New Delhi. 7. Karp, G (2009). Cell and Molecular Biology: Concepts and Experiments. 6th edition. John Wiley & Sons Inc., U.S. 8. Nelson, DL and Cox, MM (2008). Lehninger Principles of Biochemistry. 5th edition. WH Freeman and Company, New York. 9. Nigam, A and Ayyagari, A (2007). Lab Manual in Biochemistry, Immunology and Biotechnology. Tata McGraw-Hill Publishing Company Ltd., New Delhi. 10. Pollard, TD, Earnshaw, WC and Lippincott-Schwartz, J (2007). Cell Biology. 2nd edition. Elsevier Health Sciences, Philadelphia. 11. Rao, BR and Deshpande, S (2005). Experimental Biochemistry. IK International Pvt. Ltd., New Delhi. 12. Verma, SK and Verma, M (2007). A Textbook of Plant Physiology, Biochemistry and Biotechnology. 6th edition. S. Chand and Company Ltd., New Delhi. 13. Wilson, K and Goulding, KH (1986). A Biologists Guide to Principles and Techniques of Practical Biochemistry. Edward Arnold, London.											
Course Outcomes:	On completion of this course, students will be able to: 1. Recall the types and functions of subcellular components, biomolecules, vitamins, enzymes and secondary metabolites. 2. Describe the structure of the cell, subcellular components and various biomolecules. 3. Analyze the role of subcellular components, biomolecules, vitamins, and enzymes in cell functioning. 4. Develop skills in bioanalytical testing for scientific research.											
PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	2	1	1	3	1	3	3	1	1	3
CO2	3	3	2	1	1	3	1	3	3	1	1	3
CO3	3	3	2	1	1	3	1	3	3	1	1	3
CO4	3	3	3	1	1	3	2	3	3	2	1	3

Disciplinary/Interdisciplinary Major (Core)

Name of the Programme : B. Sc. (Botany)
Course Code : BOT-204
Title of the Course : Biofertilizers
Number of Credits : 4 (3 Theory + 1 Practical)
Effective from AY : 2024-25

Prerequisites for the course:	Basic knowledge of Biology.	
Course Objectives:	This course aims to: 1. Introduce the concept of biofertilizers and elucidate the benefits of their application. 2. Provide knowledge about the various types of biofertilizers and the organisms used in their formulations. 3. Familiarise students with the principles and practices of organic farming and its role in sustainable crop production.	
Content:	Theory:	45 hours
	Module 1: Introduction to biofertilizers, phosphate solubilizing microbes and mycorrhizae as biofertilizers Introduction to biofertilizers: Concept of biofertilizers; various types of microbes used as biofertilizers; carrier materials - types and quality characteristics of an ideal carrier; role of effective microorganisms and Plant Growth Promoting Rhizobacteria (PGPR) and their mode of action; benefits and limitations of usage of biofertilizers. Phosphate solubilizing microbes: Occurrence, isolation, mass production and field application. Mycorrhizae as biofertilizers: Types of mycorrhizal association and their characteristics; significance of mycorrhizae in forestry and agriculture; ectomycorrhizae as biofertilizers; Arbuscular Mycorrhizal (AM) fungi - isolation, mass production and field application.	15 hours
	Module 2: Nitrogen fixing microbes Symbiotic nitrogen fixing microbes: <i>Rhizobium</i> -root nodule symbiosis; identification, isolation, mass multiplication, production of carrier-based inoculants, techniques of field application and crop response to rhizobial inoculants; <i>Frankia</i> and actinorrhizal symbiosis; <i>Azolla-Anabaena</i> symbiosis; mass cultivation and field application of <i>Azolla</i> and its role as a green manure-cum-biofertilizer. Free living nitrogen-fixing microbes: Cyanobacteria - diversity, identification, isolation, inoculum preparation, techniques of field application and crop response to cyanobacterial inoculants. <i>Azospirillum</i> and <i>Azotobacter</i> -identification, isolation, mass multiplication, production of carrier-based inoculants, techniques of field application and crop response. Algalization technology.	15 hours

	Module 3: Organic farming, quality control and future of biofertilizers Organic farming: Principle, need and benefits of organic farming; crop rotation and its advantages; types of manure - green manure, farmyard manure, neem-coated urea, panchagavya; vermicomposting – method, advantages and disadvantages. Quality control and future of biofertilizers: Introduction to FCO (Fertilizer Control Order); standard parameters for quality control; quality management procedures; storage conditions and shelf life of biofertilizers. Government support and programmes; role of National Centre of Organic Farming. Biofertilizers for sustainable agriculture, nanotechnology in biofertilizers, selection of competitive and multi-functional biofertilizers – case study of <i>Piriformospora indica</i>.	15 hours
	Practical:	30 hours
	1. Isolation of AM spores from soil by wet-sieving and decanting method and mass production of inoculum by trap culture method.	4 hours
	2. Identification of any two cyanobacteria from rice fields.	2 hours
	3. Isolation of <i>Rhizobium</i> sp. from root nodules using YEMA medium.	4 hours
	4. Preparation of carrier-based inoculum of <i>Rhizobium</i> sp.	2 hours
	5. Induction of root nodules in a leguminous plant using <i>Rhizobium</i> sp. (demonstration).	2 hours
	6. Study of <i>Anabaena-Azolla</i> symbiosis in <i>Azolla</i> leaf.	2 hours
	7. Testing for ammonification by soil microbes using Nessler's reagent.	4 hours
	8. Determination of phosphate solubilizing efficiency of soil microbes using Pikovskaya agar.	4 hours
	9. Study of plants used as green manure - <i>Azadirachta indica</i> , <i>Getonia floribunda</i> , <i>Gliricidia sepium</i> and <i>Delonix regia</i> (botanical name, family and brief morphological description).	2 hours
	10. Preparation of compost (demonstration).	2 hours
	11. Preparation of panchagavya (demonstration).	2 hours
Pedagogy:	Lectures, use of multimedia, assignments, presentations, hands-on experiments, demonstrations and team-based learning.	
References/ Readings:	1. Bisen, PS (2014). Laboratory Protocols in Applied Life Sciences. CRC Press, Boca Raton. 2. Bukhari, MJ and Rodrigues, BF (2006). Techniques in Mycorrhizae. Government College, Quepem, Goa. 3. Dubey, RC (2005). A Text Book of Biotechnology. S. Chand & Company, New Delhi. 4. Dubey, RC and Maheshwari, DK (2012). Practical Microbiology. 3rd revised edition. S. Chand & Company, New Delhi.	

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Disciplinary/Interdisciplinary Major (Core)

Name of the Programme : B. Sc. (Botany)
Course Code : BOT-205
Title of the Course : Palynology
Number of Credits : 2 (1 Theory + 1 Practical)
Effective from AY : 2024-25

Prerequisites for the course:	Basic knowledge of Biology.	
Course Objectives:	This course aims to: 1. Introduce students to the field of palynology and its different branches. 2. Give in-depth understanding of pollen grain morphology and the applied aspect of palynology. 3. Help in developing skill in the field of palynology.	
Content:	Theory:	15 hours
	Module 1: Introduction, pollen morphology, branches and applications of palynology Introduction: Definition and brief history of palynology. Pollen Morphology: Pollen development, pollen morphology: pollen units (monad, dyad, tetrad, polyads, massulae, pollinia); polarity, symmetry, shape, size and aperture (NPC); sporoderm stratification and exine ornamentation. Pollen wall proteins. Pollen viability, estimation of pollen viability, pollen storage (short and long term) and germination; palynogram. Applications of palynology: Palynotaxonomy - definition, pollen morphological characters of taxonomic importance. Aeropalynology - definition, intramural and extramural, pollen transport in the atmosphere, pollen calendar, circadian rhythm in pollen emission; pollen allergens and allergic diseases in humans. Melittopalynology - definition, pollen load, role of pollen in honey industry (raw/artificial honey, uni-floral/multi-floral honey, bee pollen in health care) Paleopalynology - definition, study of fossil pollen and spores and their significance in paleobotany, coal and oil explorations. Forensic palynology - definition, significance of pollen in forensic science.	15 hours
	Practical:	30 hours
	1. Study of ultrastructure of pollen wall using electron micrograph.	2 hours
	2. Study of pollen units by temporary mount method: monads (Malvaceae), dyads, polyads (Mimosoideae), tetrad (Portulacaceae), pollinia (Asclepiadaceae), massulae (Orchidaceae).	2 hours
	3. Study of shape and size of pollen in <i>Ipomoea</i> sp., <i>Ocimum</i> sp., <i>Hibiscus</i> sp., <i>Acacia auriculiformis</i> and <i>Pancratium</i> sp.	4 hours

	4. Study of ornamentation patterns and aperture types using fresh pollens by acetolysis method (one plant each from Amaranthaceae, Convolvulaceae, Acanthaceae, Asteraceae and Poaceae).	4 hours
	5. Testing of pollen viability using Tetrazolium salt/ Acetocarmine /I ₂ KI reagent (flowers of any 2 families).	2 hours
	6. Calculation of percentage of pollen germination using pollen germination medium (flowers of any 4 families).	4 hours
	7. Study of pollen germination by hanging drop and sitting drop techniques in <i>Impatiens</i> sp. and <i>Catharanthus roseus</i> .	2 hours
	8. Study of aerospora (intramural and extramural) at different altitudes.	2 hours
	9. Taxonomic interpretation of pollen of related species (2 or 3 species belonging to the same genus).	4 hours
	10. Analysis of honey samples to identify their unipalynous/ multipalynous nature by Chitaley's method.	4 hours
Pedagogy:	Lectures, use of multimedia, tutorials, assignments, presentations, hands-on experiments and team-based learning.	
References/ Readings:	1. Agashe, S (2009). Pollen and Spores. Taylor and Francis Inc., U.S. 2. Bhattacharya, K and Majumdar, MR (2021). A Text book of Palynology. New Central Book Agency (P) Ltd., Kolkata, India. 3. Erdtman, G (1966). Pollen Morphology and Plant Taxonomy of Angiosperms: An introduction to Palynology. Hafner Pub. Co., London. 4. Erdtman, G (1969). Handbook of Palynology: Morphology, Taxonomy, Ecology – An Introduction to the Study of Pollen Grains and Spores. Hafner Pub. Co., New York. 5. Harley, MM, Morton, CM and Blackmores, S (2000). Pollen and Spores: Morphology and Biology. Kew Publishing, U.K. 6. Hesse, M and Ehrendorfer, F (1990). Morphology, Development and Systematic Relevance of Pollen and Spores. Springer-Verlag, New York. 7. Hesse, M, Halbritter, H, Zetter, R, Webber, M, Bucher, R, Frosch-Radivo, A and Ulrich, S (2010). Pollen Terminology. Springer-Verlag, New York. 8. Li, R (2021). Forensic Biology. CRC Press, U.S.A. 9. Nair, PKK (1970). Pollen Morphology of Angiosperms: A Historical and Phylogenic Study. Scholar Publishing House, Lucknow, India. 10. Nair, PKK (1985). Essentials of Palynology. Asia Publishing House, New York. 11. Raghavendra, NP (2019). Introduction to Palynology and Biostatistics. R.P. Publication, Delhi, India. 12. Shivanna, KR and Rangaswamy, NS (1992). Pollen Biology - A Laboratory Manual. Narosa Publishing House, New Delhi. 13. Shivanna, KR and Sawhney, VK (1997). Pollen Biotechnology for Crop Production and Improvement. Cambridge University Press, U.K. 14. Shivanna, KR (2003). Pollen Biology and Biotechnology. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, India.	

	15. Siddiqui, S and Dangi, CBS (2020). Handbook for Forensic Biology. Notion Press, Chennai, India. 16. Traverse, A (2008). Paleopalynology. Springer-Verlag, New York. 17. Vedanthan, P and Nelson, H (2021). Textbook of Allergy for the Clinician. CRS Press, India. 18. Walker, M (2014). Entomology and Palynology (Solving Crimes with Science: Forensics). Mason Crest, U.S.											
Course Outcomes:	On completion of this course, students will be able to: 1. Recall definitions and identify the different types of pollen grains from flowers. 2. Explain the morphology of pollen based on polarity, symmetry, shape, size and aperture. 3. Describe sporoderm stratification, exine ornamentation and methods of pollen viability. 4. Apply the acquired skills in identification of types of honey.											
PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	2	1	1	1	1	3	2	2	1	1
CO2	3	2	2	1	2	1	1	3	2	2	1	1
CO3	3	2	2	2	2	1	1	3	2	2	2	1
CO4	3	3	3	2	1	2	2	3	3	3	1	2

Disciplinary/Interdisciplinary Minor (VET)**Name of the Programme : B. Sc. (Botany)****Course Code : BOT-221****Title of the Course : Techniques in Floral Arrangement****Number of Credits : 4 (2 Theory + 2 Practical)****Effective from AY : 2024-25**

Prerequisites for the course:	Basic knowledge of plants.	
Course Objectives:	This course aims to: 1. Impart theoretical and practical knowledge and skill in fresh and dry flower arrangements. 2. Provide an exposure to entrepreneurial opportunities in floristry.	
Content:	Theory:	30 hours
	Module 1: Introduction to floral arrangements, elements and principles of design, requirements Introduction: Importance and scope of floral designing. Elements and principles of design: Elements of design in a floral arrangement (line, form, space, texture and pattern, colour, size); principles of design (balance, proportion and scale, focal point and emphasis, rhythm, harmony and unity). Equipment and tools: Flower holders/pin holders; containers - texture, shape, size, color; floral foam; chicken wire; wreath ring; adhesive materials; cutting tools – floral knives, florist shears, pruning shears, ribbon shears, wire cutters; picks; accessories; decorative materials – wraps, bows, ribbons, etc. Flowers and foliage for floral arrangements: Classification of flowers - line flowers, mass flowers, filler flowers, form flowers; identification and description of mass flowers (any 10), filler flowers (any 5), line flowers (any 2), form flowers (any 2), loose flowers (any 5), foliage (any 4).	15 hours
	Module 2: Floral arrangements and functioning of a retail florist outlet: Fresh flower arrangements: Types of arrangements - Line, mass, line-mass. Basic shapes of floral arrangements: Circular arrangements (mound, cone, oval, fan); triangular arrangements - symmetrical (equilateral triangle, isosceles triangle, centerpiece design), asymmetrical forms, scalene triangle, right triangle; line arrangements (inverted-T, L-pattern, vertical); crescent arrangement; S-curve arrangement; contemporary freestyle arrangements; boutonnieres; wrist corsages; crown; pomander; baskets; wreaths; bridal bouquets; garlands. Dry flower arrangements: Techniques in drying flowers, packaging and storage; types of arrangements: bouquets, wall decorations, vase arrangements, greeting cards.	15 hours

	Functioning of a retail florist outlet: Procurement of plant materials and accessories; conditioning and storing cut flowers; floral arrangements and displays; customer service; challenges and future prospects of flower business.	
	Practical:	60 hours
	1. Identification and description of equipment and tools used in floral arrangements.	6 hours
	2. Analysis of any four floral arrangements (photographs) according to the following criteria: a) Type of design—line, line mass, mass. b) Pattern of the design—horizontal, circle, right angle. c) Color harmony of the design. d) Type of balance—symmetrical, asymmetrical. e) Focal point of flower arrangement. f) Flower having the greatest emphasis. g) Classification of flowers in the arrangement either as line mass, filler, form flowers.	8 hours
	3. Identification and description of flowers/foilage used in floral arrangements: filler flowers (any 3), line flowers (any 2), form flowers (any 5), loose flowers (any 5), foliage (any 4).	8 hours
	4. Technique of wiring flowers and foliage.	4 hours
	5. Preparation of arrangements using fresh flowers: a) Circular arrangement – mound/cone/oval/fan. b) Triangular arrangement -symmetrical/asymmetrical. c) Line arrangement - inverted-T/L-pattern/vertical. d) Crescent arrangement/S-curve arrangement. e) Boutonniere/ wrist corsage/ crown/ pomander. f) Wreath. g) Handheld bridal bouquet. h) Garlands (2 types).	16 hours
	6. Collection and drying of weeds, grasses, flowers, foliage (any 4 drying techniques).	6 hours
	7. Preparation of two floral designs in each of the following categories using dry flowers: bouquet, wall decoration, vase arrangement, greeting card.	8 hours
	8. Visit to a local florist shop and report submission.	4 hours
Pedagogy:	Lectures, use of multimedia, assignments, presentations, hands-on experiments, demonstrations and field visit.	

References/ Readings:	1. Anderson, GA (1995). Floral Design and Marketing. Ohio Agricultural Education Curriculum Materials Service, Ohio.												
	2. Bhattacharjee, SK (2006). Advances in Ornamental Horticulture. Vols. I- VI. Pointer Publishers, Jaipur.												
	3. Chadha, KL (1995). Advances in Horticulture. Vol. XII. Malhotra Publishing House, New Delhi.												
	4. Griner, C (2005). Floriculture - Designing and Merchandising. Delmar Publishers, USA.												
	5. Lanker, T, Coake, D and Urban, S (2003). Florists’ Review Design School. Florists Review Enterprises, United States.												
	6. Morrison, W (1985). Drying and Preserving Flowers. Dryad Press, Great Britain.												
	7. Prasad, S and Kumar, U (2003). Commercial Floriculture. Agrobios, Rajasthan.												
	8. Randhawa, GS and Mukhopadhyay, A (1986). Floriculture in India. Allied Publishers Pvt. Ltd., New Delhi.												
	9. Reddy, S, Janakiram, B, Balaji, T, Kulkarni, S and Misra, RL (2007). Hightech Floriculture. Indian Society of Ornamental Horticulture, New Delhi.												
	10. Rutt, AH (1960). The Art of Flower and Foliage Arrangement. Macmillan Company, New York.												
	11. Swarup, V (1997). Ornamental Horticulture. MacMillan Publishers India Ltd., Chennai.												
	12. Thorpe, P (1985). Everlastings: The Complete Book of Dried Flowers. Houghton Mifflin Company, New York.												
	13. Welford, M and Wicks, S (2011). Flower Arranging. Dorling Kindersley Ltd., Great Britain.												
	Course Outcomes:	On completion of this course, students will be able to: 1. Define the principles and elements of floral design and recall the equipment and tools used in floral arrangements. 2. Identify and describe cut flowers and foliage used in different types of floral arrangements and understand the functioning of a retail florist outlet. 3. Demonstrate different techniques of floral arrangements using fresh and dry flowers and plant parts. 4. Apply the theoretical and practical knowledge and skill to design floral arrangements for entrepreneurial opportunities.											
PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5	
CO1	3	3	2	2	3	3	2	3	3	3	2	3	
CO2	3	3	3	3	3	3	3	3	3	3	3	3	
CO3	3	3	3	3	3	3	3	3	3	3	3	3	
CO4	3	3	3	3	3	3	3	3	3	3	3	3	

Exit Course

Name of the Programme : B. Sc. (Botany)
Course Code : BOT-261
Title of the Course : Organic Farming
Number of Credits : 4 (1 Theory + 3 Practical)
Effective from AY : 2024-25

Prerequisites for the course:	Basic knowledge of Biology.	
Course Objectives:	This course aims to: 1. Introduce the concept of organic farming. 2. Impart skills for sustainable agriculture and production of organically grown food. 3. Provide knowledge of organic ecosystem and its significance in the present-day scenario. 4. Familiarise students with principles and practices of organic farming and its role in sustainable development.	
Content	Theory:	15 Hours
	Module 1: Concept and practices in organic farming Concept of organic farming: Farming; organic farming – concept and principles; components of an organic farm; importance of organic farming in crop production – advantages and limitations. Soil fertility and water management: Land preparation, factors affecting soil fertility and productivity. Organic manures – FYM, green manure, neem cake, algal culture, biogas slurry, compost. Principles and methods of composting (pit/heap composting, vermicomposting). Biofertilizers and microbial inoculants. Cropping systems – crop rotation and mixed farming. Irrigation methods (surface, drip, sprinkle and furrow irrigation); fertigation. Weed and pest management: Weed management - cultural, mechanical and biological measures. Pest management - cultural, physical and biological (biopesticides and bio-control agents). Certification and entrepreneurship development: Certification of organic produce; popularization and marketing of organic produce. Entrepreneurship in organic farming. Organic farming - present status, future prospects and challenges.	15 hours
	Practical:	90 hours
	1. Determination of soil pH.	2 hours
	2. Estimation of organic carbon content of soil.	2 hours
	3. Seed and seedling treatment prior to sowing/ transplanting.	4 hours
	4. Preparation of nursery bed with well-drained soil.	4 hours
	5. a. Enrichment of compost with biofertilizer. b. Soil treatment with biofertilizer enriched compost.	6 hours

	6. Cultivation of any two vegetable crops organically.	10 hours
	7. Preparation of natural pesticide using chillies-garlic / neem.	4 hours
	8. Preparation of neem-based liquid manure.	4 hours
	9. Preparation of organic mulch and field application.	4 hours
	10. Identification of plants used in green manuring, preparation of green manure and field application.	6 hours
	11. Method of application of vermicompost and vermiwash.	4 hours
	12. Preparation of organic manure by heap composting method.	8 hours
	13. Preparation of panchagavya / jeevamrutam.	6 hours
	14. Study of any two types of mechanical traps for management of pests.	2 hours
	15. Cultivation of marigold as a trap crop for pest management.	4 hours
	16. Comparative study of performance of okra or any suitable plant grown in soil, soil with compost and soil with enriched compost (pot/grow bag planting).	6 hours
	17. Demonstration of mass cultivation and preparation of <i>Azolla</i> biofertilizer.	8 hours
	18. Field visit to organic farm/ICAR to study organic farming practices and submission of report.	6 hours
Pedagogy:	Lectures, assignments, hands-on experiments, demonstrations, field visit and team-based learning.	
References/ Readings:	1. Jagtap, MP, Awasaemal, VB, Pandagale, AD and Narkhede, WN (2019). Practical Manual: Principles of Organic Farming. Dept. of Agronomy, College of Agriculture, VNMKV, Parbhani. 2. Juneja, AC (2015). Biofertilizers and Organic Farming. Satyam Publishers & Distributors, Jaipur. 3. Kher, DS and Dhaliwal, GS (2000). Principles of Agricultural Ecology. Himalaya Publishing Company, Mumbai. 4. Kumar, M (2020). Green Manuring: Principles and Practice. Random Publications, New Delhi. 5. Kumar, S, Jha, SK, Bhambri, MC and Banjara, GP (2016). Practical Manual on Organic Farming. College of Agriculture, IGKV, Raipur. 6. NIIR Board (2004). The Complete Technology Book on Biofertilizer and Organic Farming. 2nd revised edition. National Institute of Industrial Research, Delhi. 7. Palaniappan, SP and Annadurai, K (1999). Organic Farming: Theory and Practice. 2nd edition. Scientific Publishers (India), Jodhpur. 8. Panda, H (2011). Manufacture of Biofertilizer and Organic Farming. Asia Pacific Business Press Inc., Delhi. 9. Sharma, AK (2002). A Hand Book of Organic Farming. Agrobios (India), Jodhpur. 10. Sundaramari, M (2003). Indigenous Agricultural Practices for Sustainable Farming. Agrobios (India), Jodhpur. 11. Vyas, SC, Vyas, S and Modi, HA (1998). Bio-fertilizers and Organic	

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SEMESTER V

Disciplinary/Interdisciplinary Major (Core)

Name of the Programme : B. Sc. (Botany)
Course Code : BOT-300
Title of the Course : Plant Taxonomy and Phylogeny
Number of Credits : 4 (3 Theory + 1 Practical)

Prerequisites for the course:	Basic knowledge of morphology of angiosperms.	
Course Objectives:	This course aims to: 1. Impart knowledge on the use of taxonomic tools in plant identification, nomenclature and major systems of classification. 2. Familiarize students with diagnostic characters of families and identification of some economically important plants belonging to these families. 3. Enable students to understand the concept of origin and evolutionary relationship between plants. 4. Provide skill in describing and identifying plants.	
Content:	Theory:	45 hours
	Module 1: Taxonomic tools in identification and nomenclature Herbaria: Herbarium technique, role of herbaria, virtual herbarium; important herbaria and botanical gardens (Royal Botanical Garden, Kew and Central National Herbarium, Kolkata). Taxonomic literature and keys: Flora, monographs, manuals; single access keys (yoked and bracketed key) and multi-access keys (body punched card). Botanical nomenclature: Principles and rules of ICN; ranks and names, binominal system, typification (holotype and isotype), author citation, valid publication, rejection of names, principle of priority and its limitations.	15 hours
	Module 2: Classification and systematics of angiosperms Systems of classification: A brief account of natural, artificial and phylogenetic classification; Bentham and Hooker's classification (up to series) and its merits and demerits; features of Engler and Prantl's classification. A brief account of Angiosperm Phylogeny Group (APG) system. Systematics of angiosperms: Systematic position (Bentham and Hooker's classification), diagnostic features and any two plants of economic importance of the following families: Annonaceae, Rutaceae, Leguminosae (Papilionoideae), Rubiaceae, Apocynaceae, Amaranthaceae, Orchidaceae, Musaceae, Arecaceae and Poaceae.	15 hours
	Module 3: Origin, evolution and phylogeny of angiosperms Origin and evolution of angiosperms: A general account with special reference to Bennettitalean, Gnetalean, Caytonialean and Herbaceous origin theories; evolution of flower; co-	15 hours

	evolution of flowers and insects (morphological features). Phylogeny of angiosperms: Terms and concepts (primitive and advanced, homology and analogy, parallelism and convergence, monophyly, paraphyly, polyphyly and clades). Methods of illustrating evolutionary relationship (phylogenetic tree and cladogram); significance of phylogeny.	
	Practical:	30 hours
	1. Phytography of dicot and monocot plant.	2 hours
	2. Description and identification of plants up to family and genus level using Floras (any 2 plants).	4 hours
	3. Preparation of herbarium of one terrestrial plant.	4 hours
	4. Study of classification, diagnostic characters, L.S. of flower, T.S. of ovary, floral formula, floral diagram and any 2 economically important plants each of the families mentioned in theory.	10 hours
	5. Construction of dichotomous keys using any eight locally available plants.	4 hours
	6. Study of co-evolution of flowers and insects using locally available plants.	2 hours
	7. Field visit and preparation of report.	4 hours
Pedagogy:	Lectures, use of multimedia, tutorials, assignments, presentations, hands-on experiments, demonstrations, field visit and team-based learning.	
References/ Readings:	1. Chopra, GL (1985). Angiosperm (Systematics & Life Cycles). Pradeep Publications, Jalandhar. 2. Cook, T (1958). Flora of the Presidency of Bombay. Vol. I, II & III. Botanical Survey of India, Calcutta. 3. Davis, PH and Heywood, VH (1963). Principles of Angiosperm Taxonomy. Oliver & Boyd, London. 4. Lawrence, GHM (1951). Taxonomy of Vascular Plants. MacMillan, New York. 5. Naik, VN (1984). Taxonomy of Angiosperms. Tata McGraw Hill, New Delhi. 6. Pandey, SN (2008). Taxonomy of Angiosperms. ASE Books India, New Delhi. 7. Pullaiah, T and Karuppusamy, S (2018). Taxonomy of Angiosperms. 4th edition. Astral International (P.) Ltd., New Delhi. 8. Rao, SR (1985-1986). Flora of Goa, Daman and Diu, Dadra and Nagar Haveli. Vol. I & II. BSI, Howrah. 9. Singh, G (2012). Plant Systematics: Theory and Practice. 3rd edition. Oxford & IBH Pvt. Ltd., New Delhi. 10. Subrahmanyam, NS (1995). Modern Plant Taxonomy. Vikas Publishing House Pvt. Ltd., New Delhi. 11. Woodland, DW (1991). Contemporary Plant Systematics. Prentice Hall, New Jersey.	
Course Outcomes:	On completion of this course, students will be able to: 1. Recall the various terms used in taxonomy and phylogeny of	

	angiosperms. 2. Explain the taxonomic tools and their use in identifying plants, nomenclature, types of classifications, diagnostic features of families, origin and evolution of angiosperms. 3. Apply the gained knowledge in herbarium preparation, key construction and phylogenetic trees. 4. Develop skills in identifying, classifying and describing plants.											
PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	2	2	3	3	3	3	2.5	2.5	3
CO2	3	3	3	2	2	3	3	3	3	2.5	2.5	3
CO3	3	3	3	2	2	3	3	3	3	2.5	2.5	3
CO4	3	3	3	3	2	3	3	3	3	2.5	3	3

Disciplinary/Interdisciplinary Major (Core)**Name of the Programme : B. Sc. (Botany)****Course Code : BOT-301****Title of the Course : Cytogenetics and Plant Breeding****Number of Credits : 4 (3 Theory + 1 Practical)****Effective from AY : 2025-26**

Prerequisites for the course:	Basic knowledge of Biology.	
Course Objectives:	This course aims to: 1. Provide knowledge about cell cycle, concepts of heredity and plant breeding. 2. Enable students to apply principles of heredity to solve genetic problems. 3. Familiarize students with understanding the causes of gene mutations and its impact on chromosome structure and number. 4. Impart knowledge and skill in methods of breeding, selection and hybridization for crop improvement.	
Content:	Theory:	45 hours
	Module 1: Cell cycle and concepts in cytogenetics Cell cycle: Overview of cell cycle, mitosis, meiosis and their significance. Mendelism: Principles of inheritance; backcross and test cross; incomplete dominance, codominance and lethal alleles; gene interactions – dominant, recessive, complementary, supplementary, duplicate; multiple alleles (blood groups in humans, self-incompatibility in plants). Extrachromosomal inheritance: Characteristics of extrachromosomal inheritance; cytoplasmic inheritance in <i>Mirabilis jalapa</i> ; kappa particles in <i>Paramecium</i> ; maternal effects in snail (shell coiling). Autosomes and sex chromosomes: Mechanisms of sex determination; balance concept of sex determination in <i>Drosophila</i> ; sex-linked inheritance; sex-limited characters.	15 hours
	Module 2: Recombination and gene mutations Linkage, crossing-over and chromosome mapping: Linkage and crossing-over – types and significance; recombination frequency, two-point and three-point test crosses and their significance in chromosome mapping; interference and coincidence. Gene mutations: Types of mutations; mutagens - physical and chemical (base analogs; deaminating, alkylating and intercalating agents); detection of mutations in plants (Stadler's method). Effect of mutation on chromosome structure and number: Deletion, duplication, inversion, translocation, euploidy and aneuploidy.	15 hours

	Module 3: Plant breeding and quantitative inheritance Introduction to plant breeding: Introduction and objectives; important achievements and undesirable consequences of plant breeding. Centers of origin and domestication of crop plants. Introduction and acclimatization of a plant. Methods of crop improvement: Selection methods for self-pollinated, cross-pollinated and vegetatively propagated plants; hybridization for self- and cross-pollinated plants (concepts, advantages and limitations). Role of mutation, polyploidy and distant hybridization in crop improvement. Inbreeding depression, heterosis and its application. Quantitative inheritance: Concept, monogenic v/s polygenic inheritance, examples - inheritance of kernel colour in wheat, ear length in maize.	15 hours
	Practical:	30 hours
	1. Problems on monohybrid and dihybrid cross.	4 hours
	2. Preparation of chromosome map using three-point test cross data.	4 hours
	3. Study of stages in mitosis using <i>Allium cepa</i> root tips.	2 hours
	4. Study of stages in meiosis using <i>Allium cepa</i> / <i>Tradescantia</i> sp. flower buds.	2 hours
	5. Preparation of karyotype from dividing <i>Allium cepa</i> root tip cells.	4 hours
	6. Emasculation and bagging of flowers of Brassicaceae and Malvaceae, pollinating them manually, estimating fruit and seed set.	4 hours
	7. Estimation of pollen fertility in any two locally grown crop plants (chilly, brinjal or any suitable plants).	2 hours
	8. Estimation of pollen-ovule ratio and its bearing on pollination system.	2 hours
	9. Demonstration of colchicine induced polyploidy.	2 hours
	10. Demonstration of colchicine induced mutation (root/shoot/germination/chromosomes).	4 hours
Pedagogy:	Lectures, assignments, presentations, hands-on experiments and demonstrations.	
References/ Readings:	1. Acquaah, G (2007). Principles of Plant Genetics and Breeding. 2nd edition. Blackwell Publishing, Maryland, USA. 2. Chaudhary, RC (2017). Introductory Principles of Plant Breeding. CBS Publishers & Distributors, New Delhi. 3. Gardner, EJ, Simmons, MJ and Snustad, DP (1991). Principles of Genetics. 8th edition. John Wiley & Sons, India. 4. Griffiths, AJF, Wessler, SR, Carroll, SB and Doebley, J (2010). Introduction to Genetic Analysis. 10th edition. W. H. Freeman and Co., USA. 5. Goswami, HK and Goswami, R (1993). Practical Cytology, Applied Genetics and Biostatistics. 2nd revised edition. Himalaya Publishing	

	House, Mumbai. 6. Klug, WS, Cummings, MR and Spencer, CA (2009). Concepts of Genetics. 9th edition. Benjamin Cummings, USA. 7. Pandey, BP (2007). Botany for Degree Students - Year I. S. Chand Limited, India. 8. Rastogi, VB (2020). A Text Book of Cell Biology and Genetics. Kedar Nath Ram Nath, Meerut. 9. Shukla, RS and Chandel, PS (2013). Cytogenetics, Evolution, Biostatistics and Plant Breeding. 5th edition. S. Chand & Company Pvt. Ltd., New Delhi. 10. Singh, BD (2005). Plant Breeding: Principles and Methods. 7th edition. Kalyani Publishers, Ludhiana. 11. Singh, BD (2020). Fundamentals of Genetics. 6th edition. Medtech Science Press, New Delhi. 12. Snustad, DP and Simmons, MJ (2009). Principles of Genetics. 5th edition. John Wiley & Sons Inc., India. 13. Verma, PS and Agarwal, VK (2009). Genetics. 9th Revised edition. S. Chand Limited, India.											
Course Outcomes:	On completion of this course, students will be able to: 1. Recall concepts in cytogenetics and crop improvement. 2. Understand Mendelian genetics through problem solving exercises. 3. Apply the principles of genetics in plant breeding. 4. Develop skills in plant breeding such as emasculation, pollination and induction of polyploidy.											
PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	2	2	1	3	3	3	2	2	2	3
CO2	3	3	3	1	2	3	3	3	3	3	1	3
CO3	3	3	3	3	1	3	3	3	3	2	3	3
CO4	3	3	3	3	1	3	3	3	3	2	3	3

Disciplinary/Interdisciplinary Major (Core)**Name of the Programme : B. Sc. (Botany)****Course Code : BOT-302****Title of the Course : Microbiology and Plant Pathology****Number of Credits : 4 (3 Theory + 1 Practical)****Effective from AY : 2025-26**

Prerequisites for the course:	Basic knowledge of Biology.	
Course Objectives:	This course aims to: 1. Provide knowledge of basic and advanced concepts in microbiology and plant pathology. 2. Impart skills in various microbiological techniques, safety measures in the laboratory, role of micro-organisms in diverse applications and adoption of strategies for plant disease detection and management. 3. Provide training in basic skills in isolation and handling of micro-organisms and their preservation.	
Content:	Theory:	45 hours
	Module 1: Introduction and methods in microbiology Introduction to microbiology: Aseptic technique and concept of sterilization; physical and chemical methods of sterilization; biosafety levels and biohazards in the laboratory; disposal of laboratory wastes and cultures. Methods in microbiology: Types and preparation of culture media; methods of obtaining pure cultures of micro-organisms (streak plate, spread plate and pour plate); enumeration of micro-organisms (direct and indirect methods); bacteriological determination of potability of water (standard multiple tube fermentation test and membrane filtration technique); bacterial motility; bacterial growth curve. Maintenance and preservation of microbial cultures: Methods of preservation of microbial cultures (periodic transfer, lyophilization, use of mineral oil and liquid nitrogen); culture collection centers (culture banks) and their importance.	15 hours
	Module 2: Applications of micro-organisms Role of micro-organisms in production of fermented food and dairy products (bread, yoghurt and cheese); organic acids (citric acid and vinegar); alcoholic beverages made from grapes and cashew fruit juice; antibiotics (penicillin and streptomycin). Role of micro-organisms in decomposition of plant residues, bioremediation, production of biogas and biodegradable plastics. Micro-organisms as indicators of water pollution.	15 hours
	Module 3: Introduction to plant pathology; defense mechanisms and disease management Introduction to plant pathology: Classification of plant diseases; disease symptoms caused by bacterial, fungal and viral pathogens. Pathogen attack and plant defense mechanisms: Stages of	15 hours

	disease establishment – the disease cycle; disease triangle; plant disease epidemics, monocyclic and polycyclic pathogens. Transmission and spread of plant pathogens. Structural and biochemical defense mechanisms in plants (pre-existing and induced). Plant disease management: Physical, cultural, biological and IPM systems of plant disease management; biopesticides; development of transgenics for disease management. Molecular diagnosis - identification of genes and specific molecules in disease development (DNA and protein based diagnostic kits). Computer simulation of epidemics and disease forecasting; use of remote sensing and image analysis in plant pathology.	
	Practical:	30 hours
	1. Working and handling of equipment used in microbiology laboratory.	2 hours
	2. Preparation of liquid and solid (plates and slants) culture media – Nutrient Broth, Nutrient Agar and Potato Dextrose Agar.	4 hours
	3. Isolation of micro-organisms from air and study of colony characteristics of bacteria and fungi.	4 hours
	4. Preparation of pure culture of bacteria by streak plate method; preservation of cultures by streaking on slants.	2 hours
	5. Screening for amylase producing micro-organisms in soil using starch agar by serial dilution and spread plate method.	4 hours
	6. Analysis of water sample to determine its potability (presumptive test, confirmed test and completed test).	4 hours
	7. Screening for antimicrobial activity of plant extracts by agar well/disc diffusion method (extracts of neem, garlic and lemon grass).	4 hours
	8. Demonstration of Koch's postulates for a bacterial/fungal pathogen.	2 hours
	9. Study of causal organism, symptoms, disease cycle and control measures of plant diseases (viral, bacterial and fungal – one each).	2 hours
	10. Anatomy/mounting of spores of fungus infected specimens (rust, blight and rot).	2 hours
Pedagogy:	Lectures, tutorials, use of multimedia, assignments and hands-on experiments.	
References	1. Agrios, GN (1997). Plant Pathology. Academic Press, London. 2. Dubey, RC and Maheshwari, DK (1999). A Text Book of Microbiology. S. Chand and Company Ltd., New Delhi. 3. Dubey, RC and Maheshwari, DK (2002). Practical Microbiology. S. Chand and Company Ltd., New Delhi. 4. Kale, V and Bhusari, K (2005). Practical Microbiology: Principles and Techniques. Himalaya Publishing House, Mumbai. 5. Kale, V and Bhusari, K (2021). Applied Microbiology. Himalaya	

	Publishing House, Mumbai. 6. Mehrotra, RS (1995). Plant Pathology. Tata McGraw-Hill Publishing Company Limited, New Delhi. 7. Meyneil, E and Meynell, GG (1970). Theory and Practice in Experimental Bacteriology. Cambridge University Press, Cambridge. 8. Moshraffuddin, A and Basumatany, SK (2006). Applied Microbiology: B. Sc. Botany Degree Program. MJP Publishers, Chennai. 9. Persley, GJ (1996). Biotechnologies and Integrated Pest Management. CAB International, U.K. 10. Sambamurthy, AVSS (2006). A Text Book of Plant Pathology. IK International Publishing House Pvt. Ltd., New Delhi. 11. Sharma, K (2011). Text Book of Microbiology. Anne Books Pvt. Ltd., New Delhi. 12. Sullia, SB (2001). General Microbiology. Oxford Publishers, New Delhi. 13. Tripathi, SK, Bhale, MS, Yadav, VK and Shrivastava, A (2022). Fundamentals of Plant Pathology. Scientific Publishers, India.											
Course outcomes:	On completion of this course, students will be able to: 1. Recall methods of sterilization and understand the biohazards in a microbiology laboratory and biosafety measures to be adopted. 2. Explain plant diseases, defense mechanisms in plants and conventional as well as modern strategies for detection and management of plant disease. 3. Analyze the role of micro-organisms in various fermentation processes, decomposition, bioremediation, water pollution and in production of biogas and biodegradable plastics. 4. Apply skills of basic microbiological techniques in testing water samples for presence of micro-organisms and identification of various diseases and causal agents of important plant diseases.											
PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	2	1	3	3	3	3	2	3	3
CO2	3	3	3	3	2	3	3	3	3	2	3	3
CO3	3	3	3	3	2	3	3	3	3	2	3	3
CO4	3	3	3	3	2	3	3	3	3	2	3	3

Disciplinary/Interdisciplinary Major (Core)

Name of the Programme : B. Sc. (Botany)
Course Code : BOT-303
Title of the Course : Field Botany
Number of Credits : 2 (1 Theory + 1 Practical)
Effective from AY : 2025-26

Prerequisites for the course:	Knowledge of taxonomy of angiosperms and other groups.	
Course Objectives:	This course aims to: 1. Provide students with knowledge on methods and practices of field plant taxonomy and ecology, enabling them to identify and understand plant diversity under natural habitats. 2. Train students in field identification of plants and, collection and processing of plant specimens. 3. Empower them for in-field plant identification and location skills needed for biodiversity estimation, documentation, forestry, ecological studies.	
Content:	Theory:	15 hours
	Module 1: Concepts in field botany Introduction to field botany: Importance of field botany; field tools and their uses (hand lens, GPS devices, vasculum, plant press); field notes and field voucher number; safety guidelines in fieldwork; ethical considerations in plant collection. Key concepts for field botany: Ecological succession and its role in shaping various terrestrial ecosystems (temperature and moisture shaping ecosystems); use of keys from flora guide books for plant identification (indented and bracketed key); handy tools for infield plant identification (based on canopy shape, leaf shapes, smell, taste, bark color/texture and patterns, online image search applications) and limitations of using them; Herbarium preparation techniques for various groups of plants; national herbariums. Field observations: Special ecological groups with two examples each: root parasites, aerial parasites, epiphytes, myco-heterotrophs, mangroves, <i>Myristica</i> swamps, sand dunes, lithophytes, lateritic plateaus, aquatic plants, seaweeds and their adaptations to various environments. Field experiments: Designing field experiments; data collection and analysis in the field; GIS and its application in field botany. Biodiversity assessment: Methods of assessing biodiversity in the field (Shannon index and Simpson's index); biodiversity conservation strategies; ex-situ (Lead Botanical Garden) and in-situ conservation.	15 hours
	Practical:	30 hours
	1. Familiarization with common field tools used in botany (hand lens, trowel, secateur, GPS device, vasculum and plant press).	2 hours

	2. Identification of species (any 5) of genus <i>Terminalia</i> / <i>Ipomoea</i> using keys in Flora books.	2 hours
	3. Identification of any five Fabaceae specimens using Flora books.	2 hours
	4. Study of canopy morphology and branching patterns of <i>Garcinia indica</i> , <i>Alstonia scholaris</i> , <i>Mangifera indica</i> , <i>Terminalia paniculata</i> , <i>Polyalthia longifolia</i> and <i>Sterculia foetida</i> (sketch to be drawn).	2 hours
	5. Field trip to area with natural vegetation for plant collection and in-field identification using Flora books. 5a. Identification of 10 trees using leaf-based keys (to be conducted during field trip). 5b. Creating digital logs and recording phenological data (to be conducted during field trip).	6 hours
	6. Navigation in field using toposheet and compass in the campus.	2 hours
	7. Day field trip to mangrove forest area for in-field identification using Flora books. 7a. Identification of plants using automated image recognition apps (to be conducted during field trip). 7b. Demonstration of using GPS devices for location tagging during fieldwork (to be conducted during field trip).	6 hours
	8. Preparation and submission of one herbarium specimen each of angiosperm, bryophyte and pteridophyte.	2 hours
	9. Preparation and submission of one herbarium specimen each of an alga, fungus and lichen.	2 hours
	10. Collection of wild seeds and growing them in the nursery.	2 hours
	11. Demonstration of wet preservation of angiosperms, algae, fungi, bryophytes, pteridophytes and lichens.	2 hours
Pedagogy:	Lectures, tutorials, assignments, presentations, demonstrations, field visit and team-based learning.	
References/ Readings:	Cooke, T (1901—1908). The Flora of the Presidency of Bombay. Vol I, II and III. Taylor & Francis, London. Datar, MN and Lakshminarsimhan, P (2013). Flora of Bhagwan Mahavir (Molem) National Park and Adjoinings, Goa. Botanical Survey of India, Kolkata. Gupta, RK (1981). A Text Book of Systematic Botany. Atma Ram & Sons, Delhi. Inganhalekar, S (2022). Leaf based identification for Trees of Sahyadri. Corolla Publication, Pune. Lawrence, GHM (1951). Taxonomy of Vascular Plants. Macmillan, New York. Mathur, RC (1972). Systematic Botany: Angiosperms. Agra Book Store, Agra. Naithani, HB, Sahni, KC and Bennet, SSR (1997). Forest Flora of Goa. International Book Distributors, Dehradun.	

	8. Rai, SN (1999). Nursery and Planting Techniques of Forest Trees in Tropical South-Asia. Punarvasu Publications, Dharwad. 9. Rao, RS (1986). Flora of Goa, Diu, Daman, Dadra & Nagarhaveli. Flora of India. Series 2. Vol. I and II. Botanical Survey of India, Kolkata. 10. Singh, HB and Subramaniam, B (2008). Field Manual on Herbarium Techniques. National Institute of Science Communication and Information Resources, CSIR, New Delhi. 11. Trivedi, PC (2006). Biodiversity Assessment and Conservation. Agrobios, India, Jodhpur. https://bsi.gov.in/page/en/special-and-miscellaneous-publications https://academic.oup.com/aobpla/article/12/6/plaa052/5910496 https://www.sciencedirect.com/science/article/pii/S235198942030246											
Course Outcomes:	On completion of this course students will be able to: 1. Recall basics and various key concepts in field botany, methods of in-field identification and collection of plant specimens. 2. Explain the collection and preservation procedure for plant, algae, fungi, bryophytes and pteridophytes. 3. Identify the plant based on its field characters. 4. Apply the acquired knowledge for biodiversity estimation, documentation, forestry, ecological studies.											
PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	2	2	3	3	3	3	2.5	2.5	3
CO2	3	3	3	2	2	3	3	3	3	2.5	2.5	3
CO3	3	3	3	2	2	3	3	3	3	2.5	2.5	3
CO4	3	3	3	3	2	3	3	3	3	2.5	3	3

Disciplinary/Interdisciplinary Minor**Name of the Programme : B. Sc. (Botany)****Course Code : BOT-321****Title of the Course : Mushroom Cultivation Technology****Number of Credits : 4 (3 Theory + 1 Practical)****Effective from AY : 2025-26**

Prerequisites for the course:	Basic knowledge of biology of fungi.	
Course Objectives:	This course aims to: 1. Train students in basic mushroom cultivation techniques. 2. Impart knowledge of pest and disease management and post-harvest technology. 3. Upskill students for mushroom entrepreneurship and research.	
Content:	Theory:	45 hours
	Module 1: Biology of mushroom and mushroom cultivation Mushroom biology: Morphology, diagnostic characters, reproduction, life cycle and nutritional value of <i>Agaricus bisporus</i> , <i>Calocybe indica</i> and <i>Pleurotus</i> spp. Mushroom classification based on occurrence, habitat, colour and morphology of fruiting bodies. Important features of edible and non-edible mushrooms (common look-alike mushrooms). Mushroom cultivation - Cultivation of button, oyster and milky white mushrooms - spawning, casing, cropping, picking and packing. Mushroom spore isolation and spore culture; pileus tissue culture; culture media (Potato Dextrose Agar, Malt Extract Agar). Preparation of spawn and substrate, sterilization and storage. Infrastructure requirement of a mushroom firm - composting technology, pasteurization room and growing rooms.	15 hours
	Module 2: Pest and diseases management Pest and diseases: Cultivated mushroom diseases, pests and their management - Button mushroom- fungal diseases (dry bubble, wet bubble); weed fungi (olive green mould, brown plaster mould); bacterial diseases (brown blotch, ginger blotch). Oyster mushroom- fungal diseases (<i>Cladobotryum</i> soft rot, <i>Gliocladium</i> brown rot); bacterial (rot, yellow blotch). Milky white mushroom- fungal (wet bubble, dry bubble) bacterial (blotch). Pests (Spring tails and mites). Disease management methods: Purity of spawn mother culture, strain vigor and genetic characteristics, strain improvement, fumigation, improvement in compost sterilization procedures, quality assurance steps.	15 hours
	Module 3: Post-harvest technology, storage, economics and future of mushroom cultivation in Goa Post-harvest technology: Storage of fresh mushrooms (refrigeration, vacuum cooling, ice-bank cooling, irradiation), conventional packaging, Modified Atmosphere Packaging	15 hours

	(MAP), Controlled Atmosphere Packaging (CAP), Modified Humidity Packaging (MHP), labelling. Transportation of fresh mushrooms. Long term storage, innovative products (steeping, canning, pickles, drying, papad). Economics in mushroom cultivation: Study of model of a unit for cost for site, spawn production, compost unit, machinery for small scale farm. Cost benefit ratio. Marketing in India and abroad. Alternate business models (ready to grow beds, DIY kits). Future of mushroom cultivation: Advantages of using local species, strains for mushroom cultivation (<i>Calocybe indica</i> and <i>Schizophyllum commune</i>). Popular exotic mushrooms (<i>Volvariella volvacea</i>, <i>Lentinula edodes</i>). Strain improvement in <i>Agaricus bisporus</i>. Spent mushroom substrate as organic manure. Mushrooms cultivated for their medicinal importance (<i>Ganoderma</i>, <i>Cordyceps</i>). Mushroom research centre ICAR-DMR Directorate of Mushroom Research, Solan and summary of its work.	
	Practical:	30 hours
	1. Basidiocarp morphology of oyster mushroom; L.S. of basidiocarp, section through gill and mounting of spores.	2 hours
	2. Basidiocarp morphology of button mushroom; L.S. of basidiocarp, section through gill and mounting of spores.	2 hours
	3. Preparation and sterilization of media (Malt Extract Agar and Potato Dextrose Agar).	4 hours
	4. Initiation of culture from mushroom tissues and spores.	2 hours
	5. Preparation of spawn and substrate for oyster mushroom cultivation and milky white mushroom cultivation.	6 hours
	6. Inoculation and bagging of substrate using oyster mushroom spawn and milky white mushroom spawn.	6 hours
	7. Debagging, initiation of fruiting and harvesting of oyster mushrooms.	2 hours
	8. Casing, initiation of fruiting and harvesting of milky white mushrooms.	2 hours
	9. Mushroom preservation – drying, storage in brine and pickle making.	2 hours
	10. Packaging and marketing of fresh and dry mushroom products.	2 hours
Pedagogy:	Lectures, tutorials, assignments, presentations, demonstrations and team-based learning.	
References/ Readings:	Atkinson, GF (1961). Hand book of Mushrooms. 2nd edition. Hafner Publishers, New York. Bahl, N (2000). Handbook of Mushrooms. 4th edition. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi. Biswas, S, Datta, M and Ngachan, SV (2012). Mushrooms: A Manual for Cultivation. PHI Learning Private Limited, New Delhi.	

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Internship**Name of the Programme : B. Sc. (Botany)****Course Code : BOT-361****Title of the Course : Internship****Number of Credits 2****Effective from AY : 2025-26**

SEMESTER VI

Disciplinary/Interdisciplinary Major (Core)

Name of the Programme : B. Sc. (Botany)
Course Code : BOT-304
Title of the Course : Plant Tissue Culture
Number of Credits : 4 (3 Theory + 1 Practical)

Prerequisites for the course:	Basic knowledge of Biology.	
Course Objectives:	This course aims to: 1. Provide a basic understanding of the principles and techniques involved in plant tissue culture. 2. Impart comprehensive knowledge of cellular totipotency, types of cultures and somatic hybridization. 3. Acquaint students with the diverse applications of plant tissue culture.	
Content:	Theory:	45 hours
	Module 1: Introduction to plant tissue culture Introduction: Concept and history of plant tissue culture; pioneering work and significant achievements of Indian scientists. Plant tissue culture laboratory design and basic requirements; sterilization practices. Plant tissue culture technique: Washing, packing and sterilization of glassware; composition, types, preparation and sterilization of culture media; selection, isolation, surface sterilization and inoculation of explants; establishment of <i>in vitro</i> cultures, ideal conditions for incubation of cultures, maintenance of cultures and subculture; regeneration of plantlets; acclimatization in greenhouse and hardening.	15 hours
	Module 2: Cellular totipotency, differentiation and types of cultures Cellular totipotency: Concept of cellular totipotency and differentiation (dedifferentiation and redifferentiation); role of plant growth regulators in tissue culture; role of meristems in tissue culture; somaclonal variation; organogenesis and somatic embryogenesis. Preparation of synthetic seeds. Types of culture: Principle, protocol and applications of the following types of culture – callus culture, meristem culture, embryo culture, anther and pollen culture; micropropagation. Cell suspension culture - methods for isolation of single cells, testing viability of isolated cells, protocol for cell suspension culture, types of suspension cultures (batch and continuous), growth pattern of cells in batch culture, methods for measurement of growth of cells in suspension and applications of cell suspension culture.	15 hours
	Module 3: Somatic hybridization and applications of plant tissue culture Somatic hybridization: Introduction to somatic hybridization;	15 hours

	role of enzymes in protoplast isolation, mechanical and enzymatic isolation of plant protoplasts, testing viability of isolated protoplasts, spontaneous and induced fusion of protoplasts, selection of hybrid protoplasts, culture of hybrid protoplasts and applications of somatic hybridization. Cybrids and their applications. Applications of plant tissue culture: Role of plant tissue culture for crop improvement in agriculture, forestry and horticulture; production of secondary metabolites in culture (callus culture, cell suspension culture and hairy root culture); cryopreservation and germplasm conservation methods (in-situ and ex-situ).	
	Practical:	30 hours
	1. Familiarization with working and handling of laboratory instruments and equipment; washing, packing and sterilization of glassware.	4 hours
	2. Preparation of plant tissue culture medium (MS) and its sterilization.	4 hours
	3. Surface sterilization and <i>in vitro</i> seed germination of <i>Brassica</i> spp./suitable seeds and induction of callus from hypocotyl segments.	4 hours
	4. Induction of callus from <i>Daucus carota</i> cambium as an explant.	2 hours
	5. Morphological and microscopic study of callus.	2 hours
	6. Establishment of cell suspension culture from callus and checking viability of single cells using Evan's blue stain.	4 hours
	7. Enzymatic isolation of plant protoplasts.	4 hours
	8. Encapsulation of somatic/true embryos to prepare synthetic seeds.	2 hours
	9. Embryo culture of <i>Zea mays</i> to obtain seedlings and transfer to soil.	4 hours
Pedagogy:	Lectures, tutorials, assignments, presentations, hands-on experiments and team-based learning.	
References/Readings:	1. Agarwal, J and Arora, SK (2014). Plant Tissue Culture: Theory and Practice. Campus Books, New Delhi. 2. Dwivedi, P (2023). Plant Tissue Culture. Scientific Publishers, New Delhi. 3. Kumar, S, Mishra, S and Mishra, AP (2016). Plant Tissue Culture: Theory and Techniques. Scientific Publishers, New Delhi. 4. Meetei, NT and Khanna, VK (2015). Plant Tissue Culture. 2nd edition. Kalyani Publishers, New Delhi. 5. Misra, SP (2015). Plant Tissue Culture. Ane Books Private Limited, New Delhi. 6. Narayanswamy, S (2011). Plant Cell and Tissue Culture. Tata McGraw Hill Pub. Co., New Delhi. 7. Prasad, MG, Kumar, S, Sridevi, V, Muralinath, E and Kumar, GV (2016). HandBook of Tissue Culture. White Falcon Publishing, Chandigarh.	

	8. Rao, PM (2013). Plant Tissue Culture and Biotechnology. Black Prints, Mumbai. 9. Razdan, MK (2012). Introduction to Plant Tissue Culture. Oxford & IBH Publishing Company, New Delhi. 10. Satyanarayana, U (2020). Biotechnology. Books & Allied Limited, Kolkata. 11. Sharma, V and Alam, A (2015). Plant Tissue Culture. IK, International, New Delhi. 12. Singh, BD (2022). Plant Biotechnology, 4 th edition. Medtech Science Press, New Delhi.											
Course Outcomes:	On completion of this course, students will be able to: 1. Recall the principles and techniques in culturing plant tissues. 2. Understand the significance of cellular totipotency, differentiation and the role of growth regulators in plant tissue culture. 3. Analyse the diverse types of cultures, micropropagation, somatic hybridization and applications of plant tissue culture. 4. Develop proficiency in designing a plant tissue culture laboratory and techniques of culturing plant tissues.											
PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	1	3	2	3	3	2	3	3
CO2	3	3	3	3	1	3	2	3	3	2	3	3
CO3	3	3	3	3	2	3	3	3	3	2	3	3
CO4	3	3	3	3	1	3	2	3	3	2	3	3

Disciplinary/Interdisciplinary Major (Core)**Name of the Programme : B. Sc. (Botany)****Course Code : BOT-305****Title of the Course : Plant Ecology and Phytogeography****Number of Credits : 4 (3 Theory + 1 Practical)****Effective from AY : 2025-26**

Prerequisites for the course:	Basic knowledge of ecology and environment.	
Course Objectives:	This course aims to: 1. Impart fundamental knowledge of ecology. 2. Familiarize students with population, community, succession and biome studies. 3. Provide an insight of principles of phytogeography and remote sensing and their applications. 4. Provide hands-on experience in various ecological techniques.	
Content:	Theory:	45 hours
	Module1: Basic concepts of an ecosystem, community dynamics and population ecology Ecosystem: Concept, composition, structure and function of an ecosystem; biogeochemical cycles (C, N and P) and hydrological cycle; energy flow in an ecosystem; biotic interactions; ecological adaptations of hydrophytes, xerophytes, halophytes and epiphytes. Plant communities: Definition, analytic, quantitative and synthetic characteristics; life forms; habitat and niche; ecotone and edge effect; dynamics; succession – processes and types; concept of a climax. Population ecology: Characteristics of a population (density, natality, mortality, dispersion, population size, age structure, life tables); population growth curves; population regulation; life history strategies (r and K selection).	15 hours
	Module 2: Biodiversity, major ecosystems and environmental education organizations Biodiversity: Definition, values of biodiversity and threats to biodiversity; endemic and endangered species in India. Major ecosystems: Aquatic, terrestrial, manmade (agricultural); ecosystems of west coast and Western Ghats with special reference to Goa (wetlands, mangroves, coastal, sand dunes, plateaus and forests). Environmental education organizations: National organizations (MoEF - Ministry of Environment and Forest, Govt. of India; CEE; MSSRF; NEERI; TERI); international organizations (UNESCO, CITIES, UNEP, MAB, WWF, TRAFFIC, Green Peace IUCN).	15 hours
	Module 3: Phytogeography and remote sensing Phytogeography: Definition, general principles, static and dynamic plant geography; continuous and discontinuous distribution; theories of discontinuous distribution (Land bridge	15 hours

	theory, continental drift); factors affecting distribution of species; major biomes of the world; vegetation of India; phytogeographic regions of India; local vegetation. Remote sensing and GIS in ecological applications: Definition of remote sensing; electromagnetic radiation and atmospheric windows; EMR and reflectance from vegetation; satellites and satellite remote sensing; applications of remote sensing in ecology, forestry, agriculture and environment. GIS - principle and applications. Satellite imageries and false color imaging; GPS and its applications in field; preparation of field maps and vegetation maps.	
	Practical:	30 hours
	1. Determination of minimal quadrat size for the study of herbaceous vegetation in the college campus by species area curve method (plant species to be listed).	2 hours
	2. Quantitative analysis of herbaceous vegetation for frequency, density and abundance.	4 hours
	3. Estimation of biomass of aerial parts of herbaceous plants (fresh weight and dry weight).	2 hours
	4. Study of phytoplankton and hydrophyte diversity from an aquatic ecosystem.	4 hours
	5. Study of morphological and anatomical adaptations of hydrophytes, xerophytes and epiphytes (one each).	4 hours
	6. Study of biotic interactions: Stem parasite (<i>Loranthus</i> and <i>Cuscuta</i>); epiphyte (orchid); predation (insectivorous plants – <i>Utricularia/Drosera</i> /pitcher plant).	2 hours
	7. Preparation of map of India with respect to: (i) major climatic zones, (ii) forest types and (iii) phytogeographic regions.	4 hours
	8. Preparation of map of Goa to show vegetation types as specified in theory.	2 hours
	9. Visual interpretation of remotely sensed image for vegetation types.	2 hours
	10. Use of a hand-held GPS instrument to locate coordinates of a demarcated field site (example - college campus).	2 hours
	11. Identification and description of false color images of land use patterns from a satellite image (city, reservoir, forest, agricultural land and sea-shore).	2 hours
Pedagogy:	Lectures, use of multimedia, tutorials, assignments, presentations, hands-on experiments, demonstrations, field visit and team-based learning.	
References/ Readings:	Dash, MC and Dash, SP (2012). Fundamentals of Ecology. 3rd edition. Tata McGraw Hill Education Private Limited, New Delhi. Kormondy, EJ (1996). Concepts of Ecology. 4th edition. PHI Learning Pvt. Ltd., Delhi, India. Odum, EP (2005). Fundamentals of Ecology. 5th edition. Cengage Learning India Pvt. Ltd., New Delhi. Pandey, BP (2018). Plant Ecology and Taxonomy: Botany for Degree	

	Students. S. Chand and Publications, New Delhi. 5. Sharma, PD (2010). Ecology and Environment. 8th edition. Rastogi Publications, Meerut, India. 6. Shukla, RS and Chandel, PS (2014). A Textbook of Plant Ecology Including Ethnobotany and Soil Science. 12th edition. S. Chand and Company Limited, New Delhi. 7. Singh, HR and Kumar, N (2010). Ecology and Environmental Science. Vishal Publishing Co., Jalandhar. 8. Singh, JS, Singh, SP and Gupta, SR (2006). Ecology, Environment and Resource Conservation. Anamaya Publishers, New Delhi. 9. Verma, PS and Agarwal, VK (2015). Cell Biology, Genetics, Molecular Biology, Evolution and Ecology. S. Chand and Company Pvt. Ltd., New Delhi. 10. Verma, V (1993). A Textbook of Plant Ecology. Emkay Publications. New Delhi. 11. Wilkinson, DM (2007). Fundamental Processes in Ecology: An Earth System Approach. Oxford University Press., U.S.A.											
Course Outcomes:	On completion of this course, students will be able to: 1. Recall concepts of ecosystem, phytogeography and remote sensing. 2. Describe the structure of community and dynamics of population. 3. Apply the knowledge of vegetation survey method, RS and GIS in various ecological studies. 4. Analyze the applications of RS and GIS in vegetation analysis.											
PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	2	2	3	3	3	2.5	3	2
CO2	3	3	3	3	2	3	3	3	3	2.5	3	3
CO3	3	3	3	3	2	3	3	3	3	2.5	3	3
CO4	3	3	3	3	2	2	3	3	3	2.5	3	2

Disciplinary/Interdisciplinary Major (Core)**Name of the Programme : B. Sc. (Botany)****Course Code : BOT-306****Title of the Course : Molecular Biology and Genetic Engineering****Number of Credits : 4 (3 Theory + 1 Practical)****Effective from AY : 2025-26**

Prerequisites for the course:	Basic knowledge of DNA and RNA structure and gene structure.	
Course Objectives:	This course aims to: 1. Provide students with a comprehensive understanding of the principles of molecular biology. 2. Familiarize students with intricacies of genetic code and mechanisms of DNA replication, transcription and translation. 3. Enable students to understand the techniques used in recombinant DNA technology. 4. Impart knowledge of the applications of recombinant DNA technology and the ethical concerns related to it.	
Content:	Theory:	45 hours
	Module 1: Basics in molecular biology Genetic material: DNA/RNA as carriers of genetic information (Hershey & Chase experiment and Fraenkel Conrat's experiment). Salient features of Watson and Crick's model of DNA; denaturation and renaturation of DNA. RNA and its types. Replication of DNA: Characteristics of the genetic code; central and revised dogma of molecular biology; mechanism of DNA replication; models of DNA replication (rolling circle model, theta replication, replication of linear ds DNA). Transcription and translation: Features of transcription and post-transcriptional processing. Features of translation and post-translational modification. Gene organization and regulation - Gene organization and regulation in prokaryotes (lac-operon model and trp operon model) and eukaryotes.	15 hours
	Module 2: Techniques in genetic engineering Recombinant DNA technology: Concept of recombinant DNA technology; steps in genetic engineering; enzymes used in recombinant DNA technology (restriction enzymes, DNA ligases); cloning vectors (pBR322, Ti plasmid, YAC, λ phage, cosmid); construction of genomic library. Methods of gene transfer in plants: <i>Agrobacterium</i> mediated and gene gun (biolistic) method; selectable marker (antibiotic resistance) and scorable marker/reporter genes (luciferase, GUS, GFP). Methods of DNA analyses: Southern, Northern and Western blotting; Polymerase Chain Reaction (PCR); DNA sequencing (Sanger & Coulson's method, Maxam & Gilbert's method); DNA fingerprinting technique (RFLP).	15 hours

	Module 3: Applications of genetic engineering and ethical concerns of GM crops Applications of genetic engineering: Genetically engineered plants for pest resistance (Bt-cotton); herbicide resistance (Roundup Ready soybean); improved nutritional content (golden rice); extended shelf life (Flavr Savr tomato); production of pharmaceuticals (edible vaccines); phytoremediation (<i>Arabidopsis</i> , poplar); production of biofuels (switchgrass). Genetically engineered microorganisms for bioremediation (superbug); production of pharmaceuticals (humulin, HGH). Ethical concerns of GM crops: Potential harm to human health; potential damage to the environment; negative impact on traditional farming practice; excessive corporate dominance.	15 hours
	Practical:	30 hours
	1. Study of Hershey & Chase's experiment and Frankel-Conrat's experiment using photographs.	2 hours
	2. Study of DNA replication mechanisms using models/ photographs (Rolling circle, Theta replication and semi-conservative replication).	2 hours
	3. a. Extraction of DNA from suitable plant material. b. Estimation of DNA by diphenylamine method.	4 hours
	4. a. Extraction of RNA from plant material. b. Estimation of RNA by Orcinol reagent.	4 hours
	5. Study of working of restriction enzymes and calculation of the size of fragments generated by use of restriction maps.	2 hours
	6. Study of structures of pBR322, Ti plasmid and cosmid using photographs.	2 hours
	7. Demonstration of culture of bacteria containing plasmids and maintenance of culture.	2 hours
	8. Demonstration of isolation of plasmids.	2 hours
	9. Demonstration of separation of DNA by gel electrophoresis.	4 hours
	10. Deciphering DNA sequence from a sequencing gel photograph by Sanger and Coulson's method and by Maxam and Gilbert's method.	4 hours
	11. Study of steps of genetic engineering for production of Bt cotton, golden rice, Flavr Savr tomato and humulin using photographs.	2 hours
Pedagogy:	Lectures, use of multimedia, tutorials, assignments, presentations, hands-on experiments, demonstrations and team-based learning.	
References/ Readings:	1. Agarwal, P (2017). Basic Concepts of Genetic Engineering. Pearson India Education Services, Chennai. 2. Alberts, B, Johnson, A, Lewis, J, Raff, M, Roberts, K and Walter, P (2014). Essential Cell Biology. 4 th edition. Garland Science, New York. 3. Brown, TA (2017). Genomes 4. 4 th edition. Garland Science, New York. 4. Chatterjee, R (2015). Molecular Biology of the Gene. Sapna Book	

	House, Bengaluru. 5. Dubey, RC (1993). A Textbook of Biotechnology. S. Chand and Company Pvt. Ltd., New Delhi. 6. Glick, BR and Pasternak, JJ (2003). Molecular Biotechnology: Principles and Applications of Recombinant DNA. ASM Press, Washington D.C. 7. Griffiths, AJ, Miller, JH, Suzuki, DT, Lewontin, RC and Gelbart, WM (2000). An Introduction to Genetic Analysis. W. H. Freeman, New York. 8. Khushu, S (2019). Molecular Genetics and Biotechnology. ABD Publishers, Jaipur. 9. Klug, WS, Cummings, MR, Spencer, CA and Palladino, MA (2017). Concepts of Genetics. 11th edition. Pearson Education, Boston. 10. Kulkarni, VM (2018). Molecular Biology: Concepts and Applications. McGraw-Hill Education, New Delhi. 11. Lewin, B (2019). Genes XII. Jones & Bartlett Learning, Sudbury, MA. 12. Lewin, B, Cassimeris, L, Lingappa, VR, Plopper, G and Sakai, RK (2015). Genes IX. Jones & Bartlett Learning, Sudbury, MA. 13. Lodish, H, Berk, A, Kaiser, CA, Krieger, M, Bretscher, A and Ploegh, H (2015). Molecular Cell Biology. W.H. Freeman, New York. 14. Malacinski, GM (2019). Essentials of Molecular Biology. Jones & Bartlett Learning, Sudbury, MA. 15. Nagar, S and Adhav, M (2009). Practical Biotechnology and Plant Tissue Culture. S. Chand and Company Ltd., New Delhi. 16. Primrose, SB and Twyman, RM (2006). Principles of Gene Manipulation and Genomics. 7th edition. Wiley-Blackwell, Hoboken, New Jersey, United States. 17. Purohit, SS (2008). Biotechnology: Fundamentals and Applications. Agrobios, Jodhpur. 18. Rao, CR (2016). Molecular Biology and Genetic Engineering. Universities Press, Hyderabad. 19. Russell, PJ (2010). i-Genetics - A Molecular Approach. 3rd edition. Benjamin Cummings, U.S.A. 20. Sharma, A (2017). Principles of Genetic Engineering. Tech-Max Publications, Mumbai. 21. Singh, R (2016). Genetic Engineering: Fundamentals and Applications. PHI Learning Private Limited, New Delhi. 22. Snustad, DP and Simmons, MJ (2012). Principles of Genetics. John Wiley & Sons Inc., U.S.A. 23. Stewart, CN Jr (2008). Plant Biotechnology & Genetics: Principles, Techniques and Applications. John Wiley & Sons Inc., U.S.A. 24. Verma, PS and Agarwal, VK (2009). Molecular Biology. S. Chand and Company Ltd., New Delhi. 25. Verma, S (2019). Genetic Engineering: Principles and Methods. Himalaya Publishing House, Mumbai. 26. Watson, JD, Baker, TA, Bell, SP, Gann, A, Levine, M and Losick, R (2014). Molecular Biology of the Gene. 7th edition. Cold Spring Harbor Laboratory Press, New York. 27. Yadav, R (2020). Molecular Biology Techniques. Academic Publishers,
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	Kolkata.											
Course Outcomes:	On completion of this course, students will be able to: 1. Recall the structures of nucleic acids and characteristics of the genetic code. 2. Understand the fundamental concepts of DNA replication, transcription, translation, gene organization, gene regulation and recombinant DNA technology. 3. Apply the acquired knowledge of genetic engineering principles, methods of gene transfer in plants and DNA analyses to modify genetic material leading to production of novel crops and products. 4. Analyse the various applications of genetic engineering and their ethical concerns.											
PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	2	1	1	3	2	3	2	1	2	3
CO2	3	3	3	3	2	3	3	3	3	3	3	3
CO3	3	3	3	3	2	3	3	3	3	3	3	2
CO4	3	3	2	3	2	3	3	3	3	2	3	3

Minor Project**Name of the Programme : B. Sc. (Botany)****Course Code : BOT-307****Title of the Course : Minor Project****Number of Credits 4****Effective from AY : 2025-26**

Disciplinary/Interdisciplinary Minor (VET)**Name of the Programme : B. Sc. (Botany)****Course Code : BOT-322****Title of the Course : Post-harvest Technology of Fruits and Vegetables****Number of Credits : 4 (3 Theory + 1 Practical)****Effective from AY : 2025-26**

Prerequisites for the course:	Basic knowledge of Biology.	
Course Objectives:	This course aims to: 1. Provide an overview of the various harvesting, handling, storage, packaging and preservation techniques used for post-harvest processing of fruits and vegetables. 2. Impart practical skills in preparation of various value-added food products using fruits and vegetables.	
Content:	Theory:	45 hours
	Module1: Introduction to post-harvest technology, harvesting, handling and storage techniques Introduction to post-harvest technology: Definition, scope and importance; physiology and biochemistry of fruit ripening; textural changes seen in fruits and vegetables due to over-ripening; ethylene evolution and its management; factors influencing post-harvest quality (temperature and humidity). Harvesting and handling practices: Harvesting methods for different fruits and vegetables; influence of pre-harvest practices on post-harvest quality; handling practices to minimize damage; sorting, grading and packing techniques; field containers for collection; transport from field to storage area; treatment of fruits and vegetables (washing, sanitization, waxing and curing); pre-cooling methods; packaging and shipment methods. Storage techniques: Methods for storage (cold storage, controlled atmosphere storage and modified atmosphere packaging).	15 hours
	Module 2: Microbial spoilage and preservation techniques Microbial spoilage: Introduction, causes of spoilage of fruits and vegetables; identification and management of common diseases of fruits and vegetables; integrated pest management in post-harvest handling; quarantine measures and regulations. Preservation techniques: Principles of preservation (asepsis and removal of microorganisms); methods of preservation - chemical preservation (use of preservatives); physical preservation (irradiation, low temperature, heat treatment, dehydration); canning and bottling; aseptic packaging. Quality maintenance: Monitoring and control of environmental conditions; pest and disease management during storage; quality assessment techniques; quality standards and certifications; monitoring and controlling post-harvest losses.	15 hours

	Module 3: Post-harvest processing, value addition and management Processing techniques: Principles and scope of processing; methods of processing fruits and vegetables by freezing, dehydration, pickling, preservation using sugar and salt, canning and fermentation; preparation of value-added food products (juice, squash, jam, marmalade, sauce and ketchup); quality considerations in processing. Processing of plant and vegetable products: Frozen vegetables - Carrot (<i>Daucus carota</i>) and peas (<i>Pisum sativum</i>). Dehydrated products – Potato (<i>Solanum tuberosum</i>) chips and garlic (<i>Allium sativum</i>) powder. Preparation of pickles – Bitter gourd (<i>Momordica charantia</i>) and brinjal (<i>Solanum melongena</i>). Canned products - Preparation of sugar syrup and canning of jackfruit (<i>Artocarpus heterophyllus</i>); preparation of brine and canning of green mango (<i>Mangifera indica</i>). Fermented products – Coconut (<i>Cocos nucifera</i>) vinegar and pineapple (<i>Ananas comosus</i>) wine. Juices and squashes - Kokum (<i>Garcinia indica</i>) juice and strawberry (<i>Fragaria</i> sp.) squash. Jams and marmalades - Guava (<i>Psidium guajava</i>) jam and orange (<i>Citrus sinensis</i>) marmalade. Sauces and ketchups - Chilli (<i>Capsicum annuum</i>) sauce and tomato (<i>Solanum lycopersicum</i>) ketchup. Emerging technologies in post-harvest management: Use of technology for quality control, automation in processing and packaging.	15 hours
	Practical:	30 hours
	1. Identification (botanical name and family) of fruits and vegetables (grapes, papaya, pineapple, orange, mango, kokum, tomato, lime, ginger, gooseberry and cucumber) used in preparation of value-added products.	2 hours
	2. Preparation and preservation of tomato ketchup (demonstration).	2 hours
	3. Preparation of raisins, tutti fruity and ginger/gooseberry candy (demonstration).	4 hours
	4. a. Demonstration of lime pickle/any suitable pickle. b. Demonstration of dill pickle of cucumber.	2 hours
	5. a. Demonstration of fermentation of coconut toddy or juice of any suitable fruit for production of vinegar. b. Determination of acetic acid content of vinegar.	4 hours
	6. Fermentation of fruit juice (pineapple/grapes or any suitable fruit) for preparation of wine and determination of alcohol content using a hydrometer/alcoholometer (demonstration).	4 hours

	7. Effect of heat on vitamin C content of packaged apple juice beverage.	2 hours
	8. Preparation of kokum syrup/ginger-lemon concentrate (demonstration).	2 hours
	9. Preparation of dried kokum rind/raw mango slices (demonstration).	2 hours
	10. Preparation of orange marmalade and mixed fruit jam (demonstration).	4 hours
	11. Study of different types of machinery, equipment and packaging materials used in processing/packaging of fruits and vegetables using photographs.	2 hours
Pedagogy:	Lectures, use of multimedia, assignments, presentations, hands-on experiments, demonstrations and team-based learning.	
References/ Readings:	1. Ahiduzzaman, MD (2022). Postharvest Technology: Recent Advances, New Perspectives and Applications. CBS Publishers & Distributors Pvt. Ltd., New Delhi. 2. Ashraf, SM (2008). Handbook of Fruit and Vegetable Products. Agrobios, India. 3. Cruess, WV (2004). Commercial Fruit and Vegetable Products. Agrobios, India. 4. Dubey, RC (1993). A Textbook of Biotechnology. S. Chand & Company Pvt. Ltd., New Delhi. 5. Frazier, WC and Westhoff, DC (2008). Food Microbiology. Tata McGraw Hill Education Private Limited, New Delhi. 6. Kader, AA (2002). Postharvest Technology of Horticultural Crops. University of California, Agriculture and Natural Resources, USA. 7. Lal G, Siddappa, GS and Tandon, GL (2019). Preservation of Fruits and Vegetables. ICAR, New Delhi. 8. Manay, SN and Shadaksharaswamy, M (2008). Foods: Facts and Principles. New Age International, Bengaluru. 9. Narang, RK (2010). Fruit and Vegetable Preservation Techniques. APH Publishing Corporation, Delhi. 10. Potter, NN and Hotchkiss, HJ (1996). Food Science. CBS Publishers & Distributors, New Delhi. 11. Rahman, MS (2020). Handbook of Food Preservation. 3rd edition. CRC-Press, United States. 12. Ranganna, S (1986). Handbook of Analysis and Quality Control for Fruits and Vegetable Products. 2nd edition. Tata McGraw-Hill Publishing Company Limited, New York. 13. Saldanha, E (2010). Successful Goan Home Wines. Rajhauns Vitaran, Goa. 14. Sehgal, S (2016). A Laboratory Manual of Food Analysis. I.K. International Publishing House Pvt. Ltd., New Delhi. 15. Srilakshmi, B (2007). Food Science. New Age International (P.) Limited, New Delhi. 16. Srivastava, RP and Kumar, S (2017). Fruit and Vegetable Preservation: Principles and Practices. 3rd edition. CBS Publishers	

	and Distributors Pvt. Ltd., India. 17. Thompson, AK (2003). Fruit and Vegetables: Harvesting, Handling and Storage. 2nd edition. Blackwell Publishing Ltd., U.S. 18. Verma, LR (2000). Post Harvest Technology of Fruits and Vegetables: Handling, Processing, Fermentation and Waste Management. Volume I & II. Indus Publishing Company, New Delhi. 19. Wills, R, Golding, I and Graham, D (2016). Postharvest: An Introduction to the Physiology and Handling of Fruit and Vegetables, 6th edition. Centre for Agriculture and Bioscience International, Cambridge. 20. Wolff, IA (1982). CRC Handbook of Processing and Utilization in Agriculture. Volume 1, Volume 2, Parts 1-2. CRC Press, California.											
Course Outcomes:	On completion of this course, students will be able to: 1. Recall post-harvest processes and factors influencing post-harvest quality. 2. Identify microbial spoilage of fruits and vegetables and use effective methods for preservation and maintaining the quality of fruits and vegetables. 3. Utilize effective harvesting, handling and storage strategies for marketing of fruits and vegetables ensuring minimal post-harvest losses. 4. Develop skills in processing and preparation of different value-added products using fruits and vegetables.											
PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	2	2	1	2	1	3	3	2	2	2
CO2	3	3	2	2	2	2	2	3	3	2	2	2
CO3	3	3	3	3	2	3	3	3	3	2	3	3
CO4	3	3	3	3	2	3	3	3	3	3	3	3