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-100 #@$%&* Fundamentals of Botany (3T+1P)**	**BOT-111 Plants in Everyday Life (4T)**	**BOT-131 Kitchen Gardening (3)**	(2)	**BOT-141 Nursery and Gardening (1T+2P)**					
II				(2)						**BOT-161 Floriculture (1+3)**
III	**BOT-200 @%* Diversity of Microbes and Non-flowering plants (3T+1P)** **BOT-201 #$& Plant Physiology (3T+1P)**	**BOT-211 Algal Plant-Animal Interactions (3T+1P)**	**BOT-231 Plant Propagation Methods (3T)**	(2)	**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-306 #$& Molecular Biology and Genetic Engineering (3T+1P)** **BOT-307 #$& Minor Project (4)**	**BOT-322 Post-harvest Technology of Fruits and Vegetables (3T+1P) [VET]**							**20**	

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

Name of the Programme : B. Sc. (Botany)
Course Code : BOT-100
Title of the Course : Fundamentals of Botany
Number of Credits : 3T+1P
Effective from AY : 2023-24

Prerequisites for the course:	Should have basic knowledge of Biology.	
Course Objective(s):	This course aims to increase the understanding about the diversity, identification, classification, evolutionary history, relationship of plants with man and other sciences, fundamentals of different branches in Botany, studying the plants with regards to their morphological features, physical, chemical and biological functioning of plants and various plant processes with emphasis on basic instruments and techniques used in the Botanical studies. Laboratory exercises are designed to give hands on experience in handling all specimens and to understand the processes and functioning of plants.	
Content:	**Module 1: Introduction to plant kingdom** Fundamental notions of plants: Relation of plants to man, relation of Botany to other sciences, brief description of various branches in Botany (Systematic botany- Classification, Taxonomy and nomenclature; Morphology – external, internal; Embryology, Physiology, Ecology, Phytogeography, Economic Botany, Cytology and Cytogenetics, Ethnobotany, Biotechnology, Molecular Biology, Biochemistry). Evolutionary history of plants: Evolution of plants on geological time scale; Paleobotany: Fossil formation process, types of fossils –Impression, Compression, Petrification and coal balls. Broad classification of plant kingdom: Introduction to seven kingdom classification of life, Characteristic features of the plant kingdom. Classification of Plant kingdom up to divisions (G.M. Smith's classification).	**15 hours**
	Module 2: Plant morphology Types of roots (Tap, fibrous and adventitious), stem (aerial and underground), leaf (parts of the leaf; phyllotaxy – Alternate, spiral, opposite, whorled; shapes of leaves; leaf types - compound, simple; leaf margins, leaf apex, leaf venation - parallel and reticulate, vernation), inflorescence types – cymose and racemose, flower (parts, symmetries, functions of different parts of the flower, aestivation types), fruit (Simple, Aggregate, Multiple). Seed and its structure, embryo; seed types; germination in Ricinus and Cucurbita; Seed dispersal mechanisms. Tissues in plants: Meristems – types, positions, functions; simple tissues– Parenchyma, Collenchyma, Sclerenchyma – their positions, functions; Vascular tissues - types, positions, functions	**15 hours**

	Module 3: Plant growth and Plant movements; Instrumentation Plant movements: tropic responses (phototropism, geotropism, chemotropism, hydrotropism and thigmotropism); leaf movements (nyctinasty and seismonasty). Photosynthesis, Respiration, Transpiration, Osmosis, Imbibition and Diffusion, (definition, brief process and significance). Principle, working and applications of: microscopy (Dissection and light microscope), micrometry, distillation unit, spectrophotometer, centrifuge, laminar air flow unit, orbital shaker, pH meter, Autoclave.	**15 hours**
	Practicals (15P = 15 × 2 hours)	
	1. Study of different types of fossils as mentioned in theory.	**2 hours**
	2. To study different types of stem and root	**2 hours**
	3. To study different characters of leaves with respect to: a. phyllotaxy – Alternate, spiral, opposite, whorled; shapes of leaves, leaf types - compound, simple. b. leaf margins, leaf apex, leaf venation - parallel and reticulate, vernation	**2 hours**
	4. To study various parts of the flower, types of inflorescences and fruits.	**2 hours**
	5. To study type of seeds and germination in seeds of *Ricinus* and *Cucurbita.*	**2 hours**
	6. To study types of tissues as mentioned in theory with the help of permanent slides.	**2 hours**
	7. Demonstration of tropic responses in plants - phototropism, geotropism, chemotropism, hydrotropism and thigmotropism.	**2 hours**
	8. To demonstrate leaf movements as mentioned in theory.	**2 hours**
	9. Photosynthesis and Respiration: a. To demonstrate that oxygen is evolved during photosynthesis using inverted funnel method b. Demonstration of respiration in germinating seeds by phenol red method	**2 hours**
	10. Demonstration of process of Osmosis and Imbibition in plants.	**2 hours**
	11. Demonstration of process of Diffusion and Transpiration in plants.	**2 hours**
	12. Study of basic instruments used in botanical studies: a. Dissection microscope, light microscope, distillation unit, spectrophotometer, Autoclave (1P) b. Laminar air flow unit, centrifuge, orbital shaker, micrometres (stage and ocular), pH meter (1P)	**4 hours**
	13. Field visit to observe the plant diversity (Algae, bryophytes, pteridophytes, gymnosperms, angiosperms)	**4 hours**
Pedagogy:	Lectures/ Use of Multimedia / Assignments/ Hands-on experiments/ Demonstrations/ Field visit.	

References/ Readings:	1. **Arnold CA** (2018). An introduction to Paleobotany. Surjeet Publications, Delhi. 2. **Bhojwani, SS, Bhatnagar, SP, Dantu, PK** (2015). The embryology of Angiosperms. 6th Edition. Vikas Publishing House Pvt. Ltd., New Delhi. 3. **Davis, PH and Heywood, VH** (1963). Principles of Angiosperm Taxonomy. Oliver & Boyd, London. 4. **Gangulee, SC, Das, KS, Dutta, CD. and Kar, AK** (1968). College Botany Vol. I, II and III. Central Education Enterprises. 5. **Gifford, EM and Foster, AS** (1988). Morphology and Evolution of Vascular Plants, W.H. Freeman & Company, New York. 6. **Gurumani, N** (2006). Research methodology for biological sciences. MJP Publishers, Chennai. 7. **Hopkins, WG and Huner, NP** (2009). Introduction to Plant Physiology. 4th edition. John Wiley & Sons, U.S.A. 8. **Jain, VK** (2017). Fundamentals of Plant Physiology. 19th edition. S. Chand Company Ltd. New Delhi. 9. **Lawrence, GHM** (1951). Taxonomy of Vascular Plants. MacMillan, New York. 10. **Pandey, BP** (2014). Plant Anatomy. S. Chand & Company Pvt. Ltd., New Delhi. 11. **Sambamurty AVSS** (2006). A Textbook of Bryophytes, Pteridophytes, Gymnosperms and Paleobotany. I.K. International publication, New Delhi. 12. **Sharma VK** (1991). Techniques in microscopy and cell biology. Tata McGraw-Hill, New Delhi. 13. **Singh, G.** (2012). Plant Systematics. Theory and Practice. 3rd edition. Oxford & IBH Pvt. Ltd., New Delhi. 14. **Singh, V, Pandey, PC and Jain, DK** (2017). Anatomy of Angiosperms, Rastogi Publication, Meerut. 15. **Steward, WM** (2010). Paleobotany and the Evolution of Plants. Cambridge University Press, Cambridge.
Course Outcomes:	1. Outline the classification of life and identify the characteristics features of plant kingdom. 2. Summarize the evolutionary history of plants. 3. Outline the different branches in botany and their relation to other sciences. 4. Analyse the morphological features of plants. 5. Examine the stages of plant growth, plant cells, processes and its responses.

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	2	2	3	2	3	3	3	2	3
CO2	3	3	3	2	2	3	2	3	3	3	2	3
CO3	3	3	3	3	2	3	3	3	3	3	3	3
CO4	3	3	3	2	2	3	2	3	3	3	2	3
CO5	3	3	3	3	2	3	2	3	3	3	3	3

Name of the Programme : **B. Sc. (Botany)**
Course Code : **BOT-111**
Title of the Course : **Plants in Everyday Life**
Number of Credits : **4**
Effective from AY : **2023-24**

Prerequisites for the course:	Nil	
Course Objective(s):	This course is designed to give an overview of how plants are indispensable to humans. It gives a broad exposure to the various aspects of plant resource & its utilization.	
Content:	**Module 1: Plant services to humans in everyday life** Introduction to science of Botany, plant resources in everyday life.	**2 hours**
	Role of plants: Air purifier (photosynthesis); plants used in rituals/festivals; Pollution removal (phytoremediation and its types), pollution indicator (lichens), and nutrient source (litter manure, organic manure).	**4 hours**
	Familiarizing the students to identify plants based on morphology of plant parts. Identify common wild plants using live plants/ herbarium/photographs etc.	**4 hours**
	Common wild plants and their utilization: Identification and utilization of following plants: Hirda (*Terminalia chebula*), Behda (*Terminalia bellirica*), Matti (*Terminalia elliptica*), Kinal (*Terminalia paniculata*), Savar (*Ceiba pentandra*), Kate-savar (*Bombax ceiba*), Bhillo mad (*Caryota urens*), Arjun/Pandruk (*Sterculia foetida*), Kumyo (*Careya arborea*), Asale (*Microcos paniculata*), Charan (*Buchanania cochinchinensis*), Chunna (*Ziziphus rugosa)* and Kanna (*Carissa carandas*).	**2 hours**
	Grandma's herbal pouch: Following plants to be studied with respect to botanical source, part of the plant used, and medicinal uses: Tulsi (*Ocimum sanctum*), Adulsa (*Adhatoda vasica*), Ale (*Zingiber officinale*), Halad (*Curcuma longa*), Kate kuvar (*Aloe vera*), Kirayte (*Andrographis paniculata*), Ganjan (*Cymbopogon citratus*), Ottalao (*Coleus aromaticus*), Vaikhand (*Acorus calamus*), Punarnava (*Boerhaavia diffusa*), Paripat (*Oldenlandia corymbosa*) and Gulvel (*Tinospora cordifolia*).	**3 hours**
	Module 2: Plant resources and utilization-I (including brief description of plants and/or plant parts used).	
	a. **Cereals**: Rice, Wheat, Maize	**2 hours**
	b. **Millets:** Ragi, Jowar and Bajra	**2 hours**
	c. **Legumes**: Bengal gram, Green gram, Red gram, Black gram and Cowpea.	**2 hours**
	d. **Cash crops:** Cashew, Sugarcane and Cocoa.	**2 hours**
	e. **Plantation crops:** Coconut, Banana, Mango and Jackfruit.	**3 hours**
	f. **Edible oils:** Groundnut, Coconut, Soyabean and Palm Oil.	**2 hours**
	g. **Starch and tuber crops:** Potato, Sweet potato and Yam	**1 hour**
	h. **Vegetable crops**: Red amaranth, Radish, Lady's finger, Teren,	**1 hour**

	Kudduki, Ankur and Taikhilo.	
	Module 3: Plant resources and utilization-II (including brief description of plant and/or plant parts used).	
	a. **Spices:** Chillies, Nutmeg, Clove, Black pepper, Cardamom, Star anise (Chakriful) and Dagad phul (*Parmotrema perlatum*).	**2 hours**
	b. **Beverages:** Tea and Coffee (including processing).	**2 hours**
	c. **Eco-friendly use of plant parts**: Banana fresh leaves, Arecanut spathe, Kumyo leaves (*Carea arborea*), Jackfruit leaves and Bamboo culm.	**2 hours**
	d. **Oils:** Eucalyptus, Rose and Orange peel (including methods of extraction)	**2 hours**
	e. **Fibres:** Coir, Cotton, Jute, Banana and Sisal Including method of separation of spathe, drying and storing of fibre of banana and; Collection, drying, processing and extraction of fibre from *Agave* leaf (demonstration/video)	**4 hours**
	f. **Timber:** Teak (Sailo), Rose wood (Shisham), Matti and Bamboo.	**2 hours**
	g. **Rubber:** *Hevea brasiliensis* (including demonstration of rubber extraction process)	**1 hour**
	Module 4: Utilization of plants in value added products	
	Herbal based hair dyes: Role of ingredients used in formulation; preparation of herbal dyes; application of hair dye; evaluation and uses of hair dye (Henna, Bhringaraj, Hibiscus, Amla). Including demonstration on preparation of herbal hair dye and evaluation/testing on hair wig.	**3 hours**
	Herbal cosmetics and aromatics: Introduction and scope, Extraction Methods-Maceration, infusion, decoction, distillation and tinctures, Types of herbal preparations.	**3 hours**
	Plants used in cleansers (Neem, Cucumber, Rose), scrubs (Marigold, Neem), wash (Rose –face wash, hibiscus & amla- hair wash & oil), packs (Neem, Tulsi, Sandalwood, Turmeric) and creams (Rose, Jasmin, Marigold).	
	Extraction of essential oil from lemon grass / orange peel or citrus fruit peel. Preparation of Henna powder from Henna leaves and Aloe gel from *Aloe vera*.	**2 hours**
	Preparation of plant based holi colours.	**1 hour**
	Paper making from plants: Paper industry and paper manufacturing; Raw materials, Processing and kinds of paper, paper Industry in India.	**3 hours**
	Method of making of handmade paper with demonstration/video.	**1 hour**
	Demonstration on preparation of herbal formulation/herbal tea.	**1 hour**
	Field visit in the campus to identify the plants of economic importance and report preparation.	**1 hour**
Pedagogy:	Lectures/ Tutorials/Assignments/Presentation / Demonstration/Field visit/Team based learning.	

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. Chrispeels, MJ and Sadava, DE** (1994). Plants, Genes and Agriculture. Jones & Bartlett Publishers. **4. Fuller, KW and Gallon, JA** (1985). Plant Products and New Technology. Clarendon Press, Oxford, New York. **5. Hill, AF** (1952)**.** Economic Botany: A Textbook of Useful Plants and Plant Products. McGraw Hill Publishing Company Ltd., New Delhi. **6. Kochhar, SL** (2012). Economic Botany in the Tropics. MacMillan India Ltd., New Delhi. **7. Purohit, SS and Vyas, SP** (2008). Medicinal Plant Cultivation: A Scientific Approach. Agrobios, India. **8. Rao, RS** (1985-1986). Flora of Goa, Diu, Daman & Nagar-Haveli. 2 Volumes. Botanical Survey of India. **9. Shailesh, R** (2019). Everyday Ayurveda: The complete book of Ayurvedic home remedies. Notion Press, India. **10. Sambamurty AVSS and Subramanyam NS** (1989). A Textbook of Economic Botany. Wiley Eastern Ltd., New Delhi. **11. Sen, S (**2009). Economic Botany. NCBA Publishers, New Delhi. **12. Sharma, OP** (1996). Hill's Economic Botany. Tata McGraw Hill Publishing Company Ltd., New Delhi. **13. Simpson BB and Conner-Ogorzaly M** (1986). Economic Botany - Plants in Our World. McGraw Hill, New York. **14. Singh V, Pande PC and Jain DK** (2009). A Text Book of Economic Botany. Rastogi Publications, Uttar Pradesh. **15. Trivedi, PC** (2006). Medicinal Plants: Ethnobotanical Approach. Agrobios, India. **16. 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. **17. Wickens, GE** (2001). Economic Botany: Principles & Practices. Kluwer Academic Publishers, The Netherlands.
Course Outcomes:	1. Recall various economically and medicinally important plant species used in day-to-day life. 2. Explain the uses of economically important plants and illustrate the processing of various plant parts. 3. Analyze the utilization of various plant resources in day-to-day life. 4. Apply theoretical knowledge in utilization, and report generation of economical and medicinal plants. Create awareness on conservation of medicinal plants and use of natural plant products as alternatives to synthetic products.

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	3	3	2	2	2	3	2	2.5	2.5	2
CO2	3	2	3	2	2	2	2	3	2	2.5	2	2
CO3	3	2	2	2	2	2	2	3	2	2	2.5	2
CO4	3	2	2	3	2	2	2	3	2	2	2.5	2

Name of the Programme : **B. Sc. (Botany)**
Course Code : **BOT-131**
Title of the Course : **Kitchen Gardening**
Number of Credits : **3**
Effective from AY : **2023-24**

Prerequisites for the course:	Nil	
Course Objective(s):	This course aims to create understanding about the importance of a kitchen garden, routine operations in a Kitchen Garden, Organic manures, Soil preparation, Nursery Management for vegetable crops, plants for kitchen garden and pest management.	
Content:	**Module 1: Introduction to Kitchen Garden, Nursery Management for vegetable crops and Routine operations.** Concept and importance; planning and layout of kitchen garden; indoor/urban kitchen gardening (terrace, grow bags, hanging pots, vertical garden). Seed selection, bed preparation for nursery plants, seedling trays, seed sowing, after care of nursery plants. Irrigation, mulching, transplantation, pinching, pruning, cropping patterns (intercropping and crop rotation), spacing of crops; Tools and kitchen garden implements; Plant supports (stakes, wall trellis, split bamboo, moss pole, fan trellis, etc.); Compost pit; Weed management; Manuring; harvesting; Seeds and tuber collection, traditional and modern methods of seed storage.	**15 hours**
	Module 2: Soil preparation, organic manures, Pest and disease management. Soil mixtures; vegetable plots (flat beds, raised beds, ridges and furrows, basin). Organic manures (panchagavya, beej amrit solution, compost, fish manures, bone meal, farm yard manure, vermicompost, wood ash, oil - cakes, green manure). Plant protection measures; Biocontrol agents, bio-pesticides, pheromones, trap crops, bird perches; Common Garden pests and control measures – sucking insects (mealy bugs, aphids, white flies, mites), biting and chewing insects (caterpillars, beetles, grasshoppers, larve), borers, ants, slugs and snails, rodents; Common diseases of vegetable plants, symptoms and control measures (damping off, Powdery mildew, Root knot, Vein clearing, Wilt). Visit to a local vegetable cultivation field and field report.	**15 hours**
	Module 3: Plants for kitchen garden and monthly kitchen garden activities. Identification and uses - Drumstick, curry leaves, bilimbi, lemon, tamarind, kokum, coconut, breadfruit, papaya, banana, pineapple, guava, mango, pepper, Herbs (ginger, turmeric, mint, coriander, lemon grass, Indian spinach (*Basella*)). Annual vegetables - Classification on the basis of (a) Planting	**15 hours**

	season (b) Plant part used as vegetable. General cultivation practices followed for: Cole crops (Cabbage, cauliflower, knol – khol, lettuce), Root vegetables (Raddish, carrot, turnip, beet, sweet potato, elephant foot (suran), Kate kandga, *Colocasia),* Solanaceous crops (Tomato, brinjal, chilli, bell pepper), Cucurbitaceous crops (Bottle gourd, bitter gourd, snake gourd, ridge gourd, ash gourd, little gourd, pumpkin, musk melon, water melon, cucumber), Leafy vegetables (Spinach, *Amaranthus*, Fenugreek, dill), Beans (French beans, cluster beans, virvil), Bulbs (Onion, garlic), Okra, Corn, Micro greens. Importance of a kitchen gardening planner; vegetable growing operations for every month as per the seasons (time of sowing, successional sowing, transplanting, etc.). Preparation of a yearly diary of kitchen gardening activities.	
Pedagogy:	Lectures, Tutorials, Assignments, Demonstrations, live specimens, Herbarium specimens, Videos, Field visit and report writing.	
References/ Readings:	1. **Agrawal, P.K.** (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, L.H.** (2009). Manual of Gardening. Srishti Book Distributors, New Delhi. 4. **Biles, R.E.** (2003). The Complete Book of Gardening. Biotech Books, Delhi. 5. **Bose, T.K. and Mukherjee, D.** (1972). Gardening in India. Oxford & IBH Publishing Co., New Delhi. 6. **Karanth, A.** (2013). Seed Technology. Black Prints India INC., New Delhi. 7. **Rao, K.M.** (2005). Textbook of Horticulture. 2nd edition. Macmillan India Limited, New Delhi. 8. **Rao, P.S.** (2016). Vegetable Crops Production. Sonali Publications, New Delhi. 9. **Sheela, V.L.** (2011). Horticulture. MJP Publications, Chennai. 10. **Sud, R.K. 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, P.P.** (1987). Home Gardening. Indian Council of Agricultural Research, New Delhi. 13. **Zingare, A.K.** (2013). A Manual of Gardening. Satyam Publishers & Distributors, Jaipur.	
Course Outcomes:	The students will be able to: 1. Plan and design a kitchen garden 2. Understand the techniques of Nursery Management for vegetable crops. 3. Gain knowledge of organic fertilizers, composting.	

	4. Have the basic knowledge of growing different types of vegetables. 5. Identify the plants for a kitchen garden and know their uses. 6. Plan yearly activities for a kitchen garden., Identify and manage crop pests in kitchen garden.											
PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3	3	3	3	3	3	3	3
CO2	3	3	2	2	1	2	2	3	3	2	2	2
CO3	3	1	2	3	1	2	3	3	1	2	3	3
CO4	3	2	2	2	1	3	3	3	2	2	2	3
CO5	3	1	1	2	1	3	2	3	1	1	2	3
CO6	3	3	3	3	2	3	2	3	3	3	3	3

Name of the Programme : **B. Sc. (Botany)**
Course Code : **BOT-141**
Title of the Course : **Nursery and Gardening**
Number of Credits : **3 (1 Theory + 2 Practical)**
Effective from AY : **2023-24**

Prerequisites for the course:	Should have basic knowledge of Biology.	
Course Objective(s):	This course aims to increase the understanding about the different types of gardens, their features and routine operations in nursery management and gardening. The practical component of this course aims to impart skill in designing a plant nursery, different types gardens, cultivation practices to be followed in operating a plant nursery and garden.	
Content:	**Module 1: Plant nursery, gardens and their management** Definition, objectives and scope of a plant nursery and garden. Plant nursery layout, infrastructure, planning and seasonal activities; marketing challenges. Different 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). 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**
	Practicals (30P = 30 × 2 hours)	
	1. Preparation of a layout sketch of a 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, practical, field visits, participatory learning, seminars, assignments etc.	
References/ Readings:	1. **Acquaah, G** (2019). Horticulture: Principles and Practices (4th edition). India: Pearson India Education Services Pvt. Ltd. 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: 1. Explain the objective and scope of a plant nursery and garden. 2. Describe the different types of gardens and their features.	

	3. Analyze the different routine operations in nursery management and gardening. 4. Develop skills in designing a plant nursery and different types of gardens, routine operations in gardening and nursery management, cultivation practices for entrepreneurial opportunities.											
PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	2	2	3	2	2	3	2	2	2	2
CO2	3	2	2	2	3	2	2	3	2	2	2	2
CO3	3	3	2	3	3	3	2	3	3	2	3	3
CO4	3	3	3	3	3	3	3	3	3	3	3	3

Name of the Programme : **B. Sc. (Botany)**
Course Code : **BOT-161**
Title of the Course : **Floriculture**
Number of Credits : **4 (1 Theory + 3 Practical)**
Effective from AY : **2023-24**

Prerequisites for the course:	Should have basic knowledge of Biology.	
Course Objective(s):	The course is designed to provide knowledge of nursery bed preparation, use of various methods of plant propagation, garden implements, cultivation, care, harvesting, designing floral arrangement and marketing of flowers.	
Content:	**Module 1: Floriculture: Scope, routine garden operations, propagation and commercial aspects.** Scope of floriculture; Global trends and importance. Future of floriculture as an industry in Goa and Government initiatives (SCHEMES). Different garden tools and their operations. Routine Garden Operations - 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. Different styles and types of flower arrangements, Preparation of floral bouquets, floral rangoli, Garlands, Crown, Wreaths, Baskets and Dry Flower arrangements.	**15 hours**
	Practicals (45 P)	
	1. Ornamental Garden planting plan/design	**2 hours**
	2. Garden implements and their operations; plant supports.	**4 hours**
	3. Identification and description of plants based on types and shapes: a. 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 – *Sansivieria*, bushy - *Dieffenbachia*, trailing - *Chlorophytum*, climbing - *Monstera*, standard - *Ficus benjamina*, architectural-*Chamaerops*/palms, ball - Cacti, rosette - *Haworthia*, *Echeveria*)	**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 etc.) 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 peats: Orchids and Anthuriums.	**15 hours**

	Soil: Cultivation of flowering / foliage / water / cacti / succulent plants (1 of each category).	
	9. Aesthetic grouping of plants in open and container gardens	**4 hours**
	10. Garden operations: Mulching, pricking, topping, trimming and training, feeding and repotting.	**5 hours**
	11. Harvesting, packing of cut flowers - packaging material (polythene, butter paper, brown paper, newspaper, and 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 disease and pest. (Insects, Fungal, Bacterial, Viral and Mycoplasmic)	**6 hours**
	14. Methods of drying plant materials (air-drying, desiccants, sand, microwave/oven etc.)	**4 hours**
	15. Styles of flower arrangements: Garlands (any 2); bouquets (any 2) Crown (any 1); wreath (any 1); baskets (any1); 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, Practicals, Assignment, Presentations, 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, G.S. 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 (*Dendranthema grandiflora*). Journal of Ornamental Horticulture (13): 233-236. 10. **Swarup, V.** (1997). Ornamental Horticulture. MacMillan India Ltd., UK	
Course Outcomes:	1. Understand the concept of floriculture and cultivation of commercial ornamental plants. 2. Develop basic skills in techniques and different styles flower arrangement. 3. Learn routine nursery management practices, garden operations & postharvest technology for ornamental plants. 4. Understand the concept of plant growth and plant care.	

	5. Develop insight to various government schemes in floriculture industry establish start-ups in floriculture business.											
PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	2	3	3	3	3	3	2	3	3	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	2	2	3	3	3	3	3	2	3	3	3
CO5	3	3	3	3	3	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 *Mucor*, *Aspergillus*, *Agaricus* and *Saccharomyces*; 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 *Nostoc*, *Spirogyra*, *Sargassum* and *Polysiphonia*; ecological and economic importance. **Bryophytes:** General characteristics; Smith's classification; alternation of generations; methods of reproduction; morphological features of *Riccia*, *Anthoceros* and *Funaria*; 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 (*Cooksonia* and *Rhynia*); morphological features and reproductive structures of *Psilotum*, *Selaginella*, *Equisetum* and *Pteris*; 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 *Cycas*, *Pinus* and *Gnetum*; 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 *Mucor* and *Aspergillus* (temporary mounts / permanent slides).	**4 hours**
	4. Study of *Agaricus* 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 *Nostoc*, *Spirogyra*, *Sargassum* and *Polysiphonia* (fresh or preserved specimens / permanent slides).	**2 hours**
	8. Morphology of thallus and sporophyte of *Riccia*, *Anthoceros* and *Funaria* (fresh or preserved specimens / permanent slides).	**4 hours**
	9. Morphology and reproductive structures of *Psilotum*, *Equisetum* and *Pteris* (fresh or preserved specimens / permanent slides).	**2 hours**
	10. Morphology of *Selaginella* and L.S. of its strobilus.	**2 hours**
	11. Morphology and reproductive structures (male and female cones) of *Cycas*, *Pinus* and *Gnetum* (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	

	and Development. 6th edition. Sinauer Associates, Inc., U.S.A.
Course Outcomes:	On completion of this course, students will be able to: 1. Enlist the role of mineral nutrients, plant pigments and phytohormones in plant growth. 2. Understand and describe various physiological processes such as absorption, transpiration, photosynthesis, photorespiration, translocation and nitrogen metabolism involved in plant growth. 3. Apply the knowledge of mineral nutrients and phytohormones in regulating plant growth. 4. Analyze plant responses to various growth and environmental factors and plan the experimental layout for research work.

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	1	2	3	3	2	3	3	1	2	3	2
CO2	3	2	3	3	3	3	3	3	2	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

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.	**2hours**
	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	

	and Pollinator. Princeton University Press, Princeton, New Jersey.
Course Outcomes:	On completion of this course, students will be able to: 1. Understand the relationships between plants and animals. 2. Summarize types of plant-animal interactions. 3. Evaluate the effect of climate change, habitat loss, fragmentation, hunting and introduction of invasive species and GM crops on these interactions. 4. Appraise the significance of plant-animal interactions for conservation and survival of human species.

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	2	2	2	2	2	3	2	2	2	2
CO2	3	2	2	2	3	2	2	3	2	3	2	2
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

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**, **Al** 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: *Allium sativum*, *Andrographis paniculata*, *Bixa orellana*, *Boerhavia diffusa*, *Catharanthus roseus*, *Centella asiatica, Garcinia indica*, *Hemidesmus indicus*, *Justicia adhatoda*, *Ocimum sanctum*, *Phyllanthus emblica*, *Piper longum*, *Rauwolfia serpentina, Saraca indica* and *Tinospora cordifolia* (fresh specimens or photographs).	
	2. Study of organoleptic and microscopic characters, chemical constituents and medicinal uses of the following herbs: *Aloe vera* - leaf, *Coriandrum sativum* - fruit, *Curcuma longa* - rhizome, *Cymbopogon citratus* - leaf, *Drimia indica* - bulb scale and *Zingiber officinale* - 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 **Wadhave**, **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.

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3	3	3	3	3	3	3	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

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 *Boerhavia* and *Dracaena*; 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 (megasporangium); types of ovules; megasporogenesis and development of female gametophyte (embryo sac); types of embryo sacs - monosporic (*Polygonum* type), bisporic (*Allium* type) and tetrasporic (*Peperomia* 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 *Helianthus annuus/Eupatorium odoratum* and *Oryza sativa/Zea mays*. b. Roots of *Helianthus annuus/Eupatorium odoratum* and *Oryza sativa/Zea mays.*	**4 hours**
	4. Study of multiple epidermis and cystoliths in leaves of *Ficus* sp. and buliform cells in leaves of *Zea mays.*	**2 hours**
	5. Normal secondary growth in dicot stem (*Helianthus annuus*/*Eupatorium odoratum*).	**2 hours**
	6. Anomalous secondary growth in the stems of *Boerhavia* and *Dracaena* (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. **Dickison**, **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. 7th 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 **Lippincort-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:** *Rhizobium*-root nodule symbiosis; identification, isolation, mass multiplication, production of carrier-based inoculants, techniques of field application and crop response to rhizobial inoculants; *Frankia* and actinorrhizal symbiosis; *Azolla-Anabaena* symbiosis; mass cultivation and field application of *Azolla* 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. *Azospirillum* and *Azotobacter* -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 *Piriformospora indica*.	**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 *Rhizobium* sp. from root nodules using YEMA medium.	**4 hours**
	4. Preparation of carrier-based inoculum of *Rhizobium* sp.	**2 hours**
	5. Induction of root nodules in a leguminous plant using *Rhizobium* sp. (demonstration).	**2 hours**
	6. Study of *Anabaena-Azolla* symbiosis in *Azolla* 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 - *Azadirachta indica, Getonia floribunda*, *Gliricidia sepium* and *Delonix regia* (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.	

5. **John Jothi Prakash**, **E** (2004). Outlines of Plant Biotechnology. Emkay Publication, New Delhi.
6. **Kumaresan**, **V** (2005). Biotechnology. Saras Publications, New Delhi.
7. **NIIR Board** (2004). The Complete Technology Book on Biofertilizer and Organic Farming. 2nd revised edition. National Institute of Industrial Research, Delhi.
8. **Panda**, **H** (2011). Manufacture of Biofertilizer and Organic Farming. NIIR Board. Asia Pacific Business Press Inc., Delhi.
9. **Rai**, **MK** (2006). Handbook of Microbial Biofertilizers. Food Products Press, New York.
10. **Rakshit**, **A**, **Meena**, **VS**, **Parihar**, **M**, **Singh**, **HB** and **Singh**, **AK** (Eds.) (2021). Biofertilizers: Volume 1 - Advances in Bio-inoculants. Elsevier, U.K.
11. **Rodrigues**, **BF** and **Muthukumar**, **T** (2009). Arbuscular Mycorrhizae of Goa - A Manual of Identification Protocols. Goa University, Goa.
12. **Sathe**, **TV** (2004). Vermiculture and Organic Farming. Daya Publishing House, New Delhi.
13. **Sharma**, **K** (2007). Manual of Microbiology: Tools and Techniques. 2nd edition. Ane Books Pvt. Ltd., New Delhi.
14. **Subha Rao**, **NS (**2000). Soil Microbiology. Oxford & IBH Publishers, New Delhi.
15. **Vyas**, **SC**, **Vyas**, **S** and **Modi**, **HA** (1998). Bio-fertilizers and Organic Farming. Akta Prakashan, Nadiad.

Course Outcomes:

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

1. Recall the concept of biofertilizers
2. Explain the types of biofertilizers, isolation, mass multiplication, formulations and methods of field application and benefits associated with use of biofertilizers in organic agriculture.
3. Develop skills in preparation of biofertilizer formulations for management of crops in a cost-effective and eco-friendly manner.
4. Integrate the acquired knowledge for sustainable crop production, welfare of society and employment generation.

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	2	3	3	2	3	3	2	2	3	2
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

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 *Ipomoea* sp., *Ocimum* sp., *Hibiscus* sp., *Acacia auriculiformis* and *Pancratium* 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_2KI 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 *Impatiens* sp. and *Catharanthus roseus*.	**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.	

<table>
<tr><td></td><td colspan="12">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.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="12">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.</td></tr>
<tr><td>PO/CO</td><td>PO1</td><td>PO2</td><td>PO3</td><td>PO4</td><td>PO5</td><td>PO6</td><td>PO7</td><td>PSO1</td><td>PSO2</td><td>PSO3</td><td>PSO4</td><td>PSO5</td></tr>
<tr><td>CO1</td><td>3</td><td>2</td><td>2</td><td>1</td><td>1</td><td>1</td><td>1</td><td>3</td><td>2</td><td>2</td><td>1</td><td>1</td></tr>
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<tr><td>CO3</td><td>3</td><td>2</td><td>2</td><td>2</td><td>2</td><td>1</td><td>1</td><td>3</td><td>2</td><td>2</td><td>2</td><td>1</td></tr>
<tr><td>CO4</td><td>3</td><td>3</td><td>3</td><td>2</td><td>1</td><td>2</td><td>2</td><td>3</td><td>3</td><td>3</td><td>1</td><td>2</td></tr>
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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), **f**iller 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/foliage 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 *Azolla* 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	

	Farming. Akta Prakashan, Nadiad.
Course Outcomes:	On completion of this course, students will be able to: 1. Recall the concept of organic farming. 2. Explain various cultivation and farm management practices towards sustainable farming. 3. Develop skill in preparation of organic formulations and manures for growing and managing crops organically. 4. Utilize the acquired knowledge for sustainable crop production generating entrepreneurial opportunities.

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	2	3	2	3	3	3	3	2	3	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

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)
Effective from AY : 2025-26

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 *Mirabilis jalapa*; kappa particles in *Paramecium*; maternal effects in snail (shell coiling). **Autosomes and sex chromosomes:** Mechanisms of sex determination; balance concept of sex determination in *Drosophila*; 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 *Allium cepa* root tips.	**2 hours**
	4. Study of stages in meiosis using *Allium cepa* /*Tradescantia* sp. flower buds.	**2 hours**
	5. Preparation of karyotype from dividing *Allium cepa* 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	

<table>
<tr><td></td><td colspan="12">Publishing House, Mumbai.
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8. Moshrafuddin, 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. Sambamurty, 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.</td></tr>
<tr><td>Course outcomes:</td><td colspan="12">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.</td></tr>
<tr><td>PO/CO</td><td>PO1</td><td>PO2</td><td>PO3</td><td>PO4</td><td>PO5</td><td>PO6</td><td>PO7</td><td>PSO1</td><td>PSO2</td><td>PSO3</td><td>PSO4</td><td>PSO5</td></tr>
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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, *Myristica* 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 *Terminalia/ Ipomoea* 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 *Garcinia indica*, *Alstonia scholaris*, *Mangifera indica*, *Terminalia paniculata*, *Polyalthia longifolia* and *Sterculia foetida* (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:	1. **Cooke**, **T** (1901—1908). The Flora of the Presidency of Bombay. Vol I, II and III. Taylor & Francis, London. 2. **Datar**, **MN** and **Lakshminarsimhan**, **P** (2013). Flora of Bhagwan Mahavir (Molem) National Park and Adjoinings, Goa. Botanical Survey of India, Kolkata. 3. **Gupta**, **RK** (1981). A Text Book of Systematic Botany. Atma Ram & Sons, Delhi. 4. **Inganhalekar**, **S** (2022). Leaf based identification for Trees of Sahyadri. Corolla Publication, Pune. 5. **Lawrence**, **GHM** (1951). Taxonomy of Vascular Plants. Macmillan, New York. 6. **Mathur**, **RC** (1972). Systematic Botany: Angiosperms. Agra Book Store, Agra. 7. **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 *Agaricus bisporus*, *Calocybe indica* and *Pleurotus* 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 (*Cladobotryum* soft rot, *Gliocladium* 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 (*Calocybe indica* and *Schizophyllum commune*). Popular exotic mushrooms (*Volvariella volvacea*, *Lentinula edodes*). Strain improvement in *Agaricus bisporus*. Spent mushroom substrate as organic manure. Mushrooms cultivated for their medicinal importance (*Ganoderma*, *Cordyceps*). 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:	1. **Atkinson**, **GF** (1961). Hand book of Mushrooms. 2nd edition. Hafner Publishers, New York. 2. **Bahl**, **N** (2000). Handbook of Mushrooms. 4th edition. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi. 3. **Biswas**, **S**, **Datta**, **M** and **Ngachan**, **SV** (2012). Mushrooms: A Manual for Cultivation. PHI Learning Private Limited, New Delhi.	

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<tr><td></td><td colspan="12">4. Chang, ST and Miles, PG (2004). Mushrooms: Cultivation, Nutritional Value, Medicinal Effect and Environmental Impact. CRC Press Inc., USA.
5. Dubey, RC (1993). A Textbook of Biotechnology. S. Chand & Company Pvt. Ltd., New Delhi.
6. Kannaiyan, S and Ramasamy, K (1980). A handbook of Edible Mushroom. Today and Tomorrows Printers and Publishers, New Delhi.
7. Marimuthu, T, Krishnamoorthy, AS, Sivaprakasam, K and Jayarajan, R (1991). Oyster Mushrooms. Tamil Nadu Agricultural University, Coimbatore.
8. NIIR Board (2006). Handbook of Mushroom Cultivation, Processing and Packaging. National Institute of Industrial Research, New Delhi.
9. Singh, M, Vijay, B, Kamal, S and Wakchaure, GC (2011). Mushrooms: Cultivation, Marketing and Consumption. Directorate of Mushroom Research (ICAR), Solan.
10. Stamets, P and Chilton, JS (1983). The Mushroom Cultivator: A Practical Guide to Growing Mushrooms at Home. Agaricon Press, Washington D.C.
11. Swaminathan, M (1990). Food and Nutrition. The Bangalore Printing and Publishing Company Ltd., Bangalore.
12. Tiwari, SC and Kapoor, P (1988). Mushroom cultivation. Mittal Publications, New Delhi.
13. Tripathi, DP (2005). Mushroom Cultivation. Oxford and IBH Publishing Company Pvt. Ltd., New Delhi.
https://dmrsolan.icar.gov.in/Mushroom_Cultivation_Marketing_Consumption.pdf
https://dmrsolan.icar.gov.in/html/leafletsfolders.html</td></tr>
<tr><td>Course Outcomes:</td><td colspan="12">On completion of this course, students will be able to:
1. Identify important cultivated edible mushroom species available in India.
2. Develop basic skills in spawn production, substrate preparation and mushroom cultivation.
3. Recognize and manage mushroom diseases and pests.
4. Create employment opportunities through mushroom cultivation and motivate them for research.</td></tr>
<tr><td>PO/CO</td><td>PO1</td><td>PO2</td><td>PO3</td><td>PO4</td><td>PO5</td><td>PO6</td><td>PO7</td><td>PSO1</td><td>PSO2</td><td>PSO3</td><td>PSO4</td><td>PSO5</td></tr>
<tr><td>CO1</td><td>3</td><td>3</td><td>3</td><td>3</td><td>3</td><td>3</td><td>3</td><td>3</td><td>3</td><td>3</td><td>3</td><td>3</td></tr>
<tr><td>CO2</td><td>3</td><td>3</td><td>3</td><td>3</td><td>3</td><td>3</td><td>3</td><td>3</td><td>3</td><td>3</td><td>3</td><td>3</td></tr>
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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)
Effective from AY : 2025-26

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 *in vitro* 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 *in vitro* seed germination of *Brassica* sps./suitable seeds and induction of callus from hypocotyl segments.	**4 hours**
	4. Induction of callus from *Daucus carota* 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 *Zea mays* 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.	

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<tr><td></td><td colspan="12">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, 4th edition. Medtech Science Press, New Delhi.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="12">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.</td></tr>
<tr><td>PO/CO</td><td>PO1</td><td>PO2</td><td>PO3</td><td>PO4</td><td>PO5</td><td>PO6</td><td>PO7</td><td>PSO1</td><td>PSO2</td><td>PSO3</td><td>PSO4</td><td>PSO5</td></tr>
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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 (*Loranthus* and *Cuscuta*); epiphyte (orchid); predation (insectivorous plants – *Utricularia*/*Drosera*/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:	1. **Dash**, **MC** and **Dash**, **SP** (2012). Fundamentals of Ecology. 3rd edition. Tata McGraw Hill Education Private Limited, New Delhi. 2. **Kormondy**, **EJ** (1996). Concepts of Ecology. 4th edition. PHI Learning Pvt. Ltd., Delhi, India. 3. **Odum**, **EP** (2005). Fundamentals of Ecology. 5th edition. Cengage Learning India Pvt. Ltd., New Delhi. 4. **Pandey**, **BP** (2018). Plant Ecology and Taxonomy: Botany for Degree	

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<tr><td></td><td>Students. S. Chand and Publications, New Delhi.
5. Sharma, PD (2010). Ecology and Environment. 8th edition. Rastogi Publications, Meerut, India.
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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.</td></tr>
<tr><td>Course Outcomes:</td><td>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.</td></tr>
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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:** *Agrobacterium* 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 (*Arabidopsis*, 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. 4th edition. Garland Science, New York. 3. **Brown**, **TA** (2017). Genomes 4. 4th 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.
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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,

	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: a. **Frozen vegetables -** Carrot (*Daucus carota*) and peas (*Pisum sativum*). b. **Dehydrated products** – Potato (*Solanum tuberosum*) chips and garlic (*Allium sativum*) powder. c. **Preparation of pickles** – Bitter gourd (*Momordica charantia*) and brinjal *(Solanum melongena)*. d. **Canned products** - Preparation of sugar syrup and canning of jackfruit (*Artocarpus heterophyllus*); preparation of brine and canning of green mango (*Mangifera indica*). e. **Fermented products** – Coconut (*Cocos nucifera*) vinegar and pineapple (*Ananas comosus*) wine. f. **Juices and squashes** - Kokum (*Garcinia indica*) juice and strawberry (*Fragaria* sp.) squash. g. **Jams and marmalades** - Guava (*Psidium guajava*) jam and orange (*Citrus sinensis*) marmalade. h. **Sauces and ketchups** - Chilli (*Capsicum annuum*) sauce and tomato (*Solanum lycopersicum*) 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	

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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