Botany Department (UG) approved Syllabus
2025-26

Course Structure

SEMESTER	MAJORS 1 (4 credit course)	MINOR/VOCATIONAL (4 credit course)	MDC (3 credit course)	SEC (3 credit course)
I	**UG-BOT-101** Diversity of Lower forms (Microbes, Algae, Fungi)	**UG-BOT-101** Diversity of Lower forms (Microbes, Algae, Fungi)	**UG-BOT-MDC 1** Economic Botany	**UG-BOT-SEC 1** Basics in Horticulture
II	**UG-BOT-102** Diversity of Lower Plants (Bryophytes, Pteridophytes, Gymnosperm)	**UG-BOT-102** Diversity of Lower Plants (Bryophytes, Pteridophytes, Gymnosperm	**UG-BOT-MDC 2** Kitchen Gardening	**UG-BOT-SEC 2** Algal Biotechnology
III	**UG-BOT-201** Ecology and Conservation **UG-BOT-202** Cell Biology and Biomolecules	**UG-BOT-201** Ecology and Conservation	**UG-BOT-MDC 3** Basics in Horticulture	**UG-BOT-SEC 3** Basics in Microbiology
IV	**UG-BOT-203** Plant Anatomy and Embryology **UG-BOT-204** Cytogenetics **UG-BOT-205** Plant Breeding and Biostatistics **UG-BOT-206** Enzymes and Metabolic pathways	**UG-BOT-VOC 1** Herbal Cosmetology		
V	**UG-BOT-301** Plant Physiology **UG-BOT-302** Systematics of flowering plants and Phylogeny **UG-BOT-303** Techniques and Instrumentation	**UG-BOT-VOC 3** Applied Mycology/ Plant propagation		
VI	**UG-BOT-304** Plant Genetic Engineering **UG-BOT-305** Plant Molecular Biology **UG-BOT-306** Plant Tissue Culture **UG-BOT-PRJ** Project	**UG-BOT-VOC 2** Plant pathology		

COURSE STRUCTURE FOR DOUBLE MAJOR PROGRAMME

SEMESTER	MAJORS 1 (4 credit course)	MAJORS 2 (4 credit course)
I	**UG-BOT-101** Diversity of Lower forms (Microbes, Algae, Fungi)	**UG-BOT-101** Diversity of Lower forms (Microbes, Algae, Fungi)
II	**UG-BOT-102** Diversity of Lower Plants (Bryophytes, Pteridophytes, Gymnosperm)	**UG-BOT-102** Diversity of Lower Plants (Bryophytes, Pteridophytes, Gymnosperm)
III	**UG-BOT-201** Ecology and Conservation	
		UG-BOT-202 Cell Biology and Biomolecules
IV	**UG-BOT-203** Plant Anatomy and Embryology	**UG-BOT-205** Plant Breeding and Biostatistics
	UG-BOT-204 Cytogenetics	**UG-BOT-206** Enzymes and Metabolic pathways
	UG-BOT-VOC 1 Herbal Cosmetology	
V	**UG-BOT-301** Plant Physiology	**UG-BOT-303** Techniques and Instrumentation
	UG-BOT-302 Systematics of flowering plants and Phylogeny	
	UG-BOT-VOC 2 Applied Mycology/ Plant propagation	
VI	**UG-BOT-304** Plant Genetic Engineering	**UG-BOT-306** Plant Tissue Culture
	UG-BOT-305 Plant Molecular Biology	**UG-BOT-VOC 3** Plant pathology
	UG-BOT-PRJ Project	

PROGRAMME SPECIFIC OUTCOMES

PSO-1 **Knowledge of Botany and Plant Sciences**	Equip students with foundational knowledge of Botany that enables them to explain, compare, classify, and analyse various Plant groups, Cellular Structures, Genetic and Physiological Processes, and their Ecological Interactions.
PSO-2 **Application of Botanical Knowledge**	Develop students' ability to apply theoretical knowledge through practical work, experiments, and research-based activities by utilizing basic Techniques and Instrumentation for Botanical analysis.
PSO-3 **Critical Thinking and Problem-Solving**	Foster Critical Thinking, Data Analysis, and Problem-Solving Skills to address challenges in Botany and related Ecological Fields.
PSO-4 **Higher Education and Professional Growth**	Prepare students to apply their knowledge in Professional Settings, contributing to various sectors of Botany, pursue Higher Education or careers in Teaching, Research, or Entrepreneurial Ventures.

Botany Department (UG) approved Syllabus 2025-26
(Semester I- VI)

Course Title : DIVERSITY OF LOWER FORMS (MICROBES, ALGAE, FUNGI) (CORE-THEORY)

Course Code : **UG-BOT-101**
Credits : **04**
Marks : **75**
Hours : **45**

COURSE OBJECTIVES:

This course aims to provide students with an understanding of the classification, structure, and ecological and economic importance of microbes, algae, fungi, mycorrhizae, and fossils. It covers their evolutionary background, life cycles, and contributions to various ecosystems, enhancing students' knowledge of these vital organisms.

COURSE OUTCOMES:

Upon successful completion of the course, students will be able to:
CLO1: Explain microbial life's diversity, structure, evolution, and role in the environment.
CLO2: Classify and describe major Algal groups and Lichens' morphology, life cycles, and economic significance.
CLO3: Analyse the significance of Fungi, Mycorrhizae and fossils in ecology and industry and assess the economic and ecological contributions.
CLO4: Apply laboratory techniques in the identification, morphological and anatomical analysis of Algae, Lichens, Fungi, Mycorrhizae and Fossils.

MODULE -I: MICROBES **15**

Cell types: Prokaryotic and Eukaryotic cells. Evolution of cells: Endosymbiotic theory, origin of plastids, oxygen evolution. Five kingdom classifications. Microbes from the environment (Air, soil and water). Structure of Virus: Bacteriophage and TMV. Distribution, systematic position and life cycle of Cyanophyceae: *Nostoc*. Economic and ecological importance of beneficial microbes.

MODULE II: ALGAE AND LICHENS **15**

Algae: Classification of algae (Cyanobacteria, Charophyta, Chlorophyta, Phaeophyta and Rhodophyta) following Lee (1999) up to groups with general characters and examples.
Type study: Charophyta: *Chara*, Chlorophyta: *Chlamydomonas* or *Chlorella*, Rhodophyta: *Polysiphonia*, Phaeophyta: *Sargassum*. Lichens: Types, structure and reproduction. Economic and ecological importance of algae and lichens.

MODULE III: FUNGI, MYCORRHIZAE AND PALEOBOTANY. **15**

Fungi: Classification, systematic position, general characteristics, life cycle of *Puccinia* and *Penicillium*. Mycorrhizae: Types and significance. Economic and ecological importance of fungi and mycorrhizae. Fossil: fossilisation, Birbal Sahni Institute, economic and ecological importance of fossils.

Total **45**

Course Title : DIVERSITY OF LOWER FORMS (MICROBES, ALGAE, FUNGI) (CORE-PRACTICALS)

Course Code : **UG-BOT-101**
Credits : **01**
Marks : **25**
Hours : **30**

SR.NO	MODULE IV	PRACTICAL SESSIONS
1.	Observation and study of Bacterial colonies	1
2.	Isolation and observation of microorganisms from different habitats: Air, soil and water.	3
3.	Morphological study of algal and Blue-green algal forms: *Oscillatoria / Nostoc, Chara / Spirogyra, Sargassum, Polysiphonia*	3
4.	Morphological study of fungal forms: *Puccinia, Penicillium, Albugo* and *Rhizopus*	3
5.	Observation of Mycorrhizal root colonization	1
6.	Study of lichens (Permanent slide/ specimen)	1
7.	Study of fossils: (Permanent slide/ specimen)	1
8.	Mini project: i. Collection and field study of locally available Algae, Fungi and Lichens	2
TOTAL		**15**

REFERENCES:

1. Alexopoulos, C. J., & Mims, C. W. (1983). Introductory mycology (3rd ed.). Wiley Eastern Limited.
2. Fritsch, F. E. (1956). The structure and reproduction of the algae (Vols. 1 & 2). Cambridge University Press.
3. Gupta, P. K. (1999). A textbook of cell and molecular biology. Rastogi Publications.
4. Kar, A. K., & Gangulee, H. C. (2006). College botany (Vol. 2, 2nd ed.). New Central Book Agency (P) Ltd.
5. Prescott, L. M. (2008). Microbiology. McGraw-Hill Higher Education.

6. Verma, P. S., & Agarwal, V. K. (1998). Cell biology, genetics, molecular biology, evolution and ecology (14th ed.).

WEB REFERENCES:

1. Bold, H. C., & Wynne, M. J. (1985). The structure and reproduction of the algae. PDF Drive. Retrieved from https://www.pdfdrive.com/the-structure-and-reproduction-of-the-algae-d34383978.html
2. Bennett, J. (2017). Virus: An illustrated guide to 101 incredible microbes. PDFDrive. Retrieved from https://www.pdfdrive.com/virus-an-illustrated-guide-to-101-incredible-microbes-d15808874.html

Course Title : **ECONOMIC BOTANY (MDC-THEORY)**
Course Code : **UG-BOT-MDC 1**
Credits : **03**
Marks : **50**
Hours : **30**

COURSE OBJECTIVES:

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

COURSE OUTCOMES:

CLO1: Identify, Categorise, and Evaluate economically important crop species, plants and plant parts.
CLO2: Analyse the biochemical processes of natural plant extracts and their applications.
CLO3: Develop skills in extracting plant products of potential economic value.

Module -I: Origin of Cultivated Plants (Centers of Origin, Cereals & Legumes, Beverages, Fibers and Timber Plants) **15**

Centres of origin: Concept, Vavilov's work, examples of major plant introduction, evolution of new crops/ varieties, crop domestication. Organisations and their mandates – NRRI, CFTRI, SBRI. Importance of germplasm, threats to genetic diversity. Classification, description and economic importance of cereals and legumes: Wheat, Rice (local varieties) and Millet (anyone), Chickpea, Cowpea and one fodder Legume. Beverages: Tea & Coffee, fibres: Coconut, Cotton & Jute, general account of timber plants: Teak and Matti.

Module II: Sources of Sugars & Starch, Oils & Fats, Drugs & Natural Rubber **15**

Sugar & starch sources: Sugarcane; Potato & *Dioscorea* (yam/ air potato). Fat and oil sources include Groundnut, Coconut, and Soybean. Extraction and applications of essential oils: *Eucalyptus* (Nilgiri) and *Brassica* (Mustard) oils. Therapeutic and habit-forming drugs: *Cinchona* (Quinine), *Cannabis* (Hemp), *Nicotiana* (Tobacco) (Morphology, processing, uses and health hazards). Tapping, processing and uses of *Hevea brasiliensis* (Rubber*)*.

Total **30**

Course Title : **ECONOMIC BOTANY (MDC-PRACTICAL)**
Course Code : **UG-BOT-MDC 1**
Credits : **01**
Marks : **25**
Hours : **30**

Sr. No	Module IV	Practical Sessions
1	Morphological and Anatomical study of cereal and legume seeds (Rice and Groundnut).	**4**
2	Study of essential oil-yielding plant parts (Coconut (dry copra), *Eucalyptus* (leaf), *Citrus* (rind))	**2**
3	Mini Projects: i. Extraction of essential oil from plant sources (Distillation method) ii. Analysis of starch content from plant sources (Fruits, Rhizome, Tubers) iii. Phytochemical analysis of plants for Drugs, Alkaloids and Dyes iv. Study of Fibers from plants v. Study of local Fruits and Spices	**7**
4	Field Visit to Farm/ Rubber Plantation	**2**
Total		**15**

REFERENCES:

1. Pandey, B. P. (2015). Economic botany. S. Chand & Company.
2. Kochhar, S. L. (2012). Economic botany in tropics. MacMillan & Co.
3. Wickens, G. E. (2001). Economic botany: Principles & practices. Kluwer Academic Publishers.
4. Subrahmanyam, N. S., & Sammbamurty, A. V. S. S. (2008). A textbook of modern economic botany. CBS Publishers & Distributors.

WEB REFERENCES:

1. Economic Botany. (n.d.). Home - Education. Economic Botany. Retrieved from https://www.econbot.org/home/education
2. Library of Congress. (n.d.). Economic development and the environment. Library of Congress. Retrieved from https://www.loc.gov/scitech/tracer-bullets/economic/
3. Royal Botanic Gardens, Kew. (n.d.). Economic botany collections. Retrieved from https://www.kew.org/science/collections/economic

Course Title : **BASICS IN HORTICULTURE (SEC-THEORY)**
Course Code : **UG-BOT-SEC 1**
Credits : **03**
Marks : **50**
Hours : **30**

COURSE OBJECTIVES

To provide students with fundamental knowledge and practical skills in Horticulture, Floriculture, and Landscaping, including Plant Propagation Techniques, Irrigation Methods, Fertiliser Application, Protected Cultivation, and Garden Design for adequate plant growth and Landscape Management.

COURSE LEARNING OUTCOMES

Upon completion of the course, the student will be able to:
CLO1: Explain the importance of Horticulture, Floriculture, and various Plant Propagation techniques.
CLO2: Outline the requirements for establishing and maintaining nurseries, gardens, etc.
CLO3: Apply practical skills in Nursery Management, Plant Propagation, and Sustainable Gardening.

MODULE -I: TOOLS AND TECHNIQUES IN HORTICULTURE, FLORICULTURE AND PROPAGATION METHODS 15

Definition and importance: Pomoculture, Olericulture, Floriculture.
Fertilisers: Inorganic, Organic – fertilisers: Vermicomposting, Green Manure, Algal Culture, FYM. Irrigation: Surface, Sprinkle, Drip and Gravity irrigation
Introduction to Greenhouse, Polyhouse, Moist chamber, Net frame, Introduction to Hydroponics. Introduction to sexual methods (seed propagation) – Definition, Merits and Demerits, Criteria for selection of seeds. Asexual (Vegetative) propagation – Definition and types- Cutting (root, stem, leaf), Layering (simple, air), Grafting (Whip, Approach) and Budding (T, patch), Stock–scion relationship in important horticultural crops. Use of Plant Growth Regulators in horticulture

MODULE II: LANDSCAPING 15

Locations in the garden- edges, hedges, fence, lawn, flower beds. Avenue, water garden (with two examples of each). Focal point. Auto CAD in garden designing. National parks, Botanical gardens, water gardens, rockery plants, Bonsai techniques, Hydroponics. Lawn making: type of lawn grasses and maintenance. Plants suitable for hedges. Aftercare: Weeding, top dressing methods of pruning and topiary

Total 30

Course Title : **BASICS IN HORTICULTURE (SEC-PRACTICAL)**
Course Code : **UG-BOT-SEC 1**
Credits : **01**
Marks : **25**
Hours : **30**

Sr. No	**Module III**	**Practical Sessions**
1	Familiarising with gardening tools and implements	**1**
2	Preparation of nursery bed and polybag filling	**1**
3	Preparation of potting mixture – Potting, repotting	**2**
4	Methods in vegetative propagation (cutting, grafting, budding, layering)	**2**
5	Garden designing using any software/any app	**1**
6	Preparation of Organic Compost & Vermicompost	**2**
7	Establishment of a vegetable garden using Organic Compost & Vermicompost	**3**
8	Flower arrangement	**1**
9	Improving the shelf life of cut flowers using chemicals.	**1**
10	Visit to Nurseries, Gardens and reports.	**1**
Total		**15**

REFERENCES:

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

WEB REFERENCES:

1. Botanical Society of America. (n.d.). Carnivorous plants: Insectivorous plants. Retrieved from https://botany.org/home/resources/carnivorous-plants-insectivorous-plants.html
2. Jauker, F., & Schiele, S. (2016). Available methods for the sampling of nectar, pollen, and flowers of different plant species. ResearchGate. https://www.researchgate.net/publication/302580569_211_Available_methods_for_the_sampling_of_nectar_pollen_and_flowers_of_different_plant_species

SEMESTER II

Course Title : DIVERSITY OF LOWER PLANTS (BRYOPHYTES, PTERIDOPHYTES, GYMNOSPERMS) (CORE-THEORY)

Course Code : **UG-BOT-102**
Credits : **03**
Marks : **75**
Hours : **45**

COURSE OBJECTIVES:

This course provides an understanding of the diversity, classification and evolutionary significance of Bryophytes, Pteridophytes, and Gymnosperms**.**

COURSE OUTCOMES:

Upon successful completion of the course, students will be able to:
CLO1: State, describe and explain the characters and evolutionary aspects of Bryophytes.
CLO2: State, describe and explain the characters and evolutionary aspects of Pteridophytes.
CLO3: State, describe and explain the characters and evolutionary aspects of Gymnosperms
CLO4: Identify and sketch the morphology and anatomy of selected Bryophytes, Pteridophytes and Gymnosperms.

MODULE I: BRYOPHYTES **15**

General characters, classification and alternation of generation. Type study: Study of morphological and anatomical studies and reproductive character of *Riccia, Marchantia, Anthoceros* and *Funaria*. Evolution of sporophyte in Bryophytes, Ecological and Economic Importance of Bryophytes.

15

MODUL II: PTERIDOPHYTES

General characters, classification, alternation of generation. Type study: Structure, reproduction, life history and systematic position of *Psilotum, Lycopodium and Marsilea.* Stelar evolution, Ecological and Economic Importance of Pteridophytes.

MODUL III: GYMNOSPERMS **15**

General characters, classification, alternation of generation Of Gymnosperms. Type study: Systematic position, life history of *Cycas*, *Pinus* and *Gnetum,* Ecological and Economic Importance of Gymnosperms.

Total **45**

Course Title **: DIVERSITY OF LOWER PLANTS (BRYOPHYTES, PTERIDOPHYTES, GYMNOSPERMS) (PRACTICAL)**

Course Code : **UG-BOT-102**
Credits : **01**
Marks : **25**
Duration : **30 hours (15 sessions)**

Sr. No.	Module IV	Practical sessions
1.	Morphological and anatomical study of Bryophyte (*Riccia* and *Anthoceros/ Funaria*)	03
2.	Morphological and anatomical study of Pteridophytes (*Selaginella* and *Lycopodium/Psilotum*)	03
3.	Morphological and anatomical study of Gymnosperm (*Cycas* and *Pinus*)	03
4.	Understanding stelar evolution	01
5.	Mini Project: 1. Mini project: Collection and field study of locally available Bryophytes, Pteridophytes, and Gymnosperms. 2. Preservation of Bryophytes, Pteridophytes and Gymnosperms by Herbarium technique.	05
	Total	**15**

REFERENCE:

Mandatory Reading

1. Bhatnagar, S.P. and Moitra, A. (1996). *Gymnosperms.* New Age InternationalLimited.
2. Parihar N.S. (2012); An introduction to Embryophyta: Pteridophytes.Vol II, fifthedition, Surjeet Publications.
3. Parihar N.S. (2013). An introduction to Embryophyta: Bryophyta.Vol I, fifth edition,Surjeet Publications.
4. Sharma, O. P. (2017). *Diversity of Microbes and Cryptogams- Bryophyta.* McGraw HillEducation.
5. Sharma, O. P. (2017). *Diversity of Microbes and Cryptogams- Pteridophyta.* McGrawHill Education.
6. Smith, Gilbert M. (1955). Cryptogamic Botany Bryophyta & Pteridophyta Volume2; 2nd Edition; McGraw-Hill book Comp.Tokyo.

Supplementary Reading

1. Kar, A. K., & Gangulee, H. C. (2006). *College botany* (Vol. 2, 2nd ed.). New Central Book Agency (P) Ltd.

WEB REFERENCES

1. Conifers.org. (n.d.). *Conifers: The conifer database*. Retrieved from https://www.conifers.org/
2. BSI ENVIS. (n.d.). *Pteridophytes in India*. BSI ENVIS. Retrieved

from http://www.bsienvis.nic.in/Database/Pteridophytes-in-India_23432.aspx

Course Title **: KITCHEN GARDENING (MDC-THEORY)**
Course Code : **UG-BOT-MDC 2**
Credits **03**
Marks **50**
Hours **30**

COURSE OBJECTIVES:

The course provides knowledge of the principles and practices of Kitchen Gardening.

COURSE OUTCOMES:

Upon successful completion of the course, students will be able to:
CLO1: Explain the principles of kitchen gardening, soil fertility and management.
CLO2: Identify and describe various herbs, vegetables, and fruits suitable for kitchen gardening, using effective pest control and sustainable practices.
CLO3: Develop skills in planting, nurturing, and maintaining a variety of vegetables and herbs.

Module I: Introduction to Kitchen Gardening, Soil, Soil Fertility Management and Fertilizers. **15**

Introduction To Kitchen Gardening. Soil types and characteristics, Soil health and soil tillage. Factors affecting soil fertility and Productivity. Potting mixtures. Plant nutrients. Types of Fertilisers and Manures, Vermicomposting.

Module II: Cultivation and Plant Disease Management **15**

Cultivation, harvesting, and nutritional value of the following crops in India are Onion, Potato, Tomato, Cauliflower, Coriander, Cucurbits, and Cabbage. Cultivation, harvesting and Nutritional value of the following crops of Goa: Agassaim Brinjal, seven ridge Okra, Red Amaranthus, Khola Mirchi and Kokum. Fruits in kitchen garden: Papaya, Guava, Banana, Coconut. Plant protection: Cultural and mechanical. Plant protection: Bio-pesticide and Bio-control agents. Allelopathic methods of weed control.

Total **30**

Course Title **: KITCHEN GARDENING (CORE-THEORY)**
Course Code : **UG-BOT-MDC 2**
Credits **01**
Marks **25**
Hours **30**

Sr. No.	Module III	Practical sessions
1.	Ideal potting mix	01
2.	Effect of AM and compost on growth of plants.	02
3.	Study of soil (pH, texture and WHC)	01
4.	Soil analysis of NPK (Based on secondary data obtained from ICAR)	01
5.	Study of germination percentage of various seeds	01
6.	Understanding the growth rate of (any 2) leafy vegetables.	01
7.	Market survey (to be done by students) to understand the market value of various vegetables.	01
8.	Mini Project:	
	1. Preparation of compost	02
	2. Setting up a kitchen garden on campus.	04
	3. Growing microgreens	01
Total		**15**

References

1. Kochhar, S.L. (2012). *Economic Botany in Tropics*. New Delhi: MacMillan & Co.
2. Wickens, G.E. (2001). *Economic Botany: Principles & Practices*. Netherlands: Kluwer Academic Publishers.
3. Chakraverty, A. (1991). Post-*harvest technology of cereal, pulses and oil seeds*. Oxford: IBH Publishing Co. Pvt Ltd.
4. Deshmukh, S.N. (2012). Organic Farming: Principles, Prospects and Problems, India: Agrobios Publishers.
5. Kanwar, J.S. (1978). *Soil Fertility, Theory and Practice*. Indian Council of Agricultural Research Publication.
6. Richard Bird. (2016). The Kitchen Garden Book: The Complete Practical Guide to Kitchen Gardening, from Planning and Planting to Harvesting and Storing: Anness Publishing.
7. Matt Montanez (2017). Vegetable Gardening for Beginners. My Ebook Publishing House.

Course Title : **ALGAL BIOTECHNOLOGY (SEC-THEORY)**
Course Code : **UG-BOT-SEC 2**
Credits : **03**
Marks : **50**
Hours : **30**

COURSE OBJECTIVES:

This course provides knowledge on the diversity of algal types and understands the potential

significance of algal resources such as food, fodder, fuel, and environmental sustenance.

COURSE OUTCOMES:

Upon completion of the course, the student will be able to:

CLO1: Explain techniques for isolating, culturing, and maintaining algae. Analyse their role in Pollution, Eutrophication, and Phycoremediation.

CLO2: Evaluate the commercial uses of Algae in food, pharmaceuticals, biofuels, and biofertilisers. Perform culturing and pigment analysis.

CLO3: Apply techniques in algal culture, conduct the algal collection, culture, and market surveys and document findings through reports and mini-projects.

Module I: Methods of Algal Isolation, Culture and Algal Pollution **15**

Introduction to Algal Biotechnology, freshwater and marine algae. Methods of algal isolation. Types of algal cultures (synchronous, continuous, mass culture). Maintenance and multiplication of algae (Cyanophyta) Algae as an indicator of pollution. Eutrophication and its impact on water quality, Algal Blooms and their control. Phycoremediation

15

Module II: Commercial Applications of Algal Technology

Single-cell algal proteins. Algae as food and fodder. Algae in pharmaceutical industries. Algae in Biofuels and Bioplastics. Algae as Biofertilisers

Total **30**

Course Title : **ALGAL BIOTECHNOLOGY (SEC-PRACTICAL)**
Course Code : **UG-BOT-SEC 2**
Credits : **01**
Marks : **25**
Hours : **30**

Sr. no	Module III	Practical sessions
1.	Sterilisation and preparation of media (freshwater Algae)	**2**
2.	Culturing of freshwater Algae	**1**
3.	Chromatographic separation of Algal pigments	**2**
4.	Isolation and estimation of Algal proteins	**2**
5.	Preparation of algal biofertiliser (powdered and liquid)	**2**
6.	Visit to NIO and submission of the report	**1**

Mini Projects **5**

1. Collection, culturing and maintenance of commonly found Algae in Goa (Fresh & Marine water, one each)
2. Survey of market products of algal material

Total **15**

REFERENCES:

1. Becker, S. W. (1994). *Micro algae biotechnology and microbiology*. Cambridge University Press.
2. Ignacimuthu, S. (1996). *Basic biotechnology*. Tata McGraw Hill Publishing Limited.
3. Tridevi, P. C. (2001). *Algal biotechnology*. Point Publisher.
4. Venkatraman, G. S. (1972). *Algal biofertilizers and rice cultivation*. Today and Tomorrow Printers and Publishers.
5. Zajic, J. E. (1970). *Properties and products of algae*. Plenum Press.
6. Bold, H. C., & Wynne, M. J. (1976). *Introduction to algae: Structure and reproduction*. Prentice Hall.
7. Prescott, G. W. (1970). *How to know freshwater algae.* W.C. Brown Company.
8. Desikachary, T. V. (1972). *Taxonomy and biology of blue-green algae*. University of Madras.

WEB REFERENCES:

5. Gauthier, J. M., & Sharma, R. (2017). Algal bloom dynamics and eutrophication in aquatic ecosystems. *Environmental Science and Pollution Research*, 24(8), 6796-6805. https://doi.org/10.1007/s11356-017-0081-4
6. Guo, L., & Yu, Z. (2020). Cyanophyta as indicators of water pollution: A review. *Journal of Environmental Management*, 256, 109918. https://doi.org/10.1016/j.jenvman.2019.109918
7. Foteini, D., & Papadakis, E. (2021). Phycoremediation: A sustainable approach for water treatment. *Science of the Total Environment*, 755, 142704. https://doi.org/10.1016/j.scitotenv.2020.142704
8. Vázquez, M., & Cordero, B. (2020). Algal biofertilizers: Potentials for agricultural applications. Frontiers in Plant Science, 11, 567. https://doi.org/10.3389/fpls.2020.00567

SEMESTER III

Course Title : **ECOLOGY AND CONSERVATION (THEORY)**
Course Code : **UG-BOT-201**
Credits : **03**
Marks : **75**
Duration : **45 hours**

COURSE OBJECTIVES:

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

COURSE OUTCOMES:

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

CLO1: Discuss, explain and review the concept of ecosystem, phytogeography and population ecology.

CLO2: Analyze and evaluate the pollution scenario of the area and relate the theory in the natural environment and work towards conservation of the environment and its legalities.

CLO3: Quantitatively estimate the oxygen and Carbon dioxide from different water samples.

CLO4: Evaluate and determine minimum area of sampling unit (using quadrant) for the study of local vegetation.

MODULE 1: CONCEPT OF ECOSYSTEM, PHYTOGEOGRAPHY AND POPULATION ECOLOGY 15 hrs

Concept of Ecosystem, Ecological adaptations of plants belonging to following ecological groups: Hydrophytes, Xerophytes and Halophytes. Shelford's law of tolerance. Introduction to Species diversity indices (Simpson's & Shannon-Weiner) of herbaceous vegetation.

Phytogeography – plant distribution, theories on plant distribution; Endemism, Biomes of the world and phytogeographical regions of India.

Population Ecology: Survivorship curves- Type I, Type II, Type III.

Population growth: Population growth curves – Carrying capacity K, Exponential growth (J shaped curve) and Logistic growth (S shaped curve).

MODULE II: ECOLOGICAL FACTORS AND COMMUNITY RELATIONSHSHIPS 15 hrs

Light - quality, duration, absorption, intensity & effects on plants.

Temperature-variation due to altitude effects on plants, thermal constant and stratification. Water- precipitation, moisture & measurement of rainfall, Wind - speed, advantages and damages caused to plants. Soil- Soil profile, texture, classification and organic matter. Community relationships: Biotic interactions, Gaia Hypothesis, Introduction to Optimal foraging theory.

MODULE III: POLLUTION, LAWS AND ORGANISATIONS 15 hrs

Air pollution- polluting gases; ozone depletion, greenhouse effect, global warming, acid rain and smog. Water pollution-eutrophication, sewage, industrial waste, heavy metal Pollution. Soil pollution – chemical pollutants and Bioremediation. Forest conservation act, Indian forest

act, Biodiversity act, Western Ghat. Protection act, Kasthurirangan Act, Gadgil committee report, Mining committee reports, wild life act (recent acts to be studied). Organizations (National & International) working for conservation (NEERI, TERI, MSSRF, IUCN, TRAFFIC).

TOTAL 45 hrs

Course Title : **ECOLOGY AND CONSERVATION (PRACTICAL)**
Course Code : **UG-BOT-201**
Credits : **01**
Marks : **25**
Duration : **30 hours (15 sessions)**

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

REFERENCES:

1. Ambasht, R.S. (1988). *A Text Book of Plant Ecology*. Varanasi: Students Friends Co.
2. Day A. K., (2002). *Environmental Chemistry*. Fourth Edition. New Delhi:New AgeInternational Publishers.
3. Jogdand, SN, (1995), *Environmental Biotechnology.* Mumbai: Himalaya Publishing House.

4. Moore, P.W. and Chapman, S.B. (1986). *Methods in Plant Ecology*. Blackwell ScientificPublications.
5. Odum E.P. and Barret G.W., (2004) *Fundamental of Ecology*. Fifth edition, Brooks/ColePublishers.
6. P. D. Sharma (2004), *Ecology and environment*. 7th edition, Meerut: Rastogi publications.
7. Piper, C.S. (1950). *Soil and Plant Analysis*. Australia: University of Adelaide,
8. Sangodkar U.M.X and Masur Patil Uma (2018). *Fundamentals in Environmental Biotechnology*, 1st Edition, CinnamonTeal Publishers.
9. Santra S.C., (2017). *Environmental Science*. New Delhi: New Central Agency.
10. Sharma B. K., (2001). *Environmental chemistry*. Sixth revised edition. Meerut: Goelpublication house.
11. Sharma, P.D. (2017). *Ecology and Environment*. 13th edition. Meerut. Rastogi Publishers.
12. Subrahmanyam, N.S.; Sambamurty, A.V.S.S. (2006); *Ecology*; 2nd edition; New Delhi: NarosaPublishing House.

WEB LINKS:

1. Science Direct: https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/carrying-capacity.
2. World Wide Fund – India: https://www.wwfindia.org/
3. NEERI: https://www.neeri.res.in/
4. TRAFFIC: https://www.worldwildlife.org/initiatives/traffic-the-wildlife-trade-monitoring- network
5. International Union for conservation of nature: https://www.iucn.org/
6. MSSRF- https://www.mssrf.org/
7. TERI-https://www.teriin.org/

Course Title : **CELL BIOLOGY AND BIOMOLECULES (CORE-THEORY)**
Course Code : **UG-BOT-202**
Credits : **04**
Marks : **75**
Hours : **45**

COURSE OBJECTIVES:

This course will provide a detailed discussion on a wide range of topics in Cell biology & Bio- molecules, emphasising experimental approaches and key experiments that have provided important insights. The course aims to convey an understanding of how cellular structure and function arise due to the properties of cellular macromolecules. Emphasis will be on the dynamic nature of cellular organisation, structure and function.

COURSE OUTCOME:

Upon successful completion of the course, students will be able to:
CLO 1: Define and describe the fundamental principles of cell biology, including the

structure and function of the Cell Wall, Plasma Membrane, and Cytoskeleton.
CLO 2: Define, describe, compare and analyse the structural and functional differences between Cell Organelles
CLO 3: Explain the biochemical significance of biomolecules such as Carbohydrates, Proteins, and Lipids and their role in cellular metabolism.
CLO 4: Demonstrate proficiency in laboratory techniques such as cell staining, preparation of solutions, and qualitative detection of macromolecules.

Module I: History, classification and ultrastructure **15**

Structure and functions of the Cytoskeleton. Structure and function of Microtubule, Intermediate filaments, Microfilaments. Structure and function of cell wall, Chemical composition of cell wall. Extracellular matrix and cell interactions, Gap -Junctions & plasmodesmata. Structure and function of the plasma membrane, Active and Passive transport of solute (channels & pumps).

Modul II: Study of Cell Organelles **15**

Structure & functions of Chloroplast, Mitochondria, Peroxisome, Glyoxysome & Lysosomes; semi-autonomy and gene control. Nucleus and its Organization: Nuclear envelope, nuclear pore complex, nuclear matrix, Chromosomes and chromatin structure. Structure and function of the ribosome. Endomembrane systems- Endoplasmic reticulum and Golgi complex

Module III: Biochemistry of Amino Acids and Proteins Carbohydrates, Lipids **15**

Definition & importance of biomolecules; types of bonds in bio-molecules; pH and buffers; Water as a biological solvent. Classification and biological functions of carbohydrates and lipids. Classification and biological functions of amino acids and proteins.

Total **45**

Course Title : **CELL BIOLOGY AND BIOMOLECULES (CORE-PRACTICAL)**
Course Code : **UG-BOT-202**
Credits : **01**
Marks : **25**
Hours : **30**

Sr. no	Module III	Practical sessions
1.	Study of cell structure in *Hydrilla* and *Tradescantia* staminal Hairs	**1**
2.	Examination of Prokaryotic cells, Eukaryotic cells and cell organelles by EM graphs	**1**
3.	Preparation of temporary slides to observe different types of cells	**2**
4.	Staining and preparation of slides: a. Cytochemical staining of Nucleus- Acetocarmine b. Cytochemical staining of polysaccharides- Periodic Acid Schiff's (PAS) c. Cytochemical staining of Mitochondria – Jannis Green d. Cytochemical staining of Total proteins Bromophenol blue e. Cytochemical staining of Histones – Fast Green	**6**
5.	Qualitative detection of Macromolecules (Carbohydrates, Proteins, Lipids)	**3**
6.	Preparations of solutions (Normal, Molar, PPM) and Buffers	**2**

Total **15**

REFERENCES:

Mandatory References:

1. Gupta, P. K. (1999). *A textbook of cell and molecular biology*. Rastogi Publications.
2. Karp, G. (1999). *Cell and molecular biology: Concepts and experiments* (2nd ed.). John Wiley & Sons Inc.
3. Satyanarayana, U., & Chakrapani, U. (2000). *Biochemistry* (4th ed.). Elsevier Publishing.
4. Verma, P. S., & Agarwal, V. K. (1998). *Cell biology, genetics, molecular biology, evolution and ecology* (14th ed.). S Chand Publishers.

Supplementary Reading

1. Nelson, D. L., & Cox, M. M. (2013). *Lehninger principles of biochemistry* (4th ed.). W.H. Freeman & Co.
2. Voet, D., Voet, J. G., & Pratt, C. W. (2002). *Fundamentals of biochemistry* (2nd ed.). John Wiley & Sons Pvt Ltd.
3. Horton, R. A. (2006). *Principles of biochemistry* (4th ed.). Pearson Prentice Hall.
4. Berg, J. M., Tymoczko, J. L., & Stryer, L. (2002). *Biochemistry* (5th ed.). W.H. Freeman & Company.
5. Flinch, P. (1999). *Carbohydrate structure, synthesis & dynamics*. Kluwer Academic Publishers.
6. Weselake, R. J., Singer, S. D., & Chen, G. (2018). Introduction to plant biomolecules and cellular metabolism. In *Springer*. Retrieved February 13, 2020, from https://link.springer.com/chapter/10.1007/978-1-4939-8616-3_2
7. NPTEL. (2013). Retrieved February 13, 2020, from https://nptel.ac.in/courses/102103012/
8. Biology Junction. (2017). Structure & function of the cells. Retrieved February 13, 2020, from https://www.biologyjunction.com/cell++notes+bi.html

WEB REFERENCES:

1. Britannica. (n.d.). *Encyclopaedia Britannica*. Retrieved from https://www.britannica.com
2. Springer. (n.d.). *Springer*. Retrieved from https://www.springer.com
3. Biology Discussion. (n.d.). *Biology discussion*. Retrieved from https://www.biologydiscussion.com
4. Cell Biology Journal. (n.d.). *Cell Biology Journal*. Retrieved from https://www.cellbiologyjournal.org
5. Academia.edu. (n.d.). *Academia.edu*. Retrieved from https://www.academia.edu

Course Title : **BASICS IN HORTICULTURE (THEORY)**
Course Code**: UG-BOT-MDC 3**
Credits **02**
Marks **50**
Duration : **30 hours**
Prerequisite : **Biology at XII preferred.**

COURSE OBJECTIVES:

Is to provide entrepreneur opportunities.

COURSE OUTCOMES:

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

CO1: Explain the basics of Horticulture, floriculture and landscaping

CO2: Outline the requirements for building up nurseries, garden, etc.

CO3: Inculcate the technique of vegetative propagation of plants.

CO4: Identify and relate the scope of these fields in building up career

MODULE I: TOOLS AND TECHNIQES IN HORTICULTURE, FLORICULTURE AND PROPAGATION METHODS **15**

Definition and importance; scope of Pomoculture, Olericulture, Floriculture. Fertilizers: inorganic, Organic – biofertilizers: vermin composting, greenmanure, algal culture, FYM. Irrigation:- Surface, Sprinkle, Drip and Gravity irrigation. Introduction to Green house, Poly house, Moist chamber, Net frame. Introduction to sexual methods (seed propagation)– Definition, Merits and Demerits, Criteria for selection of seeds. Asexual (Vegetative) propagation – Definition, and types- Cutting (root, stem, leaf), Layering (simple, air), Grafting (Whip, Approach) and Budding (T, patch), Stock – scion relationship in important horticultural crops.Use of plant growth regulators in horticulture.

MODULE II: LANDSCAPING

Types of garden: Formal, informal and kitchen garden.Locations in the garden-15 edges, hedges, fence, lawn, flower beds, Avenue, water garden (with two examples of each). Focal point. Auto CAD in garden designing. National parks, Botanical gardens, water garden, rockery plants, Bonsai techniques, Hydroponics. Lawn making: type of lawn grasses and maintenance. Plants suitable for hedges. Aftercare: Weeding, top dressing methods of pruning and topiary.

Course Title : **BASICS IN HORTICULTURE (PRACTICAL)**
Course Code : **UG-BOT-MDC-3**
Credits : **01**
Marks : **25**
Duration : **30 hours (15 sessions)**

SR.NO	MODULE IIL: TOPICS	PRACTICAL SESSIONS
1.	Preparation of nursery bed and polybag filling	01
2.	Preparation of potting mixture – Potting, repotting	02
3.	Field work in cutting, grafting, budding, layering	02
4.	Garden designing using Auto CAD software/any app	01
5..	Familiarizing gardening tools and implements	01

6.	Preparation of organic compost & vermicompost	02
7.	Establishment of vegetable garden using organic compost & vermi-compost	03
8.	Flower arrangement	01
9.	Visit to nurseries, gardens and Report	01
10.	Improving the shelf life of cut flowers using chemicals	01
	Total	**15**

REFERENCES:

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

WEBLINK

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

Course Title : **BASICS IN MICROBIOLOGY (SEC-THEORY)**
Course Code : **UG-BOT-SEC 3**
Credits : **03**
Marks : **50**
Hours : **30**

COURSE OBJECTIVES:

The objective of this course is to introduce students to the microbial world. The course aims to understand Microbial Survival, Distribution, Structure, Composition, and Characterisation.

COURSE OUTCOMES:

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

CLO1: Explain the historical development of microbiology and microbial classification using Bergey's Manual, and describe the ultrastructure and reproduction of Bacteria and Viruses.

CLO2: Analyse factors affecting microbial growth and evaluate different culture media and techniques for isolating and maintaining pure microbial cultures.

CLO3: Perform fundamental microbiological techniques, including sterilisation, media preparation, microbial isolation, staining, and microbial quality assessment of water and milk.

Module I: History, classification and ultrastructure **15**

History and Scope of Microbiology. Microbial Taxonomy: Bergey's Manual of Classification – Archaea, Bacteria, Protozoa, Fungi, Algae. Bacterial cell organisation and ultrastructure: Cell wall structure and chemical composition; Gram characteristics; Pili, Fimbriae and Capsule; Flagella structure and function; Nucleoid and Plasmids; Endospore: structure, sporulation and germination; reserve materials. Structure and general characteristics of Viruses, viral replication (Lytic and Lysogenic). Reproduction in Bacteria: binary fission, conjugation, transformation and transduction.

Module II: Isolation, characterisation of microbial growth **15**

Sterilisation Techniques. Types of culture media: synthetic/defined, solid, liquid, selective, and differential. Cultivation of microorganisms: Broth culture, agar plate, pour plate. Microbial growth: Growth curve; diauxic growth curve; growth factors. Determination of viable count: Serial

dilution, spread plating, pour plating, determination of colony forming units (cfu) and calculation of viable count—preparation of pure cultures, streak plate, and colony morphology.

Total **30**

Course Title **: BASICS IN MICROBIOLOGY (SEC-PRACTICAL)**
Course Code : **UG-BOT-SEC 3**
Credits : **01**
Marks : **25**
Hours : **30**

Sr. No	Module III	Practical Sessions
1	Introduction to laboratory equipment: autoclave, laminar Air Flow, Hot Air Oven, Microscopes, pH meter	**1**
2	Sterilisation of glassware	**1**
3	Preparation of media and sterilization	**1**
4	Preparation of media agar plates	**1**
5	Isolation of pure cultures (T-streak, quadrant)	**2**
6	Serial dilution and cell count by Haemocytometer	**2**
7	Gram staining techniques of bacteria.	**3**
8	Mini Project: a) Microbial examination of water b) Bacteriological testing of milk	**4**
	Total	**15**

REFERENCES:

Mandatory Reading

1. Aneja, K. R. (2007). *Experiments in microbiology, plant pathology and biotechnology* (5th ed.). New Age International Publishers.
2. Prescott, L. M. (2005). *Microbiology* (6th ed.). McGraw Hill.
3. Pelczar, M. J., Chan, E. C. S., & Krieg, N. R. (1993). *Microbiology*. Fong and Sons Printers Pvt. Ltd.
4. Willey, J. M., Sherwood, L., Woolverton, C. J., & Prescott, L. M. (2008). *Prescott, Harley and Klein's microbiology*. McGraw Hill Higher Education.
5. Atlas, R. M. (1997). *Principles of microbiology* (2nd ed.). McGraw Hill.
6. Dubey, R. C., & Maheshwari, D. K. (2002). *Practical microbiology*. S Chand & Company Ltd.

7. Anantnaryan, R., & Paniker, C. K. J. (2005). *Textbook of microbiology* (7th ed.). Orient Blackswan.
8. Madigan, M. T., Martinko, J. M., & Parker, J. (2007). *Brock's biology of microorganisms*.Pearson Prentice Hall.

Supplementary Reading

1. Salle, A. J. (1999). *Fundamental principles of bacteriology* (7th ed.). McGraw Hill.
2. Powar, C. B., & Daginawala, H. F. (1982). *General microbiology* (Vol. II). Himalaya Publishing House.

Web References:

1. Microbe Notes. (n.d.). Streak plate method: Principle, methods, significance, and limitations. Retrieved from https://microbenotes.com/streak-plate-method-principle- methods-significance-limitations/
2. Microbiology Info. (n.d.). Gram staining: Principle, procedure, interpretation, examples, and animation. Retrieved from https://microbiologyinfo.com/gram-staining-principle- procedure-interpretation-examples-and-animation/
3. Biology Discussion. (n.d.). Reproduction in bacteria: 5 methods with diagram. Retrieved from https://www.biologydiscussion.com/bacteria/reproduction-in-bacteria-5-methods- with-diagram/47062
4. Microbe Notes. (n.d.). History of microbiology. Retrieved from https://microbenotes.com/history-of-microbiology/

SEMESTER IV

Course Title : **PLANT ANATOMY AND EMBRYOLOGY (THEORY)**
Course Code : **UG-BOT-203**
Credits : **04**
Marks **75**
Duration : **45 hours**
Prerequisite Courses: Biology at XIIth preferred.

COURSE OBJECTIVES:

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

COURSE OUTCOME:

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

CLO1: Define, describe and explain theories, the basic plant organisation and anatomical features of shoot, root and leaf.

CLO2: Define, describe, explain wood structure and its components

CLO3: Define, describe, explain components and processes in reproductive biology, pollination and fertilization

CLO4: Examine the organization of tissues and embryological features through histological techniques.

MODULE I: SHOOT, ROOT AND LEAF ANATOMY **15**

Organization of Shoot apical meristem. Apical cell theory, Histogen theory, Tunica-Corpus theory, Cyto-histological zonation. Organization of root apical meristem. Korper-Kappe theory, Quiescent centre. Anatomy of leaf: epidermis, mesophyll and vascular tissue. Stomata and its diversity, leaf abscission.

MODULE II: WOOD STRUCTURE **15**

Vascular cambium, Secondary xylem, Xylary elements.

Secondary phloem, Phloem elements and Periderm. Conifer wood, Dicotyledon wood, wood anatomy-TS, TLS, RLS.

MODULE III: REPRODUCTIVE BIOLOGY, POLLINATION AND FERTILIZATION **15**

Floral development: ABC model of flowering

Structure and development of male gametophyte- Microsporangium Microsporogenesis& Pollen grains. Structure and development female gametophyte – Megasporangium. Mechanism of pollination and fertilization- types of pollination, germination of pollen grain, pollen pistil interaction, self- incompatibility. Double fertilization, embryo (dicot and monocot) and endosperm formation. General account of Apomixis and Polyembryony.

TOTAL 45

Course Title : **PLANT ANATOMY AND EMBRYOLOGY (PRACTICAL)**
Course Code : **UG-BOT-203**
Credits : **01**
Marks : **25**
Duration : **30 hours (15 sessions)**

Sr.No.	Practical Title	Practical sessions
1.	Study of simple and complex tissues by using permanent slides/ EM graphs.	**02**
2.	Microscopic study of wood tissues in T.S, T.L.S. and R.L.S. (Permanent slides) and maceration (Any one species)	**03**
3.	Study of Meristems, Microsporogenesis and Megasporogenesis through permanent slides	**02**
4.	Mini Project- Study of diversity in leaf anatomy, stomata and female gametophyte exhibiting self-incompatibility.	**03**
5.	Embryo and Endosperm with haustoria mounting (*Tridax/ Cucurbit*).	**02**
6.	In vitro growth of pollen tube in *Portulaca/ Vinca.*	**01**

7.	Pollen studies: Chitaley's method for analysis in *Ipomoea, Ocimum, Hibiscus*, *Acacia auriculiformis* and Grass.	**02**

TOTAL 15

REFERENCES:

List of books recommended for reference

1. Bhojwani, S. S and Bhatnagar, S.P. (2009). *The Embryology of Angiosperms*, New Delhi: Vikas Publishing House Pvt. Ltd.,
2. Dwivedi. J.N. (1988). *Embryology of Angiosperms.* Meerut: Rastogi and Co.
3. Esau, K. (1977). *Plant Anatomy,* 2nd Edition. New Delhi: Wiley Eastern Private Limited.
4. Fahn, A. (1982). *Plant Anatomy* (3rd edition). Oxford: Pergoman Press.
5. Mauselth, J.D. (1988). *Plant Anatomy.* California, USA: The Benjamin Cummings Publishing Co. Inc.
6. Maheswari, P. (1971). *An Introduction to the Embryology of Angiosperms.* New Delhi: Tata McGrawhill.
7. Pandey, B.P. (1981). *A textbook of Botany Angiosperms*. New Delhi: S. Chand and Co.
8. Pandey, B.P. (1978). *Plant Anatomy.* New Delhi: S Chand and

Co., Weblinks:

1. http://virtualplant.ru.ac.za/Main/ANATOMY/prac9.htm
2.http://www.biologydiscussion.com/plants/wood-anatomy-of-some-important-plants- biology/57016

MANDATORY READING:

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

Course Title : **CYTOGENETICS (THEORY)**
Course Code : **UG-BOT-204**
Credits : **04**
Marks : **75**
Duration : **45 hours**

COURSE OBJECTIVES:

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

COURSE OUTCOMES:

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

CLO1 Restate, apply, analyze and access the fundamentals of Mendelian genetics and linkage.

CLO2 To discuss, explain and interpret extra nuclear inheritance and Sex linked inheritance

CLO3 Identify, explain, compare and contrast various chromosomal abberations.

CLO4 To employ and evaluate Mendelian genetics at a practical level.

MODULE I: Mendelian Genetics, Linkage and Mutation **15**

Mendel's Laws, backcross and test cross. Allelic and non-allelic interactions, Epistatic interactions. Multiple alleles in Drosophila (eye colour), man (blood groups) and plants (self-incompatibility).

Linkage- Coupling and Repulsion Hypothesis Chromosome maps. Mutations and its types. Types of mutagens. Transitions and transversions; frame shift mutations. DNA repair mechanisms, Applications of mutations.

MODULE II: Extranuclear inheritance and Sex linked inheritance **15**

Extranuclear inheritance and maternal influence: Kappa particles in *Paramecium;* CO2 sensitivity in *Drosophila*; cytoplasmic inheritance in mitochondria and plastids; Shell coiling in snails; eye colour in flour moth.

Sex Chromosomes, Mechanisms of sex determination; Genic balance mechanism.

Sex-linked inheritance- X linked and Y linked inheritance.

MODULE III: Genetic variation due to chromosome structure and number **15**

Chromosomal aberrations – duplications, deletions, inversions and translocation

Variations in chromosome number; auto-and allo-polyploidy - types and effects; artificial induction of polyploidy. Auto and allo-polyploid crop species Aneuploid segregations in plants- tetrasomics and nullisomics; triploid and tetraploid plants. Applications of polyploidy

TOTAL 45

Course Title : **CYTOGENETICS (PRACTICAL)**
Course Code : **UG-BOT-205**
Credits : **01**
Marks : **25**
Duration : **30 hours (15 sessions)**

Sr. No.	Practical Title	Practical sessions
1.	Study of Mitosis and meiosis using suitable plant material	03
2.	Karyotype analysis and preparation of ideogram	02

3.	Detection of anomalies in cell division using suitable plant material.	02
4.	Study of multiple allelism in blood groups of human beings.	01
5.	Effect of physical and chemical mutagen on seed germination	03
6.	Preparation of chromosome maps from 3-point test cross data and calculation of Interference and coincidence	01
7.	Induction of polyploidy using Colchicine treatment.	02
8.	Study of sex linked inheritance	01
	Total	**15**

List of books recommended for reference:

Mandatory References:

1. Gardner, E.J., Simmons, M.J. and Snustad, D.P. (1991) Principles of Genetics (8th edition). John Wiley & sons, India.
2. Gardner, Eldon J.; Snustad, Peter D.; (1984) Principles of genetics; 7th edition; New York: John Wiley & Sons.
3. Griffiths, A.J.F., Wessler, S.R., Carroll, S. B. and Doebley, J. (2010) Introduction to Genetic Analysis (10th edition). W. H. Freeman and Co., U.S.A.
4. Gupta, P.K. (1990) Genetics. Rastogi Publications .
5. Gupta, P.K.; (2004) Cytogenetics; 1st edition, reprint; Meerut:Rastogi Publications.
6. Gupta, P.K.; Genetics: A textbook for University students; 3rd edition; Meerut: Rastogi Publications (2007).
7. Klug, W.S., Cummings, M.R. and Spencer, C.A. (2009) Concepts of Genetics, (9 th edition). Benjamin Cummings, U.S.A.
8. Pierce, B. (2008) Genetics : A Conceptual Approach 3rd Edition, Freeman & Co.
9. Shukla, R.S. and Chandel, P.S.; (2007) Cytogenetics, Evolution, Biostatistics and Plant Breeding.
10. Snustad, D.P. and Simmons, M.J. (2010) Principles of Genetics, (5th edition). John Wiley & Sons Inc., India.
11. Snustad, P. and Simmons, M. (2006) Principles of Genetics, 4th Edition, John Wiley and Sons Co.
12. Verma, P.S., Agarwal, V.K. (2009) Genetics, (9th Revised Edition). S. Chand and Co., New Delhi.
13. W. S. Klug, M. R. Cummings, C. A. Spencer. (2006) Concepts of Genetics 8 Edition, Pearson Education International.

Supplementary References:

1. Watson, J. D., Baker, T. A. Bell,S. P. Gann, A. Levine, M. Losick, R. (2004) Molecular Biology of the Gene 5th Edition, Pearson Education.
2. Russell, P. (2006) Genetics 2nd Edition, Pearson International (2006).

Web References:

1. https://ndli.iitkgp.ac.in

Course Title	:	**PLANT BREEDING AND BIOSTATISTICS (THEORY)**
Course Code	:	**UG-BOT-205**
Credits	:	**04**
Marks	:	**75**
Duration	:	**45 hours**

COURSE OBJECTIVES:

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

COURSE OUTCOMES:

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

CLO1 Identify and assess the role of various institutions, certification programs and breeders, rights in plant breeding.

CLO2 Describe and compare various techniques in hybridization and mutation breeding

CLO3 Employ and practice various bio statistical methods.

CLO4 Interpret, analyze and evaluate various experiments in plants breeding and biostatistics.

MODULE I: Introduction to Plant breeding, Organisations and Certifications **15**

Introduction, history, objectives, achievements and prospects. Centres of origin of crop plants. Organizations & their mandate – CCARI- ICAR, ICRISAT, IRRI (Indian & International) Plant breeders' & Farmers' Rights Phytosanitary and Seed Certifications.

MODULE II: Hybridisation, Heterosis, Inbreeding Depression and Mutation breeding **15**

Pure line and mass selection, Types and Techniques in hybridization. Introduction, domestication and acclimatization. Heterosis and inbreeding depression.

Varieties developed in India through mutation breeding; Limitations of mutation breeding.

MODULE III: Biostatistical methods and Genetics of Pathogenicity **15**

Introduction to biostatistics: Terms used in biostatistics, types of data, Sampling theories- random sample, sample size determination, precision, data collection, processing and presentation of data: qualitative and quantitative

Measures of central tendency: Mean, Median, Mode. Measures of variation: standard deviation, standard error. Concept of correlation between two variables and regression line, Chi square.

Physiological races and types. Genetics of pathogenicity; vertical and horizontal resistance & breeding for various biotic stresses in rice/wheat.

TOTAL 45

Course Title : **PLANT BREEDING AND BIOSTATISTICS (PRACTICAL)**
Course Code : **UG-BOT-205**
Credits : **01**
Marks : **25**
Duration : **30 hours (15 sessions)**

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

List of books recommended for reference:

Mandatory References:

1. Acquaah, G. (2007) Principles of Plant Genetics & Breeding. Blackwell Publishing.
2. Mahajan, B.K.; (1997) Methods in biostatistics; 6th edition; New Delhi:Jaypee Brothers.
3. Shukla, R.S. and Chandel, P.S.; (2007) Cytogenetics, Evolution, Biostatistics and Plant Breeding.
4. Singh, B.D. (2005) Plant Breeding: Principles and Methods (7th edition). Kalyani Publishers, Ludhiana.

5. Singh, B.D.; (2009) A textbook of Plant Breeding; Kalyani Publishers.
6. Zar J H, (1998) Biostatistical analysis 4th ed. Prentice Hall.

Supplementary References:

1. Sokal R R and Rahlf H A. (1995) Biometry: the principles and practice of Statistics for Biology. research. 3rd edi W H Freeman and Co.

Web References:

1. https://icar.org.in
2. https://ndli.iitkgp.ac.in

Course Title **: ENZYMES AND METABOLIC PATHWAYS (CORE: THEORY)**
Course Code**: UG- BOT-206**
Marks **: 75**
Credits **: 3**
Hours **: 45**

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

Course Outcomes:
Upon successful completion, the students will be able to:
CLO1: Classify the different enzymes based on its structure and function
CLO2: Identify the role of enzymes in various biological processes
CLO3: Outline the various mechanisms of enzyme action
CLO4: Estimate and apply enzymology concepts.

Hours

Module I: Basic Concept and Catalysis of Enzymes **15**

Classifications & nomenclature (IUB system). Biological role of enzymes; Concept of holoenzymes, apoenzymes, prosthetic group, iso-enzymes, allosteric enzymes and Active sites. Chemical nature of enzymes, Characteristics of enzymes **(**Physico-chemical and biological properties) Enzyme activity. Role of co-factors (NAD, NADP+, FMN/FAD, Co-enzyme A, Pyridoxyl phosphate and metal ions).

Module II: Enzyme Kinetics **15**

Factors affecting enzyme activity (concentration, substrate, pH, temperature, inhibitors). Michaelis-Menten equation and its significance. Fisher's lock and key model and Koschland (induced fit theory), Arrhenius plot. Enzyme action (competitive and noncompetitive)

Module III: Metabolic Concepts of Enzymes **15**

Glycolysis, Fate of pyruvate (Lactic acid & alcohol fermentation). Citric acid cycle, Glycogen cycle, Respiratory substrate, Respiratory quotient, Mitochondrial Electron transport, Cytochrome, Alternate oxidase pathway. Biosynthesis and degradation of triglycerides. Pathway for amino acid metabolism: Role of Nitrogenase enzyme**,** NIF, Nod genes and nodulines.

Total 45

Course Title **: ENZYMES AND METABOLIC PATHWAYS (PRACTICALS)**
Course Code **: UG-BOT- 206**
Marks **: 25**
Credits **: 1**
Hours **: 30**

Sr. no	**Module IV: List of Experiments**	**Practical sessions**
1	Qualitative and quantitative determination for amylase enzyme in the given plant samples.	**3**
2	Effect of enzyme concentration, temperature, substrate, inhibitors and pH on the activity of α-amylases	**5**
3	To extract and determine the activity of catalase, lipase and peroxidase enzymes	**3**
4	Mini project i. Role of Nitrogen in plants ii. Application of enzymes in industries (dairy/ sugar/ waste management/ food) iii. Anaerobic respiration in germinating seeds.	**4**
	Total	**15**

Mandatory References:

1. Berg, J. M., Tymoczko, J. L., Gatto, G. J., Jr., & Stryer, L. (2019). *Biochemistry* (9th ed.). WH Freeman.
2. Breaker, R. R. (2000). Making catalytic DNAs. *Science, 290*(5498), 2095–2096. https://doi.org/10.1126/science.290.5498.2095
3. Campbell, N. A., Reece, J. B., & Mitchell, L. G. (1999). *Biology* (5th ed.). Benjamin/Cummings.
4. Deeth, R. J. (1997). Chemical choreography. *New Scientist, 155*(2103), 24–27.
5. Price, C. N., & Lewis, S. (1999). *Fundamentals of enzymology*. Oxford University Press.

Suggested References:

1. Palmer, T., & Bonner, P. L. (2007). *Enzymes: Biochemistry, biotechnology, clinical chemistry* (2nd ed.). Woodhead Publishing.
2. Voet, D., & Voet, J. (2010). *Biochemistry* (4th ed.). John Wiley & Sons, Inc.
3. Devasena, T. (2010). *Enzymology*. Oxford University Press.
4. Satyanarayana, U., & Chakrapani, U. (2020). *Biochemistry* (5th ed.). Elsevier.
5. Jain, J. L., Jain, S., & Jain, N. (2016). *Fundamentals of biochemistry*. S. Chand Pvt. Ltd.
6. Rodwell, V., Bender, D., Botham, K., Kennelly, P., & Weil, P. A. (2018). *Harper's illustrated biochemistry*. McGraw Hill Education**.**

Web Refrences:

1. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4692135/
2. https://www.imedpub.com/insights-in-enzyme-research/
3. https://iopscience.iop.org/book/978-0-7503-1302-5/chapter/bk978-0-7503-1302-5chl
4. https://www.biologydiscussion.com/enzymes/enzymes-meaning-mechanism-classification-factors- and-importance/17003
5. https://nptel.ac.in/courses/102102033

Course Title **: HERBAL COSMETOLOGY (VOCATIONAL: THEORY)**
Course Code**: UG- BOT-VOC-1**
Marks **: 75**
Credits **: 3**
Hours **: 45**

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

Course Learning Outcomes:
Upon successful completion of the course, students will be able:
CLO 1: Explain the basics of herbal cosmetology.
CLO 2: Outline the requirements for making herbal.
CLO 3: Interpret the techniques of herbal formulations in detail.
CLO 4: Identify, describe and assess the herbs used in cosmetic products.

Hours

Module I: Introduction to Herbal Cosmetology **15**

History, Definition, Concept. Collection and processing of herbal material, Natural and artificial drying of herbal material. Herbal remedies for holistic health. Current status of Herbal Cosmetic; Industry in India. Introduction herbal products beneficial for skin and hair. Aroma therapy; concept and applications; herbs used in aroma therapy. Comparative study: Herbal and synthetic cosmetology. Safety and efficacy of herbals cosmetics. Future prospects of herbal cosmetic Industry.

Module II: Identification (Botanical Name and Family), Description and Utilization of Following Plants with Cosmetic Benefits and Their Cosmetic Uses **15**

Curcuma longa, Lawsonia inermis, Aloe vera, Azadirachta indica, Carica papaya, Cocus nucifera, Acacia concinna, Sapindus mukorossi, Citrus limon, Mentha sp., Tagetes sp., Musa paradisica, Rosa sp., Manjistha, Sandalwood. Plants beneficial to skin: Cucumber, *Aloe vera*, Calendula, Jasmine.Plants beneficial for hair: Hibiscus, Amla, Brahmi, *Aloe vera.* Ethical sourcing and sustainability, Environmental impact of herbal cosmetic production, entrepreneurship in herbal cosmetology.

Module III: Standardization of Raw Material and Commonly Used Herbs in The Herbal Cosmetics **15**

Importance of standardization. Physical and chemical methods of standardization. Quantitative and qualitative estimation of phyto- constitutes

Herbs used in the following cosmetic product: Herbal Shampoo(s) and soap(s), Herbal Conditioner, Herbal Hair Dye/ Herbal Hair Oil/Hair Cream/Hair Gel, Herbal Face Mask, Herbal Bath Oil.

Study of protocol for preparation of: Different types of Herbal face masks- for dry skin, oily skin, pigmented skin & wrinkled skin, Special Herbal masks for sensitive skin, Herbal Shampoo(s) and soap(s). Entrepreneurship and startup in the field of herbal cosmetology.

TOTAL 45

Course Title **: HERBAL COSMETOLOGY (PRACTICAL)**
Course Code **:UG- BOT- VOC-1**
Marks **: 25**
Credits **: 1**
Hours **: 30**

Sr. No.	Module IV: List of Experiment	Practical Sessions
1.	Herbal face masks for dry skin, oily skin, pigmented skin, wrinkled skin.	**2**
2.	Preparation of Herbal Shampoo(s) and soap(s)	**2**
3.	Preparation of herbal hair oils	**1**
4.	Comparison of constituents of Herbal products to non-herbal Products	**1**

5.	Visit to an Ayurvedic institute / local ayurvedic clinic.	**2**
6.	Extraction of plant pigments- *Lawsonia inermis* (mehndi) and *Curcuma longa* (turmeric),	**2**
7.	Mini project:	**5**

i. Study of various skin and hair care herbal products available in the market.
ii. Study of locally available herbal Churnas.
iii. Local Survey about awareness w.r.t home remedies for cosmetic purpose.
iv. Survey to analyse and compare the herbal and non-herbal products.
v. Case study and analysis of successful herbal cosmetic brands

Total **15**

Mandatory References:

1. Panda, H. (2022). *The complete technology book on herbal beauty products (cosmetic industry) with formulations, manufacturing process, machinery equipment details & plant layout*. Asia Pacific Business Press.
2. Sachs, M. (2014). *Ayurvedic beauty care: Ageless techniques to invoke natural beauty* (ISBN 9788120818804)
3. Fuller, K. W., & Gallon, J. A**.** (1985). *Plant products and new technology*. Clarendon Press

Suggested References:

1. Kocchar, S. L. (1998). *Economic botany in the tropics*. Macmillan India Ltd.
2. Simpson, B. B., & Conner-Ogorzaly, M. (1986). *Economic botany: Plants in our world*. McGraw Hill.
3. Sharma, O. P. (1998). *Hill's economic botany*. Tata McGraw Hill Publishing Company Ltd.

Web References:

1. https://www.biologydiscussion.com/herbal-drugs/modern-methods-of-herbal- drugs-extraction/25348
2. www.santulan.in

3. www.pvayurveda.com
4. https://wjpr.s3.ap-south-1.amazonaws.com/article_issue/1522478937.pdf
5. https://www.planetayurveda.com/stholyantak-churna/

SEMESTER V

Course Title : **PLANT PHYSIOLOGY (CORE: THEORY)**
Course Code : **UG-BOT-301**
Marks : **75**
Credits : **3**
Hours : **45**

Course Objectives
Relate physiological mechanism of plants and their functioning.
Analyze biosynthesis of valuable plant metabolites (primary/ secondary) and their role.

Course Learning Outcome:
Upon successful completion of the course, students will be able to:
CLO1: discuss and analyse the plant water relations in the plants.
CLO2: analyse and understand photosynthetic mechanisms in plants
CLO3: recognize and relate various developmental processes and secondary metabolites in plants
CLO4: formulate and design experiments to explain physiological concepts.

Hours

Module -I: Plant Water Relations and Solute Transport **15**
Water and its significance to plants. Osmotic & water potential of cell. Transpiration, stomatal regulation & anti-transpirants. Ascent of sap: Uptake, transport and translocation of water. Essentiality of mineral nutrition and its uptake (active and passive); Role of membranes. Transport of organic solutes (source sink relationship); Assimilate partitioning

Module II: Photosynthesis and Stress Physiology **15**
Chloroplast, Photosynthetic pigments and Light harvesting complexes. Light Reaction: Z scheme of photosynthesis & Mechanisms of electron transport. Carbon fixation (C3, C4 and CAM pathways). Photoprotective mechanisms (photorespiration). Environment change and its impact on photosynthesis. Responses of plants to abiotic & biotic stress.

Module III: Plant Growth and Development and Secondary Metabolites **15**
Role of phytochromes & cryptochromes and its functions. Plant hormones, transport and physiological functions. Photoperiodism & vernalization. Senescence, seed dormancy & germination. Biosynthetic pathway of phenolic compounds, terpenes, alkaloids and their functions.

Total 45

Course Title : **PLANT PHYSIOLOGY (CORE: PRACTICAL)**
Course Code : **UG-BOT-301**
Marks : **25**
Credits : **1**
Hours : **30**

Sr. No	Module IV -List of Experiments	Practical Sessions
1	Determination of osmotic potential of plant cell sap by plasmolytic method.	1

2	Determine water potential of given tissue by falling drop/ tissue weight method	**1**
3	Chromatographic separation of plant pigments and plant sugars by paper chromatography	**2**
4	Determination of Chla, Chlb, and total Chl in sun & shade plants	**2**
5	Role of Plant hormones (Auxins/ Gibberellin/ Cytokinin) in plant growth	**3**
6	Mini Project: i. Mineral deficiency symptoms in plants ii. Secondary metabolites in plants (qualitative/ quantitative basis) iii. Oxygen evolution during photosynthesis iv. Starch production during photosynthesis v. Use of hydroponic technique for plant growth	**6**
	Total	**15**

Mandatory References:

1. Hou, H. J., Najafpour, M. M., Moore, G. F., & Allakhverdiev, S. I. (Eds.). (2017). *Photosynthesis: Structures, mechanisms, and applications* (Vol. 417). Cham, Switzerland: Springer International Publishing.

2. Jordan Smith (2016) *Plant and Crop Physiology*. Syrawood Publishing House.

3. Jain, V. K. (2018). *Fundamentals of plant physiology*. S. Chand Publishing.

4. Taiz, L., & Zeiger, E. (2002). *Plant physiology*. Sinauer associates.

5. Noggle, G. R., & Fritz, G. J. (1976). Introductory Plant Physiology.

6. Taiz, L., Zeiger, E., Møller, I. M., & Murphy, A. (2006). Chapter 12: Respiration and lipid metabolism. *Plant Physiology, 4th ed.; Sinauer Associates, Inc.: Sunderland, MA, USA*, 244.

7. Salisbury, F. B., & Ross, C. W. (1978). Plant Physiology 3rd edition, Wadsworth Inc.

Suggested reading

1. Goodwin, T. W., & Mercer, E. I. (1972). Introduction to plant biochemistry. 2nd edition CBS Publishers and distributors.

2. Moore, T.C. (1989). *Biochemistry and Physiology of Plant Hormones.* New York, USA: Springer –Verlag.

3. Singhal G.S., Renger G., Sopory, S.K., Irrgang K.D & Govindjee (1999).*Concept in Photobiology; Photosynthesis and Photomorphogenesis*. , New Delhi: Narosa Publishing House.

4. Hopkins, W.G. & Huner, P.A. (2008) *Introduction to Plant Physiology.* John Wiley and Sons.

5. Nelson, D.I. & Cox M. M. (2000). *Lehninger. Principles of biochemistry*, 3rdedition, U.K: Macmillan.

6. Plummer, D. T. (1985). *An introduction to Practical Biochemistry.* 2nd edition. Tata Mcgraw Hill Publishing company Ltd.

Current Literature (Journal Articles):
Plant Physiology, The Plant Cell, Journal of Plant Physiology, Physiologia Plantarum, Plant Physiology and Biochemistry, Postharvest Biology and Technology, Journal of the American Society for Horticultural Science, Nature, Scientific American and Science reporter.

Web References:
1. http://www.nrce.niepa.ac.in › ... › Life Science
2. http://exa.unne.edu.ar › biologia › fisiologia.vegetal
3. https://www.springer.com › journal
4. https://www.ncbi.nlm.nih.gov › pmc › journals
5. https://www.biologydiscussion.com/plant-physiology-2/notes-plant-physiology/34597

Course Title **: SYSTEMATICS OF FLOWERING PLANTS AND PHYLOGENY (CORE: THEORY)**
Course Code **: UG- BOT- 302**
Marks **: 75**
Credits **: 3**
Hours **: 45**

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

Course Learning Outcomes:
Upon successful completion of the course, students will be able to:
CLO1: Define Plant Classification, documentation and nomenclature in Plant Systematics.
CLO2: Explain, examine the concept of taxonomic evidences and phylogeny of angiosperms.
CLO3: Explain, analyze and interpret the systems of classification, features of families in Systematics of flowering plants.
CLO4: Identify plants with help of Floras, taxonomic keys, prepare herbarium and construct Cladograms.

Hours

Module I: Introduction to Plant Classification and Nomenclature **15**

Plant classification, nomenclature & biosystematics. Field inventory; Functions of Herbarium; Important herbaria and botanical gardens (India & world), virtual herbarium; e-flora. Documentation: Flora, Monographs, Journals; Keys: Single access and Multi-access. Principles and rules (ICBN); Ranks and names; Typification, author citation, valid publication. Rejection of names, principle of priority and its limitations; Names of hybrids.

Module II: Concept, Taxonomic Evidences and Phylogeny of Angiosperms **15**

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

Module III: Systems of Classification; Position And Diagnostic Features of Families **15**

Concepts of evolution and phylogeny. Major contributions by Linnaeus, Bentham and Hooker, Engler and Prantl; Brief reference of Angiosperm Phylogeny group (APG III) Classification. Annonaceae, Capparaceae, Brassicaceae, Malvaceae, Rutaceae, Myrtaceae, Cucurbitaceae, Rubiaceae, Apocyanaceae, Solanaceae, Verbenaceae, Zingiberaceae, Leguminosae, Poaceae.

Total **45**

Course Title **: SYSTEMATICS OF FLOWERING PLANTS AND PHYLOGENY (PRACTICAL)**
Course Code **: UG- BOT-302**
Marks **: 25**
Credits **: 1**
Hours **: 30**

Sr. No	Module IV: List of Experiments	Practical Sessions
1	Plant identification using flora and database	**1**
2	Identification of 09 families mentioned in unit IV (Bentham & Hooker's system) studied in theory from locally available specimens (with floral diagram).	**9**
3	Use of taxonomic keys and construction of dichotomous keys	**1**
4	Taxonomic interpretation using pollen of related species	**1**
5	Construction of Phenogram and Cladogram	**1**
6	Mini project: i. Preparation of herbarium	**2**

ii. Field visit

Total 15

Mandatory References:

1. Mondal, A.K. (2009). *Advanced Plant Taxonomy*, New Delhi: New Central Book Agency Ltd.
2. Pandey, S.N. (2008). *Taxonomy of angiosperms*, New Delhi: ASE books India.
3. Singh, G. (1999). *Plant Systematics*: Theory and Practice. New Delhi: Oxford & IBH Pvt. Ltd.
4. Subrahmanyam, N. S. (1995). *Modern plant taxonomy*, Vikas publishing house pvt. Ltd.
5. Rao, R. S. (1985). *Flora of Goa, Diu, Daman, Dadra and Nagarhaveli*.

Suggested References:

1. Chopra, G. L. (1985). *Angiosperm (Systematics& Life cycles*). Jaladhar, India : Pradeep Publications, pp.339-350.
2. Pandey, B. P. (1969). *Taxonomy of Angiosperms*. New Delhi: S. Chand and company Ltd, India, pp.102-105.
3. Naik, V.N. (1984). *Taxonomy of Angiosperms*. New Delhi: Tata McGraw Hill.
4. Radford, A.E. (1986). *Fundamentals of Plant Systematics*. New York: Harper and Row.
5. Davis, P.H. & Heywood, V.H. (1963). *Principles of Angiosperm Taxonomy*. London: Oliver and Boyd.
6. Heywood, V.H. & Moore, D.M. (1984). *Current Concepts in Plant Taxonomy*. London: Academic Press.

Web References

1. http://www.nrce.niepa.ac.in › ... › Life Science
2. http://exa.unne.edu.ar › biologia › fisiologia.vegetal
3. https://www.springer.com › journal
4. https://www.ncbi.nlm.nih.gov › pmc › journals
5. https://www.biologydiscussion.com/plant-physiology-2/notes-plant-physiology/34597

Course Title **: TECHNIQUES & INSTRUMENTATION IN BOTANY(CORE:THEORY)**
Course Code **: UG- BOT-303**
Marks **: 75**
Credits **: 3**
Hours **: 45**

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

Course Learning Outcomes:
Upon successful completion of the course, students will be able:
CLO 1: Define and explain the principle, instrumentation and working of microscopy and radiobiology techniques used in Botanical research.
CLO2: Define and Explain the principle, working and applications of centrifugation and spectrophotometry in Botanical research.
CLO 3: Define the principle, working and applications of chromatography, electrophoresis and molecular techniques.
CLO 4: Analyse and interpret the techniques studied.

	Hours
Module I: Microscopy and Radiobiology (Principle, Methodology and Applications)	**15**

Light microscopy (compound microscopy and Phase contrast microscopy) Fluorescence microscopy. Transmission and Scanning electron microscopy (sample preparation for electron microscopy, cryofixation.). Microscopic measurements (Micrometry & cytometry) and photography (micro and macro). Radioactivity and its measurements (Geiger Muller and Scintillation counter and autoradiography).

Module II: Centrifugation and Spectrophotometry: Principle, Methodology and Applications	**15**

Centrifugation: Low speed, high speed, cooling centrifuges and ultracentrifugation Analytical, preparatory and gradient centrifugation. UV visual spectrophotometry. Fluorescence spectrophotometry. Flame (Atomic absorption) spectrophotometry. Mass spectrophotometry.

Module III: Chromatography, Electrophoresis and Molecular Techniques; Principle, Methodology and Applications	**15**

Adsorption and partition chromatography. Column chromatography (isocratic and gradient). High Performance Liquid Chromatography& Gas Chromatography. Electrophoresis: Agarose Gel Electrophoresis, Sodium Dodecyl Sulphate Polyacrylamide Gel Electrophoresis, Iso-Electric Focussing and 2- Dimensional Electrophoresis. Polymerase Chain Reaction, Real Time PCR

Total	**45**

Course Title **: TECHNIQUES & INSTRUMENTATION IN BOTANY (PRACTICAL)**
Course Code**: UG- BOT-303**
Marks **: 25**
Credits **: 1**
Hours **: 30**

Sr. No	Module IV: List of Experiments	Practical Sessions
1	Precautions & Lab safety, Preparation of Molar, Normal and ppm solutions	**2**
2	Determination of Lambda (λ) max of a given solution Verification of Beer's Law	**1**
3	Micrometric dimensions (cytometry and micrometry)	**2**
4	Preparation of TLC plate and Separation of biomolecules	**2**
5	Demonstration of SDS- PAGE/ Agarose gel Electrophoresis	**2**
6	Demonstration of Flame photometry	**1**
7	Visit to Instrumentation Lab (NIO/College/ Goa University)	**1**
	Mini project: i. Comparison of ultra and gradient Centrifugation ii. Microscopy: Analysis of different photo micrographs iii. Photography: To submit a report of macro and microphotography iv. Preparation of column for column chromatography.	**4**
	Total	**15**

Mandatory References:

1. Ghatak, K. L. (2011). *Techniques and methods in Biology*. NY: Prentice Hall India Learning Private Limited.
2. Plummer, D. T. (2009). *An Introduction to Practical Biochemistry*. 3rd edition. New Delhi: Tata Mc Graw Hill Education Private Ltd.
3. Bajpai, P. K. (2006). *Biological instrumentation and methodology*. Mumbai: S. Chand and Company. Ltd.
4. Karp, G. (1999). *Cell and molecular Biology, Concepts and experiments*. 2nd edition John Wiley and Sons Inc.

Suggested References:

1. Davey, H. M., & Kell, D. B. (1996). *Flow cytometry and cell sorting of heterogeneous microbial populations: the importance of single-cell analyses. Microbiol.* Mol. Biol. Rev., 60(4), 641-696.
2. Flegler, S. L., & Flegler, S. L. (1997). *Scanning & Transmission Electron Microscopy*. Oxford University Press.
3. Feist, A. (2018). *Next-generation ultrafast transmission electron microscopy-development and applications* (Doctoral dissertation, Georg-August-UniversitätGöttingen).
4. Kirsch, D. G., Diehn, M., Kesarwala, A. H., Maity, A., Morgan, M. A., Schwarz, J. K., ... & Bernhard, E. J. (2018). The future of radiobiology. *JNCI: Journal of the National Cancer Institute*, *110*(4), 329-340.

Web References:

1. amrita.olabs.edu.in,. (2013). Paper Chromatography. Retrieved 12 February 2020, from amrita.olabs.edu.in/?brch=8&cnt=1&sim=133&sub=73
2. vlab.amrita.edu,. (2011). Polyacrylamide Gel Electrophoresis. Retrieved 12 February 2020, from vlab.amrita.edu/?sub=3&brch=186&sim=319&cnt=1
3. vlab.amrita.edu,. (2012). Experiment-2 : Differential Protein Expression Analysis. Retrieved 12 February 2020, from vlab.amrita.edu/?sub=3&brch=237&sim=1248&cnt=1
4. vlab.amrita.edu,. (2011). Spectrophotometry. Retrieved 12 February 2020, from vlab.amrita.edu/?sub=2&brch=190&sim=338&cnt=1

Course Title **: APPLIED MYCOLOGY(VOCATIONAL:THEORY)**
Course Code**: UG-BOT-VOC 3**
Marks **: 75**
Credits **: 3**
Hours **: 45**

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

Course Learning Outcomes: The students be able to:
CLO 1: Describe fungal cultures and media formulations
CLO2: Analyse the role of fungi in industries.
CLO3: Evaluate the role of fungi in agriculture and mycotechnology
CLO4: Demonstrate mycological techniques.

Hours

Module-I: Introduction and Fungal Culture Studies **15**

General account of fungi. Microscopic structure, Chemical composition and understanding of fungal cell wall. Environmental factors influencing fungal growth. Studies of fungal culture; Introduction to culture collections, Culture Media formulations and types of media used in mycology. Culture databases.

Various techniques for pure culture isolation and maximum recovery from different habitats (Soil, Litter, Water, Dung) Baiting, moist-chamber and particle-plating techniques. Isolation of pure cultures and maintenance. Study of colony characters and growth patterns. Fungal gene banks-Culture Collection Centers.

Module II: Industrial Mycology **15**

Role of fungi in biotechnology. Applications of fungi in food industry: Flavors and texture, Fermentation and baking, Organic acids (Preferably Citric acid), Enzymes (Preferably Cellulases and Pectinases). Mycoproteins– SCP (Yeast)

Endophytic fungi and its industrial applications.

Module III: Fungi in Agriculture, Medicine and Recent Mycological Advance **15**

Fungi as biofertilizers (Preferably Trichoderma) Fungi as biocontrol agents- Mycofungicides, Mycoherbicides, Mycoinsecticides. Mycorrhizae and its role. Medical mycology - Secondary metabolites- Pharmaceutical preparations from fungi, antibiotics from fungi. (Preferably Penicillium and Ganoderma). Mushroom cultivation & recent advances in mycotechnology; Mushroom cultivation techniques: Oyster and Button mushrooms. Applications of PCR and other molecular techniques in mycology, Mycoinformatics, Mycoremediation

Total **45**

Course Title **: APPLIED MYCOLOGY(PRACTICAL)**
Course Code**: UG-BOT-VOC 3**
Marks **: 25**
Credits **: 1**
Hours : **30**

Sr. No	Module IV: List of Experiments	Practical Sessions
1	Isolation and preparation of pure culture from a mixed culture plate on solid medium.	**2**
2	Preparation of moist chamber and incubation of fungi	**1**
3	Particle dilution plating for fungi	**1**
4	Isolation of endophytic fungi from plant leaves	**1**
5	Study of effect of incubation temperatures and pH on fungal growth	**2**
6	Colorimetric estimation of cellulase and amylase produced by fungi	**2**

7	Production of Citric acid (using *Aspergillus*) in broth and testing for its presence.	**2**
8	Mushroom cultivation- Oyster mushrooms and its protein estimation	**3**
9	Understanding structures of fungal enzymes using Bioinformatics tools.	**1**
	Total	**15**

Mandatory References:

1. Aneja, K. R. (2007). Experiments in Microbiology Plant Pathology & Biotechnology. (5th ed.) New Delhi: New Age International Publishers.

2. Bhat, D. J. (2010). Fascinating Microfungi (Hyphomycetes) of Western Ghats – India. First edition., Goa: Broadway Book Centre.

3. Powar, C.B. & Daginawala, H.F. (1982). General Microbiology–Volume II. Mumbai: Himalaya Publishing house.

4. Prescott, L. M. (2005). Microbiology. 6th ed., New Delhi: Mc Graw-Hill.

5. Shivkumar, P.K., Joe, M.M. & Sukesh K. (2010). An Introduction to Industrial Microbiology. (1st ed.). New Delhi: S. Chand& Company Pvt. Ltd.

6. Trivedi, P.S. & Pandey, S.N. (2009). A Textbook of Botany. Volume I. New Delhi: Vikas Publishing House Pvt Limited.

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1. https://www.adelaide.edu.au/mycology/
2. https://www.researchgate.net/publication/341822811_Spawn_Production_and_Mushroom_Cultivation_Technology
3. Introductory mycology : Alexopoulos, Constantine John, 1907- : Free Download, Borrow, and Streaming : Internet Archive

SEMESTER VI

Course Title **: PLANT GENETIC ENGINEERING (CORE:THEORY)**
Course Code **: UG BOT- 304**
Marks **: 75**
Credits **: 3**
Hours **: 45**

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

Course Learning Outcome:
Upon successful completion of the course, students will be able to:
CLO1: Explain and outline the basic knowledge of tools in DNA cloning
CLO2: Interpret, analyse and understand the techniques in plant genetic engineering.
CLO3: State and summarize the applications in genetic engineering
CLO4: Apply and interpret the knowledge of plant genetic engineering.

Hours

Module I: Tools in Recombinant DNA Technology 15

Introduction to Recombinant DNA technology, DNA cloning: cell based and cell free (PCR based). Vectors- Key features, advantages and disadvantages. Prokaryotic vectors - plasmids, cosmids, Lambda phage. Eukaryotic vectors- Bacterial Artificial Chromosome, Yeast Artificial Chromosome. Enzymes- Importance in plant genetic engineering, Nucleases: Exo and endonucleases; Types I, II, III. DNA ligases. DNA modifying enzymes, Factors affecting enzyme activation. DNA ligation, transformation, selection of transformed bacteria. DNA Isolation and sequencing (Sanger & Coulson, Maxam & Gilbert).

Module II: Techniques in Recombinant DNA Technology 15

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

Module III: Gene Transfer Methods in Plants, Biosafety and Applications Of Genetic Engineering 15

Applications in Agriculture: Transgenic crops with improved quality traits: FLAVR SAVR Tomato, Golden rice, Bt cotton, herbicide resistant plants, roundup soyabean/ corn. Applications in Environment: Role of transgenics in bioremediation (Superbug) Mycoremediation, Phytoremediation, and Waste management (UASB reactor), Remediation of Xenobiotic compounds. Molecular techniques in Phytoremediation. Applications in Industries: Edible vaccines; Industrial enzymes (Protease, Lipase); Genetically Engineered Products – Human Growth Hormone; Humulin; Superweeds. Bioethics and Biosafety: Intellectual Property Rights, Genetic engineering and public issues. Biosafety regulations

Total 45

Course Title **: PLANT GENETIC ENGINEERING (PRACTICAL)**
Course Code **: UG BOT- 304**
Marks **: 75**
Credits **: 3**
Hours **: 45**

Sr. No	Module IV: List of experiments	Practical Sessions
1	DNA isolation by CTAB/(any other) method	**2**
2	Estimation of DNA	**1**
3	Agarose Gel Electrophoresis	**2**
4	Restriction digestion of DNA (Problem based)	**2**
5	Sequence reading – Sanger method/Maxam Gilbert method – problem	**2**
6	*Agrobacterium tumefaciens*-mediated plant transformation. (Virtual Library)	**2**
7	Demonstration of Plasmid isolation	**1**
8	Demonstration Restriction digestion of DNA	**1**
9	Visit to a leading biotechnology institute and Report making.	**2**
	Total	**15**

Mandatory References:

1. Brown, T. A. (2006). *Gene cloning and DNA analysis An Introduction*. UK: Blackwell scientific publishers.
2. Chawla, H. S. (2000). *Introduction to Plant Biotechnology*. New Delhi: CRC Press.
3. Dubey, R. C. (2014). *Introduction to Plant Biotechnology*. New Delhi: S. Chand & Co.
4. Purohit, S. S. (2003). *Agricultural Biotechnology*. New Delhi: Agrobios.
5. Sobti, R. C. & Pachauri, S. S. (2009). *Essentials of Biotechnology*. New Delhi: AneBooks.
6. Gupta, P. K. (1996). *Elements of Biotechnology*. Meerut: Rastogi Publications.
7. Lewin, B. (2004*). Genes VIII*. UK: Oxford University Press.

Suggested reading

1. Primrose, S. B, Twyman, R. M. & Old R. W. (2001). *Principles of gene manipulation: An Introduction to genetic engineering,* 6 ed. UK: Blackwellscientific publishers.
2. Smith, J.E. (2005). *Biotechnology.* UK: Cambridge University press.
3. Wilson, K. & Walker, J. (2008). *Principles and Techniques of Biochemistry and*

Molecular Biology. UK: Cambridge University Press.

4. Stekel, D. (2003). *Microarray bioinformatics*. Cambridge University Press.

5. Ignacimuthu, S. (1997). *Plant Biotechnology*. New Hampshire: Science Publishers.

Web references:

1. Thomson, J. (2011). Genetic Engineering Of Plants.

https://www.semanticscholar.org/paper/GENETIC-ENGINEERING-OF-PLANTS-

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2. https://ndl.iitkgp.ac.in/

3. Hsu, P. D., Lander, E. S., & Zhang, F. (2014). Development and applications of CRISPR-

Cas9for genome engineering. Cell, 157(6), 1262-1278.

4. Ran, F. A., Hsu, P. D., Wright, J., Agarwala, V., Scott, D. A., & Zhang, F. (2013).

Genome engineering using the CRISPR-Cas9 system. Nature protocols, 8(11), 2281- 2308.

5. Mathur, R. (2018). Genetic engineering and biosafety in the use of genetically modified foods. IJASRM, 2018(I), 76-82.

6. Cahoon, E. B. (2003). Genetic enhancement of soybean oil for industrial uses: prospects and challenges. AgBioForum, 6(1&2): 11-13.

Course Title **: PLANT MOLECULAR BIOLOGY (CORE: THEORY)**
Course **: UG BOT-305**
Marks **: 75**
Credits **: 3**
Hours **: 45**

Course Objective:

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

Course Learning Outcomes

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

CLO1: Describe and summarize the characteristics of genetic material and process of DNA replication

CLO2: Appraise the molecular mechanism of transcription and DNA damage.

CLO3: Elaborate the molecular mechanism of translation and gene regulation.

CLO4: Determine and interpret basic molecular techniques of nucleic acid isolation and screening.

Hours

Module-I: Nature of Genetic Material and DNA Replication **15**

Characteristics of genetic material, evidences to prove DNA & RNA as genetic material, Watson and Crick's model of DNA; Polymorphism of DNA. Central dogma of molecular biology, Model organism for studying molecular biology; C-value paradox; Chargaff's Law, Franklin's and Wilkin's work. General feature of DNA replication (replication eye, replication forks); Types of DNA replication, mechanism of DNA replication in Prokaryotes & in Eukaryotes (Dispersive, Conservative and Semi- conservative); enzymes of replication –DNA Primase; DNA polymerases. DNA Recombination: Holliday model.

Module II: DNA Damages and Transcription **15**

Types of DNA damages and repair (direct reversal of damage, excision repair). Structure and functions of mRNA, tRNA and rRNA, RNA polymerases. Transcription in prokaryotes & eukaryotes. Post transcriptional events (splicing, capping & processing).

Module III: Gene Regulation, Expression & Translation **15**

Units of gene (Cistron, recon, muton, enhancers, split genes, overlapping genes; transposons and its role in gene structure, promoters & terminators. Gene regulation in prokaryotes (Lac operon concept/tryptophan) & eukaryotes; Inducible and repressible mechanism. Mechanism & factors involved in the process of Translation. Post translational modifications; Protein targeting

Total 45

Course Title **: PLANT MOLECULAR BIOLOGY (PRACTICALS)**

Course Code **: UG BOT-305**

Marks **: 25**
Credit **: 1**
Hours **:30**

Sr. No	Module IV: List of Experiments	Practical Sessions
1	Isolation of plant genomic and purity estimation of DNA	3
2	Quantification of DNA by DPA method.	2
3	Isolation and estimation plant RNA from tissue.	2
4	Designing of primers for DNA amplification	1
5	Preparation of Agarose gel and running of DNA and RNA	3
6	Demonstration of DNA amplification by PCR	2
7	Mini Project 1. Spooling of DNA from different plant samples	2
	Total	**15**

Mandatory References:

1. Gupta P.K. (2018) *Molecular Biology*. Rastogi Publications.

2. Alberts, B. (2002). Molecular biology of the cell 4th edition.

3. Buchanan, B. B., Gruissem, W., & Jones, R. L. (Eds.). (2015). *Biochemistry and molecular biology of plants*. John wiley & sons.

4. Pal, J.K. & Ghaskadabi S.S. (2008) *Fundamentals of Molecular Biology*. Oxford.

5. Watson, J. D. (2008). *Molecular Biology of the Gene* (6th Edition)

6. Kleinsmith, L. J., & Kish, V. M. (1995). *Principles of cell and molecular biology* (Vol. 2). New York: HarperCollins.

Suggested reading

1. Nelson, D. L., Lehninger, A. L., & Cox, M. M. (2008). *Lehninger principles of biochemistry*. Macmillan.

2. Dubey, R. C. (1993). *A textbook of Biotechnology*. S. Chand Publishing.

3. Lewin B. (2000). *Genes VII*. New York: Oxford University Press.

4. Buchanan, B. B., Gruissem, W., & Jones, R. L. (Eds.). (2015). *Biochemistry and molecular biology of plants*. John wiley & sons.

5. Johnson, C. (2009). *Plant molecular biology*. Oxford Book company.

6. David, F. (1983). Jones & Bartlett publishers. *Molecular biology*. 2nd Ed. Reprint 1993. Narosa Publishing House.

Web References:

1. https://www.schoolfinder.com
2. http://www.plantcell.org › content › teaching-tools-plant
3. htps://www.cell.com › molecular-plant
4. https://www.freebookcentre.net › The-Molecular-Biolo…
5. https://nptel.ac.in/courses/102106025

Course Title **: PLANT TISSUE CULTURE (CORE:THEORY)**
Course Code**: UG BOT-306**
Marks **: 75**
Credits **: 3**
Hours **: 45**

Course Objectives: To develop the plant tissue culture skills.
Course Learning Outcome: Upon successful completion, the students will be able to:
CLO 1: Explain and discuss the general theoretical concept and plant tissue culture techniques.
CLO 2: Explain and compare, culture types and techniques.
CLO 3: Discuss applications in horticulture, forestry, agriculture.
CLO 4: Demonstrate techniques in plant tissue culture.

Hours

Module-I: Introduction and Differentiation **15**

Scope and history of plant tissue culture, Laboratory organization. Culture techniques – Sterilization methods of glassware, explant preparation, sterilization, media composition and preparation. Cellular differentiation and totipotency; effect of growth regulators on differentiation.

Module II: Culture Types and Techniques in Tissue **15**

Cell culture types- callus, single cell and suspension culture Organogenesis and embryogenesis; Somaclonal variation; meristem. Micropropagation, Germplasm conservation; Isolation and regeneration of protoplasm; Somatic hybridization, cybrids, Synthetic seeds, Cryopreservation, secondary metabolite production.

Module III: Application of Plant Tissue Culture **15**

Horticulture: Plant propagation, micropropagation, Single cell culture, suspension culture and meristem culture. Agriculture: Single cell culture, suspension culture and meristem culture. Hairy root culture, germplasm conservation methods (*in-situ* and *ex-situ*). Forestry: Single cell culture, suspension culture and meristem culture, production of haploids. Applications of PTC in genetic engineering

Total **45**

Course Title**: PLANT TISSUE CULTURE (PRACTICAL)**
Course Code **: UG BOT-306**
Marks **: 25**
Credits **: 1**
Hours **: 30**

Sr. No	Module IV: List of Experiments	Practical Sessions
1	Preparation of MS Medium; Sterilization techniques	**3**
2	Embryo culture of maize	**2**
3	Callus induction and its morphological studies.	**3**

4	Sub-culturing callus for rooting and shooting	**3**
5	Enzymatic Isolation of plant protoplast	**1**
6	Synthetic seed preparation	**1**
7	Visit to Plant tissue culture unit	**2**
	Total	**15**

Mandatory References:

1. Satyanarayana, U. (2013). Biotechnology. New Delhi: Books and allied (P) Ltd.
2. Smith, R. H. (2013). *Plant tissue culture: Techniques and experiments* (3rd ed.). Academic Press.
3. Razdan, M. K. (2002). Introduction to Plant Tissue Culture. New Delhi: Oxford &IBH Publishing Co. Pvt. Ltd.
4. Kumar, U. (1999). Methods in Plant Tissue Culture. Jodhpur: Agrobios.
5. Bhojwani, S. S., & Razdan, M. K. (1996). *Plant tissue culture: Theory and practice* (Revised ed.). Elsevier.

Suggested References:

1. Vasil, I. K. & Thorpe, T.A. (1994). Plant Cell and Tissue Culture. Netherlands: Kluwer Academic Publishers.
2. Trigiano, R. N., & Gray, D. J. (Eds.). (2016). *Plant tissue culture, development, and biotechnology* (2nd ed.). CRC Press.
3. George, E. F., Hall, M. A., & De Klerk, G.-J. (2008). *Plant propagation by tissue culture* (3rd ed.). Springer.
4. Thorpe, T. A. (Ed.). (2007). *Development in plant tissue culture* (Vol. 5). Springer.
5. Dodds, J. H., & Roberts, L. W. (1985). *Experiments in plant tissue culture* (2nd ed.). Cambridge University Press.
6. Gamborg, O. L., & Phillips, G. C. (Eds.). (1995). *Plant cell, tissue and organ culture: Fundamental methods*. Springer.
7. Thorpe, T. A., & Yeung, E. C. (2011). *Plant tissue culture: Techniques and experiments* (3rd ed.). Springer.
8. Namasivayam, P. (2007). *Plant cell and tissue culture*. Tata McGraw-Hill Education.
9. Gahan, P. B., & George, E. F. (2008). *Plant tissue culture: An introductory text*. Springer.

Web References

1. https://www.isaaa.org/resources/publications/pocketk/14/default.asp.
2. https://www.sciencedirect.com/journal/journal-of-biotechnology/vol/26/issue/1

Course Title	**: PLANT PATHOLOGY (VOCATIONAL: THEORY)**
Course Code	**: UG-BOT-VOC-3**
Marks	**: 75**
Credits	**: 3**
Hours	**: 45**

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

COURSE OUTCOME:
Upon successful completion of the course, students will be able to:
CLO1: Identify various diseases and its causal agents of economically important plants.
CLO2: Explain plant pathogen interaction.
CLO3: Analyze control measures to deal with pathogens.
CLO4: Isolate, observe and culture plant disease causing pathogens.

MODULE I: AN INTRODUCTION AND EPIDEMOLOGY OF PLANTS DISEASE (15 Hours)
History, Definitions and Importance of plant pathology. Concepts and types of diseases in plants. Infectious agents (nematodes, protozoans, bacteria, fungi & viruses). Growth, reproduction, survival, multiplication and dispersal of important plant pathogens (*Puccinia*). Disease triangle.

MODULE II: PLANT DISEASE DEVELOPMENT (PATHOGENESIS) AND MANAGEMENT (15 Hours)

Parasitism and pathogenicity. Symptomatology. Host parasite interaction (recognition and infection). Role of enzymes, toxins & growth regulators in pathogenesis. Quantitative resistance (Physical, Biological & cultural methods). Biochemical defense mechanism (oxidative burst; Phenolics, Phytoalexins, PR proteins, antimicrobial substances and plantibodies). Quarantine measures.

MODULE III: GENETICS OF PLANT DISEASE AND STUDY OF PLANT DISEASES IN INDIA (15 Hours)
Altered plant metabolism due to pathogens attack. Genetics of resistance ('R' & avr genes, elicitors responses). Signaling and programmed cell death. Study of Diseases (Name of disease, pathogen, symptoms and control measures need to be studied). Important diseases (Any 2 of each) of Paddy, Arecanut, Wheat, Banana, Coconut, Sugarcane, Mango, Amaranth and Radish.

COURSE TITLE: **PLANT PATHOLOGY (PRACTICAL)**
COURSE CODE : **UG-BOT-VOC 3**
CREDITS : **01**
MARKS : **25**
DURATION : **30 hours**

SR. NO	**MODULE IV - TOPICS**	**PRACTICAL SESSIONS**
1	Isolation and culture of fungal and bacterial pathogens.	02
2.	Demonstration of Koch's postulates	01
3.	Assay for cellulase /pectinase enzyme from diseased plant	02
4.	Study of plant diseases with reference to pathogen & symptomology (Viral, Bacterial & Fungal) (any 10 as per theory)	05
5	Anatomical observations of fungal infected plants (rust, blight, rots)	03
6	Study of antagonistic behavior of bacterial pathogens	01
7.	Mini project: Collection and identification of plant diseases (Any five)	01
	Total	**15**

Mandatory References

1. Singh, R. S. (2019). Introduction to Principles of Plant Pathology. USA: Medtech.
2. Sharma, P.D. (2018). Plant Pathology. New Delhi: Rastogi Publishers.
3. Mehrotra, R.S. & Agarwal, A. (2017). *Plant Pathology*: Bangalore: MaGraw Hill Education.
4. Ownley, B. H. & Trigiano, R. N. (2017). Plant Pathology, Concepts and Laboratory Exercises. Florida: CRC Press.
5. Aneja, K.R. (2009). *Experiments in Microbiology Plant Pathology & Biotechnology*. 4th ed. NewDelhi: New Age International (P) Limited.

Supplementary Reading

6. Agrios, G.N. (2005). *Plant Pathology* (5th ed.). London: Academic Press.
7. Bilgrami, K.H. & Dube, H.C. (1976). *A textbook of Modern Plant Pathology*. Lucknow: International Book Distributing Co.
8. Mehrotra, R.S. (1980). *Plant Pathology*. New Delhi: TMH
9. Pandey, B.P. (1999). *Plant Pathology, Pathogen and Plant diseases*. New Delhi: S. Chand & Co.
10. Rangaswami, G. (1999). *Disease of Crop plants of India*. New Delhi: Prentice Hall of India Pvt. Ltd.
11. Gunasekaran, P. (2005). *Laboratory manual in Microbiology*. New Delhi: New Age International (P) Limited.

WEBLINKS:

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