MANIPUR UNIVERSITY

CANCHIPUR – 795003, MANIPUR

SYLLABUS FOR FOUR YEAR UNDERGRADUATE COURSE IN BOTANY – 2025

NATIONAL EDUCATION POLICY - 2020

Manipur University

Syllabus for Four Year Undergraduate Programme in Botany

2025

The Preamble

Plant Science is an integrated discipline that combines traditional areas of study with modern scientific approaches in biochemistry, molecular biology, biotechnology, and ecology. Over the last few decades, research in plant sciences has generated enormous advances in understanding plant diversity, physiology, reproduction, and adaptation. These developments have also led to significant applications in agriculture, conservation, environmental management, and biotechnology. There is growing global alarm over the rapid loss of biodiversity, widespread habitat degradation, escalating pollution, and the intensifying effects of climate change. Plants, being at the core of ecosystems and food security, are central to addressing these challenges. Field plant biologists and conservationists play a crucial role in documenting plant diversity, understanding ecological processes, and developing strategies for sustainable resource management. At the same time, advancements in molecular techniques and computational tools have created unprecedented opportunities to investigate plant functions at genetic, biochemical, and cellular levels.

North East India, including the state of Manipur, is recognized as one of the world's biodiversity hotspots. The region harbors unique ecosystems, a wide variety of plant species, and rich indigenous knowledge systems. This diversity provides excellent opportunities for botanical research, sustainable bio-prospecting, and community-based conservation. Harnessing these resources requires a strong foundation in both classical and contemporary plant sciences. In this context, the Four-Year Undergraduate Programme (FYUGP) in Botany at Manipur University, designed in alignment with the National Education Policy-2020 (NEP-2020), National Higher Education Qualification Framework (NHEQF) and National Credit Framework (NCrF), seeks to provide students with a balanced and comprehensive understanding of plant sciences. The curriculum integrates core areas of plant diversity, taxonomy, anatomy, physiology, biochemistry, molecular biology, ecology, economic botany, and reproduction. Equal emphasis is given to the study of environmental change and its impact on plants.

The programme also focuses on the application of knowledge to address real-world challenges. Students will acquire practical skills through hands-on laboratory training, field explorations, research projects, and community engagement. Skill-oriented and entrepreneurship-driven courses have been included to prepare graduates for professional opportunities in plant-based industries, environmental sectors, and allied fields. By blending theoretical knowledge with experiential learning, the programme equips

students to critically analyze contemporary issues, contribute to biodiversity conservation, and support sustainable development. Graduates will be empowered to pursue higher studies, research, or entrepreneurship and to contribute meaningfully to society.

Graduate Attributes

Graduate Attributes represent the core competencies, skills, and values that students of the Botany programme at Manipur University are expected to develop by the time they complete the Four-Year Undergraduate Programme (FYUGP). These attributes bridge academic learning with real-world application and ensure that graduates emerge as knowledgeable, skilled, and responsible individuals capable of addressing local, regional, and global challenges through higher studies, professional careers, entrepreneurship, and meaningful contributions to society.

Graduates of the Four-Year Undergraduate Programme in Botany will possess a deep and coherent understanding of plant sciences and allied disciplines, integrating theoretical concepts with practical skills to address biodiversity conservation, environmental sustainability, and societal development. They will be able to think critically and analytically, systematically examining complex issues, evaluating evidence from multiple perspectives, and applying innovative and context-sensitive approaches to solve problems in scientific, professional, and community settings. Graduates will demonstrate the ability to communicate effectively through oral, written, and digital media, conveying complex botanical and environmental concepts clearly to diverse audiences, including peers, professionals, policymakers, and communities. They will be capable of working productively in collaborative and interdisciplinary teams, showing interpersonal competence, adaptability, leadership potential, and cultural sensitivity in diverse contexts. They will be proficient in the ethical use of digital tools, information resources, and contemporary research methodologies to collect, analyze, and interpret data, thereby supporting scientific inquiry, conservation, and informed decision-making. Graduates will uphold the highest standards of moral and professional integrity, demonstrate responsibility towards environmental stewardship and community well-being, and commit themselves to lifelong learning by continuously updating their knowledge, skills, and values in response to evolving scientific, technological, and societal challenges.

Qualification Descriptors

By the completion of the Four-Year Undergraduate Programme (FYUGP), graduates will:

- Achieve Level 6.0 learning outcomes as defined by the National Higher Education Qualifications Framework (NHEQF) and meet the National Credit Framework (NCrF) requirement of earning a

minimum of 180 credits for the Four-Year Undergraduate Honours/Honours with Research degree.

- Demonstrate a coherent and in-depth understanding of plant sciences in a multidisciplinary framework, with comprehensive and systematic knowledge of core and applied areas.
- Apply specialized knowledge and practical skills to pursue higher studies, research, entrepreneurship, and professional practice in universities, colleges, research institutions, government and public services, plant research centres, farm consultancy, and other allied sectors.
- Critically evaluate and address complex issues by using disciplinary knowledge and transferable skills to analyze a wide range of ideas and real-life problems in botany and related fields.
- Contribute ethically and responsibly to biodiversity conservation, environmental sustainability, and socio-economic development while upholding professional integrity.
- Engage in lifelong learning and adapt to emerging scientific, technological, and societal challenges to ensure continued personal and professional growth..

Programme Outcomes

Programme Outcomes (POs) define the broad set of abilities and competencies that every graduate of the FYUGP is expected to achieve. They serve as common goals across disciplines, ensuring that students can apply their knowledge, skills, and values effectively in professional, academic, and societal contexts.

PO Code	PO Name	Programme Outcome Statement
PO1	Disciplinary Knowledge and Application	Integrate and apply advanced disciplinary knowledge of plant sciences and allied fields to analyze and address professional, societal, and environmental challenges independently and effectively.
PO2	Communication	Prepare, present, and defend complex ideas, research findings, and technical information clearly in oral, written, and digital formats to diverse audiences.
PO3	Critical Thinking and Analytical Reasoning	Evaluate, interpret, and synthesize information from multiple sources to draw conclusions and solve complex problems using logical, evidence-based reasoning.
PO4	Problem-Solving	Design, implement, and assess innovative solutions for real-world challenges by applying interdisciplinary knowledge and advanced analytical approaches.
PO5	Research and Inquiry	Formulate research questions, design methodologies, conduct investigations, analyze data, and generate new knowledge through

PO Code	PO Name	Programme Outcome Statement
		independent and collaborative research.
PO6	Digital and Information Literacy	Select, use, and evaluate advanced digital tools, information systems, and emerging technologies proficiently and ethically in learning, research, and professional practice.
PO7	Teamwork and Leadership	Collaborate effectively, coordinate tasks, and lead projects in multidisciplinary teams by demonstrating interpersonal competence, accountability, and strategic decision-making.
PO8	Moral, Ethical,and Environmental Responsibility	Apply ethical frameworks, evaluate impacts, and implement actions that support biodiversity conservation, environmental sustainability, and social equity at local, national, and global levels.
PO9	Lifelong Learning	Identify and undertake self-directed learning and professional development activities, and demonstrate adaptability to evolving scientific, technological, and societal contexts.

Programme Specific Outcome for FYUGP (Botany)

Programme Specific Outcomes reflect both subject-specific expertise and broad, transferable skills and competencies. Students completing a programme of study are expected to demonstrate the knowledge and abilities gained during the course and apply them effectively, fulfilling the requirements for the award of the degree. Graduates of the FYUGP in Botany programme will be able to acquire and apply

PSO No.	Programme Specific Outcome Statement
PSO 1	Classify plant groups from lower to higher taxa based on diversity, structure, reproduction, genetics, evolution, ecology, and economic importance, and demonstrate the ability to identify representative species accurately.
PSO 2	Explain concepts of Morphology, Taxonomy, Anatomy, Physiology, Biochemistry, Molecular Biology, and Ecology, and analyze advanced topics such as Plant Biotechnology, Developmental Botany, and Plant–Pathogen Interactions.
PSO 3	Design and conduct laboratory and field investigations, collect and analyze data using appropriate tools, and interpret results with evidence-based reasoning.
PSO 4	Apply botanical knowledge and allied sciences to develop strategies and evaluate innovative solutions for agricultural, environmental, and societal challenges.
PSO 5	Utilize digital tools, bioinformatics software, biostatistics, and modern laboratory and field technologies to analyze and communicate biological data effectively.

PSO No.	Programme Specific Outcome Statement
PSO 6	Plan and execute entrepreneurial or industry-oriented activities in applied branches such as Organic Farming, Mushroom Cultivation, Landscaping, Floriculture, Herbal Technology, Ecotourism, and Biofertilizer production.
PSO 7	Demonstrate self-directed learning skills by setting goals, selecting resources, and evaluating progress for higher education, competitive examinations, and professional development.
PSO 8	Practice professional ethics and integrity, and adhere to responsible conduct in research, education, and professional activities.
PSO 9	Document, conserve, and implement sustainable practices for the utilization of plant resources, and evaluate biodiversity and climate change issues using scientific and traditional knowledge.
PSO 10	Collaborate effectively in multidisciplinary teams, lead when required, and present ideas and findings clearly through oral, written, and digital communication.
PSO 11	Engage in outreach programmes, extension activities, and community-based projects by applying botanical knowledge to solve local and regional challenges.

PO-PSO mapping matrix

PSO No.	PO1	PO2	PO 3	PO4	PO5	PO6	PO 7	PO8	PO9
PSO 1	3	–	2	–	–	–	–	2	–
PSO 2	3	–	2	–	2	–	–	–	–
PSO 3	2	–	3	2	3	2	–	–	–
PSO 4	2	–	3	3	2	–	–	2	–
PSO 5	2	2	2	–	3	3	–	–	–
PSO 6	2	–	–	2	–	2	2	–	2
PSO 7	–	–	2	–	–	2	–	–	3
PSO 8	–	–	–	–	–	–	–	3	2
PSO 9	2	–	–	–	–	–	–	3	2
PSO 10	–	3	–	–	–	2	3	–	–
PSO 11	2	–	–	2	–	–	2	2	–

Each PSO is mapped to one or more relevant POs with ratings of High (3), Moderate (2), or Low (1) relevance. In this programme, the generic Programme Outcomes (POs) are achieved through the discipline-specific Programme Specific Outcomes (PSOs) in Botany.

Curriculum Structure

Year I (Course Level 100)

Semester I (Academic Level 4.5)

Major Course (MJC)		
Course Code	**Title of the Course**	**Credit**
MJC45BOT101(T)25 MJC45BOT101(P)25	Introductory Botany (Theory) Introductory Botany (Practical)	3 1
Minor Course (MNC) to be selected one course from other programmes		
		4/3+1
Multidisciplinary Course (MDC) to be selected one course from other disciplines or from open sources MOOCS/SWAYAM*		
		3/2+1
Ability Enhancement Course (AEC)		
	Major Indian Language (Language and Communication Skills)/ English (Language and Communication Skills)	4
Skills Enhancement Course (SEC) to be selected one course **		
SEC45BOT101a(T)25 SEC45BOT101a(P)25		2 1
SEC45BOT101b(T)25 SEC45BOT101b(P)25		2 1
Value-Added Course (VAC) to be selected one course from central pool		
		2
Total Credit 20		

*Courses already studied at the 12th-grade (higher secondary school) level in the intended major or minor cannot be selected.

**SEC should be major oriented.

Minor Course (MNC) offer to candidates of other interdisciplinary subjects

Course Code	**Title of the Course**	**Credit**

MNC45BOT101(T)25	Introductory Botany (Theory)	3
MNC45BOT101(P)25	Introductory Botany (Practical)	1

Course Contents

Major Course - Introductory Botany (Theory)

Nature of Course	Major				
Course Code	MJC45BOT101(T)25				
Course Title	Introductory Botany				
Course Level	Level 100				
Credit Details	Total Credit	Lecture/ Week	Tutorial/ Week	Practical/ Week	Total Hours/ Week
	3	3			3
Course Audience	Major Students enrolled in the FYUGP in Botany				
Proposed by (for Non Core courses)					
Pre Requisites (if any)	Basic understanding of plant biology at the higher secondary level or equivalent.				
Skill Training Required (if any)	1. 2.				
Pre-Requisite Course Required (if any)	Successful completion of Biology at the higher secondary level or equivalent examination.				
Faculty Eligibility and Specialization (if any)	Master's Degree in Botany or Life Sciences with a specialisation in Botany; candidates with Ph.D. and/or NET qualifications will be preferred.				

Course Objective

To provide foundational knowledge of cell biology and plant diversity, covering algae, bryophytes, pteridophytes, gymnosperms, and angiosperms, along with an introduction to microorganisms and fungi relevant to plant sciences. The course also aims to develop basic skills in identification, classification, and interpretation of diagnostic characters and life-cycle features using standard botanical terminology and illustrations.

Course Learning Outcomes

By the end of the course, students will be able to:

1. Distinguish prokaryotic and eukaryotic cells based on structural organization and complexity and describe the structure and functions of the nucleus and major cell organelles.

2. Describe the stages of the cell cycle and the sequential events of mitosis and meiosis, and explain their regulation in relation to growth and reproduction.
3. Classify major groups of microorganisms based on diagnostic features and explain their structure and reproduction.
4. Classify fungi based on their diagnostic features and describe their characteristic features, thallus organization, reproductive structures and life cycles.
5. Identify the diagnostic features, thallus organization, and reproductive strategies of cryptogams (algae, bryophytes, pteridophytes) and describe their evolutionary significance.
6. Describe the diagnostic features and reproductive mechanisms of phanerogams (gymnosperms and angiosperms).
7. Provide a general introduction to Paleobotany, describe types of plant fossils, representative fossil taxa, and explain their significance in understanding plant evolution and ancient environments.
8. Illustrate the life cycles of representative genera (e.g., *Rhizopus*, *Nostoc*, *Marchantia*, *Selaginella*, *Cycas*, *Pinus*) using appropriate diagrams and annotations.
9. Identify and describe the morphological features and modifications of roots, stems, leaves, inflorescences, fruits, and seeds,
10. Explain the phyllode theory, specialized leaf modifications, and the concept of the primitive flower with reference to stamen and carpel morphology and polymorphism.
11. Classify inflorescence types, placentation types, fruit types, and seed morphology based on diagnostic features, and discuss the foliar and axial theories of the ovary.

Detailed Syllabus Content

Unit 1: Cell Biology

Prokaryotic Cells: General characteristics, structure, nutrition and reproduction; Eukaryotic cells:Structure and functions, nucleus, cell organelles; Cell cycle and its regulation

Unit 2: Introduction to Microbiology

Basic concepts in microbiology, importance in plant sciences

Introduction to viruses: structural organization, classification and importance

Bacteria: structure and reproduction;

Type species:*Bacillus subtilis*, *Escherichia coli* and *Streptococcus aureus*

Introduction to Fungi: Characteristic features and reproduction (asexual and sexual); Life cycles of representative species (*Phytophthora, Rhizopus, Saccharomyces, Agaricus*)

Lichens: Characteristics and types

Unit 3: Algae and Bryophytes

Algae: Characteristic features, range of thallus organization;Life cycles of representative species:*Nostoc* (Cyanophyta), *Volvox* (Chlorophyta), *Chara* (Charophyta), *Vaucheria* (Xanthophyta), *Ectocarpus* (Phaeophyta), *Polysiphonia* (Rhodophyta)

Bryophytes: Characteristic features, thallus structure; Life cycles: *Marchantia* (Liverworts), *Anthoceros* (Hornworts), *Funaria* (Mosses)

Unit 4: Pteridophytes, Gymnosperms* and*Palaeobotany

Pteridophytes: Characteristic features, tissue organization; Life cycles: *Rhynia*, *Lycopodium*, *Selaginella*

Gymnosperms: Characteristic features and life cycles: *Cycas*, *Pinus*

Introduction to Paleobotany; types of fossils; significance

Unit 5: Morphology of Angiosperms

Root: types, structures and modifications, special and complex root forms

Stem and leaves: morphology (terminologies and forms), phyllode theory, specialized leaves and modifications.

Inflorescence and fruits: concept of primitive flower, stamen and carpel, polymorphism, foliar and axial concept of ovary

Placentation types, fruit types, and seed morphology

Suggested Readings

1. Alexopoulos, C. J., Mims, C. W., & Blackwell, M. (1996). *Introductory Mycology* (4th ed.). John Wiley & Sons (Asia).
2. Bhatnagar, S. P., & Moitra, A. (1996). *Gymnosperms*. New Age International Publishers.
3. Kaur, I., & Uniyal, P. L. (2019). *Text Book of Gymnosperms*. Daya Publishing House.
4. Kaur, I., & Uniyal, P. L. (2020). *Text Book of Bryophytes*. Daya Publishing House.
5. Kumar, H. D. (1999). *Introductory Phycology* (2nd ed.). Affiliated East-West Press.
6. Lee, R. E. (2008). *Phycology* (4th ed.). Cambridge University Press.
7. Pandey, S. N., Misra, S. P., & Trivedi, P. S. (1983). *A Textbook of Botany: Vol. 2. Bryophyta, Pteridophyta, Gymnosperms and Palaeobotany*. Vikas Publishing House Pvt. Ltd.
8. Parihar, N. S. (1972). *An Introduction to Embryophyta: Vol. II. Pteridophyta*. Central Book Depot.

9. Parihar, N. S. (1991). *An Introduction to Embryophyta: Vol. I. Bryophyta*. Central Book Depot.
10. Pelczar, M. J. (2001). *Microbiology* (5th ed.). Tata McGraw-Hill.
11. Sarbhoy, A. K. (2006). *Text Book of Mycology*. ICAR Publications.
12. Sethi, I. K., & Walia, S. K. (2011). *Text Book of Fungi and Their Allies*. Macmillan Pub. India Ltd.
13. Sharma, T. A., Dubey, R. C., & Maheshwari, D. K. (1999). *A Text Book of Microbiology*. S Chand and Co.
14. Stewart, W.N. and Rothwell, G.W. (1993). *Paleobotany and the Evolution of Plants*. 2nd Edition. Cambridge University Press.
15. Vashistha, P. C., Sinha, A. K., & Kumar, A. (2010). *Pteridophyta*. S. Chand.
16. Webster, J., & Weber, R. (2007). *Introduction to Fungi* (3rd ed.). Cambridge University Press.
17. Wiley, J. M., Sherwood, L. M., & Woolverton, C. J. (2013). *Prescott's Microbiology* (9th ed.). McGraw Hill International.

Additional Readings

1. Bidlack, J. E., Stern, K. R., & Jansky, S. H. (2021). *Stern's Introductory Plant Biology* (16th ed.). McGraw-Hill.
2. Carlile, M. J., Watkinson, S. C., & Gooday, G. W. (2001). *The Fungi* (2nd ed.). Academic Press.
3. Esau, K. (1977). *Anatomy of Seed Plants* (2nd ed.). John Wiley & Sons.
4. Fahn, A. (1990). *Plant Anatomy* (4th ed.). Pergamon Press.
5. Madigan, M. T., Bender, K. S., Buckley, D. H., Sattley, W. M., & Stahl, D. A. (2022). *Brock Biology of Microorganisms* (16th ed.). Pearson.
6. Mauseth, J. D. (2017). *Botany: An Introduction to Plant Biology* (6th ed.). Jones & Bartlett Learning.
7. Raven, P. H., Evert, R. F., & Eichhorn, S. E. (2023). *Biology of Plants* (9th ed.). W. H. Freeman and Company.
8. Taylor, T. N., Taylor, E. L., & Krings, M. (2009). *Paleobotany: The Biology and Evolution of Fossil Plants* (2nd ed.). Academic Press.

CO–PSO Mapping Matrix

COs	**PSO 1**	**PSO2**	**PSO3**	**PSO 4**	**PSO5**	**PSO6**	**PSO 7**	**PSO8**	**PSO9**	**PSO1 0**	**PSO11**
CO1	1	3	1		2			1			
CO2		3	1		1						
CO3	3	2		2		1			1		1

CO4	3	2		1		2					
CO5	3	2		1					2		
CO6	3	2							2		
CO7	2	2		1					3		
CO8	2	2	1		2		1			2	
CO9	2	2		2		1			1	1	1
CO10	2	3								1	
CO11	3	2								1	

Legend

- 3 = Strongly maps
- 2 = Moderately maps
- 1 = Weakly maps
- Blank = No mapping

Assessment Methods

- Oral and written examinations
- Closed-book and open-book tests,
- Problem-solving exercises,
- Individual and group project reports,
- Seminar and presentations,
- Interactive sessions.

Major Course - Introductory Botany (Practical)

Nature of Course	Major				
Course Code	MJC45BOT101(P)25				
Course Title	Introductory Botany (Practical)				
Course Level	Level 100				
Credit Details	Total Credit	Lecture/ Week	Tutorial/ Week	Practical/Week	Total Hours/ Week
	1			1	2
Course Audience	Major Students enrolled in the FYUGP in Botany				
Associated Theory Courses (Topics)					
Skill Training	Basic understanding of plant biology at the higher secondary level or				

Required (if any)	equivalent.
Pre-Requisite Course Required (if any)	1. 2.
Faculty Eligibility and Specialization (if any)	Successful completion of Biology at the higher secondary level or equivalent examination.

Course Description

This practical course provides hands-on training in cell biology and the study of plant diversity. Students will learn basic microscopic techniques, preparation of temporary mounts, and the observation of cell structures and organelles. Through laboratory work and specimen study, students will acquire skills to identify diagnostic vegetative and reproductive characters of algae, bryophytes, pteridophytes, gymnosperms, and angiosperms. The course also emphasizes the use of botanical terminology, accurate illustration of diagnostic features, and preparation of practical records.

Course Learning Outcomes

By the end of this practical course, students will be able to:

1. Prepare temporary mounts and use microscopes to observe and interpret cell structure and organelles.
2. Identify diagnostic vegetative and reproductive features of algae, bryophytes, and pteridophytes through laboratory and field specimens.
3. Identify diagnostic vegetative and reproductive features of gymnosperms through laboratory and field specimens.
4. Identify diagnostic vegetative and reproductive features of angiosperms, including floral characters, specialized roots, leaves, inflorescences, fruits, and seeds.
5. Illustrate and label diagnostic characters and life-cycle stages of representative genera using standard botanical diagrams.
6. Apply botanical terminology accurately while describing plant specimens and preparing practical records.

Detailed Syllabus Content

Sl. No.	Practical Exercise	No. of Sessions
1	Study of plant cell structure with epidermal peel mounts (Onion, *Rhoeo*, *Crinum*)	1
2	Observation of cell organelles using electron micrographs	1
3	Microbiology – Gram staining of bacteria and observation under microscope	1
4	Study of vegetative and reproductive structures of *Rhizopus*, *Saccharomyces*, *Agaricus* and *Penicillium*	1
5	Study of thallus structure of crustose, foliose and fructicose lichens	1
6	Study of vegetative and reproductive structures of *Nostoc* (Cyanophyta),*Volvox* (Chlorophyta) and *Chara* (Charophyta)	1
7	Study of *Vaucheria* (Xanthophyta),*Ectocarpus* (Phaeophyta) and *Polysiphonia* (Rhodophyta)	1
8	Study of vegetative and reproductive structures of *Marchantia* (Liverworts) and *Anthoceros* (Hornworts)	1
9	Study of *Funaria* (Mosses)	1
10	Study of vegetative and reproductive structures of *Lycopodium* and*Selaginella*	1
11	Study of vegetative and reproductive structures of *Pinus* and *Cycas*	1
12	Study of fossil types and fossil slides	1
13	Study of floral and vegetative characters for identification of five angiosperms (Session 1)	1
14	Study of floral and vegetative characters for identification of five angiosperms (Session 2)	1
15	Observation of specialized root forms of five angiosperms, specialized leaves of ten angiosperms, and observation of special inflorescences and fruit types of ten angiosperms	1

.*Each Session covers 2 hours.*

Suggested Readings

1.Bendre and Kumar. 2018. A Text BookOfPractical Botany, Volume I. Rastogi Publications.

2.Choudhary, S. S., Choudhary, P. and Prasad, T. 2001. Practical Botany (Cryptogams & Gymnosperms). CBS Publishers.

Additional Readings

1. British Columbia Ministry of Forests. 1996. Techniques and procedures forcollecting, preserving, processing, and storing botanical specimens. Res. Br.,B.C. Min. For., Victoria, B.C. Work. https://www.floridamuseum.ufl.edu/wp-content/uploads/sites/67/2021/08/Wp18.pdf

List of Essential Major Equipment

- Compound light microscopes (with 40X–1000X magnification)
- Dissecting microscopes (stereo microscopes)
- Microtome (for sectioning plant tissues)
- Autoclave (for sterilisation of media and materials)
- Hot air oven and incubator
- Laminar air flow unit (for microbial work)
- Electronic balance (analytical)
- Refrigerators and deep freezer (for storage of specimens and chemicals)
- Computerized Microscope or USB Digital camera attachment for microscopes (optional, for recording observations)

Major Laboratory Stores/Consumables Required

- Glassware: Slides, cover slips, Petri dishes, test tubes, beakers, flasks, measuring cylinders, watch glasses
- Dissecting tools: Forceps, needles, scalpels, scissors, brushes
- Mounting media and stains: Glycerine, lactophenol, safranin, iodine solution, cotton blue, crystal violet, etc.
- Permanent slides and preserved specimens (lower plants and angiosperms)
- Culture media for bacteria and fungi (e.g., PDA, Nutrient Agar medium)
- Disinfectants and laboratory cleaning supplies
- Drawing sheets, notebooks, and stationeries for students

Essential Software (Licensed/Open-Source)

- ImageJ (Open-source) – for analysing micrographs
- BioRender (Licensed/Online) –for preparing life-cycle diagrams and illustrations (optional)

Minor Course– Introductory Botany (Theory)

(*offered to candidates of other disciplines*)

Nature of Course	Minor				
Course Code	MNC45BOT101(T)25				
Course Title	Introductory Botany				
Course Level	Level 100				
Credit Details	Total Credit	Lecture/ Week	Tutorial/ Week	Practical/Week	Total Hours/ Week
	3	3			3
Course Audience	Major Students enrolled in the FYUGP in Botany				
Proposed by (for Non Core courses)					
Pre Requisites (if any)	Basic understanding of plant biology at the higher secondary level or equivalent.				
Skill Training Required (if any)	1. 2.				
Pre-Requisite Course Required (if any)	Successful completion of Biology at the higher secondary level or equivalent examination.				
Faculty Eligibility and Specialization (if any)	Master's Degree in Botany or Life Sciences with a specialisation in Botany; candidates with Ph.D. and/or NET qualifications will be preferred.				

Course Objective

To provide foundational knowledge of cell biology and plant diversity, covering algae, bryophytes, pteridophytes, gymnosperms, and angiosperms, along with an introduction to microorganisms and fungi relevant to plant sciences. The course also aims to develop basic skills in identification, classification, and interpretation of diagnostic characters and life-cycle features using standard botanical terminology and illustrations.

Course Learning Outcomes

By the end of the course, students will be able to:

1. Distinguish prokaryotic and eukaryotic cells based on structural organization and complexity and describe the structure and functions of the nucleus and major cell organelles.
2. Describe the stages of the cell cycle and the sequential events of mitosis and meiosis, and explain their regulation in relation to growth and reproduction.
3. Classify major groups of microorganisms based on diagnostic features and explain their structure and reproduction.
4. Classify fungi based on their diagnostic features and describe their characteristic features, thallus organization, reproductive structures and life cycles.
5. Identify the diagnostic features, thallus organization, and reproductive strategies of cryptogams (algae, bryophytes, pteridophytes) and describe their evolutionary significance.
6. Describe the diagnostic features and reproductive mechanisms of phanerogams (gymnosperms and angiosperms).
7. Provide a general introduction to Paleobotany, describe types of plant fossils, representative fossil taxa, and explain their significance in understanding plant evolution and ancient environments.
8. Illustrate the life cycles of representative genera (e.g., *Rhizopus*, *Nostoc*, *Marchantia*, *Selaginella*, *Cycas*, *Pinus*) using appropriate diagrams and annotations.
9. Identify and describe the morphological features and modifications of roots, stems, leaves, inflorescences, fruits, and seeds,
10. Explain the phyllode theory, specialized leaf modifications, and the concept of the primitive flower with reference to stamen and carpel morphology and polymorphism.
11. Classify inflorescence types, placentation types, fruit types, and seed morphology based on diagnostic features, and discuss the foliar and axial theories of the ovary.

Detailed Syllabus Content

Unit 1: Cell Biology

Prokaryotic Cells: General characteristics, structure, nutrition and reproduction; Eukaryotic cells: Structure and functions, nucleus, cell organelles; Cell cycle and its regulation

Unit 2: Introduction to Microbiology

Basic concepts in microbiology, importance in plant sciences

Introduction to viruses: structural organization, classification and importance

Bacteria: structure and reproduction; Type species: *Bacillus subtilis*, *Escherichia coli* and *Streptococcus aureus*

Introduction to Fungi: Characteristic features and reproduction (asexual and sexual); Life cycles of representative species (*Phytophthora, Rhizopus, Saccharomyces, Agaricus*)

Lichens: Characteristics and types

Unit 3: Algae and Bryophytes

Algae: Characteristic features, range of thallus organization;Life cycles of representative species:*Nostoc* (Cyanophyta), *Volvox* (Chlorophyta), *Chara* (Charophyta), *Vaucheria* (Xanthophyta), *Ectocarpus* (Phaeophyta), *Polysiphonia* (Rhodophyta)

Bryophytes: Characteristic features, thallus structure; Life cycles: *Marchantia* (Liverworts), *Anthoceros* (Hornworts), *Funaria* (Mosses)

Unit 4: Pteridophytes, Gymnosperms and Palaeobotany

Pteridophytes: Characteristic features, tissue organization; Life cycles: *Rhynia*, *Lycopodium*, *Selaginella*

Gymnosperms: Characteristic features and life cycles: *Cycas*, *Pinus*

Introduction to Palaeobotany; types of fossils; significance

Unit 5: Morphology of Angiosperms

Root: types, structures and modifications, special and complex root forms

Stem and leaves: morphology (terminologies and forms), phyllode theory, specialized leaves and modifications.

Inflorescence and fruits: concept of primitive flower, stamen and carpel, polymorphism, foliar and axial concept of ovary

Placentation types, fruit types, and seed morphology

Suggested Readings

18. Alexopoulos, C. J., Mims, C. W., & Blackwell, M. (1996). *Introductory Mycology* (4th ed.). John Wiley & Sons (Asia).
19. Bhatnagar, S. P., & Moitra, A. (1996). *Gymnosperms*. New Age International Publishers.
20. Kaur, I., & Uniyal, P. L. (2019). *Text Book of Gymnosperms*. Daya Publishing House.
21. Kaur, I., & Uniyal, P. L. (2020). *Text Book of Bryophytes*. Daya Publishing House.

22. Kumar, H. D. (1999). *Introductory Phycology* (2nd ed.). Affiliated East-West Press.
23. Lee, R. E. (2008). *Phycology* (4th ed.). Cambridge University Press.
24. Pandey, S. N., Misra, S. P., & Trivedi, P. S. (1983). *A Textbook of Botany: Vol. 2. Bryophyta, Pteridophyta, Gymnosperms and Palaeobotany*. Vikas Publishing House Pvt. Ltd.
25. Parihar, N. S. (1972). *An Introduction to Embryophyta: Vol. II. Pteridophyta*. Central Book Depot.
26. Parihar, N. S. (1991). *An Introduction to Embryophyta: Vol. I. Bryophyta*. Central Book Depot.
27. Pelczar, M. J. (2001). *Microbiology* (5th ed.). Tata McGraw-Hill.
28. Sarbhoy, A. K. (2006). *Text Book of Mycology*. ICAR Publications.
29. Sethi, I. K., & Walia, S. K. (2011). *Text Book of Fungi and Their Allies*. Macmillan Publishers India Ltd.
30. Sharma, T. A., Dubey, R. C., & Maheshwari, D. K. (1999). *A Text Book of Microbiology*. S Chand and Co.
31. Stewart, W.N. and Rothwell, G.W. (1993). *Paleobotany and the Evolution of Plants*. 2nd Edition. Cambridge University Press.
32. Vashistha, P. C., Sinha, A. K., & Kumar, A. (2010). *Pteridophyta*. S. Chand.
33. Webster, J., & Weber, R. (2007). *Introduction to Fungi* (3rd ed.). Cambridge University Press.
34. Wiley, J. M., Sherwood, L. M., & Woolverton, C. J. (2013). *Prescott's Microbiology* (9th ed.). McGraw Hill International.

Additional Readings

9. Bidlack, J. E., Stern, K. R., & Jansky, S. H. (2021). *Stern's Introductory Plant Biology* (16th ed.). McGraw-Hill.
10. Carlile, M. J., Watkinson, S. C., & Gooday, G. W. (2001). *The Fungi* (2nd ed.). Academic Press.
11. Esau, K. (1977). *Anatomy of Seed Plants* (2nd ed.). John Wiley & Sons.
12. Fahn, A. (1990). *Plant Anatomy* (4th ed.). Pergamon Press.
13. Madigan, M. T., Bender, K. S., Buckley, D. H., Sattley, W. M., & Stahl, D. A. (2022). *Brock Biology of Microorganisms* (16th ed.). Pearson.
14. Mauseth, J. D. (2017). *Botany: An Introduction to Plant Biology* (6th ed.). Jones & Bartlett Learning.
15. Raven, P. H., Evert, R. F., & Eichhorn, S. E. (2023). *Biology of Plants* (9th ed.). W. H. Freeman and Company.
16. Taylor, T. N., Taylor, E. L., & Krings, M. (2009). *Paleobotany: The Biology and Evolution of Fossil Plants* (2nd ed.). Academic Press.

CO–PSO Mapping Matrix

COs	PSO 1	PSO2	PSO3	PSO 4	PSO5	PSO6	PSO 7	PSO8	PSO9	PSO1 0	PSO11
CO1	1	3	1		2			1			
CO2		3	1		1						
CO3	3	2		2		1			1		1
CO4	3	2		1		2					
CO5	3	2		1					2		
CO6	3	2							2		
CO7	2	2		1					3		
CO8	2	2	1		2		1			2	
CO9	2	2		2		1			1	1	1
CO10	2	3								1	
CO11	3	2								1	

Legend

- 3 = Strongly maps
- 2 = Moderately maps
- 1 = Weakly maps
- Blank = No mapping

Assessment Methods

- Oral and written examinations
- Closed-book and open-book tests,
- Problem-solving exercises,
- Individual and group project reports,
- Seminar and presentations,
- Interactive sessions.

Minor Course - Introductory Botany (Practical)

Nature of Course	Minor
Course Code	MNC45BOT101(P)25
Course Title	Introductory Botany (Practical)
Course Level	Level 100

Credit Details	Total Credit	Lecture/ Week	Tutorial/ Week	Practical/Week	Total Hours/ Week
	1			1	2
Course Audience	Major Students enrolled in the FYUGP in Botany				
Associated Theory Courses (Topics)					
Skill Training Required (if any)	Basic understanding of plant biology at the higher secondary level or equivalent.				
Pre-Requisite Course Required (if any)	1. 2.				
Faculty Eligibility and Specialization (if any)	Successful completion of Biology at the higher secondary level or equivalent examination.				

Course Description

This practical course provides hands-on training in cell biology and the study of plant diversity. Students will learn basic microscopic techniques, preparation of temporary mounts, and the observation of cell structures and organelles. Through laboratory work and specimen study, students will acquire skills to identify diagnostic vegetative and reproductive characters of algae, bryophytes, pteridophytes, gymnosperms, and angiosperms. The course also emphasizes the use of botanical terminology, accurate illustration of diagnostic features, and preparation of practical records.

Course Learning Outcomes

By the end of this practical course, students will be able to:

1. Prepare temporary mounts and use microscopes to observe and interpret cell structure and organelles.
2. Identify diagnostic vegetative and reproductive features of algae, bryophytes, and pteridophytes through laboratory and field specimens.
3. Identify diagnostic vegetative and reproductive features of gymnosperms through laboratory and field specimens.
4. Identify diagnostic vegetative and reproductive features of angiosperms, including floral characters, specialized roots, leaves, inflorescences, fruits, and seeds.

5. Illustrate and label diagnostic characters and life-cycle stages of representative genera using standard botanical diagrams.
6. Apply botanical terminology accurately while describing plant specimens and preparing practical records.

Detailed Syllabus Content

Sl. No.	Practical Exercise	No. of Sessions
1	Study of plant cell structure with epidermal peel mounts (Onion, *Rhoeo*, *Crinum*)	1
2	Observation of cell organelles using electron micrographs	1
3	Microbiology – Gram staining of bacteria and observation under microscope	1
4	Study of vegetative and reproductive structures of *Rhizopus*, *Saccharomyces*, *Agaricus* and *Penicillium*	1
5	Study of thallus structure of crustose, foliose and fructicose lichens	1
6	Study of vegetative and reproductive structures of *Nostoc* (Cyanophyta),*Volvox* (Chlorophyta) and *Chara* (Charophyta)	1
7	Study of *Vaucheria* (Xanthophyta),*Ectocarpus* (Phaeophyta) and *Polysiphonia* (Rhodophyta)	1
8	Study of vegetative and reproductive structures of *Marchantia* (Liverworts) and *Anthoceros* (Hornworts)	1
9	Study of *Funaria* (Mosses)	1
10	Study of vegetative and reproductive structures of *Lycopodium* and *Selaginella*	1
11	Study of vegetative and reproductive structures of *Pinus* and *Cycas*	1
12	Study of fossil types and fossil slides	1
13	Study of floral and vegetative characters for identification of five angiosperms (Session 1)	1
14	Study of floral and vegetative characters for identification of five angiosperms (Session 2)	1
15	Observation of specialized root forms of five angiosperms, specialized leaves of ten angiosperms, and observation of special inflorescences and fruit types of ten angiosperms	1

.Each Session covers 2 hours

Suggested Readings

1.Bendre and Kumar. 2018. A Text BookOfPractical Botany, Volume I. Rastogi Publications.

2.Choudhary, S. S., Choudhary, P. and Prasad, T. 2001. Practical Botany (Cryptogams & Gymnosperms). CBS Publishers.

Additional Readings

1. British Columbia Ministry of Forests. 1996. Techniques and procedures for collecting, preserving, processing, and storing botanical specimens. Res. Br., B.C. Min. For., Victoria, B.C. Work. https://www.floridamuseum.ufl.edu/wp-content/uploads/sites/67/2021/08/Wp18.pdf

List of Essential Major Equipment

- Compound light microscopes (with 40X–1000X magnification)
- Dissecting microscopes (stereo microscopes)
- Microtome (for sectioning plant tissues)
- Autoclave (for sterilisation of media and materials)
- Hot air oven and incubator
- Laminar air flow unit (for microbial work)
- Electronic balance (analytical)
- Refrigerators and deep freezer (for storage of specimens and chemicals)
- Computerized Microscope or USB Digital camera attachment for microscopes (optional, for recording observations)

Major Laboratory Stores/Consumables Required

- Glassware: Slides, cover slips, Petri dishes, test tubes, beakers, flasks, measuring cylinders, watch glasses
- Dissecting tools: Forceps, needles, scalpels, scissors, brushes
- Mounting media and stains: Glycerine, lactophenol, safranin, iodine solution, cotton blue, crystal violet, etc.
- Permanent slides and preserved specimens (lower plants and angiosperms)
- Culture media for bacteria and fungi (e.g., PDA, Nutrient Agar medium)
- Disinfectants and laboratory cleaning supplies
- Drawing sheets, notebooks, and stationeries for students

Essential Software (Licensed/Open-Source)

- ImageJ (Open-source) – for analysing micrographs

- BioRender (Licensed/Online) –for preparing life-cycle diagrams and illustrations (optional)

Skill Enhancement Course

Nursery Management and Gardening (Theory)

Nature of Course	Skill Enhancement Course				
Course Code	SEC45BOT101a(T)25				
Course Title	Nursery Management and Gardening (Theory)				
Course Level	Level 100				
Credit Details	Total Credit	Lecture/ Week	Tutorial/ Week	Practical/Week	Total Hours/ Week
	2	2			2
Course Audience	Major Students enrolled in the FYUGP in Botany				
Associated Theory Courses (Topics)					
Skill Training Required (if any)	Basic understanding of plant biology at the higher secondary level or equivalent.				
Pre-Requisite Course Required (if any)	1. 2.				
Faculty Eligibility and Specialization (if any)	Successful completion of Biology at the higher secondary level or equivalent examination.				

Course Objective

This course aims to equip students with foundational skills in nursery management and gardening. Students will learn the processes of seed sowing, vegetative propagation, raising and maintaining seedlings, and the planning of home and landscape gardens. Emphasis is placed on practical exposure, including the cultivation of common vegetables and ornamental plants, and field visits to nurseries to develop hands-on competency in applied botany.

Course Learning Outcomes

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

1. Understand the principles and techniques of seed sowing and nursery establishment.

2. Identify and list essential resources and structures required for a functional nursery.
3. Differentiate various methods of plant propagation and apply them to common species.
4. Analyse and perform basic gardening operations, including soil preparation, manuring, and pest management.
5. Demonstrate appreciation for plant diversity through practical nursery and gardening activities.
6. Observe, record, and document the growth and development of ornamental and vegetable plants in nursery and home garden settings.

Detailed Syllabus Content

Unit 1: Nursery Management

Definition, objectives, scope; infrastructure development; seasonal activities; direct seeding vs. transplanting.

***Unit 2: Seed Biology and* Handling**

Structure and types of seeds; dormancy and its breaking; seed storage and seed banks; seed viability and genetic erosion; basics of seed production, testing, and certification.

Unit 3: Vegetative Propagation and Protected Structures

Methods (cutting, layering, grafting); selection and treatment of cuttings; hardening of plants; greenhouse, shade house, mist chamber, and glasshouse.

Unit 4: Gardening Principles

Definition and objectives; types of gardens (landscape, home, park); garden design and plant materials; computer applications in landscaping;

Unit 5: Gardening Operations

Soil laying, manuring, watering, pest and disease management, transplanting of seedlings; cultivation of vegetables (cabbage, mustard, brinjal, lady's finger, onion, allium, tomato, carrot); basics of storage and marketing.

Suggested Readings

1. Bose, T.K. & Mukherjee, D. (1972). *Gardening in India.* Oxford & IBH Publishing Co., New Delhi.
2. Sandhu, M.K. (1989). *Plant Propagation.* Wiley Eastern Ltd., Bengaluru.
3. Kumar, N. (1997). *Introduction to Horticulture.* Rajalakshmi Publications, Nagercoil.

4. Edmond, J.B., Musser, A.M. & Andres, F. (1978). *Fundamentals of Horticulture.* McGraw-Hill Book Co., New Delhi.
5. Agrawal, P.K. (1993). *Handbook of Seed Technology.* Department of Agriculture & Cooperation, National Seed Corporation Ltd., New Delhi.
6. Janick, J. (1979). *Horticultural Science* (3rd Ed.). W.H. Freeman and Co., San Francisco, USA.

Skill Enhancement Course

Nursery Management and Gardening (Practical)

Course Code: SEC45BOT101a(P)25

Credit: 1

Detailed Syllabus Content

Sl. No.	Practical Activity / Experiment	No. of Sessions
1	Study the process of seed sowing in nursery beds and trays.	1
2	Demonstration of soil preparation and potting mixtures for nursery beds.	1
3	Study of different forms of seed sowing and plant growing methods (direct seeding, transplanting, tray method).	1
4	Observation and recording of germination and seedling care in nursery.	1
5	Study of vegetative propagation methods – stem cutting and air-layering.	1
6	Vegetative propagation demonstration – grafting and budding (seasonal or video demo).	1
7	Observation of growth stages of nursery seedlings and transplanted vegetables.	1
8	Maintenance practices in nursery – watering, thinning, weeding, and manuring.	1
9	Observation of pest and disease symptoms in nursery plants and basic management methods.	1
10	Demonstration of transplanting seedlings to pots or garden beds.	1
11	Preparation and labelling of potted plants for small garden displays.	1
12	Study of cold storage models and simple storage methods for harvested vegetables.	1

13	Computer-aided garden layout and landscaping demonstration using basic/free tools.	1
14	Field visit to a local nursery – observation of layout, propagation, and storage facilities.	1
15	Preparation and submission of nursery visit report with observations and simple plant inventory.	1

Each Session covers 2 hours

Major Equipment (Laboratory and Field Use)

- Nursery seed trays and germination trays
- Potting benches and seedling racks
- Watering cans, sprayers, and hose pipes
- Hand tools: trowels, pruners, cutters, and weeding forks
- Mist chamber / simple propagation chamber (if available)
- Shade net and mini greenhouse (demonstration, if possible)
- Simple cold storage cabinet / model for vegetables
- Weighing balance (for soil and manure mixing)

Consumables / Stores

- Garden soil, sand, compost, and FYM (farmyard manure)
- Seeds of common vegetables and ornamental plants
- Polybags, pots, and trays for seedling raising
- Labels, markers, and plastic tags for plant identification
- Basic pesticides/fungicides for demonstration (as per safety norms)
- Fertilizers: Urea, DAP, Potash (for demonstration only)
- Disposable gloves and cleaning materials
- Gardening epuipments

CO-PSO Mapping

CLOs	PSO 1	PSO2	PSO3	PSO4	PSO 5	PSO6	PSO7	PSO 8	PSO9	PSO10	PSO11
CLO1	–	–	**3**	**3**	–	**2**	–	–	–	–	–
CLO2	–	–	**2**	**3**	–	**2**	–	–	–	–	–
CLO3	–	–	**3**	**3**	–	**3**	–	–	–	–	–

CLO4	–	–	**3**	**3**	–	**3**	–	–	**2**	–	**2**
CLO5	**3**	–	–	**2**	–	**2**	–	–	**3**	–	**2**
CLO6	–	–	**3**	**2**	**2**	**2**	–	–	–	**2**	**2**

Theory Course Teaching-Learning Process

The important relevant teaching and learning processes involved in this course are;

- Class lectures
- Seminars
- Tutorials
- Group discussions and Workshops
- Statement, reasoning and explanation
- Project-based learning
- Field-based learning
- Presentations through Posters and power point
- Internship in industry and research institutional

Student Activities for Practical Courses

- Field visit to local nurseries
- Nursery bed preparation
- Seed sowing practice
- Maintenance of nurseries
- Nursery record maintenance
- Practice of vegetative propagation methods
- Maintenance of potted plants
- Harvesting of vegetables
- Visit to local cold storages
- Quiz or spot tests
- Maintenance of practical record books

Skill Enhancement Course

Biofertilizers (Theory)

Nature of Course	Skill Enhancement Course				
Course Code	SEC45BOT101b(T)25				
Course Title	Biofertilizers (Theory)				
Course Level	Level 100				
Credit Details	Total Credit	Lecture/ Week	Tutorial/ Week	Practical/Week	Total Hours/ Week
	2	2			2
Course Audience	Major Students enrolled in the FYUGP in Botany				
Associated Theory Courses (Topics)					
Skill Training Required (if any)	Basic understanding of plant biology at the higher secondary level or equivalent.				
Pre-Requisite Course Required (if any)	1. 2.				
Faculty Eligibility and Specialization (if any)	Successful completion of Biology at the higher secondary level or equivalent examination.				

Course Objective

This course aims to introduce the role of biofertilizers in sustainable agriculture and teach basic preparation techniques for plant-associated microbial inoculants. Students will learn to prepare, test, and apply simple biofertilizers like *Rhizobium* and *Azotobacter*, linking botanical knowledge with agricultural applications.

Course Learning Outcomes

Students will be able to:

1. Understand the basic concept of biofertilizers.
2. Explain the importance of biofertilizers in plant growth and soil health.
3. Explain the attributes of bio-inoculants in soil fertility.
4. Demonstrate preparation and storage of simple microbial biofertilizers.
5. Familiarize the commercial bifertilizers.
6. Apply biofertilizers to plants and assess basic growth responses.

Detailed Syllabus Content

Unit 1: Types of Biofertilizers

Introduction, types and importance of bio-fertilizers in agriculture, organic farming system and biocontrol of plant diseases; History of bio-fertilizers production; Micro-organisms used in bio-fertilizer production- *Rhizobium, Azobacter, Azospirillum,* Cyanobacteria, Mycorrhiza, Actinomycorrhiza.

Unit II: Nitrogen Fixing Biofertilizers

Classification of biological nitrogen fixation; factors influencing nitrogen fixation; Rhizobia, process of nodule formation, role of Nif and Nod gene in biological nitrogen fixation; *Azolla* and *Anabaena* association, cyanobacteria in rice cultivation. Actinomycorrhizal symbiosis

Unit III: Mycorrhizal Biofertilizers

Mycorrhizal association: type, colonization of mycorrhiza and contribution in nutrient uptake. taxonomy, occurrence and distribution, phosphorus nutrition, growth and yield, its influence on growth and yield of crop plants.

Unit IV: Decomposers

Organisms used as decomposers (bacteria, fungi, insects and earthworms); Role and importance of decomposers in ecosystems (including agro-ecosystems); Steps of decomposition; Factors affecting decomposition; Role of decomposers in soil fertility

Unit V: Mass Production of Biofertilizers

Strategies of Mass multiplication and packaging; Quality standard for bio-fertilizers; Different methods of application of bio-fertilizers, Methods of quality control assessment in respect of bio-fertilizers; Registration of bio-fertilizers.

Skill Enhancement Course

Biofertilizers (Practical)

Course Code: SEC45BOT101b(P)25Credit: 1

Detailed Syllabus Content

Sl. No.	Practical Activity / Experiment	No. of Sessions
1	Study of bacteria, cyanobacteria (used in biofertilizers) from temporary mounts /permanent slides.	1
2	Study of *Rhizobium* from root nodules of leguminous plants by Gram staining method	1
3	Preparation of Yeast Extract-Mannitol-Agar medium (for *Rhizobium* culture)	1
4	Isolation of *Rhizobium* from root nodules	1
5	Morphological study and isolation of *Anabaena* from *Azolla* leaf	1
6	Observation of different mycorrhizae from temporary mounts/permanent slides of mycorrhizal roots	1
7	Familiarity of different commercial biofertilizer formulations	1
8	Methods for field application of biofertilizers	1
9	Effect of biofertilizer application on plant growth	1
10	Study of phosphate solubilising fungal species (*Aspergillus, Penicillium* and *Trichoderma*) from temporary mount or permanent slides	1
11	Study of decomposer fungal species *Fusarium, Chaetomium* and *Trichoderma* from temporary mount or permanent slides	1
12	Preparation Potato-Dextrose-Agar medium	1
13	Pure culture maintenance of *Aspergillus/Penicillium/Trichoderma*	1
14	Quality control of bio-fertilizers: ISI standards specified and estimating the viable bacterial count in carrier based bio-fertilizers	1
15	Preparation of proposal of bio-fertilizers production unit	1

Each Session covers 2 hours

Suggested readings

1. Anonymous 2016. Proceedings of Workshop on Biofertilizers.New Delhi. Delhi: Zakir Husain Delhi College
2. Kumaresan, V. 2005. Biotechnology.New Delhi, Delhi: Saras Publication.

3. Sathe, T.V. 2004. Vermiculture and Organic Farming.New Delhi, Delhi: Daya publishers.
4. Subha Rao, N.S. 2000. Soil Microbiology.New Delhi, Delhi: Oxford & IBH Publishers.
5. Subba Rao, N.S. 1993. Biofertilizers in Agriculture and Forestry. Oxford and IBH. Publ. Co., New Delhi.
6. Vayas,S.C, Vayas, S., Modi, H.A. 1998. Bio-fertilizers and organic Farming. Nadiad, Gujarat: Akta Prakashan
7. https://www.biologyonline.com/dictionary/decomposer.
8. https://byjus.com/biology/what-is-decomposition.
9. https://education.nationalgeographic.org/resource/decomposers.
10. https://biologydictionary.net/decomposer.

Major Laboratory Stores/Consumables Required

- Glassware: Slides, cover slips, Petri dishes, test tubes, beakers, flasks, measuring cylinders, watch glasses
- Dissecting tools: Forceps, needles, scalpels, scissors, brushes
- Mounting media and stains: Glycerine, lactophenol, safranin, iodine solution, cotton blue, crystal violet, etc.
- Permanent slides of fungal species
- Culture media for bacteria and fungi (e.g., PDA, Yeast Extract Agar, Nutrient Agar)
- Laminar Air Flow for microbiological works
- Microscopes
- Disinfectants and laboratory cleaning supplies
- Drawing sheets, notebooks, and stationeries for students

CO-PSO Mapping

CLOs	PSO 1	PSO2	PSO3	PSO4	PSO 5	PSO6	PSO7	PSO 8	PSO9	PSO10	PSO11
CLO1	–	–	**3**	**3**	–	**2**	–	–	–	–	–
CLO2	–	–	**2**	**3**	–	**2**	–	–	–	–	–
CLO3	–	–	**3**	**3**	–	**3**	–	–	–	–	–
CLO4	–	–	**3**	**3**	–	**3**	–	–	**2**	–	**2**
CLO5	**3**	–	–	**2**	–	**2**	–	–	**3**	–	**2**
CLO6	–	–	**3**	**2**	**2**	**2**	–	–	–	**2**	**2**

Theory Course Teaching-Learning Process

The important relevant teaching and learning processes involved in this course are:

- Class lectures
- Seminars
- Tutorials
- Group discussions and Workshops
- Statement, reasoning and explanation
- Field-based learning
- Presentations through posters and power point
- Internship in industry and research institutional

Student Activities for Practical Courses

- Collection of *Azolla* and root nodules and laboratory studies
- Collection of micorrhizal roots and laboratory studies
- Preparation of bacterial and fungal culture media
- Pure culture isolation of *Anabaena* and *Rhizobium*
- Examination of carrier based commercial biofertilizers
- Field application of biofertilizers
- Study of phosphate solubilising fungal species
- Study of decomposer fungal species
- Field monitoring of biofertilizer applied plants
- Visit to local available biofertilizer labs
- Quiz or spot tests
- Maintenance of practical record books

Manipur University

Syllabus for Four Year Undergraduate Programme in Botany

2025

The Preamble

Plant Science is an integrated discipline that combines traditional areas of study with modern scientific approaches in biochemistry, molecular biology, biotechnology, and ecology. Over the last few decades, research in plant sciences has generated enormous advances in understanding plant diversity, physiology, reproduction, and adaptation. These developments have also led to significant applications in agriculture,

conservation, environmental management, and biotechnology. There is growing global alarm over the rapid loss of biodiversity, widespread habitat degradation, escalating pollution, and the intensifying effects of climate change. Plants, being at the core of ecosystems and food security, are central to addressing these challenges. Field plant biologists and conservationists play a crucial role in documenting plant diversity, understanding ecological processes, and developing strategies for sustainable resource management. At the same time, advancements in molecular techniques and computational tools have created unprecedented opportunities to investigate plant functions at genetic, biochemical, and cellular levels.

North East India, including the state of Manipur, is recognized as one of the world's biodiversity hotspots. The region harbors unique ecosystems, a wide variety of plant species, and rich indigenous knowledge systems. This diversity provides excellent opportunities for botanical research, sustainable bio-prospecting, and community-based conservation. Harnessing these resources requires a strong foundation in both classical and contemporary plant sciences. In this context, the Four-Year Undergraduate Programme (FYUGP) in Botany at Manipur University, designed in alignment with the National Education Policy-2020 (NEP-2020), National Higher Education Qualification Framework (NHEQF) and National Credit Framework (NCrF), seeks to provide students with a balanced and comprehensive understanding of plant sciences. The curriculum integrates core areas of plant diversity, taxonomy, anatomy, physiology, biochemistry, molecular biology, ecology, economic botany, and reproduction. Equal emphasis is given to the study of environmental change and its impact on plants.

The programme also focuses on the application of knowledge to address real-world challenges. Students will acquire practical skills through hands-on laboratory training, field explorations, research projects, and community engagement. Skill-oriented and entrepreneurship-driven courses have been included to prepare graduates for professional opportunities in plant-based industries, environmental sectors, and allied fields. By blending theoretical knowledge with experiential learning, the programme equips students to critically analyze contemporary issues, contribute to biodiversity conservation, and support sustainable development. Graduates will be empowered to pursue higher studies, research, or entrepreneurship and to contribute meaningfully to society.

Graduate Attributes

Graduate Attributes represent the core competencies, skills, and values that students of the Botany programme at Manipur University are expected to develop by the time they complete the Four-Year Undergraduate Programme (FYUGP). These attributes bridge academic learning with real-world application and ensure that graduates emerge as knowledgeable, skilled, and responsible individuals

capable of addressing local, regional, and global challenges through higher studies, professional careers, entrepreneurship, and meaningful contributions to society.

Graduates of the Four-Year Undergraduate Programme in Botany will possess a deep and coherent understanding of plant sciences and allied disciplines, integrating theoretical concepts with practical skills to address biodiversity conservation, environmental sustainability, and societal development. They will be able to think critically and analytically, systematically examining complex issues, evaluating evidence from multiple perspectives, and applying innovative and context-sensitive approaches to solve problems in scientific, professional, and community settings. Graduates will demonstrate the ability to communicate effectively through oral, written, and digital media, conveying complex botanical and environmental concepts clearly to diverse audiences, including peers, professionals, policymakers, and communities. They will be capable of working productively in collaborative and interdisciplinary teams, showing interpersonal competence, adaptability, leadership potential, and cultural sensitivity in diverse contexts. They will be proficient in the ethical use of digital tools, information resources, and contemporary research methodologies to collect, analyze, and interpret data, thereby supporting scientific inquiry, conservation, and informed decision-making. Graduates will uphold the highest standards of moral and professional integrity, demonstrate responsibility towards environmental stewardship and community well-being, and commit themselves to lifelong learning by continuously updating their knowledge, skills, and values in response to evolving scientific, technological, and societal challenges.

Qualification Descriptors

By the completion of the Four-Year Undergraduate Programme (FYUGP), graduates will:

- Achieve Level 6.0 learning outcomes as defined by the National Higher Education Qualifications Framework (NHEQF) and meet the National Credit Framework (NCrF) requirement of earning a minimum of 180 credits for the Four-Year Undergraduate Honours/Honours with Research degree.
- Demonstrate a coherent and in-depth understanding of plant sciences in a multidisciplinary framework, with comprehensive and systematic knowledge of core and applied areas.
- Apply specialized knowledge and practical skills to pursue higher studies, research, entrepreneurship, and professional practice in universities, colleges, research institutions, government and public services, plant research centres, farm consultancy, and other allied sectors.
- Critically evaluate and address complex issues by using disciplinary knowledge and transferable skills to analyze a wide range of ideas and real-life problems in botany and related fields.

- Contribute ethically and responsibly to biodiversity conservation, environmental sustainability, and socio-economic development while upholding professional integrity.
- Engage in lifelong learning and adapt to emerging scientific, technological, and societal challenges to ensure continued personal and professional growth..

Programme Outcomes

Programme Outcomes (POs) define the broad set of abilities and competencies that every graduate of the FYUGP is expected to achieve. They serve as common goals across disciplines, ensuring that students can apply their knowledge, skills, and values effectively in professional, academic, and societal contexts.

PO Code	PO Name	Programme Outcome Statement
PO1	Disciplinary Knowledge and Application	Integrate and apply advanced disciplinary knowledge of plant sciences and allied fields to analyze and address professional, societal, and environmental challenges independently and effectively.
PO2	Communication	Prepare, present, and defend complex ideas, research findings, and technical information clearly in oral, written, and digital formats to diverse audiences.
PO3	Critical Thinking and Analytical Reasoning	Evaluate, interpret, and synthesize information from multiple sources to draw conclusions and solve complex problems using logical, evidence-based reasoning.
PO4	Problem-Solving	Design, implement, and assess innovative solutions for real-world challenges by applying interdisciplinary knowledge and advanced analytical approaches.
PO5	Research and Inquiry	Formulate research questions, design methodologies, conduct investigations, analyze data, and generate new knowledge through independent and collaborative research.
PO6	Digital and Information Literacy	Select, use, and evaluate advanced digital tools, information systems, and emerging technologies proficiently and ethically in learning, research, and professional practice.
PO7	Teamwork and Leadership	Collaborate effectively, coordinate tasks, and lead projects in multidisciplinary teams by demonstrating interpersonal competence, accountability, and strategic decision-making.

PO Code	PO Name	Programme Outcome Statement
PO8	Moral, Ethical, and Environmental Responsibility	Apply ethical frameworks, evaluate impacts, and implement actions that support biodiversity conservation, environmental sustainability, and social equity at local, national, and global levels.
PO9	Lifelong Learning	Identify and undertake self-directed learning and professional development activities, and demonstrate adaptability to evolving scientific, technological, and societal contexts.

Programme Specific Outcome for FYUGP (Botany)

Programme Specific Outcomes reflect both subject-specific expertise and broad, transferable skills and competencies. Students completing a programme of study are expected to demonstrate the knowledge and abilities gained during the course and apply them effectively, fulfilling the requirements for the award of the degree. Graduates of the FYUGP in Botany programme will be able to acquire and apply

PSO No.	Programme Specific Outcome Statement
PSO 1	Classify plant groups from lower to higher taxa based on diversity, structure, reproduction, genetics, evolution, ecology, and economic importance, and demonstrate the ability to identify representative species accurately.
PSO 2	Explain concepts of Morphology, Taxonomy, Anatomy, Physiology, Biochemistry, Molecular Biology, and Ecology, and analyze advanced topics such as Plant Biotechnology, Developmental Botany, and Plant–Pathogen Interactions.
PSO 3	Design and conduct laboratory and field investigations, collect and analyze data using appropriate tools, and interpret results with evidence-based reasoning.
PSO 4	Apply botanical knowledge and allied sciences to develop strategies and evaluate innovative solutions for agricultural, environmental, and societal challenges.
PSO 5	Utilize digital tools, bioinformatics software, biostatistics, and modern laboratory and field technologies to analyze and communicate biological data effectively.
PSO 6	Plan and execute entrepreneurial or industry-oriented activities in applied branches such as Organic Farming, Mushroom Cultivation, Landscaping, Floriculture, Herbal Technology, Ecotourism, and Biofertilizer production.
PSO 7	Demonstrate self-directed learning skills by setting goals, selecting resources, and evaluating progress for higher education, competitive examinations, and professional development.
PSO 8	Practice professional ethics and integrity, and adhere to responsible conduct in research, education, and professional activities.

PSO No.	Programme Specific Outcome Statement
PSO 9	Document, conserve, and implement sustainable practices for the utilization of plant resources, and evaluate biodiversity and climate change issues using scientific and traditional knowledge.
PSO 10	Collaborate effectively in multidisciplinary teams, lead when required, and present ideas and findings clearly through oral, written, and digital communication.
PSO 11	Engage in outreach programmes, extension activities, and community-based projects by applying botanical knowledge to solve local and regional challenges.

PO-PSO mapping matrix

PSO No.	PO1	PO2	PO 3	PO4	PO5	PO6	PO 7	PO8	PO9
PSO 1	3	–	2	–	–	–	–	2	–
PSO 2	3	–	2	–	2	–	–	–	–
PSO 3	2	–	3	2	3	2	–	–	–
PSO 4	2	–	3	3	2	–	–	2	–
PSO 5	2	2	2	–	3	3	–	–	–
PSO 6	2	–	–	2	–	2	2	–	2
PSO 7	–	–	2	–	–	2	–	–	3
PSO 8	–	–	–	–	–	–	–	3	2
PSO 9	2	–	–	–	–	–	–	3	2
PSO 10	–	3	–	–	–	2	3	–	–
PSO 11	2	–	–	2	–	–	2	2	–

Each PSO is mapped to one or more relevant POs with ratings of High (3), Moderate (2), or Low (1) relevance. In this programme, the generic Programme Outcomes (POs) are achieved through the discipline-specific Programme Specific Outcomes (PSOs) in Botany.

Curriculum Structure

Year I (Course Level 100)

Semester I (Academic Level 4.5)

Major Course (MJC)

Course Code	Title of the Course	Credit
MJC45BOT101(T)25 MJC45BOT101(P)25	Introductory Botany (Theory) Introductory Botany (Practical)	3 1
Minor Course (MNC) to be selected one course from other programmes		
		4/3+1
Multidisciplinary Course (MDC) to be selected one course from other disciplines or from open sources MOOCS/SWAYAM*		
		3/2+1
Ability Enhancement Course (AEC)		
	Major Indian Language (Language and Communication Skills)/ English (Language and Communication Skills)	4
Skills Enhancement Course (SEC) to be selected one course **		
SEC45BOT101a(T)25 SEC45BOT101a(P)25		2 1
SEC45BOT101b(T)25 SEC45BOT101b(P)25		2 1
Value-Added Course (VAC) to be selected one course from central pool		
		2
Total Credit 20		

*Courses already studied at the 12th-grade (higher secondary school) level in the intended major or minor cannot be selected.

**SEC should be major oriented.

Minor Course (MNC) offer to candidates of other interdisciplinary subjects

Course Code	Title of the Course	Credit
MNC45BOT101(T)25 MNC45BOT101(P)25	Introductory Botany (Theory) Introductory Botany (Practical)	3 1

Course Contents

Major Course - Introductory Botany (Theory)

Nature of Course	Major				
Course Code	MJC45BOT101(T)25				
Course Title	Introductory Botany				
Course Level	Level 100				
Credit Details	Total Credit	Lecture/ Week	Tutorial/ Week	Practical/ Week	Total Hours/ Week
	3	3			3
Course Audience	Major Students enrolled in the FYUGP in Botany				
Proposed by (for Non Core courses)					
Pre Requisites (if any)	Basic understanding of plant biology at the higher secondary level or equivalent.				
Skill Training Required (if any)	1. 2.				
Pre-Requisite Course Required (if any)	Successful completion of Biology at the higher secondary level or equivalent examination.				
Faculty Eligibility and Specialization (if any)	Master's Degree in Botany or Life Sciences with a specialisation in Botany; candidates with Ph.D. and/or NET qualifications will be preferred.				

Course Objective

To provide foundational knowledge of cell biology and plant diversity, covering algae, bryophytes, pteridophytes, gymnosperms, and angiosperms, along with an introduction to microorganisms and fungi relevant to plant sciences. The course also aims to develop basic skills in identification, classification, and interpretation of diagnostic characters and life-cycle features using standard botanical terminology and illustrations.

Course Learning Outcomes

By the end of the course, students will be able to:

12. Distinguish prokaryotic and eukaryotic cells based on structural organization and complexity and describe the structure and functions of the nucleus and major cell organelles.

13. Describe the stages of the cell cycle and the sequential events of mitosis and meiosis, and explain their regulation in relation to growth and reproduction.
14. Classify major groups of microorganisms based on diagnostic features and explain their structure and reproduction.
15. Classify fungi based on their diagnostic features and describe their characteristic features, thallus organization, reproductive structures and life cycles.
16. Identify the diagnostic features, thallus organization, and reproductive strategies of cryptogams (algae, bryophytes, pteridophytes) and describe their evolutionary significance.
17. Describe the diagnostic features and reproductive mechanisms of phanerogams (gymnosperms and angiosperms).
18. Provide a general introduction to Paleobotany, describe types of plant fossils, representative fossil taxa, and explain their significance in understanding plant evolution and ancient environments.
19. Illustrate the life cycles of representative genera (e.g., *Rhizopus*, *Nostoc*, *Marchantia*, *Selaginella*, *Cycas*, *Pinus*) using appropriate diagrams and annotations.
20. Identify and describe the morphological features and modifications of roots, stems, leaves, inflorescences, fruits, and seeds,
21. Explain the phyllode theory, specialized leaf modifications, and the concept of the primitive flower with reference to stamen and carpel morphology and polymorphism.
22. Classify inflorescence types, placentation types, fruit types, and seed morphology based on diagnostic features, and discuss the foliar and axial theories of the ovary.

Detailed Syllabus Content

Unit 1: Cell Biology

Prokaryotic Cells: General characteristics, structure, nutrition and reproduction; Eukaryotic cells: Structure and functions, nucleus, cell organelles; Cell cycle and its regulation

Unit 2: Introduction to Microbiology

Basic concepts in microbiology, importance in plant sciences

Introduction to viruses: structural organization, classification and importance

Bacteria: structure and reproduction;

Type species: *Bacillus subtilis*, *Escherichia coli* and *Streptococcus aureus*

Introduction to Fungi: Characteristic features and reproduction (asexual and sexual); Life cycles of representative species (*Phytophthora, Rhizopus, Saccharomyces, Agaricus*)

Lichens: Characteristics and types

Unit 3: Algae and Bryophytes

Algae: Characteristic features, range of thallus organization;Life cycles of representative species:*Nostoc* (Cyanophyta), *Volvox* (Chlorophyta), *Chara* (Charophyta), *Vaucheria* (Xanthophyta), *Ectocarpus* (Phaeophyta), *Polysiphonia* (Rhodophyta)

Bryophytes: Characteristic features, thallus structure; Life cycles: *Marchantia* (Liverworts), *Anthoceros* (Hornworts), *Funaria* (Mosses)

Unit 4: Pteridophytes, Gymnosperms* and *Palaeobotany

Pteridophytes: Characteristic features, tissue organization; Life cycles: *Rhynia*, *Lycopodium*, *Selaginella*

Gymnosperms: Characteristic features and life cycles: *Cycas*, *Pinus*

Introduction to Paleobotany ; types of fossils; significance

Unit 5: Morphology of Angiosperms

Root: types, structures and modifications, special and complex root forms

Stem and leaves: morphology (terminologies and forms), phyllode theory, specialized leaves and modifications.

Inflorescence and fruits: concept of primitive flower, stamen and carpel, polymorphism, foliar and axial concept of ovary

Placentation types, fruit types, and seed morphology

Suggested Readings

35. Alexopoulos, C. J., Mims, C. W., & Blackwell, M. (1996). *Introductory Mycology* (4th ed.). John Wiley & Sons (Asia).
36. Bhatnagar, S. P., & Moitra, A. (1996). *Gymnosperms*. New Age International Publishers.
37. Kaur, I., & Uniyal, P. L. (2019). *Text Book of Gymnosperms*. Daya Publishing House.
38. Kaur, I., & Uniyal, P. L. (2020). *Text Book of Bryophytes*. Daya Publishing House.
39. Kumar, H. D. (1999). *Introductory Phycology* (2nd ed.). Affiliated East-West Press.
40. Lee, R. E. (2008). *Phycology* (4th ed.). Cambridge University Press.
41. Pandey, S. N., Misra, S. P., & Trivedi, P. S. (1983). *A Textbook of Botany: Vol. 2. Bryophyta, Pteridophyta, Gymnosperms and Palaeobotany*. Vikas Publishing House Pvt. Ltd.
42. Parihar, N. S. (1972). *An Introduction to Embryophyta: Vol. II. Pteridophyta*. Central Book Depot.

43. Parihar, N. S. (1991). *An Introduction to Embryophyta: Vol. I. Bryophyta*. Central Book Depot.
44. Pelczar, M. J. (2001). *Microbiology* (5th ed.). Tata McGraw-Hill.
45. Sarbhoy, A. K. (2006). *Text Book of Mycology*. ICAR Publications.
46. Sethi, I. K., & Walia, S. K. (2011). *Text Book of Fungi and Their Allies*. Macmillan Pub. India Ltd.
47. Sharma, T. A., Dubey, R. C., & Maheshwari, D. K. (1999). *A Text Book of Microbiology*. S Chand and Co.
48. Stewart, W.N. and Rothwell, G.W. (1993). *Paleobotany and the Evolution of Plants*. 2nd Edition. Cambridge University Press.
49. Vashistha, P. C., Sinha, A. K., & Kumar, A. (2010). *Pteridophyta*. S. Chand.
50. Webster, J., & Weber, R. (2007). *Introduction to Fungi* (3rd ed.). Cambridge University Press.
51. Wiley, J. M., Sherwood, L. M., & Woolverton, C. J. (2013). *Prescott's Microbiology* (9th ed.). McGraw Hill International.

Additional Readings

17. Bidlack, J. E., Stern, K. R., & Jansky, S. H. (2021). *Stern's Introductory Plant Biology* (16th ed.). McGraw-Hill.
18. Carlile, M. J., Watkinson, S. C., & Gooday, G. W. (2001). *The Fungi* (2nd ed.). Academic Press.
19. Esau, K. (1977). *Anatomy of Seed Plants* (2nd ed.). John Wiley & Sons.
20. Fahn, A. (1990). *Plant Anatomy* (4th ed.). Pergamon Press.
21. Madigan, M. T., Bender, K. S., Buckley, D. H., Sattley, W. M., & Stahl, D. A. (2022). *Brock Biology of Microorganisms* (16th ed.). Pearson.
22. Mauseth, J. D. (2017). *Botany: An Introduction to Plant Biology* (6th ed.). Jones & Bartlett Learning.
23. Raven, P. H., Evert, R. F., & Eichhorn, S. E. (2023). *Biology of Plants* (9th ed.). W. H. Freeman and Company.
24. Taylor, T. N., Taylor, E. L., & Krings, M. (2009). *Paleobotany: The Biology and Evolution of Fossil Plants* (2nd ed.). Academic Press.

CO–PSO Mapping Matrix

COs	**PSO 1**	**PSO2**	**PSO3**	**PSO 4**	**PSO5**	**PSO6**	**PSO 7**	**PSO8**	**PSO9**	**PSO1 0**	**PSO11**
CO1	1	3	1		2			1			
CO2		3	1		1						
CO3	3	2		2		1			1		1

CO4	3	2		1		2					
CO5	3	2		1					2		
CO6	3	2							2		
CO7	2	2		1					3		
CO8	2	2	1		2		1			2	
CO9	2	2		2		1			1	1	1
CO10	2	3								1	
CO11	3	2								1	

Legend

- 3 = Strongly maps
- 2 = Moderately maps
- 1 = Weakly maps
- Blank = No mapping

Assessment Methods

- Oral and written examinations
- Closed-book and open-book tests,
- Problem-solving exercises,
- Individual and group project reports,
- Seminar and presentations,
- Interactive sessions.

Major Course - Introductory Botany (Practical)

Nature of Course	Major				
Course Code	MJC45BOT101(P)25				
Course Title	Introductory Botany (Practical)				
Course Level	Level 100				
Credit Details	Total Credit	Lecture/ Week	Tutorial/ Week	Practical/Week	Total Hours/ Week
	1			1	2
Course Audience	Major Students enrolled in the FYUGP in Botany				
Associated Theory Courses (Topics)					
Skill Training	Basic understanding of plant biology at the higher secondary level or				

Required (if any)	equivalent.
Pre-Requisite Course Required (if any)	1. 2.
Faculty Eligibility and Specialization (if any)	Successful completion of Biology at the higher secondary level or equivalent examination.

Course Description

This practical course provides hands-on training in cell biology and the study of plant diversity. Students will learn basic microscopic techniques, preparation of temporary mounts, and the observation of cell structures and organelles. Through laboratory work and specimen study, students will acquire skills to identify diagnostic vegetative and reproductive characters of algae, bryophytes, pteridophytes, gymnosperms, and angiosperms. The course also emphasizes the use of botanical terminology, accurate illustration of diagnostic features, and preparation of practical records.

Course Learning Outcomes

By the end of this practical course, students will be able to:

7. Prepare temporary mounts and use microscopes to observe and interpret cell structure and organelles.
8. Identify diagnostic vegetative and reproductive features of algae, bryophytes, and pteridophytes through laboratory and field specimens.
9. Identify diagnostic vegetative and reproductive features of gymnosperms through laboratory and field specimens.
10. Identify diagnostic vegetative and reproductive features of angiosperms, including floral characters, specialized roots, leaves, inflorescences, fruits, and seeds.
11. Illustrate and label diagnostic characters and life-cycle stages of representative genera using standard botanical diagrams.
12. Apply botanical terminology accurately while describing plant specimens and preparing practical records.

Detailed Syllabus Content

Sl. No.	Practical Exercise	No. of Sessions
1	Study of plant cell structure with epidermal peel mounts (Onion, *Rhoeo*, *Crinum*)	1
2	Observation of cell organelles using electron micrographs	1
3	Microbiology – Gram staining of bacteria and observation under microscope	1
4	Study of vegetative and reproductive structures of *Rhizopus*, *Saccharomyces*, *Agaricus* and *Penicillium*	1
5	Study of thallus structure of crustose, foliose and fructicose lichens	1
6	Study of vegetative and reproductive structures of *Nostoc* (Cyanophyta),*Volvox* (Chlorophyta) and *Chara* (Charophyta)	1
7	Study of *Vaucheria* (Xanthophyta),*Ectocarpus* (Phaeophyta) and *Polysiphonia* (Rhodophyta)	1
8	Study of vegetative and reproductive structures of *Marchantia* (Liverworts) and *Anthoceros* (Hornworts)	1
9	Study of *Funaria* (Mosses)	1
10	Study of vegetative and reproductive structures of *Lycopodium* and*Selaginella*	1
11	Study of vegetative and reproductive structures of *Pinus* and *Cycas*	1
12	Study of fossil types and fossil slides	1
13	Study of floral and vegetative characters for identification of five angiosperms (Session 1)	1
14	Study of floral and vegetative characters for identification of five angiosperms (Session 2)	1
15	Observation of specialized root forms of five angiosperms, specialized leaves of ten angiosperms, and observation of special inflorescences and fruit types of ten angiosperms	1

.*Each Session covers 2 hours.*

Suggested Readings

1.Bendre and Kumar. 2018. A Text Book Of Practical Botany, Volume I. Rastogi Publications.

2.Choudhary, S. S., Choudhary, P. and Prasad, T. 2001. Practical Botany (Cryptogams & Gymnosperms). CBS Publishers.

Additional Readings

2. British Columbia Ministry of Forests. 1996. Techniques and procedures for collecting, preserving, processing, and storing botanical specimens. Res. Br., B.C. Min. For., Victoria, B.C. Work. https://www.floridamuseum.ufl.edu/wp-content/uploads/sites/67/2021/08/Wp18.pdf

List of Essential Major Equipment

- Compound light microscopes (with 40X–1000X magnification)
- Dissecting microscopes (stereo microscopes)
- Microtome (for sectioning plant tissues)
- Autoclave (for sterilisation of media and materials)
- Hot air oven and incubator
- Laminar air flow unit (for microbial work)
- Electronic balance (analytical)
- Refrigerators and deep freezer (for storage of specimens and chemicals)
- Computerized Microscope or USB Digital camera attachment for microscopes (optional, for recording observations)

Major Laboratory Stores/Consumables Required

- Glassware: Slides, cover slips, Petri dishes, test tubes, beakers, flasks, measuring cylinders, watch glasses
- Dissecting tools: Forceps, needles, scalpels, scissors, brushes
- Mounting media and stains: Glycerine, lactophenol, safranin, iodine solution, cotton blue, crystal violet, etc.
- Permanent slides and preserved specimens (lower plants and angiosperms)
- Culture media for bacteria and fungi (e.g., PDA, Nutrient Agar medium)
- Disinfectants and laboratory cleaning supplies
- Drawing sheets, notebooks, and stationeries for students

Essential Software (Licensed/Open-Source)

- ImageJ (Open-source) – for analysing micrographs
- BioRender (Licensed/Online) –for preparing life-cycle diagrams and illustrations (optional)

Minor Course– Introductory Botany (Theory)

(*offered to candidates of other disciplines*)

Nature of Course	Minor				
Course Code	MNC45BOT101(T)25				
Course Title	Introductory Botany				
Course Level	Level 100				
Credit Details	Total Credit	Lecture/ Week	Tutorial/ Week	Practical/Week	Total Hours/ Week
	3	3			3
Course Audience	Major Students enrolled in the FYUGP in Botany				
Proposed by (for Non Core courses)					
Pre Requisites (if any)	Basic understanding of plant biology at the higher secondary level or equivalent.				
Skill Training Required (if any)	1. 2.				
Pre-Requisite Course Required (if any)	Successful completion of Biology at the higher secondary level or equivalent examination.				
Faculty Eligibility and Specialization (if any)	Master's Degree in Botany or Life Sciences with a specialisation in Botany; candidates with Ph.D. and/or NET qualifications will be preferred.				

Course Objective

To provide foundational knowledge of cell biology and plant diversity, covering algae, bryophytes, pteridophytes, gymnosperms, and angiosperms, along with an introduction to microorganisms and fungi relevant to plant sciences. The course also aims to develop basic skills in identification, classification, and interpretation of diagnostic characters and life-cycle features using standard botanical terminology and illustrations.

Course Learning Outcomes

By the end of the course, students will be able to:

12. Distinguish prokaryotic and eukaryotic cells based on structural organization and complexity and describe the structure and functions of the nucleus and major cell organelles.
13. Describe the stages of the cell cycle and the sequential events of mitosis and meiosis, and explain their regulation in relation to growth and reproduction.
14. Classify major groups of microorganisms based on diagnostic features and explain their structure and reproduction.
15. Classify fungi based on their diagnostic features and describe their characteristic features, thallus organization, reproductive structures and life cycles.
16. Identify the diagnostic features, thallus organization, and reproductive strategies of cryptogams (algae, bryophytes, pteridophytes) and describe their evolutionary significance.
17. Describe the diagnostic features and reproductive mechanisms of phanerogams (gymnosperms and angiosperms).
18. Provide a general introduction to Paleobotany, describe types of plant fossils, representative fossil taxa, and explain their significance in understanding plant evolution and ancient environments.
19. Illustrate the life cycles of representative genera (e.g., *Rhizopus*, *Nostoc*, *Marchantia*, *Selaginella*, *Cycas*, *Pinus*) using appropriate diagrams and annotations.
20. Identify and describe the morphological features and modifications of roots, stems, leaves, inflorescences, fruits, and seeds,
21. Explain the phyllode theory, specialized leaf modifications, and the concept of the primitive flower with reference to stamen and carpel morphology and polymorphism.
22. Classify inflorescence types, placentation types, fruit types, and seed morphology based on diagnostic features, and discuss the foliar and axial theories of the ovary.

Detailed Syllabus Content

Unit 1: Cell Biology

Prokaryotic Cells: General characteristics, structure, nutrition and reproduction; Eukaryotic cells: Structure and functions, nucleus, cell organelles; Cell cycle and its regulation

Unit 2: Introduction to Microbiology

Basic concepts in microbiology, importance in plant sciences

Introduction to viruses: structural organization, classification and importance

Bacteria: structure and reproduction; Type species: *Bacillus subtilis*, *Escherichia coli* and *Streptococcus aureus*

Introduction to Fungi: Characteristic features and reproduction (asexual and sexual); Life cycles of representative species (*Phytophthora, Rhizopus, Saccharomyces, Agaricus*)

Lichens: Characteristics and types

Unit 3: Algae and Bryophytes

Algae: Characteristic features, range of thallus organization;Life cycles of representative species:*Nostoc* (Cyanophyta), *Volvox* (Chlorophyta), *Chara* (Charophyta), *Vaucheria* (Xanthophyta), *Ectocarpus* (Phaeophyta), *Polysiphonia* (Rhodophyta)

Bryophytes: Characteristic features, thallus structure; Life cycles: *Marchantia* (Liverworts), *Anthoceros* (Hornworts), *Funaria* (Mosses)

Unit 4: Pteridophytes, Gymnosperms and Palaeobotany

Pteridophytes: Characteristic features, tissue organization; Life cycles: *Rhynia*, *Lycopodium*, *Selaginella*

Gymnosperms: Characteristic features and life cycles: *Cycas*, *Pinus*

Introduction to Palaeobotany; types of fossils; significance

Unit 5: Morphology of Angiosperms

Root: types, structures and modifications, special and complex root forms

Stem and leaves: morphology (terminologies and forms), phyllode theory, specialized leaves and modifications.

Inflorescence and fruits: concept of primitive flower, stamen and carpel, polymorphism, foliar and axial concept of ovary

Placentation types, fruit types, and seed morphology

Suggested Readings

52. Alexopoulos, C. J., Mims, C. W., & Blackwell, M. (1996). *Introductory Mycology* (4th ed.). John Wiley & Sons (Asia).
53. Bhatnagar, S. P., & Moitra, A. (1996). *Gymnosperms*. New Age International Publishers.
54. Kaur, I., & Uniyal, P. L. (2019). *Text Book of Gymnosperms*. Daya Publishing House.
55. Kaur, I., & Uniyal, P. L. (2020). *Text Book of Bryophytes*. Daya Publishing House.
56. Kumar, H. D. (1999). *Introductory Phycology* (2nd ed.). Affiliated East-West Press.
57. Lee, R. E. (2008). *Phycology* (4th ed.). Cambridge University Press.

58. Pandey, S. N., Misra, S. P., & Trivedi, P. S. (1983). *A Textbook of Botany: Vol. 2. Bryophyta, Pteridophyta, Gymnosperms and Palaeobotany*. Vikas Publishing House Pvt. Ltd.
59. Parihar, N. S. (1972). *An Introduction to Embryophyta: Vol. II. Pteridophyta*. Central Book Depot.
60. Parihar, N. S. (1991). *An Introduction to Embryophyta: Vol. I. Bryophyta*. Central Book Depot.
61. Pelczar, M. J. (2001). *Microbiology* (5th ed.). Tata McGraw-Hill.
62. Sarbhoy, A. K. (2006). *Text Book of Mycology*. ICAR Publications.
63. Sethi, I. K., & Walia, S. K. (2011). *Text Book of Fungi and Their Allies*. Macmillan Publishers India Ltd.
64. Sharma, T. A., Dubey, R. C., & Maheshwari, D. K. (1999). *A Text Book of Microbiology*. S Chand and Co.
65. Stewart, W.N. and Rothwell, G.W. (1993). *Paleobotany and the Evolution of Plants*. 2nd Edition. Cambridge University Press.
66. Vashistha, P. C., Sinha, A. K., & Kumar, A. (2010). *Pteridophyta*. S. Chand.
67. Webster, J., & Weber, R. (2007). *Introduction to Fungi* (3rd ed.). Cambridge University Press.
68. Wiley, J. M., Sherwood, L. M., & Woolverton, C. J. (2013). *Prescott's Microbiology* (9th ed.). McGraw Hill International.

Additional Readings

25. Bidlack, J. E., Stern, K. R., & Jansky, S. H. (2021). *Stern's Introductory Plant Biology* (16th ed.). McGraw-Hill.
26. Carlile, M. J., Watkinson, S. C., & Gooday, G. W. (2001). *The Fungi* (2nd ed.). Academic Press.
27. Esau, K. (1977). *Anatomy of Seed Plants* (2nd ed.). John Wiley & Sons.
28. Fahn, A. (1990). *Plant Anatomy* (4th ed.). Pergamon Press.
29. Madigan, M. T., Bender, K. S., Buckley, D. H., Sattley, W. M., & Stahl, D. A. (2022). *Brock Biology of Microorganisms* (16th ed.). Pearson.
30. Mauseth, J. D. (2017). *Botany: An Introduction to Plant Biology* (6th ed.). Jones & Bartlett Learning.
31. Raven, P. H., Evert, R. F., & Eichhorn, S. E. (2023). *Biology of Plants* (9th ed.). W. H. Freeman and Company.
32. Taylor, T. N., Taylor, E. L., & Krings, M. (2009). *Paleobotany: The Biology and Evolution of Fossil Plants* (2nd ed.). Academic Press.

CO–PSO Mapping Matrix

COs	PSO	PSO2	PSO3	PSO	PSO5	PSO6	PSO	PSO8	PSO9	PSO1	PSO11

	1			**4**			**7**			**0**	
CO1	1	3	1		2			1			
CO2		3	1		1						
CO3	3	2		2		1			1		1
CO4	3	2		1		2					
CO5	3	2		1					2		
CO6	3	2							2		
CO7	2	2		1					3		
CO8	2	2	1		2		1			2	
CO9	2	2		2		1			1	1	1
CO10	2	3								1	
CO11	3	2								1	

Legend

- 3 = Strongly maps
- 2 = Moderately maps
- 1 = Weakly maps
- Blank = No mapping

Assessment Methods

- Oral and written examinations
- Closed-book and open-book tests,
- Problem-solving exercises,
- Individual and group project reports,
- Seminar and presentations,
- Interactive sessions.

Minor Course - Introductory Botany (Practical)

Nature of Course	Minor				
Course Code	MNC45BOT101(P)25				
Course Title	Introductory Botany (Practical)				
Course Level	Level 100				
Credit Details	Total Credit	Lecture/ Week	Tutorial/ Week	Practical/Week	Total Hours/ Week

	1			1	2
Course Audience	Major Students enrolled in the FYUGP in Botany				
Associated Theory Courses (Topics)					
Skill Training Required (if any)	Basic understanding of plant biology at the higher secondary level or equivalent.				
Pre-Requisite Course Required (if any)	1. 2.				
Faculty Eligibility and Specialization (if any)	Successful completion of Biology at the higher secondary level or equivalent examination.				

Course Description

This practical course provides hands-on training in cell biology and the study of plant diversity. Students will learn basic microscopic techniques, preparation of temporary mounts, and the observation of cell structures and organelles. Through laboratory work and specimen study, students will acquire skills to identify diagnostic vegetative and reproductive characters of algae, bryophytes, pteridophytes, gymnosperms, and angiosperms. The course also emphasizes the use of botanical terminology, accurate illustration of diagnostic features, and preparation of practical records.

Course Learning Outcomes

By the end of this practical course, students will be able to:

7. Prepare temporary mounts and use microscopes to observe and interpret cell structure and organelles.
8. Identify diagnostic vegetative and reproductive features of algae, bryophytes, and pteridophytes through laboratory and field specimens.
9. Identify diagnostic vegetative and reproductive features of gymnosperms through laboratory and field specimens.
10. Identify diagnostic vegetative and reproductive features of angiosperms, including floral characters, specialized roots, leaves, inflorescences, fruits, and seeds.
11. Illustrate and label diagnostic characters and life-cycle stages of representative genera using standard botanical diagrams.

12. Apply botanical terminology accurately while describing plant specimens and preparing practical records.

Detailed Syllabus Content

Sl. No.	Practical Exercise	No. of Sessions
1	Study of plant cell structure with epidermal peel mounts (Onion, *Rhoeo*, *Crinum*)	1
2	Observation of cell organelles using electron micrographs	1
3	Microbiology – Gram staining of bacteria and observation under microscope	1
4	Study of vegetative and reproductive structures of *Rhizopus*, *Saccharomyces*, *Agaricus* and *Penicillium*	1
5	Study of thallus structure of crustose, foliose and fructicose lichens	1
6	Study of vegetative and reproductive structures of *Nostoc* (Cyanophyta),*Volvox* (Chlorophyta) and *Chara* (Charophyta)	1
7	Study of *Vaucheria* (Xanthophyta), *Ectocarpus* (Phaeophyta) and *Polysiphonia* (Rhodophyta)	1
8	Study of vegetative and reproductive structures of *Marchantia* (Liverworts) and *Anthoceros* (Hornworts)	1
9	Study of *Funaria* (Mosses)	1
10	Study of vegetative and reproductive structures of *Lycopodium* and *Selaginella*	1
11	Study of vegetative and reproductive structures of *Pinus* and *Cycas*	1
12	Study of fossil types and fossil slides	1
13	Study of floral and vegetative characters for identification of five angiosperms (Session 1)	1
14	Study of floral and vegetative characters for identification of five angiosperms (Session 2)	1
15	Observation of specialized root forms of five angiosperms, specialized leaves of ten angiosperms, and observation of special inflorescences and fruit types of ten angiosperms	1

.*Each Session covers 2 hours*

Suggested Readings

1. Bendre and Kumar. 2018. A Text Book Of Practical Botany, Volume I. Rastogi Publications.

2. Choudhary, S. S., Choudhary, P. and Prasad, T. 2001. Practical Botany (Cryptogams & Gymnosperms). CBS Publishers.

Additional Readings

2. British Columbia Ministry of Forests. 1996. Techniques and procedures for collecting, preserving, processing, and storing botanical specimens. Res. Br., B.C. Min. For., Victoria, B.C. Work. https://www.floridamuseum.ufl.edu/wp-content/uploads/sites/67/2021/08/Wp18.pdf

List of Essential Major Equipment

- Compound light microscopes (with 40X–1000X magnification)
- Dissecting microscopes (stereo microscopes)
- Microtome (for sectioning plant tissues)
- Autoclave (for sterilisation of media and materials)
- Hot air oven and incubator
- Laminar air flow unit (for microbial work)
- Electronic balance (analytical)
- Refrigerators and deep freezer (for storage of specimens and chemicals)
- Computerized Microscope or USB Digital camera attachment for microscopes (optional, for recording observations)

Major Laboratory Stores/Consumables Required

- Glassware: Slides, cover slips, Petri dishes, test tubes, beakers, flasks, measuring cylinders, watch glasses
- Dissecting tools: Forceps, needles, scalpels, scissors, brushes
- Mounting media and stains: Glycerine, lactophenol, safranin, iodine solution, cotton blue, crystal violet, etc.
- Permanent slides and preserved specimens (lower plants and angiosperms)
- Culture media for bacteria and fungi (e.g., PDA, Nutrient Agar medium)
- Disinfectants and laboratory cleaning supplies
- Drawing sheets, notebooks, and stationeries for students

Essential Software (Licensed/Open-Source)

- ImageJ (Open-source) – for analysing micrographs
- BioRender (Licensed/Online) –for preparing life-cycle diagrams and illustrations (optional)

Skill Enhancement Course

Nursery Management and Gardening (Theory)

Nature of Course	Skill Enhancement Course				
Course Code	SEC45BOT101a(T)25				
Course Title	Nursery Management and Gardening (Theory)				
Course Level	Level 100				
Credit Details	Total Credit	Lecture/ Week	Tutorial/ Week	Practical/Week	Total Hours/ Week
	2	2			2
Course Audience	Major Students enrolled in the FYUGP in Botany				
Associated Theory Courses (Topics)					
Skill Training Required (if any)	Basic understanding of plant biology at the higher secondary level or equivalent.				
Pre-Requisite Course Required (if any)	1. 2.				
Faculty Eligibility and Specialization (if any)	Successful completion of Biology at the higher secondary level or equivalent examination.				

Course Objective

This course aims to equip students with foundational skills in nursery management and gardening. Students will learn the processes of seed sowing, vegetative propagation, raising and maintaining seedlings, and the planning of home and landscape gardens. Emphasis is placed on practical exposure, including the cultivation of common vegetables and ornamental plants, and field visits to nurseries to develop hands-on competency in applied botany.

Course Learning Outcomes

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

7. Understand the principles and techniques of seed sowing and nursery establishment.
8. Identify and list essential resources and structures required for a functional nursery.

9. Differentiate various methods of plant propagation and apply them to common species.
10. Analyse and perform basic gardening operations, including soil preparation, manuring, and pest management.
11. Demonstrate appreciation for plant diversity through practical nursery and gardening activities.
12. Observe, record, and document the growth and development of ornamental and vegetable plants in nursery and home garden settings.

Detailed Syllabus Content

Unit 1: Nursery Management

Definition, objectives, scope; infrastructure development; seasonal activities; direct seeding vs. transplanting.

***Unit 2: Seed Biology and* Handling**

Structure and types of seeds; dormancy and its breaking; seed storage and seed banks; seed viability and genetic erosion; basics of seed production, testing, and certification.

Unit 3: Vegetative Propagation and Protected Structures

Methods (cutting, layering, grafting); selection and treatment of cuttings; hardening of plants; greenhouse, shade house, mist chamber, and glasshouse.

Unit 4: Gardening Principles

Definition and objectives; types of gardens (landscape, home, park); garden design and plant materials; computer applications in landscaping;

Unit 5: Gardening Operations

Soil laying, manuring, watering, pest and disease management, transplanting of seedlings; cultivation of vegetables (cabbage, mustard, brinjal, lady's finger, onion, allium, tomato, carrot); basics of storage and marketing.

Suggested Readings

7. Bose, T.K. & Mukherjee, D. (1972). *Gardening in India.* Oxford & IBH Publishing Co., New Delhi.
8. Sandhu, M.K. (1989). *Plant Propagation.* Wiley Eastern Ltd., Bengaluru.
9. Kumar, N. (1997). *Introduction to Horticulture.* Rajalakshmi Publications, Nagercoil.

10. Edmond, J.B., Musser, A.M. & Andres, F. (1978). *Fundamentals of Horticulture.* McGraw-Hill Book Co., New Delhi.
11. Agrawal, P.K. (1993). *Handbook of Seed Technology.* Department of Agriculture & Cooperation, National Seed Corporation Ltd., New Delhi.
12. Janick, J. (1979). *Horticultural Science* (3rd Ed.). W.H. Freeman and Co., San Francisco, USA.

Skill Enhancement Course

Nursery Management and Gardening (Practical)

Course Code: SEC45BOT101a(P)25

Credit: 1

Detailed Syllabus Content

Sl. No.	Practical Activity / Experiment	No. of Sessions
1	Study the process of seed sowing in nursery beds and trays.	1
2	Demonstration of soil preparation and potting mixtures for nursery beds.	1
3	Study of different forms of seed sowing and plant growing methods (direct seeding, transplanting, tray method).	1
4	Observation and recording of germination and seedling care in nursery.	1
5	Study of vegetative propagation methods – stem cutting and air-layering.	1
6	Vegetative propagation demonstration – grafting and budding (seasonal or video demo).	1
7	Observation of growth stages of nursery seedlings and transplanted vegetables.	1
8	Maintenance practices in nursery – watering, thinning, weeding, and manuring.	1
9	Observation of pest and disease symptoms in nursery plants and basic management methods.	1
10	Demonstration of transplanting seedlings to pots or garden beds.	1
11	Preparation and labelling of potted plants for small garden displays.	1
12	Study of cold storage models and simple storage methods for harvested vegetables.	1

13	Computer-aided garden layout and landscaping demonstration using basic/free tools.	1
14	Field visit to a local nursery – observation of layout, propagation, and storage facilities.	1
15	Preparation and submission of nursery visit report with observations and simple plant inventory.	1

Each Session covers 2 hours

Major Equipment (Laboratory and Field Use)

- Nursery seed trays and germination trays
- Potting benches and seedling racks
- Watering cans, sprayers, and hose pipes
- Hand tools: trowels, pruners, cutters, and weeding forks
- Mist chamber / simple propagation chamber (if available)
- Shade net and mini greenhouse (demonstration, if possible)
- Simple cold storage cabinet / model for vegetables
- Weighing balance (for soil and manure mixing)

Consumables / Stores

- Garden soil, sand, compost, and FYM (farmyard manure)
- Seeds of common vegetables and ornamental plants
- Polybags, pots, and trays for seedling raising
- Labels, markers, and plastic tags for plant identification
- Basic pesticides/fungicides for demonstration (as per safety norms)
- Fertilizers: Urea, DAP, Potash (for demonstration only)
- Disposable gloves and cleaning materials
- Gardening epuipments

CO-PSO Mapping

CLOs	PSO 1	PSO2	PSO3	PSO4	PSO 5	PSO6	PSO7	PSO 8	PSO9	PSO10	PSO11
CLO1	–	–	**3**	**3**	–	**2**	–	–	–	–	–
CLO2	–	–	**2**	**3**	–	**2**	–	–	–	–	–
CLO3	–	–	**3**	**3**	–	**3**	–	–	–	–	–

CLO4	–	–	**3**	**3**	–	**3**	–	–	**2**	–	**2**
CLO5	**3**	–	–	**2**	–	**2**	–	–	**3**	–	**2**
CLO6	–	–	**3**	**2**	**2**	**2**	–	–	–	**2**	**2**

Theory Course Teaching-Learning Process

The important relevant teaching and learning processes involved in this course are;

- Class lectures
- Seminars
- Tutorials
- Group discussions and Workshops
- Statement, reasoning and explanation
- Project-based learning
- Field-based learning
- Presentations through Posters and power point
- Internship in industry and research institutional

Student Activities for Practical Courses

- Field visit to local nurseries
- Nursery bed preparation
- Seed sowing practice
- Maintenance of nurseries
- Nursery record maintenance
- Practice of vegetative propagation methods
- Maintenance of potted plants
- Harvesting of vegetables
- Visit to local cold storages
- Quiz or spot tests
- Maintenance of practical record books

Skill Enhancement Course

Biofertilizers (Theory)

Nature of Course	Skill Enhancement Course				
Course Code	SEC45BOT101b(T)25				
Course Title	Biofertilizers (Theory)				
Course Level	Level 100				
Credit Details	Total Credit	Lecture/ Week	Tutorial/ Week	Practical/Week	Total Hours/ Week
	2	2			2
Course Audience	Major Students enrolled in the FYUGP in Botany				
Associated Theory Courses (Topics)					
Skill Training Required (if any)	Basic understanding of plant biology at the higher secondary level or equivalent.				
Pre-Requisite Course Required (if any)	1. 2.				
Faculty Eligibility and Specialization (if any)	Successful completion of Biology at the higher secondary level or equivalent examination.				

Course Objective

This course aims to introduce the role of biofertilizers in sustainable agriculture and teach basic preparation techniques for plant-associated microbial inoculants. Students will learn to prepare, test, and apply simple biofertilizers like *Rhizobium* and *Azotobacter*, linking botanical knowledge with agricultural applications.

Course Learning Outcomes

Students will be able to:

1. Understand the basic concept of biofertilizers.
2. Explain the importance of biofertilizers in plant growth and soil health.
3. Explain the attributes of bio-inoculants in soil fertility.
4. Demonstrate preparation and storage of simple microbial biofertilizers.
5. Familiarize the commercial bifertilizers.
6. Apply biofertilizers to plants and assess basic growth responses.

Detailed Syllabus Content

Unit 1: Types of Biofertilizers

Introduction, types and importance of bio-fertilizers in agriculture, organic farming system and biocontrol of plant diseases; History of bio-fertilizers production; Micro-organisms used in bio-fertilizer production- *Rhizobium, Azobacter, Azospirillum,* Cyanobacteria, Mycorrhiza, Actinomycorrhiza.

Unit II: Nitrogen Fixing Biofertilizers

Classification of biological nitrogen fixation; factors influencing nitrogen fixation; Rhizobia, process of nodule formation, role of Nif and Nod gene in biological nitrogen fixation; *Azolla* and *Anabaena* association, cyanobacteria in rice cultivation. Actinomycorrhizal symbiosis

Unit III: Mycorrhizal Biofertilizers

Mycorrhizal association: type, colonization of mycorrhiza and contribution in nutrient uptake. taxonomy, occurrence and distribution, phosphorus nutrition, growth and yield, its influence on growth and yield of crop plants.

Unit IV: Decomposers

Organisms used as decomposers (bacteria, fungi, insects and earthworms); Role and importance of decomposers in ecosystems (including agro-ecosystems); Steps of decomposition; Factors affecting decomposition; Role of decomposers in soil fertility

Unit V: Mass Production of Biofertilizers

Strategies of Mass multiplication and packaging; Quality standard for bio-fertilizers; Different methods of application of bio-fertilizers, Methods of quality control assessment in respect of bio-fertilizers; Registration of bio-fertilizers.

Skill Enhancement Course

Biofertilizers (Practical)

Course Code: SEC45BOT101b(P)25 **Credit: 1**

Detailed Syllabus Content

Sl. No.	Practical Activity / Experiment	No. of Sessions
1	Study of bacteria, cyanobacteria (used in biofertilizers) from temporary mounts /permanent slides.	1
2	Study of *Rhizobium* from root nodules of leguminous plants by Gram staining method	1
3	Preparation of Yeast Extract-Mannitol-Agar medium (for *Rhizobium* culture)	1
4	Isolation of *Rhizobium* from root nodules	1
5	Morphological study and isolation of *Anabaena* from *Azolla* leaf	1
6	Observation of different mycorrhizae from temporary mounts/permanent slides of mycorrhizal roots	1
7	Familiarity of different commercial biofertilizer formulations	1
8	Methods for field application of biofertilizers	1
9	Effect of biofertilizer application on plant growth	1
10	Study of phosphate solubilising fungal species (*Aspergillus, Penicillium* and *Trichoderma*) from temporary mount or permanent slides	1
11	Study of decomposer fungal species *Fusarium, Chaetomium* and *Trichoderma* from temporary mount or permanent slides	1
12	Preparation Potato-Dextrose-Agar medium	1
13	Pure culture maintenance of *Aspergillus/Penicillium/Trichoderma*	1
14	Quality control of bio-fertilizers: ISI standards specified and estimating the viable bacterial count in carrier based bio-fertilizers	1
15	Preparation of proposal of bio-fertilizers production unit	1

Each Session covers 2 hours

Suggested readings

11. Anonymous 2016. Proceedings of Workshop on Biofertilizers.New Delhi. Delhi: Zakir Husain Delhi College
12. Kumaresan, V. 2005. Biotechnology.New Delhi, Delhi: Saras Publication.

13. Sathe, T.V. 2004. Vermiculture and Organic Farming.New Delhi, Delhi: Daya publishers.
14. Subha Rao, N.S. 2000. Soil Microbiology.New Delhi, Delhi: Oxford & IBH Publishers.
15. Subba Rao, N.S. 1993. Biofertilizers in Agriculture and Forestry. Oxford and IBH. Publ. Co., New Delhi.
16. Vayas,S.C, Vayas, S., Modi, H.A. 1998. Bio-fertilizers and organic Farming. Nadiad, Gujarat: Akta Prakashan
17. https://www.biologyonline.com/dictionary/decomposer.
18. https://byjus.com/biology/what-is-decomposition.
19. https://education.nationalgeographic.org/resource/decomposers.
20. https://biologydictionary.net/decomposer.

Major Laboratory Stores/Consumables Required

- Glassware: Slides, cover slips, Petri dishes, test tubes, beakers, flasks, measuring cylinders, watch glasses
- Dissecting tools: Forceps, needles, scalpels, scissors, brushes
- Mounting media and stains: Glycerine, lactophenol, safranin, iodine solution, cotton blue, crystal violet, etc.
- Permanent slides of fungal species
- Culture media for bacteria and fungi (e.g., PDA, Yeast Extract Agar, Nutrient Agar)
- Laminar Air Flow for microbiological works
- Microscopes
- Disinfectants and laboratory cleaning supplies
- Drawing sheets, notebooks, and stationeries for students

CO-PSO Mapping

CLOs	PSO 1	PSO2	PSO3	PSO4	PSO 5	PSO6	PSO7	PSO 8	PSO9	PSO10	PSO11
CLO1	–	–	**3**	**3**	–	**2**	–	–	–	–	–
CLO2	–	–	**2**	**3**	–	**2**	–	–	–	–	–
CLO3	–	–	**3**	**3**	–	**3**	–	–	–	–	–
CLO4	–	–	**3**	**3**	–	**3**	–	–	**2**	–	**2**
CLO5	**3**	–	–	**2**	–	**2**	–	–	**3**	–	**2**
CLO6	–	–	**3**	**2**	**2**	**2**	–	–	–	**2**	**2**

Theory Course Teaching-Learning Process

The important relevant teaching and learning processes involved in this course are:

- Class lectures
- Seminars
- Tutorials
- Group discussions and Workshops
- Statement, reasoning and explanation
- Field-based learning
- Presentations through posters and power point
- Internship in industry and research institutional

Student Activities for Practical Courses

- Collection of *Azolla* and root nodules and laboratory studies
- Collection of micorrhizal roots and laboratory studies
- Preparation of bacterial and fungal culture media
- Pure culture isolation of *Anabaena* and *Rhizobium*
- Examination of carrier based commercial biofertilizers
- Field application of biofertilizers
- Study of phosphate solubilising fungal species
- Study of decomposer fungal species
- Field monitoring of biofertilizer applied plants
- Visit to local available biofertilizer labs
- Quiz or spot tests
- Maintenance of practical record books