To,

The Additional Chief Secretary

Lok Bhawan, Bihar, Patna.

Date: 29th June 2026

Subject: Submission of revised Proposed Course Structure and Uniform Syllabus for M.Sc. in Botany (Semester I and II) under the Two-Year Postgraduate Programme in accordance with NEP 2020 and UGC Regulations

Ref.- Letter No. BSU(UGC)-02/2023-1153/GS(1), Dated 10/06/2026 and email dt. 23/06/2026

Sir,

With reference to the letter cited above, and in compliance with the directions contained therein, we are pleased to submit the revised version of proposed Course Structure and Uniform Syllabus for M.Sc. in Botany for Semester I and Semester II of the Two-Year Postgraduate Programme.

The proposed curriculum has been prepared in conformity with the University Grants Commission (UGC) Regulations, the UGC Curriculum and Credit Framework for Postgraduate Programmes, and the provisions of the National Education Policy (NEP), 2020, with due emphasis on multidisciplinary learning, outcome-based education, academic flexibility, and research orientation.

The same is submitted for kind consideration and further necessary action.

Enclosed – as above.

Yours' faithfully

[Professor Sushil Kumar Singh]
Department of Botany
A. N. College Patna
Patliputra University Patna

[Dr. Meenu Gupta]
Department of Botany
J. D. Women's College Patna
Patliputra University Patna

[Dr. Sumit Kumar]
Department of Botany
Nalanda College Bihar Sharif
Patliputra University Patna

Post Graduate Curriculum Framework

With effect from the Academic Session 2026–27, the M.Sc. in Botany programme in the Universities of Bihar shall be offered in accordance with the UGC Curriculum and Credit Framework for Postgraduate Programmes (PGCF) and the provisions of the National Education Policy (NEP), 2020.

The programme provides flexibility to students to pursue either a Two-Year Master's Degree Programme or a One-Year Master's Degree Programme for candidates who have completed a four-year undergraduate degree with the requisite credits and qualifications as prescribed by UGC.

The curriculum is designed under the Choice Based Credit System (CBCS) and comprises a combination of Core Courses (CCs), Discipline Specific Electives (DSEs), Generic Electives (GEs), Skill Enhancement Courses (SECs), Ability Enhancement Courses (AECs), and Value Added Courses (VACs). The programme seeks to impart advanced theoretical knowledge, computational proficiency, research aptitude, and practical skills in Statistics and its applications.

Each academic year shall consist of two semesters. Students shall be required to successfully complete the prescribed combination of Core, Elective (Discipline/Generic/Open), Skill Enhancement, Ability Enhancement, and Value Added Courses in each semester to fulfil the credit requirements of the programme.

The curriculum integrates contemporary developments in Botany, including DNA barcoding for quality control, cell signaling mechanisms, socio-ecological frameworks, bioactivity-guided fractionation, biostimulants and biofertilizers, the application of plant breeding for developing climate- and pathogen-resilient crop varieties, the production of renewable energy sources such as biofuels, intellectual property rights (IPR) related to plant products, and the ecological role of algae in the global carbon cycle, alongside the core areas of the discipline. The syllabus and reading materials shall be reviewed periodically to ensure alignment with emerging developments in academia, research, industry, and public policy.

Teaching-learning methodologies may include lectures, tutorials, seminars, laboratory sessions, statistical computing exercises, case studies, project work, field-based applications, and research assignments. Practical training shall provide hands-on experience in the use of statistical software packages, data analysis techniques, computational tools, and real-world problem-solving.

Assessment shall be conducted through a combination of continuous evaluation and end-semester examinations, including assignments, presentations, practical examinations, projects, viva-voce examinations, and written tests, as prescribed by the authorities concerned from time to time.

Students shall have the opportunity to choose elective and generic courses in accordance with their academic interests, subject to the availability of courses and institutional regulations, thereby promoting interdisciplinary learning and specialization within the broad domain of Botany.

24/07/26

Kalpana Srivastava
Officer on special duty (Judicial)

COURSE OF STUDIES	
Botany (M.Sc.)	
Programme Level	Master of Science (M.Sc.)
Subject / Discipline	Botany
Faculty	Faculty of Science
University	Universities of Bihar Established under the BSU AC 1976/PU Act 1976.
Duration	Two Years / Four Semesters
NHEQF Level	Level 6.5
Effective from	2026-27 onwards

A PART A — PROGRAMME OVERVIEW & OBJECTIVES

A.1 Graduate Attributes (GAs)

The programme nurtures the following Graduate Attributes in alignment with the National Higher Education Qualifications Framework (NHEQF) Level 6.5:

- Demonstrate in-depth conceptual knowledge of biomolecules, Cell Biology, Molecular Biology, Plant Physiology, Genetics, Ecology, Plant Taxonomy, and Biotechnology, along with a comprehensive understanding of the evolutionary trends of diverse plant groups ranging from algae to phanerogams.
- Competence in specialized fields like Plant Pathology, Ethnobotany and Recombinant DNA Technology.
- The ability to conceptualize, design, and execute independent research projects and laboratory experiments, along with proficiency in operating modern laboratory instruments, applying statistical tools for handling complex datasets and using bioinformatics tools.
- Competence in identifying and classifying plant species with the help of standard keys.
- Capability of analytical reasoning and identify gaps or logical flaws in existing plant science literature and hypothesis testing.
- Ability to monitor biodiversity and competence in biodiversity mapping, with the capacity to design and implement conservation strategies for threatened species and address climate adaptation challenges through restoration ecology.
- Good proficiency in writing peer-reviewed research papers, project reports and presenting complex data.
- Ability to interface effectively with stakeholders in agricultural sectors, pharmaceutical industries and environmental consultancies.
- Assess the impact of global environmental changes on plant diversity and recognize that solutions require international and intercultural cooperation.
- Critically evaluate how different cultures classify, use and conserve plants, integrating scientific botanical knowledge with indigenous and local knowledge systems.

24/07/26
Kalpana Srivastava
Officer on special duty (Judicial)

24.06.2026

- Identify culturally significant plants and understand their role in identity, tradition and livelihood across different societies.
- Absolute compliance with biosafety protocols, laboratory safety mandates, and ethical standards regarding genetic modification and publication codes and adherence to legal and ethical protocols regarding the sourcing and utilization of medicinal plants and ethnobotanical assets.
- Identify market opportunities in plant-based products and services.

A.2 Programme Outcomes (POs)

The Programme Educational Objectives describe the career and professional accomplishments that postgraduates are expected to attain within two to three years of post-graduation.

1. PO 1 — Demonstrate a sound understanding of the academic and technical aspects of Botany, its various domains of learning and applications and its linkages with related interdisciplinary subjects.
2. PO 2 — Acquire knowledge of Ecology, Ethnobotany, plant diversity, Conservation Biology, and Climate Change Biology, enabling them to contribute to the conservation of biodiversity and the mitigation of climate change impacts.
3. PO 3 — Develop the competence to pursue careers in premier scientific institutions as Research Fellows, Project Scientists, Agronomists, Plant Pathologists, Ecologists, Environmental Consultants, or professionals in Quality Control (QC) and Research & Development (R&D) sectors.
4. PO 4 — Develop technical skills in Biotechnology, Biostatistics and Biophysical techniques, and apply these skills effectively in research, academia and industry.
5. PO 5 — Be empowered with the knowledge and entrepreneurial skills required to establish commercial plant nurseries, mushroom cultivation units, organic farming enterprises, tissue culture laboratories and businesses related to the formulation and production of herbal and botanical products.

A.3 Programme Specific Outcomes (PSOs)

Upon successful completion of this programme, a student shall demonstrate the following learning outcomes:

1. PSO 1 — Demonstrate comprehensive knowledge of fundamentals and evolving paradigms of Botany.
2. PSO 2 — Equip the student with skills to analyze problems, formulate hypotheses, evaluate and validate results and draw reasonable conclusions regarding plant forms, with appropriate consideration for public safety and the environment.
3. PSO 3 — Create, select and apply proper strategy and techniques in understanding problems and to provide possible solutions, interpret data to provide valid conclusions in Botany and related fields.
4. PSO 4 — Able to communicate effectively on plant processes, their diversity, distribution and abundance and to comprehend and write effective reports, design documentation and make effective presentations.

24/07/26

29.06.2026

Meeru.

Kalpana Srivastava
Officer on special duty (Judicial)

5. PSO 5 — Understand the structure and functioning of the ecosystem, issues and management of various resources and their sustainable use.

B PART B — COURSE STRUCTURE (CBCS/NHEQF FRAMEWORK)

B.1 Semester-wise Course Structure

The following table presents the full four-semester course structure. Column headings: L = **Lectures per week**; T = Tutorials per week; P = Practicals per week; CC = Core Course; DSE = Discipline Specific Elective; GE/OE = Generic/Open Elective; SEC = Skill Enhancement Course; PROJ = Project/Dissertation.

S.No.	Paper Code	Title of the Course/Paper	L	T	P	Credits	Max. Marks	Type
SEMESTER I								
1	MSBOT-CC101	Core Course I: Biomolecules and Cell Biology	3	1	0	4	100	CC
2	MSBOT-CC102	Core Course II: Phycology, Microbiology, Mycology & Plant Pathology	3	1	0	4	100	CC
3	MSBOT-CC103	Core Course III: Archegoniates, Paleobotany & Plant Anatomy	3	1	0	4	100	CC
4	MSBOT-PC104	Core Course IV: Practicals	0	0	4	4	100	PC
5	MSBOT-GE105/GE106	Generic Elective I: (One course to be chosen from the basket I)	3	1	0	4	100	GE
6		VAC/AEC/SEC	2	0	0	2	100	VAC/AEC/SEC
		Total — Semester I	14	4	4	**22**	**600**	
SEMESTER II								
1	MSBOT-CC201	Core Course I: Plant Taxonomy, Embryology, and Tissue culture	3	1	0	4	100	CC
2	MSBOT-CC202	Core Course II: Plant Physiology	3	1	0	4	100	CC

24/07/26

Meenu.

S.No.	Paper Code	Title of the Course/Paper	L	T	P	Credits	Max. Marks	Type
3	MSBOT-CC203	Core Course III: Genetics and Plant Breeding	3	1	0	4	100	CC
4	MSBOT-PC204	Core Course IV: Practicals	0	0	4	4	100	PC
5	MSBOT-GE205/GE206	Generic Elective I: (One course to be chosen from the basket II)	3	1	0	4	100	GE
6		VAC/AEC/SEC	2	0	0	2	100	VAC/AEC/SEC
		Total — Semester II	**14**	**4**	**4**	**22**	**600**	

Particulars	Semester	Course Code	Course Title
Basket I	I	MSBOT-GE105	Mushroom Cultivation
		MSBOT-GE106	Biofuels
Basket II	II	MSBOT-GE205	Biofertilizer Technology
		MSBOT-GE206	Intellectual Property Rights (IPR)

24/07/26
Kalpana Srivastava
Officer on special duty (Judicial)

C PART C — COURSES OF STUDIES

MSBOT-CC101

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSBOT-CC101
Title of the Paper	Core Course I: Biomolecules and Cell Biology
Programme / Subject	M.Sc.— Botany
Semester	Semester I
Nature of Course	Core Course (CC)
L – T – P	3 – 1 – 0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours for ESE

C.2 Marks Distribution

Component	Paper I	Practical	IA	Total (ESE+IA)
End Semester Examination	70	—	—	70
Internal Assessment	—	—	30	30
Maximum Marks	**70**	—	**30**	**100**
Passing Marks	**32**	—	**13**	**45 (45%)**

Note: Internal Assessment shall be evaluated on the basis of attendance, class tests, seminars, assignments, and *viva voce* as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	To explain the structural and functional aspects of Biomolecules
COB 2	To explain the structure of enzymes and their mechanism of action.
COB 3	To elucidate the structural and functional aspects of a cell.
COB 4	To elucidate the concept of chromatin and its coiling to form chromosomes.
COB 5	To illustrate the concept of Cell reproduction and regulation of Cell Cycle.

24/07/26

Meena.

C.4 Course Outcomes (COs)

After completing this course, students will be able to:

CLO No.	Course Learning Outcome
CLO 1	Explain the composition, structure, properties and biological functions of major biomolecules.
CLO 2	Explicate enzyme structure, classification, catalytic mechanisms, kinetics and regulation.
CLO 3	Analyze the principles and applications of microscopy techniques for the visualization of cells and subcellular components.
CLO 4	Elucidate the structural and functional organization of cellular membranes and membrane transport processes.
CLO 5	Elucidate the structure, organization and functions of cellular organelles, cytoskeleton and nuclear components.
CLO 6	Develop a comprehensive understanding of cell cycle regulation, mitosis and meiosis.

C.5 Syllabus — Unit-wise Breakdown

Course Name: Biomolecules and Cell Biology (MSBOT-CC101)		
Unit	**Content**	**Suggested Lectures hours**
I	Composition, structure and function of biomolecules: Carbohydrates, Lipids, Amino acids, Proteins, Conformation of proteins; Stabilizing interactions.	10L + 3T
II	Principles of catalysis, enzymes and enzyme kinetics, enzyme regulation, mechanism of enzyme catalysis, isozymes.	10L + 4T
III	Visualization of cells and subcellular components by light microscopy and advanced microscopic techniques; Scanning and transmission electron microscopes; Cellular Organization: Cell wall and cell membrane: structure and function, Membrane Transport: diffusion, osmosis, ion channels, active transport, membrane pumps, mechanism of sorting and regulation of intracellular transport; Electrical properties of membranes; Cell Signaling: Principles of Cell-Cell Communication in Plants.	08L + 3T
IV	Structural organization and function of cellular organelles- Mitochondria, Plastids, GERL- Endoplasmic Reticulum, Golgi Bodies, Lysosomes, Vacuoles; Ribosomes, Proteasomes, Microbodies - Peroxisomes, Glyoxysomes, cytoskeleton and its role in motility, Cilia, Flagella, Vaults, Cell inclusions;	08L + 3T

24/07/26

Kalpana Srivastava
Officer on special duty (Judicial)

	Nucleus and its organization;	
V	Structure of chromatin and chromosomes, heterochromatin and euchromatin, transposons, Organization and structure of chromosomes; Cell division : Steps in cell cycle, Mitosis and Meiosis, their regulation, apoptosis, necrosis and autophagy.	9L + 2T
	Total Suggested Lectures	**60 (For 4 Credit Course) [45 L+15 T]**

Suggested Pedagogical Methods

1. Debate on Catalysis by students.
2. Visual analysis based on side-by-side images of the same organelle taken via TEM and SEM.
3. Disease Connect: For each organelle, link it to a human/plant pathology (e.g., Mitochondria -> Oxidative stress and aging)
4. Cell Cycle "What If" Scenarios: Based on hypothetical mutations (e.g., Cyclin-CDK complex is overexpressed; p53 is knocked out) students must trace the biochemical consequences through the cell cycle checkpoints (G1/S, G2/M).
5. Flipped Journal Club: Students should be assigned to find and present the experimental evidence that proved protein folding is determined by primary sequence.
6. Thermodynamic Problem-Solving: Numerical/conceptual problems on Gibbs free energy (ΔG) changes in macromolecular interactions,
7. Inhibitor Case Studies for students and on the basis of plot, identification of the type of inhibition and calculation of Ki.

C.6 Recommended Textbooks

1. Ali, S. (2014). *The Cell: Organisation, Functions and Regulatory Mechanisms*. (1st ed.). Pearson India.
2. Choudhary, K. (2025). *Biochemistry*. (5th ed.). IFAS Publication.
3. Verma, P.S. and Agarwal, V.K. (2022). *Cell Biology (Cytology, Biomolecules and Molecular Biology)*. LPSPE, S. Chand Publishing.

C.7 Reference Books & Readings

1. Berg, J.M., Gatto Jr., G.J., Hines, J., Tymoczko, J.L. and Stryer, L. (2023). *Biochemistry*. (10th ed.). W.H. Freeman Macmillan Learning.
2. Buchanan, B., Gruissem, G. and Jones, R. (2015). *Biochemistry and Molecular Biology of Plants*. (2nd ed.). American Society of Plant Physiologists, USA.
3. Campbell, M.K., Farrell, S.O. and McDougal, O.M. (2018). *Biochemistry*. (9th ed.). Cengage Learning.
4. Cooper, G.M. and Hausman, R.E. (2009). *The Cell: A Molecular Approach*. (5th ed.). ASM.
5. De Robertis, E.D.P. and De Robertis, E.M.P. (2018). *Cell and Molecular Biology*. (8th ed.). Wolters Kluwer.
6. Hardin, J., Becker, G. and Kliensmith, L.J. (2021). *Becker's World of the Cell*. (10th ed.). Pearson Education Inc., U.S.A.

24/07/26

Kalpana Srivastava
Officer on special duty (Judicial)

7. Heldt, H.-W. and Piechulla, B. (2024). *Plant Biochemistry*. (6th ed.). Academic Press, New York.
8. Karp, G., Iwasa, J. and Marshall, W. (2020). *Cell Biology*. (9th ed.). John Wiley & Sons, U.S.A.
9. Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A. and Martin, K.C. (2021). *Molecular Cell Biology*. (9th ed.). W.H. Freeman, Macmillan Learning.
10. Nelson, D.L., Cox, M.M. and Hoskins, A. (2021). *Lehninger Principles of Biochemistry*. (8th ed.). W.H. Freeman & Company.

C.7 Suggested E-Resources / Digital Repositories

1. SWAYAM/NPTEL: Cell Biology: Cellular organization, division and processes- https://onlinecourses.nptel.ac.in/e-learning/preview/noc26_bt08
2. SWAYAM/NPTEL: Essentials Of Biomolecules: Nucleic Acids And Peptides- https://onlinecourses.nptel.ac.in/e-learning/preview/noc25_cy14
3. e-PGPathshala:Biomolecules- https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=MNhNzp1RQlU+6LM40KjY1Q==
4. e-PG Pathshala: Cell Biology- https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=1p0OY7YTBClr5D2KEqnvVg==

C.8 Assessment Pattern & Question Paper Design

The **End-Semester examination** shall be conducted as per the following question paper design:

Section A: MCQs/Short Answer Questions (10 × 2 marks = 20 marks) — Covering all Units (mandatory)

Section B: Medium Answer Questions (4 × 5 marks = 20 marks) — Attempt any 4 out of 6 (These 6 questions should cover all Units).

Section C: Long Answer / Essay Questions (3 × 10 marks = 30 marks) — Attempt 3 out of 5 (At least one question from each Unit).

Internal Assessment (30 marks) breakdown:

Written Test(s): 20 marks

Seminar/Assignment/Project: 05 marks

Attendance & Class Participation: 05 marks

24/07/26

Kalpana Srivastava
Officer on special duty (Judicial)

MSBOT-CC102

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSBOT-CC102
Title of the Paper	Core Course II: Phycology, Microbiology, Mycology & Plant Pathology
Programme / Subject	M.Sc.— Botany
Semester	Semester I
Nature of Course	Core Course (CC)
L – T – P	3 – 1 – 0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours for ESE

C.2 Marks Distribution

Component	Paper II	Practical	IA	Total (ESE+IA)
End Semester Examination	70	—	—	70
Internal Assessment	—	—	30	30
Maximum Marks	**70**	**—**	**30**	**100**
Passing Marks	**32**	**—**	**13**	**45 (45%)**

Note: Internal Assessment shall be evaluated on the basis of attendance, class tests, seminars, assignments, and *viva voce* as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	Understanding of algal diversity while emphasizing advances in molecular systematics and phylogenetics.
COB 2	Analyze the salient features of major algal groups.
COB 3	Develop foundational knowledge of Bacterial and Viral biology.
COB 4	Examines the importance of algae, bacteria and viruses in nutrient cycling, primary productivity, symbiosis and ecosystem functioning.
COB 5	Understand the principles of agricultural and industrial microbiology.
COB 6	Comprehensive understanding of fungal diversity and its applied significance in industry.

24/07/26

Kalpana Srivastava
Officer on special duty (Judicial)

C.4 Course Outcomes (COs)

After completing this course, students will be able to:

CLO No.	Course Learning Outcome
CLO 1	Classify major groups of algae, bacteria, and viruses, and explain recent advances in molecular systematics.
CLO 2	Analyze the ecological roles of algae as primary producers and CO_2 fixers, and assess the economic importance of algae as food, feed, and industrial resources.
CLO 3	Conceptualize the principles of bacterial and viral biology.
CLO 4	Elucidate the ecological significance of bacteria and viruses, including their roles in nutrient cycling and symbiotic associations.
CLO 5	Evaluate the economic and applied importance of the microorganisms.
CLO 6	Explain the structural, reproductive and genetic diversity of Fungi and Lichens and evaluate their ecological and economic roles.
CLO 7	Explicate the fundamental principles of plant pathology and apply this knowledge to diagnose and recommend appropriate control measures for specific plant diseases.

C.5 Syllabus — Unit-wise Breakdown

Course Name: Phycology, Microbiology, Mycology & Plant Pathology (MSBOT-CC102)		
Unit	**Content**	**Suggested Lectures hours**
I	Algae: Cell structure, thallus organization and reproduction; Origin and evolution of sex; Types of life cycles; Classification: Role of cell wall, flagella, pigments, reserve food, eye spot and pyrenoids in classification and evolution of algae; Advances in molecular systematics and phylogenetics of algae; Salient features of Cyanophyta, Chlorophyta, Xanthophyta, Bacillariophyta, Phaeophyta and Rhodophyta; Use of algae as food, feed and in industry; Ecological significance- Algae as primary producers and CO_2 fixers in global carbon cycles.	10L + 3T
II	Diversity of microorganisms: Archaea, Bacteria, Phytoplasma, Rickettsia. Ultra-structure of bacteria and archaea; Nutritional classification of bacteria; Bacterial reproduction and genetic recombination; Nature, characteristics and ultrastructure of Virions (TMV and Bacteriophages);	10L + 4T

24/07/26

Kalpana Srivastava
Officer on special duty (Judicial)

	Viral multiplication (Lytic and Lysogenic cycles), transmission and interaction with host plants. Viroids and Prions.	
III	Industrial Microbiology: Industrial production of organic acids (citric acid), antibiotics (penicillin) and enzymes (amylase), microbial strain selection, fermentation technology, downstream processing, quality control and the industrial applications of microbial products in food, pharmaceutical and biotechnology sectors.	08L + 3T
IV	General characters of fungi, cell ultrastructure, thallus, nutrition and reproduction; Sexuality in Fungi, Heterothallism, Heterokaryosis and Parasexuality. Classification of fungi: Recent trends; Brief account of Chytidiomycetes, Zygomycetes, Glomeromycetes, Ascomycetes, Basidiomycetes, Deuteromycetes; Fungi in industry, medicine and as food. Lichens: General account and Economic Importance.	09L + 3T
V	Classification of plant diseases and appearance of symptoms due to different microbes; Role of enzymes and toxin in pathogenesis; Effect of infection on the physiology of the host; Host defense mechanism with special reference to structural and biochemical defense; Genetics of resistance (Vertical vs. Horizontal; Gene-for-gene concept).	08L + 2T
	Total Suggested Lectures	**60 (For 4 Credit Course) [45 L+15 T]**

Suggested Pedagogical Methods

1. Emphasis on hands-on lab work where students observe diverse thallus organization of algae.
2. Ecological and economic context linking algal cellular structures to practical uses like biofuel production, hydrocolloid extraction (alginates/carrageenan), and biofertilizers.
3. Lifecycle tracing by teaching fungal life-cycles using flowcharts, interactive digital animations, and comparative diagrams.
4. Inquiry-based laboratory sessions where students utilize the Gram stain, selective/differential media, and aseptic techniques to isolate and identify unknown bacterial samples.
5. Molecular integration connecting standard microbiological morphology with modern genomic concepts.
6. Diagnosis of plant diseases based on symptoms.
7. Integrated Pest Management (IPM) of disease control by studying biological control agents, host resistance, and chemical interventions.

24/07/26

Kalpana Srivastava
Officer on special duty (Judicial)

8. Digital Repositories: Encourage the use of virtual slide libraries and online herbaria for students to observe fungal spores, viral architectures, and algal diversity outside the physical lab.
9. Project-Based Learning: Assign student projects focusing on applied aspects.

C.6 Recommended Textbooks

1. Dube, H.C. (2007). *Plant Pathology: A Textbook of Fungi, Bacteria and Viruses*. Agrobios India.
2. Dube, H.C. (2024). *An Introduction to Fungi*. (4th ed.). Scientific Publishers, Rajasthan, India.
3. Dubey, R.C. and Maheshwari, D.K. (2005). *A Text Book of Microbiology*. (2nd ed.). S. Chand & Company Ltd.
4. Kumar, H.D. (1999). *Introductory Phycology*. (2nd ed.). Affiliated East-West Press, Delhi.
5. Khan, J. and Dijkstra, J. (2006). *Handbook of Plant Virology*. CRC Press.
6. Mehrotra, R.S. and Aggarwal, A. (1980). *Plant Pathology*. Tata McGraw-Hill Publishing.
7. Singh, R.S. (2024). *Plant Diseases*. (11th ed). MedTech Science Press, New Delhi, India.
8. Srivastava, H.N. (2005). *Algae*. (12th ed.). Pradeep Publication.
9. Vashishtha, B.R., Sinha, A.K. and Singh, V.P. (2010). *Botany for Degree Students: Algae*. (2nd ed.). S. Chand & Company Ltd.

C.7 Reference Books & Readings

1. Ahmadjian, V. and Hale, M.E. (Eds.). (1973). *The Lichen*. Academic Press.
2. Agrios, G.N. (2024). *Plant Pathology*. Ed. Richard Oliver. (6th ed.). Academic Press, Inc.
3. Alexopoulos, C.J., Mims, C.W. and Blackwell, M. (1996). *Introductory Mycology*. John Wiley & Sons.
4. Bold, H.C. and Wynne, M.J. (1984). *Introduction to the Algae* (2nd ed.). Prentice-Hall.
5. Campbell, N.A., Reece, J.B., Urry, L.A., Cain, M.L., Wasserman, S.A., Minorsky, P.V. and Jackson, R.B. (2020). *Biology*. (12th ed.) Pearson Benjamin Cummings, USA.
6. Hull, R. (2003). *Matthew's Plant Virology* (4th ed.). Elsevier.
7. Madigan, M.T., Bender, K.S., Buckley, D.H., Sattley, W.M. and Stahl, D.A. (2021). *Brock Biology of Microorganisms* (16th ed.). Pearson.
8. Lee, R.E. (2018). *Phycology*. (5th ed.). Cambridge University Press, Cambridge.
9. Moore, D., Robson, G.D. and Trinci, A.P.J. (2021). *21st Century Guidebook to Fungi*. 2nd ed., Cambridge University Press, Cambridge.
10. Nash III, T.H. (Ed.). (2008). *Lichens Biology* (2nd ed.). Cambridge University Press.
11. Pelczar, M.J. (2024). *Microbiology*. (6th ed.). Tata McGraw-Hill Co., New Delhi.
12. Sarbhoy, A.K. (2006). *Textbook of Mycology*. ICAR Publications.
13. Tortora, G.J., Funke, B.R. and Case, C.L. (2016). *Microbiology: An Introduction* (11th ed.). Pearson India Education.
14. Webster, J. and Weber, R. (2007). *Introduction to Fungi* (3rd ed.). Cambridge University Press.
15. Willey, J., Sandman, K. and Wood, D. (2020). *Prescott's Microbiology*. (11th ed.). McGraw Hill, India.

24/07/26

Kalpana Srivastava
Officer on special duty (Judicial)

C.7 Suggested E-Resources / Digital Repositories

1. SWAYAM/NPTEL: Phycology and Microbiology - https://onlinecourses.swayam2.ac.in/e-learning/preview/cec25_bt12
2. SWAYAM/NPTEL: Advanced Microbiology - https://onlinecourses.swayam2.ac.in/e-learning/preview/cec22_bt20
3. e-PG Pathshala: Microbial Biodiversity - https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=0Xvq9yUM2ILDrJ07FvlArQ==

C.8 Assessment Pattern & Question Paper Design

The **End-Semester examination** shall be conducted as per the following question paper design:

Section A: MCQs/Short Answer Questions (10 × 2 marks = 20 marks) — Covering all Units (mandatory)

Section B: Medium Answer Questions (4 × 5 marks = 20 marks) — Attempt any 4 out of 6 (These 6 questions should cover all Units).

Section C: Long Answer / Essay Questions (3 × 10 marks = 30 marks) — Attempt 3 out of 5 (At least one question from each Unit).

Internal Assessment (30 marks) breakdown:

Written Test(s): 20 marks

Seminar/Assignment/Project: 05 marks

Attendance & Class Participation: 05 marks

KD 24/07/26

Kalpana Srivastava
Officer on special duty (Judicial)

MSBOT-CC103

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSBOT-CC103
Title of the Paper	Core Course III: Archegoniates, Paleobotany & Plant Anatomy
Programme / Subject	M.Sc. — Botany
Semester	Semester I
Nature of Course	Core Course (CC)
L – T – P	3 – 1 – 0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours for ESE

C.2 Marks Distribution

Component	Paper III	Practical	IA	Total (ESE+IA)
End Semester Examination	70	—	—	70
Internal Assessment	—	—	30	30
Maximum Marks	**70**	—	**30**	**100**
Passing Marks	**32**	—	**13**	**45 (45%)**

Note: Internal Assessment shall be evaluated on the basis of attendance, class tests, seminars, assignments, and *viva voce* as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	Analyze the classification, morphology, reproduction, and evolutionary trends in Bryophytes, Pteridophytes and Gymnosperms.
COB 2	Evaluate the adaptive significance of conducting tissues, stelar evolution, heterospory and pollination mechanisms in land plant evolution.
COB 3	Compare and contrast the reproductive strategies across major Cryptogam and Gymnosperm groups.
COB 4	Examine the ecological and economic importance of Bryophytes, Pteridophytes and Gymnosperms, including their roles in ecosystem dynamics, carbon budget, and human use.
COB 5	Interpret fossil evidence and deduce the affinities and evolutionary significance of key fossil plant groups.

24/07/26

Kalpana Srivastava
Officer on special duty (Judicial)

Meeru

COB 6	Analyze the structural organization, developmental differentiation and functional specialization of plant tissues.

C.4 Course Outcomes (COs)

After completing this course, students will be able to:

CLO No.	Course Learning Outcome
CLO 1	Classify and distinguish major orders of Bryophyta, Pteridophtya and Gymnosperm based on vegetative and reproductive features.
CLO 2	Discuss the major evolutionary trends in Archegoniates that facilitated the adaptation to higher plants on land.
CLO 3	Describe the mechanisms of vegetative propagation, perennation, capsule dehiscence and spore dispersal in Bryophytes as well as gametophyte and nutrient ecology in Pteridophytes.
CLO 4	Assess the economic importance of Bryophyta and Pteridophtya and the impact of coniferous forests on human life.
CLO 5	Analyze the comparative anatomy and reproductive structures of living Gymnosperms and discuss their interrelationships.
CLO 6	Identify and interpret major fossil groups with respect to their morphology, anatomy, reproductive structures, geological time scale and evolutionary affinities.
CLO 7	Interpret anomalous secondary growth, nodal anatomy from a phylogenetic perspective and apply wood anatomical features to solve problems in plant identification and drug authentication.

C.5 Syllabus — Unit-wise Breakdown

Course Name: Archegoniates, Paleobotany & Plant Anatomy (MSBOT-CC103)		
Unit	**Content**	**Suggested Lectures hours**
I	General features and Classification (Recent trends in classification); Comparative morphology, anatomy and reproductive adaptations of Hepaticopsida-Marchantiales Anthocerotopsida-Antocerotales Bryopsida- Sphagnales and Funariales Gametophytes; Evolutionary trends in sporophytes; Conducting tissues in Bryophyta.	8L + 3T
II	Distinguishing features and Classification of Pteridophytes; Comparative morphology, anatomy and reproduction of *Psilotum, Lycopodium, Selaginella, Equisetum, Ophioglossum, Dryopteris Marsilea.* Evolution of stelar types; Heterospory and seed habit in Pteridophytes;	10L + 4T

KD 24107126

	Comparative account of Apospory and Apogamy; Ecological and economical perspective of pteridophytes.	
III	Characteristic features, distribution and economic importance of Gymnosperms; Classification of Gymnosperms; Morphology, vegetative anatomy and reproductive morphology of Cycadales, Ginkgoales, Coniferale, Ephedrales, Welwitschiales and Gnetales. Evolution of pollination mechanisms in Gymnosperms.	10L + 4T
IV	Types and Nomenclature of fossils; Fossilization process and geological time-scale; Comparative morphology, anatomy, reproductive structure and affinities of the following fossil groups: Psilophytales, Lepidodendrales, Cycadeoidales, Cordaitales, Pentoxylales.	9L + 2T
V	Organization of shoot and root apical meristem, shoot and root development, leaf development and phyllotaxy, transition to flowering, floral meristems, organogenesis and floral development. Cambium and its derivative tissues, differentiation of secondary xylem and secondary phloem; Cork cambium and its derivatives, function of cork and abscission layers, Nodal Anatomy - A phylogenetic consideration.	8L + 2T
	Total Suggested Lectures	**60 (For 4 Credit Course) [45 L+15 T]**

Suggested Pedagogical Methods

1. Field visit to observe bryophyte diversity in their natural environment and study their ecological roles.
2. Comparative Morphology Workshop: Study prepared slides and live specimens of bryophytes, and prepare a comparative table of their gametophytic and sporophytic features, with emphasis on the evolutionary progression of the sporophyte.
3. Literature Review: Students should present a review article on the phylogenetic position of bryophytes using molecular data.
4. Stele Evolution: Students examine prepared sections of various stelar types (protostele, siphonostele, dictyostele, etc.).
5. Seed Habit Debate - Was the seed habit a 'quantum leap' or a 'gradual evolution' in plant history?"
6. Ecological Focus: Discussion on the role of pteridophytes in ancient and modern ecosystems, including their use as bioindicators, in phytoremediation, and in the horticulture industry.
7. A visit to a botanical garden to observe and study the morphology and reproductive structures of living gymnosperms.

24/07/26

Kalpana Srivastava
Officer on special duty (Judicial)

8. Pollination Mechanism Workshop: Students trace the evolution of pollination from simple anemophily (wind) in conifers to entomophily (insect) in *Gnetum*.
9. Geological Time-Scale Exercise: Students construct a detailed geological time-scale, marking the appearance, dominance, and extinction of major plant groups.
10. Secondary Growth Analysis
11. Primary Literature Dive to understand the molecular control of flower development (e.g., the ABC model). Students presentation on the role of specific transcription factors.

C.6 Recommended Textbooks

1. Bhatnagar, S.P. and Moitra, A. (1996). *Gymnosperms*. New Age International (P) Ltd.
2. Bhojwani, S.S., Bhatnagar, S.P. and Dantu, P.K. (2015). *The Embryology of Angiosperms*. Vikas Publishing House Pvt. Ltd.
3. Biswas, C. and Johri, B.M. (1997). *The Gymnosperms*. Springer.
4. Chopra, R.N. and Kumra, P.K. (1988). *Biology of Bryophytes*. New Age International (P) Ltd.
5. Johri, B.M. (1984). *Embryology of Angiosperms*. Springer-Verlag.
6. Kharade, S.S. (2025). *A Text Book of Plant Diversity: Algae, Fungi, Bacteria, Bryophytes, Pteridophytes, Gymnosperm, Paleobotany, Angiosperm*. Shashwat Publication.
7. Parihar, N.S. (1961). *An Introduction to Embryophyta: Volume I – Bryophyta,* Central Book Depot.
8. Parihar, N.S. (1965). *The Biology and Morphology of Pteridophytes*. The Indian Universities Press.
9. Pant, D.D. (2002). *An Introduction to Gymnosperms, Cycas and Cycadales*. Birbal Sahni Institute of Palaeobotany (BSIP).
10. Raghavan, V. (2000). *Developmental Biology of Flowering Plants*. Springer-Verlag.
11. Rashid, A. (1998). *An Introduction to Bryophyta (Diversity, Development and Differentiation)*. Vikas Publication House Pvt. Ltd.
12. Rashid, A. (1999). *An Introduction to Pteridophyta: Diversity and Differentiation*. Vikas Publication House Pvt. Ltd.
13. Sahni, K.C. (1990). *Gymnosperms of India and Adjacent Countries*. M/S Bishen Singh Mahendra Pal Singh.
14. Sambamurty, A.V.S.S. (2016). *A Textbook of Bryophytes, Pteridophytes, Gymnosperms and Paleobotany*. I.K. International Pvt. Ltd.
15. Singh, H. (1978). *Embryology of Gymnosperms*. Gebrüder Borntraeger.Sinnott, E.W. (1960). *Plant Morphogenesis*. McGraw-Hill Book Company, Inc.
16. Singh, V., Pande, P.C. and Jain, D.K. (1987). *Anatomy of Seed Plants*. Rastogi Publications.
17. Vasishta, P.C., Sinha, A.K. and Kumar, A. (1976). *Botany for Degree Students, Vol. V: Gymnosperms*. S. Chand & Co. Ltd.

C.7 Reference Books & Readings

1. Chamberlain, C.J. (1986). *Gymnosperms: Structure and Evolution*. CBS Publishers and Distributors.
2. de Vogel, E.F. (1980). *Seedlings of Dicotyledons*. Centre for Agricultural Publishing and Documentation.

24/07/26
Kalpana Srivastava
Officer on special duty (Judicial)

3. Eames, A.J. and MacDaniels, L.H. (1972). *An Introduction to Plant Anatomy*. McGraw-Hill.
4. Esau, K. (1971). *Anatomy of Seed Plants*. John Wiley & Sons.
5. Fahn A. (1982). *Plant Anatomy*. Pergamon Press.
6. Rudall, P.J. (2007). *Anatomy of Flowering Plants: An Introduction to Structure and Development*. (3rd ed.). Cambridge University Press.
7. Smith, G.M. (1972). *Cryptogamic Botany: Bryophytes and Pteridophytes* (Vol. II). Tata McGraw-Hill Publishing Company Ltd.
8. Sporne, K.R. (1962). *The Morphology of Pteridophytes*. Hutchinson & Co. Publishers Ltd.
9. Sporne, K.R. (1965). *The Morphology of Gymnosperms*. Hutchinson & Co. (Publishers) Ltd.
10. Turrill, W.B., Rollins, R.C. and Taylor, G. (Eds.). (2013). *Vistas in Botany*. (1st ed.). Pergamon Press.
11. Vanderpoorten, A. and Goffinet, B. (Eds.). (2009). *Introduction to Bryophytes*. Cambridge University Press.

C.7 Suggested E-Resources/Digital Repositories

1. SWAYAM/NPTEL: Plant groups (Plant Diversity) - https://onlinecourses.swayam2.ac.in/e-learning/preview/cec22_bt19
2. SWAYAM/NPTEL: Anatomy of Flowering Plants - https://onlinecourses.swayam2.ac.in/e-learning/preview/ini25_bt10
3. e-PG Pathshala: Plant Development - https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=1p0OY7YTBClr5D2KEqnvVg==
4. Glime, J.M. (2017). Bryophyte Ecology - Volume 1–5. Ebook sponsored by Michigan Technological University and the International Association of Bryologists. Available at https://digitalcommons.mtu.edu/bryophyte-ecology/

C.8 Assessment Pattern & Question Paper Design

The **End-Semester examination** shall be conducted as per the following question paper design:

Section A: MCQs/Short Answer Questions (10 × 2 marks = 20 marks) — Covering all Units (mandatory)

Section B: Medium Answer Questions (4 × 5 marks = 20 marks) — Attempt any 4 out of 6 (These 6 questions should cover all Units).

Section C: Long Answer / Essay Questions (3 × 10 marks = 30 marks) — Attempt 3 out of 5 (At least one question from each Unit).

Internal Assessment (30 marks) breakdown:

Written Test(s): 20 marks

Seminar/Assignment/Project: 05 marks

Attendance & Class Participation: 05 marks

24/07/26

Officer on special duty (Judicial)

MSBOT-PC104

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSBOT-PC104
Title of the Paper	Core Course IV: Practicals Based on CC-101,102 & 103 (MSBOT-PC104)
Programme / Subject	M.Sc. — Botany
Semester	Semester I
Nature of Course	Practical Course (PC)
L – T – P	0 – 0 – 4
Credits	4
Maximum Marks	100 (Practicals: 70 + Internal Assessment: 30)
Duration of Examination	6 Hours for ESE

C.2 Marks Distribution

Component	Paper IV	Practical	IA	Total (PRAC+IA)
End Semester Examination	—	—	—	—
Practical / Lab Work	—	70	—	70
Internal Assessment	—	—	30	30
Maximum Marks	—	**70**	**30**	**100**
Passing Marks	—	**32**	**13**	**45 (45%)**

Note: Internal Assessment shall be evaluated on the basis of attendance, experiments performed, seminars, assignments, and *viva voce* as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	Enable students to perform qualitative and quantitative estimation of biomolecules using chromatographic, spectrophotometric, and electrophoretic techniques.
COB 2	Develop skills in enzyme kinetics experiments, including determination of Km values and identification inhibition type.
COB 3	Introduce principles of sterilization, culture media preparation and isolation techniques for bacteria, fungi and cyanobacteria.
COB 4	To familiarize students with the vegetative, anatomical and reproductive morphology of representative groups.
COB 5	To provide practical skills in plant anatomy, including tissue staining and observation of anomalous secondary growth in selected plants.

24/07/26

Kalpana Srivastava
Officer on special duty (Judicial)

Meeru.

C.4 Course Outcomes (COs)

After completing this course, students will be able to:

CLO No.	Course Learning Outcome
CLO 1	Perform qualitative and quantitative estimation of Biomolecules using (TLC) and spectrophotometer
CLO 2	Determine the Km value of given enzyme, analyze the effect of different factors on enzyme activity, distinguish between different types of inhibition using kinetic data.
CLO 3	Prepare cytological stains and fixed samples, prepare mitotic and meiotic slides from common plants, perform karyotype analysis.
CLO 4	Operate sterilization instruments, prepare culture media (PDA, Nutrient Agar, *Rhizobium/Azotobacter/Nostoc* media), isolate bacteria and fungi from soil and water, perform Gram's staining.
CLO 5	Identify common fungal diseases and prepare temporary slides to study the vegetative and reproductive morphology of common Algae, Bryophytes, Pteridophytes and Gymnosperms.
CLO 6	Identify and stain xylem and phloem elements in plant tissues, and recognize anomalous secondary growth patterns in selected plants.

C.5 Syllabus — Unit-wise Breakdown

Course Name: Practicals Based on CC-101,102 & 103 (MSBOT-PC104)		
Unit	**Content**	**Suggested Lectures hours**
I	**Biomolecules & Cell Biology** 1. Separation of amino acids by TLC. 2. Separation of proteins by SDS PAGE 3. Estimation of protein (Qualitative and Quantitative using Bradford and Lowry Assays). 4. Study of alpha-amylase in germinating seedlings. 5. Study of enzyme kinetics for determination of Km value, and nature of inhibition – competitive/non-competitive/uncompetitive. 6. Study of enzyme kinetics for effect of time/enzyme concentration/pH. 7. Cytological techniques: Preparation of cytological stains, fixation of sample etc. 8. Mitotic slide preparation of common plants. 9. Meiotic slide preparation of common plants. 10. Karyotype analysis. 11. Calculation of chiasma frequency. 12. Quantitative Estimation of Total Soluble Sugars and Reducing Sugars in Plant Samples	30
II	**Microbiology, Mycology and Plant Pathology** 1. Principles and use of different sterilization instruments like autoclave. oven. laminar air flow system etc.	28

24/07/26

Kalpana Srivastava
Officer on special duty (Judicial)

	2. Preparation of culture media for growth of *Rhizobium, Azotobacter* and *Nostoc*. 3. Isolation of Bacteria from water. 4. Characterization of bacterial isolate by Gram's staining 5. Biochemical tests for identification of bacteria-IMViC test 6. Isolation of fungi from soil and Identification of fungal isolates. 7. Counting of fungal spore by haemocytometer. 8. Temporary slide preparation of vegetative and reproductive stages of common fungi and their study, study of permanent slides. 9. Study of common fungal diseases - Rust of linseed, Blight of potato, Rust of wheat, Stem gall of coriander, Downy mildew, Powdery mildew etc.	
III	**Phycology and Bryology** 1. Temporary slide preparation and identification and study of common Algae, study of permanent slides. 2. Study of vegetative habit, anatomy and reproductive morphology of common Bryophytes, study of permanent slides.	18
IV	**Pteridophyta and Gymnosperm** 1. Study of vegetative habit, anatomy and reproductive morphology of common Pteridophyta (*Psilotum, Lycopodium, Selaginella, Marsilea* etc.), study of permanent slides. 2. Study of vegetative habit, anatomy and reproductive morphology of common Gymnosperm (*Cycas, Pinus, Ginkgo, Gnetum* etc.), study of permanent slides.	22
V	**Anatomy** 1. Study of different of tissues and staining of xylem and phloem elements 2. Anomalous secondary growth of some common plants (T*inospora, Boerhaavia, Nyctanthes, Aristolochia, Amaranthus, Dracaena*).	22
	Total Suggested Contact Hours For Practical/Field Work Courses	**120 Hours/Semester**

C.6 Recommended Textbooks

1. Bendre, A.M. and Kumar, A. (1984). *A Text Book of Practical Botany*, Vol. I and Vol. II. Rastogi Publications.
2. Dubey, R.C. and Maheshwari, D.K. (2023). *Practical Microbiology*. (4th ed.). S. Chand and Company Limited.
3. Pandey, B.P. (2011). *Practical Botany* (Vols. I & II). S. Chand and Company Limited.
4. Sadasivam, S. and Manickam, A. (2005). *Biochemical Methods*. (2nd ed.). New Age Publishers, New Delhi.
5. Tripathi, N.N., Sharma, S. and Thakur, D.P. (1991). *Plant Pathology Laboratory Manual*. Vol. 44, No. 2. ICAR Publications.

24/07/26

Kalpana Srivastava
Officer on special duty (Judicial)

C.7 Reference Books & Readings

1. Cappuccino, J.G. and Welsh, C.T. (2016). *Microbiology: A Laboratory Manual.* (11th ed.). Pearson Education.
2. Hofmann, A. and Clokie, S. (Eds.) (2018). *Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology.* (8th ed.). Cambridge University Press.
3. Plummer, D.T. (1978). *An Introduction to Practical Biochemistry*. (2nd ed.). McGraw-Hill.

C.7 Suggested E-Resources/Digital Repositories

1. Biochemistry (Virtual Lab Simulations): https://www.labxchange.org/; https://www.biointeractive.org/
2. Cell Biology (Virtual Lab Simulations): https://www.vlab.co.in/; https://www.labxchange.org/
3. Microbiology (Virtual Lab Simulations): https://vlab.amrita.edu/; https://www.vlab.co.in/
4. Plant Anatomy (Virtual Lab Simulations): https://www.plantsci.cam.ac.uk/; https://virtualmicroscope.org/

C.8 Assessment Pattern & Question Paper Design

The **End-Semester practical examination** shall be conducted as per the following question paper design:

The examinee shall perform any **four** experiments or provide comments on a model, instrument, or specimen from five practicals, with one practical drawn from each unit: $4 \times 12 = 48$ marks

Spotting: 10 marks

***Viva voce*:** 06 marks

Practical Record: 06 marks

Internal Assessment (30 marks) breakdown:

Two practicals or practical and spotting from the syllabus: $10 \times 2 = 20$ marks

Seminar/Assignment/Project: 05 marks

Attendance & Class Participation: 05 marks

24/07/26

Kalpana Srivastava
Officer on special duty (Judicial)

Meeru.

MSBOT-GE105

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSBOT-GE105
Title of the Paper	General Elective I: Mushroom Cultivation
Programme / Subject	M.Sc. — Botany
Semester	Semester I
Nature of Course	General Elective (GE)
L – T – P	3 – 1 – 0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours for ESE

C.2 Marks Distribution

Component	Elective Paper I	Practical	IA	Total (ESE+IA)
End Semester Examination	70	—	—	70
Internal Assessment	—	—	30	30
Maximum Marks	**70**	—	**30**	**100**
Passing Marks	**32**	—	**13**	**45 (45%)**

Note: Internal Assessment shall be evaluated on the basis of attendance, class tests, seminars, assignments, and *viva voce* as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	Provide fundamental knowledge of fungi and mushrooms, their life cycle, classification, nutritional importance and ecological roles.
COB 2	Develop an understanding of mushroom cultivation technologies, including infrastructure requirements, spawn production, substrate preparation and cultivation practices for commercially important edible mushrooms.
COB 3	Introduce students to mushroom disease management, post-harvest technology, preservation techniques, processing methods and value addition for improving product quality and marketability.
COB 4	Familiarize learners with quality assurance, food safety standards, value chain management and the economic aspects of mushroom production, marketing and enterprise development.

24/07/26

Officer on special duty (Judicial)

C.4 Course Outcomes (COs)

After completing this course, students will be able to:

CLO No.	Course Learning Outcome
CLO 1	Explain the biology of fungi and mushrooms, including their life cycle, classification, and ecological significance.
CLO 2	Demonstrate the techniques of mushroom cultivation, including spawn production, and the cultivation of edible mushrooms such as *Agaricus bisporus* and *Pleurotus*.
CLO 3	Analyze the factors influencing mushroom production, post-harvest handling, disease incidence, and the effectiveness of various preservation and processing methods for enhancing product quality and shelf life.
CLO 4	Evaluate quality control measures, food safety standards, HACCP principles, value addition strategies and the economic feasibility of mushroom production and marketing systems.
CLO 5	Develop practical understanding in mushroom culture maintenance, strain preservation, entrepreneurship planning and value-added mushroom products through hands-on training and industry-oriented applications.

C.5 Syllabus — Unit-wise Breakdown

Course Name: Mushroom Cultivation (MSBOT-GE105)		
Unit	**Content**	**Suggested Lectures hours**
I	General characters of fungi, Outline of fungal classification; A general life cycle of mushrooms; History, scope and significance of mushroom cultivation in India and Bihar; Edible and Poisonous mushrooms; Different aspects of mushroom cultivation in relation to the environment; Economic importance and health benefits of mushrooms.	10L + 2T
II	Mushroom Cultivation Techniques Infrastructure: spawn lab, cropping room, compost yard, sterilization setup; Substrate preparation: composting, pasteurization, sterilization methods; Production method of some edible mushrooms – Button mushroom (*Agaricus bisporus*), oyster mushroom (*Pleurotus sajor-caju*).	12L + 4T
III	Diseases on mushrooms caused by bacteria, fungi and viruses and their control; Post-Harvest Technology and Value Addition: Drying, preservation, packaging and storage of fresh mushrooms; Processing: pickles, soup powders, nuggets, snacks;	10L + 3T

24/07/26

Kalpana Srivastava
Officer on special duty (Judicial)

	Quality control, shelf life and safety standards; Food safety and HACCP in mushroom processing units; Value chain management and market trends.	
IV	Mushroom Industry, Research and Entrepreneurship; +Economics of mushroom production: cost-benefit analysis; Training, extension and entrepreneurship opportunities. Government schemes and subsidies (NABARD, RKVY, SFAC); Different methods of maintenance of mushroom culture and its strain preservation.	8L + 3T
V	Hands-on-Training Program on Mushroom Cultivation or Visit to a Mushroom Production Unit and preparation of a report.	5L + 3T
	Total Suggested Lectures	**60 (For 4 Credit Course) [45 L+15 T]**

Suggested Pedagogical Methods

1. Comparative Life Cycle Analysis: A detailed comparative flowchart of the life cycles of Button mushroom (*Agaricus bisporus*) and Oyster mushroom (*Pleurotus sajor-caju*) be prepared by students with focus on the differences in mating types, spawn production and environmental triggers for fructification.
2. Flipped Journal Club: Assign students a recent research paper on the medicinal properties of mushrooms (e.g., beta-glucans, anti-cancer properties, or immunomodulatory effects) to discuss the clinical significance.
3. Problem-Based Learning: Present a real-world scenario - "A family in rural Bihar consumed wild mushrooms and developed severe symptoms." Students must: (a) Identify the likely toxin (e.g., amatoxins, phallotoxins), (b) Describe the mechanism of action, (c) Propose a treatment protocol, and (d) Discuss public health measures to prevent such incidents.
4. State-Level SWOT Analysis: Students conduct a SWOT analysis of the mushroom industry in Bihar vs. a leading state (e.g., Himachal Pradesh or Uttarakhand).
5. Live Demonstration & Virtual Tour: Conduct a live demonstration of substrate preparation (composting, pasteurization) and spawning in the laboratory which may be supplemented with a virtual tour of a commercial mushroom production unit, allowing students to observe large-scale infrastructure.
6. "Designing a Small-Scale Mushroom Farm": Students work in groups to design a small-scale mushroom production unit.
7. Value Addition – Product Development: Students are divided into groups and each group is given a task to develop a new value-added product from mushrooms (e.g., mushroom-based soup powder, mushroom pickles, mushroom nuggets, or mushroom tea).
8. Government Scheme Scavenger Hunt: Students must research and prepare a comprehensive report on government schemes available for mushroom entrepreneurs in Bihar.

C.6 Recommended Textbooks

1. Borkar, S.G. and Patil, N. (2020). *Mushroom: A Nutritive Food and Its Cultivation*. Daya Publishing House, New Delhi.
2. Chand, G. and Kumar, S. (2018). *Techniques of Mushroom Cultivation*. Daya Publishing House, New Delhi.

24/07/26

Deepesh Srivastava
Officer on special duty (Judicial)

3. ICAR–DMR Training Manuals and Production Guides (2016). *Mushroom Cultivation, Marketing and Consumption*. ICAR Publications.
4. Keshamma, E. and Lokre, P. (2023). *Mushroom Farming: A Practical Guide for Entrepreneurship*. Book Saga Publications.
5. Singh, A.K. and Srivastava, J.N. (2024). *Diseases of Horticultural Crops: Diagnosis and Management (Volume 4: Important Plantation Crops, Medicinal Crops, and Mushrooms)*. Apple Academic Press.

C.7 Reference Books & Readings

1. Alexopoulos, C.J., Mims, C.W. and Blackwell, M.M. (1996). *Introductory Mycology*. (4th ed.). John Wiley & Sons, New York.
2. Chang, S.T. and Miles, P.G. *Mushrooms: Cultivation, Nutritional Value, Medicinal Effect and Environmental Impact*.
3. Marshall, E. and Nair, N.G. (Tan) (2009). *Make Money by Growing Mushrooms*. FAO.
4. Oei, P. (2003). *Mushroom Cultivation: Appropriate Technology for Mushroom Growers*. (3rd ed.). Backhuys Publishers.
5. Stamets, P. and Chilton, J.S. (1983). *The Mushroom Cultivator: A Practical Guide to Growing Mushrooms at Home*. Agarikon Press.

C.7 Suggested E-Resources/Digital Repositories

1. SWAYAM/NPTEL: Mushroom Production - https://onlinecourses.swayam2.ac.in/e-learning/preview/nos20_ge07
2. SWAYAM PRABHA: https://www.youtube.com/watch?v=lISoERnscuw

C.8 Assessment Pattern & Question Paper Design

The **End-Semester examination** shall be conducted as per the following question paper design:

Section A: MCQs/Short Answer Questions (10 × 2 marks = 20 marks) — Covering all Units (mandatory)

Section B: Medium Answer Questions (4 × 5 marks = 20 marks) — Attempt any 4 out of 6 (These 6 questions should cover all Units).

Section C: Long Answer / Essay Questions (3 × 10 marks = 30 marks) — Attempt 3 out of 5 (At least one question from each Unit).

Internal Assessment (30 marks) breakdown:

Written Test(s): 20 marks

Seminar/Assignment/Project: 05 marks

Attendance & Class Participation: 05 marks

24/07/26

MSBOT-GE106

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSBOT-GE106
Title of the Paper	General Elective II: Biofuels
Programme / Subject	M.Sc. — Botany
Semester	Semester I
Nature of Course	General Elective (GE)
L – T – P	3 – 1 – 0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours for ESE

C.2 Marks Distribution

Component	Elective Paper II	Practical	IA	Total (ESE+IA)
End Semester Examination	70	—	—	70
Internal Assessment	—	—	30	30
Maximum Marks	**70**	**—**	**30**	**100**
Passing Marks	**32**	**—**	**13**	**45 (45%)**

Note: Internal Assessment shall be evaluated on the basis of attendance, class tests, seminars, assignments, and *viva voce* as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	To provide students with an understanding of the fundamental concepts, classification and global significance of biofuels.
COB 2	To provide comprehensive knowledge of feedstocks, production technologies (1st to 4th generation) and biorefinery models.
COB 3	To develop skills for assessing environmental, economic and social sustainability of biofuel systems.
COB 4	To explore India's National Biofuel Policy, government initiatives and global best practices.

24/07/26

Officer on special duty (Judicial)

C.4 Course Outcomes (COs)

After completing this course, students will be able to:

CLO No.	Course Learning Outcome
CLO 1	Explain the classification, historical context and relevance of biofuels in the renewable energy landscape.
CLO 2	Analyze the production processes and technological challenges of various biofuel generations (1st to 4th).
CLO 3	Evaluate the sustainability (environmental, economic, social) of biofuel projects using LCA and GIS tools.
CLO 4	Critically appraise Indian biofuel policies and propose feasible biofuel solutions for local/regional contexts.

C.5 Syllabus — Unit-wise Breakdown

Course Name: Biofuels (MSBOT-GE106)		
Unit	**Content**	**Suggested Lectures hours**
I	Introduction to Biofuels and Renewable Energy Context: Global energy scenario, fossil fuels vs. renewables; Concept of biofuels: Definition, history, advantages, and disadvantages; Classification: Primary (firewood, agri-residue) vs. secondary biofuels; solid, liquid, gaseous biofuels.	8L + 2T
II	Feedstocks and Biomass Characterization: First-generation feedstocks - Sugarcane, maize, oil palm, soybean; Second-generation feedstocks - Agricultural residues (rice straw, wheat straw, corn stover), forest residues, energy crops (switchgrass, Napier grass, *Jatropha curcas*, *Pongamia pinnata* – Indian context); Third-generation feedstocks - Microalgae (*Chlorella*, *Spirulina*, *Scenedesmus*), macroalgae, cultivation systems (open ponds, PBRs), harvesting and dewatering; Fourth-generation feedstocks - Genetically engineered algae/cyanobacteria for direct lipid/sugar secretion, synthetic biology approaches; Biomass chemistry: Cellulose, hemicellulose, lignin, starch, lipids, proteins – their role in biofuel conversion.	12L + 4T
III	Biofuel Production Technologies Liquid biofuels: Bioethanol-Feedstock selection, pretreatment (physical, chemical, biological), saccharification (acid/enzyme), fermentation (*S. cerevisiae*, *Z. mobilis*), distillation, dehydration;	10L + 3T

24/07/26
Kalpana Srivastava
Officer on special duty (Judicial)

	Biodiesel: Oil extraction (mechanical, solvent), transesterification (batch/continuous), catalyst types (NaOH, KOH, lipase), glycerol separation, washing, drying.	
IV	Gaseous and solid biofuels Biogas/Compressed Biogas (CBG): Anaerobic digestion– hydrolysis, acidogenesis, acetogenesis, methanogenesis; Types of digesters (floating drum, fixed dome, plug flow); Biogas purification (removal of CO_2, H_2S); Solid biofuels: Pelleting, briquetting, torrefaction, pyrolysis (slow/fast), biochar, syngas; Biorefinery concept: Integrated production of biofuels, biochemicals, biofertilizers, and animal feed – zero-waste approach.	10L + 3T
V	Sustainability, Policy and Future Perspectives Environmental sustainability: Life Cycle Assessment (LCA) – goal, scope, inventory, impact categories (GWP, eutrophication, water footprint, land use change, ILUC); Economic viability: Capital and operational costs, break-even analysis, incentives (VGF, subsidies), carbon credits; Policy frameworks in depth: National Policy on Biofuels – categories (basic, advanced), targets (20% ethanol blending by 2025), roles of MoPNG, MNRE, CPCB; state biofuel policies; Emerging trends: Algae-based jet fuel (SAF), Bio-CNG for transport.	5L + 3T
	Total Suggested Lectures	**60 (For 4 Credit Course) [45 L+15 T]**

Suggested Pedagogical Methods

1. Debate: "Fossil Fuels vs. Renewables – A Realistic Transition" Organize a structured debate where students argue for/against the rapid phase-out of fossil fuels considering economic, social, environmental, and geopolitical factors, citing evidence from recent reports (IPCC, IEA, NITI Aayog).
2. Timeline Project: Students create a visual timeline of the history of biofuel development (from wood combustion to cellulosic ethanol and algae-based jet fuel).
3. SWOT Analysis of Biofuels: Students conduct a SWOT analysis of biofuels as an energy source, comparing them with solar, wind, and hydro power presenting a comparative report.
4. Experimental Design – Feedstock Selection: Students are given a research problem: "Design an experiment to compare the bioethanol yield from three different feedstocks (rice straw, sugarcane bagasse, and maize stover) using different pretreatment methods." Students must: (a) Formulate a hypothesis, (b) Design the experimental setup with proper controls and replicates,
5. Carbon Credits Simulation: Students learn about carbon credits and carbon trading mechanisms (e.g., VER, CDM).
6. Emerging Trends – Student Seminar Students choose an emerging biofuel technology (e.g., algae-based SAF, Bio-CNG, synthetic biology approaches) and present a seminar.

24/07/26

Kalpana Srivastava
Officer on special duty (Judicial)

C.6 Recommended Textbooks

1. Baskar, C., Baskar, S. and Dhillon, R.S. (2012). *Biomass Conversion: The Interface of Biotechnology*. Chemistry and Materials Science. Springer.
2. Chandel, A.K. and Sukumaran, R.K. (Eds.) (2017). *Sustainable Biofuels Development in India*. Springer (CSIR-IICT, Hyderabad).
3. Goyal, H.B. and Saxena, R.C. (2015). *Biofuels: Challenges and Opportunities*. TERI Press, New Delhi.
4. Prasad, S. (2021). *Algae Biofuels: Potential and Challenges in Indian Scenario*. IK International Publishing House.
5. Vijayakumar, S. (Ed.) (2019). *Biofuels: Greenhouse Gas Mitigation and Global Warming*. Springer.

C.7 Reference Books & Readings

1. Lee, S., & Shah, Y. T. (2015). *Biofuels and Bioenergy: Processes and Technologies*. CRC Press.
2. Wagemann, K. and Tippkötter, N. (2019). *Biorefineries: A Step Towards Sustainable Bioeconomy*. Springer.
3. MNRE, Govt. of India. (2023). *Annual Report 2022-23 on New & Renewable Energy*. Available online.

C.7 Suggested E-Resources/Digital Repositories

1. SWAYAM/NPTEL: Biomass Conversion and Biorefinery- https://onlinecourses.nptel.ac.in/e-learning/preview/noc22_ch28
2. NPTEL: Production of Biofuel using microbes- https://www.youtube.com/watch?v=PQAdAt6kx2U
3. SWAYAM PRABHA: https://www.youtube.com/watch?v=M2AuR8QSoUs

C.8 Assessment Pattern & Question Paper Design

The **End-Semester examination** shall be conducted as per the following question paper design:

Section A: MCQs/Short Answer Questions (10 × 2 marks = 20 marks) — Covering all Units (mandatory)

Section B: Medium Answer Questions (4 × 5 marks = 20 marks) — Attempt any 4 out of 6 (These 6 questions should cover all Units).

Section C: Long Answer / Essay Questions (3 × 10 marks = 30 marks) — Attempt 3 out of 5 (At least one question from each Unit).

Internal Assessment (30 marks) breakdown:

Written Test(s): 20 marks

Seminar/Assignment/Project: 05 marks

Attendance & Class Participation: 05 marks

24/09/26

Kalpana Srivastava
Officer on special duty (Judicial)

MSBOT-CC201

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSBOT-CC201
Title of the Paper	Core Course I: Plant Taxonomy, Embryology and Tissue culture
Programme / Subject	M.Sc. — Botany
Semester	Semester II
Nature of Course	Core Course (CC)
L – T – P	3 – 1 – 0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours for ESE

C.2 Marks Distribution

Component	Paper I	Practical	IA	Total (ESE+IA)
End Semester Examination	70	—	—	70
Internal Assessment	—	—	30	30
Maximum Marks	**70**	**—**	**30**	**100**
Passing Marks	**32**	**—**	**13**	**45 (45%)**

Note: Internal Assessment shall be evaluated on the basis of attendance, class tests, seminars, assignments, and *viva voce* as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	To provide a comprehensive understanding of the principles, concepts and methodologies of Plant taxonomy.
COB 2	To acquaint students with the diversity, phylogenetic relationships, diagnostic characteristics and economic importance of major angiosperm families.
COB 3	To introduce contemporary taxonomic tools and interdisciplinary approaches such as Cytotaxonomy, Chemotaxonomy, Palynotaxonomy, Numerical taxonomy, Biosystematics and Molecular systematics.
COB 4	To develop a thorough understanding of embryology in flowering plants.
COB 5	To impart theoretical knowledge and practical skills in plant tissue culture techniques.

24/07/23

Kalpana Srivastava
Officer on special duty (Judicial)

C.4 Course Outcomes (COs)

After completing this course, students will be able to:

CLO No.	Course Learning Outcome
CLO 1	Explain the principles of plant taxonomy, nomenclature, classification systems and the significance of plant collection, herbarium preparation, botanical gardens, plant identification and documentation.
CLO 2	Demonstrate the use of taxonomic keys, taxonomic literature, herbarium techniques, and modern tools for the identification, classification and documentation of angiosperm diversity.
CLO 3	Analyze the concepts of taxa, characters, variation, phylogenetic relationships and the contributions of classical and contemporary classification systems, including APG systems.
CLO 4	Evaluate the principles and rules of botanical nomenclature and nomenclatural changes in accordance with the International Code of Nomenclature.
CLO 5	Analyze reproductive and embryological processes in flowering plants and recent biotechnological applications.
CLO 6	Develop an understanding of phylogenetic trends, cladistics and the diagnostic features and economic importance of major dicot and monocot angiosperm families.
CLO 7	Demonstrate, evaluate, and develop practical skills in plant tissue culture techniques and their applications in crop improvement, conservation and biotechnology.

C.5 Syllabus — Unit-wise Breakdown

Course Name: Plant Taxonomy, Embryology and Tissue culture (MSBOT-CC201)		
Unit	**Content**	**Suggested Lectures hours**
I	Plant collection and documentation: Methods of collecting plants; Herbarium preparation, virtual/digital herbarium; Plant identification: Taxonomic keys; taxonomic literature; Classification: Natural systems, Phylogenetic systems and contemporary systems: Arthur Cronquist, Armen Takhatajan, Robert F. Thorne and Rolf M.T. Dahlgren; Basics of APG System; Concept of taxa: Species, subspecies, variety and form; genus, family and higher categories; Concept of characters: 'Good' and 'Bad' characters; Correlation of characters, character weighting and variation.	10L + 3T

24/07/26

Kalpana Srivastava
Officer on special duty (Judicial)

Suggested Pedagogical Methods

1. Field-Based Experiential Learning: Engage students in field-based experiential learning through the collection of plant specimens from local habitats using plant presses, field notebooks, and GPS-enabled devices for accurate geo-referencing.
2. Blended Digital Learning: Encourage students to develop a virtual herbarium alongside traditional herbarium sheets by using digital platforms such as iNaturalist or a shared Google Drive repository to upload high-resolution images, macro photographs of floral dissections, and geo-referenced specimen data.
3. Interactive Cladogram Modelling: Facilitate the understanding of the Angiosperm Phylogeny Group (APG) classification system through physical string-and-card models or digital phylogenetic tree-building software, enabling students to visualize evolutionary relationships based on molecular evidence rather than solely on morphological characters.
4. Character Analysis through Sorting Exercises: Provide students with a diverse collection of plant specimens to distinguish between reliable and variable taxonomic characters. Encourage critical discussions on stable diagnostic characters (e.g., floral symmetry) versus environmentally influenced traits (e.g., leaf size).
5. Case-Based Learning in Botanical Nomenclature: Adopt a case-based approach by presenting historical botanical scenarios and engaging students in applying the principles of nomenclature, including priority, typification, valid publication, and conservation, as members of a simulated nomenclature committee.
6. Bioinformatics Laboratory Exercises: Dedicate laboratory sessions to the use of freely available bioinformatics tools by guiding students to retrieve nucleotide sequences from GenBank, perform BLAST searches for species identification, and construct phylogenetic trees using software such as MEGA or Phylogeny.fr.
7. Dissection-Based Practical Learning: Provide fresh specimens representing major angiosperm families for hands-on floral dissection. Students should prepare floral formulae, construct floral diagrams, and identify key diagnostic characters of each family.
8. Evolutionary Perspective in Teaching: Present the evolutionary progression of angiosperms by tracing the transition from relatively primitive families, such as Ranunculaceae, to more evolutionarily derived families, such as Orchidaceae and Asteraceae, highlighting their adaptive evolution in response to specialized pollination mechanisms.
9. Concept Mapping for Advanced Plant Biotechnology: Employ concept maps and visual flowcharts to illustrate the sequential processes involved in protoplast culture, somatic hybridization, and cybridization, explicitly identifying critical steps and barriers, such as enzymatic degradation of the cell wall.

C.6 Recommended Textbooks

1. Anis, M. and Ahmad, N. (Eds.). (2016). *Plant Tissue Culture: Propagation, Conservation and Crop Improvement*. Springer, Singapore.
2. Bhojwani, S.S. and Dantu, P.K. (2013). *Plant Tissue Culture: An Introductory Text*. Springer India, New Delhi.

24/07/26

Kalpana Srivastava
Officer on special duty (Judicial)

3. Bhojwani, S.S., Dantu, P.K. and Bhatnagar, S.P. (2025). *The Embryology of Angiosperms*. (7th ed.). Vikas Publishing House, New Delhi.
4. Dutta Gupta, S. and Ibaraki, Y. (Eds.). (2006). *Plant Tissue Culture Engineering*. Springer, Dordrecht.
5. Johri, B.M. (2012). *Embryology of Angiosperms*. Springer, New Delhi.
6. Maheshwari, P. (2012). *An Introduction to the Embryology of Angiosperms*. McGraw-Hill Education, New Delhi.
7. Pandey, B.P. (2019). *Taxonomy of Angiosperms*. S. Chand Publishing, New Delhi.
8. Raghavan, V. (2006). *Double Fertilization: Embryo and Endosperm Development in Flowering Plants*. Springer, Berlin.
9. Razdan, M.K. (2003). *Introduction to Plant Tissue Culture*. (2nd ed.). Science Publishers, Enfield.
10. Sharma, O.P. (2017). *Plant Taxonomy*. (3rd ed.). McGraw Hill Education, New Delhi.
11. Shivanna, K.R. (2014). *Reproductive Assurance through Pollination and Seed Production: Plant Functional Biology*. Springer, New Delhi.
12. Singh, G. (2019). *Plant Systematics: An Integrated Approach*. (4th ed.). CRC Press, Boca Raton.

C.7 Reference Books & Readings

1. George, E.F., Hall, M.A. and De Klerk, G.-J. (2008). *Plant Propagation by Tissue Culture*. (3rd ed.). Springer, Dordrecht.
2. Judd, W.S., Campbell, C.S., Kellogg, E.A., Stevens, P.F. and Donoghue, M.J. (2016). *Plant Systematics: A Phylogenetic Approach*. (4th ed.). Sinauer Associates, Sunderland.
3. Simpson, M.G. (2019). *Plant Systematics*. (3rd ed.). Academic Press, London.
4. Stace, C.A. (2019). *Plant Taxonomy and Biosystematics*. (3rd ed.). Cambridge University Press, Cambridge.
5. Trigiano, R.N. and Gray, D.J. (2016). *Plant Tissue Culture, Development, and Biotechnology*. CRC Press, Boca Raton.

C.7 Suggested E-Resources/Digital Repositories

1. SWAYAM/NPTEL: Plant Systematics - https://onlinecourses.swayam2.ac.in/e-learning/preview/cec25_bt11
2. SWAYAM/NPTEL: Plant Developmental Biology - https://onlinecourses.nptel.ac.in/e-learning/preview/noc26_bt49
3. SWAYAM/NPTEL: Plant Physiology and Plant Tissue Culture - https://onlinecourses.swayam2.ac.in/e-learning/preview/cec19_bt01
4. e-PGPathshala: Plant Embryology - https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=1p0OY7YTBClr5D2KEqnvVg==

C.8 Assessment Pattern & Question Paper Design

The **End-Semester examination** shall be conducted as per the following question paper design:

Section A: MCQs/Short Answer Questions (10 × 2 marks = 20 marks) — Covering all Units (mandatory)

24/07/26

Section B: Medium Answer Questions (4 × 5 marks = 20 marks) — Attempt any 4 out of 6 (These 6 questions should cover all Units).

Section C: Long Answer / Essay Questions (3 × 10 marks = 30 marks) — Attempt 3 out of 5 (At least one question from each Unit).

Internal Assessment (30 marks) breakdown:

Written Test(s): 20 marks

Seminar/Assignment/Project: 05 marks

Attendance & Class Participation: 05 marks

24/07/26

Officer on special duty (Judicial)

MSBOT-CC202

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSBOT-CC202
Title of the Paper	Core Course II: Plant Physiology
Programme / Subject	M.Sc. — Botany
Semester	Semester II
Nature of Course	Core Course (CC)
L – T – P	3 – 1 – 0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours for ESE

C.2 Marks Distribution

Component	Paper II	Practical	IA	Total (ESE+IA)
End Semester Examination	70	—	—	70
Internal Assessment	—	—	30	30
Maximum Marks	**70**	**—**	**30**	**100**
Passing Marks	**32**	**—**	**13**	**45 (45%)**

Note: Internal Assessment shall be evaluated on the basis of attendance, class tests, seminars, assignments, and viva voce as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	To provide a comprehensive understanding of plant water relations, transpiration, xylem and phloem transport and osmoregulation.
COB 2	To develop knowledge of mineral nutrition, nutrient uptake processes, hydroponics and aeroponics.
COB 3	To acquaint students with the biochemical and physiological principles of photosynthesis, respiration and carbon sequestration.
COB 4	To introduce the mechanisms of nitrogen fixation, lipid metabolism and the functional importance of secondary metabolites in plant defence and adaptation.
COB 5	To enhance understanding of plant growth regulators and their modes of action.

24/9/26

COB 6	To impart advanced knowledge of the physiological and molecular basis of flowering, photoperiodism, vernalization, photomorphogenesis and their applications in crop improvement.

C.4 Course Outcomes (COs)

After completing this course, students will be able to:

CLO No.	Course Learning Outcome
CLO 1	Explain the fundamental principles of plant water relations, including xylem transport, phloem translocation and osmoregulation in plants.
CLO 2	Analyse the biochemical and physiological processes of photosynthesis and respiration.
CLO 3	Evaluate the mechanisms of nitrogen metabolism, lipid metabolism and functional roles of secondary metabolites in plant defence and adaptation.
CLO 4	Explain and analyse the chemical nature, biosynthesis and physiological roles of major phytohormones, as well as biotic and abiotic stress conditions.
CLO 5	Evaluate the physiological and molecular mechanisms regulating flowering, photoperiodism, vernalization and photomorphogenesis.
CLO 6	Develop the ability to integrate knowledge of plant physiological processes to interpret plant responses to environmental changes, stress adaptation, productivity enhancement and sustainable crop improvement strategies.

C.5 Syllabus — Unit-wise Breakdown

Course Name: Plant Physiology (MSBOT-CC202)		
Unit	**Content**	**Suggested Lectures hours**
I	Uptake, transport and translocation of water, ions, solutes and macromolecules from soil, through cells, across membranes, through xylem and phloem, mechanisms of loading and unloading of photoassimilates. Transpiration: Mechanism of Transpiration and Stomatal Physiology, Osmoregulation in Plants.	9L + 3T
II	Bioenergetics, Laws of thermodynamics and its application in biological systems, concept of entropy and enthalpy, concept of free energy, energy rich bonds and high energy compounds; Respiration: Glycolysis, Hexose Monophosphate Shunt, Krebs Cycle, Glyoxalate Cycle, Electron Transport System, Oxidative Phosphorylation-Chemiosmotic Theory;	10L + 3T
III	Photosynthesis: Light harvesting complexes, mechanisms of electron transport, photoprotective mechanisms, CO2 fixation - C3, C4 and CAM pathways, photorespiration, C4 syndrome; Carbon Sequestration and climate change;	9L + 3T

24/07/26

Officer on special duty (Judicial)

IV	Nitrogen Metabolism: Nitrate and ammonium assimilation; amino acid biosynthesis, biological nitrogen fixation. Lipid Metabolism: β-Oxidation of fatty acids and biosynthesis of fatty acids;	8L + 3T
V	Phytohormones: Biosynthesis, storage, breakdown and transport, physiological effects and mechanisms of action. Sensory Photobiology: Light perception, structure, function and mechanisms of action of phytochromes, cryptochromes and phototropins, photoperiodism and biological clock; Vernalization;	9L + 3T
	Total Suggested Lectures	**60 (For 4 Credit Course) [45 L+15 T]**

Suggested Pedagogical Methods

1. Problem-Based Learning (PBL) – Water Potential Calculations (a) Calculate water potential and, (b) Determine the direction of water movement.
2. Use of Teaching Tools in Plant Biology: Published by the American Society of Plant Biologists (ASPB),is a trusted pedagogical resource integrating peer-reviewed content with flexible presentation components, lecture slides, and short essays
3. Thermodynamics Problem-Solving Workshop: Students solve problems on: (a) Calculation of ΔG for coupled reactions (e.g., ATP hydrolysis + endergonic reaction), (b) Relationship between ΔG and equilibrium constant (Keq), (c) Redox potential and electron transport. Develops quantitative and biochemical literacy.
4. Chemiosmotic Theory – Interactive Simulation: Use an online simulation (or physical model) to demonstrate the proton motive force (PMF) and ATP synthase mechanism.
5. Comparative Metabolism – Glyoxylate Cycle vs. Krebs Cycle: Students create a detailed comparison of the Krebs Cycle and Glyoxylate Cycle.
6. Comparative study – C4 *vs* C3.
7. Flipped Journal Club – Photorespiration and Engineering C4 into C3: Assign a recent paper on engineering C4 photosynthesis into C3 plants.
8. Carbon Sequestration – Case Study on carbon sequestration potential of different ecosystems (tropical forests, agroforestry, grasslands, blue carbon).
9. Nitrogen Assimilation – Pathway Tracing: Students trace the path of nitrogen from nitrate → nitrite → ammonium → amino acids (glutamine, glutamate, aspartate).
10. Photoperiodism – Problem Solving & Data Interpretation: Provide students with data on flowering responses of SDP, LDP, and day-neutral plants under different day-length treatments.

C.6 Recommended Textbooks

1. Jain, V.K. (2017). *Fundamentals of Plant Physiology*. (18th ed.). S. Chand Publishing, New Delhi.
2. Kumar, H.D. and Purohit, S.S. (2018). *Plant Physiology*. Agrobios (India), Jodhpur.

24/07/26

3. Pandey, S.N. and Sinha, B.K. (2021). *Plant Physiology*. (5th ed.). Vikas Publishing House, New Delhi.
4. Srivastava, L.M. (2019). *Plant Growth and Development: Hormones and Environment*. Revised ed., Academic Press, London.
5. Verma, V. (2020). *Textbook of Plant Physiology*. Emkay Publications, New Delhi.

C.7 Reference Books & Readings

1. Buchanan, B.B., Gruissem, W. and Jones, R.L. (2015). *Biochemistry and Molecular Biology of Plants*. (2nd ed.). Wiley Blackwell, Chichester.
2. Davies, P.J. (Ed.). (2010). *Plant Hormones: Biosynthesis, Signal Transduction, Action!*. (3rd ed.). Springer, Dordrecht.
3. Hopkins, W.G. and Hüner, N.P.A. (2024). *Introduction to Plant Physiology*. (6th ed.). Wiley, Hoboken.
4. Lambers, H., Oliveira, R.S. and Plaxton, W.C. (2025). *Plant Physiological Ecology*. (3rd ed.). Springer Nature, Cham.
5. Nobel, P.S. (2020). *Physicochemical and Environmental Plant Physiology*. (5th ed.). Academic Press, London.
6. Noggle, G.R. and Fritz, G.J. (1983). *Introductory Plant Physiology*. Prentice Hall, Nature.
7. Salisbury, F.B. and Ross, C.W. (2020). *Plant Physiology*. Indian Reprint, Cengage Learning India, New Delhi.
8. Taiz, L., Zeiger, E., Møller, I.M. and Murphy, A. (2022). *Plant Physiology and Development*. (7th ed.). Oxford University Press, New York.

C.7 Suggested E-Resources/Digital Repositories

1. SWAYAM/NPTEL: Plant Physiology and Metabolism - https://onlinecourses.swayam2.ac.in/e-learning/preview/cec20_bt01
2. SWAYAM/NPTEL: Plant Physiology - https://onlinecourses.swayam2.ac.in/e-learning/preview/cec19_bt09
3. SWAYAM/NPTEL: Plant Physiology and Plant Tissue Culture - https://onlinecourses.swayam2.ac.in/e-learning/preview/cec19_bt01
4. e-PGPathshala: Plant Tissue Culture- https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=t5vt4STquHRj94mcOBMr5g==
5. e-PGPathshala: Plant Embryology - https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=1p0OY7YTBClr5D2KEqnvVg==

C.8 Assessment Pattern & Question Paper Design

The **End-Semester examination** shall be conducted as per the following question paper design:

Section A: MCQs/Short Answer Questions (10 × 2 marks = 20 marks) — Covering all Units (mandatory)

Section B: Medium Answer Questions (4 × 5 marks = 20 marks) — Attempt any 4 out of 6 (These 6 questions should cover all Units).

Section C: Long Answer / Essay Questions (3 × 10 marks = 30 marks) — Attempt 3 out of 5 (At least one question from each Unit).

Internal Assessment (30 marks) breakdown:

24/07/26

Anupama Srivastava
Officer on special duty (Judicial)

Written Test(s): 20 marks

Seminar/Assignment/Project: 05 marks

Attendance & Class Participation: 05 marks

24/07/26

MSBOT-CC203

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSBOT-CC203
Title of the Paper	Core Course III: Genetics and Plant Breeding
Programme / Subject	M.Sc. — Botany
Semester	Semester II
Nature of Course	Core Course (CC)
L – T – P	3 – 1 – 0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours for ESE

C.2 Marks Distribution

Component	Paper III	Practical	IA	Total (ESE+IA)
End Semester Examination	70	—	—	70
Internal Assessment	—	—	30	30
Maximum Marks	**70**	**—**	**30**	**100**
Passing Marks	**32**	**—**	**13**	**45 (45%)**

Note: Internal Assessment shall be evaluated on the basis of attendance, class tests, seminars, assignments, and viva voce as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	To provide a thorough understanding of the principles of inheritance and modern genetics.
COB 2	To develop knowledge of the molecular mechanisms governing DNA replication, repair, gene expression and regulation in prokaryotic and eukaryotic systems.
COB 3	To familiarise students with the concepts of genetic variation, cytogenetics and their applications in biological research and crop improvement.
COB 4	To impart comprehensive knowledge of conventional and advanced plant breeding methods and the utilisation of genetic resources for developing improved crop varieties.
COB 5	To enable students to apply genetic and breeding principles in designing strategies for crop improvement, stress resistance and sustainable agriculture.

24/07/26

C.4 Course Outcomes (COs)

After completing this course, students will be able to:

CLO No.	Course Learning Outcome
CLO 1	Explain the principles of Mendelian and non-Mendelian inheritance, as well as the nature and significance of chromosomal variations.
CLO 2	Analyse the structure, organisation, and function of genes, mutations, chromosome alterations, and population genetic principles governing inheritance and genetic variation.
CLO 3	Demonstrate a comprehensive understanding of DNA replication, DNA damage and repair mechanisms, transcription, RNA processing, translation, and gene regulation.
CLO 4	Evaluate the molecular basis of genetic disorders, mutations, and the consequences of impaired DNA repair mechanisms on cellular functions and organismal health.
CLO 5	Explain and analyse the concepts of plant genetic resources, centres of origin, domestication, reproductive systems, and breeding implications in crop improvement.
CLO 6	Develop scientifically sound breeding strategies for crop improvement by integrating principles of genetics, molecular biology, cytogenetics and plant breeding for enhanced variety development.

C.5 Syllabus — Unit-wise Breakdown

Course Name: Genetics and Plant Breeding (MSBOT-CC203)		
Unit	**Content**	**Suggested Lectures hours**
I	Principles of Mendelian inheritance, codominance, incomplete dominance, penetrance and expressivity, gene interactions, pleiotropy, genomic imprinting, linkage and cross-over, Sexlinked inheritance, Sex-influenced and Sex-limited inheritance; Cytoplasmic Inheritance; Structural and Numerical alterations of chromosomes: Deletion, duplication, inversion, translocation, ploidy and their genetic implications.	10L + 3T
II	Allele, multiple alleles, pseudoallele, complementation tests; Mutation types, causes and detection; mutant types – lethal, conditional, biochemical, loss of function, gain of function, dominant-negative; germinal versus somatic mutations, molecular basis of mutation; Population Genetics and Hardy-Weinberg equilibrium.	8L + 3T

24/07/26

III	DNA and its replication, fidelity of replication, extrachromosomal replicons; DNA damage and repair mechanisms, homologous and site-specific recombination; Mechanism and regulation of transcription, transcriptional inhibitors, transcription factors and machinery, transcription activators and repressors, RNA polymerases, RNA processing, RNA editing, structure and function of different types of RNA, RNA transport, ribozyme, riboswitches, non-coding RNA. Genetic code: Cracking of code; characteristics; Mechanism of translation and its regulation, translational inhibitors, post- translational modification of proteins, protein trafficking and transport, protein degradation.	12L + 4T
IV	Regulation of gene expression in phages, viruses, prokaryotes and eukaryotes, role of chromatin in gene expression and gene silencing, epigenetic regulation.	6L + 2T
V	Conventional and Specialized Plant Breeding: Concept of centre of origin of Species; Domestication, genetic resources and hybridisation; Modes of reproduction and breeding implications; Apomixis, Self-Incompatibility and Male Sterility; Selection methods for self and cross pollinated plants; Inbreeding and hybrid vigour; Induced Mutation and Ploidy Breeding; Resistance Breeding to biotic and abiotic stress adaptation; Cytogenetic aspects of wide hybridisation and introgression; Breeding maintenance and Variety release.	9L + 3T
	Total Suggested Lectures	**60 (For 4 Credit Course) [45 L+15 T]**

Suggested Pedagogical Methods

1. Problem-Based Learning (PBL) – Students are given complex genetic cross data involving gene interactions (e.g., epistasis, complementary genes, inhibitory genes), linkage, and sex-linked traits. They must: (a) Determine the mode of inheritance, (b) Calculate recombination frequencies, (c) Construct genetic maps, (d) Predict progeny ratios.
2. Chromosomal Aberration Workshop: Students study karyotypes and idiograms of normal vs. mutant plants (e.g., trisomics, monosomics, translocations). They must: (a) Identify the chromosomal aberration.
3. Population Genetics – Hardy-Weinberg Problem-Solving: Students solve problems on: (a) Calculating allele and genotype frequencies.
4. DNA Repair Pathways – Concept Mapping: Students create a detailed concept map of DNA repair mechanisms (BER, NER, MMR, DSB repair via NHEJ and HR).
5. Transcription & Translation – Pathway Tracing: Provide students with a DNA sequence and ask them to: (a) Transcribe it into mRNA, (b) Process the mRNA (splicing, capping, polyadenylation), (c) Translate it into a protein using the genetic code, (d) Identify regulatory elements (promoter, enhancer, termination signals).
6. Translational Inhibitors – Case StudyPresent case studies on translational inhibitors (e.g., antibiotics like cycloheximide, chloramphenicol, streptomycin). Students must: (a) Describe

24/07/26

the mechanism of action, (b) Distinguish between prokaryotic and eukaryotic inhibitors, (c) Discuss the use of inhibitors in research and medicine.

7. Flipped Journal Club – Non-Coding RNAs & Riboswitches: Assign a paper on non-coding RNAs (e.g., microRNAs, siRNAs, lncRNAs) or riboswitches. Students present the discovery, mechanism of action, and physiological significance in plants or animals.
8. Prokaryotic Gene Regulation – Lac Operon & Trp Operon: Students create a detailed flow chart of the Lac Operon (induction) and Trp Operon (repression). They must: (a) Describe the roles of the operator, promoter, repressor, and inducer/corepressor, (b) Predict the effect of mutations in each component
9. Eukaryotic Gene Regulation – Case Study: Present a case study on a eukaryotic gene regulated by multiple transcription factors and enhancers (e.g., globin genes, heat shock genes, or plant stress-responsive genes).

C.6 Recommended Textbooks

1. Chawla, H.S. (2019). *Introduction to Plant Biotechnology*. (4th ed.). CRC Press, Boca Raton.
2. Gupta, P.K. (2022). *Genetics*. (6th ed.). Rastogi Publications, Meerut.
3. Sharma, J.R. (2017). *Principles and Practice of Plant Breeding*. (2nd ed.). Tata McGraw-Hill Education, New Delhi.
4. Singh, B.D. (2021). *Plant Breeding: Principles and Methods*. (12th ed.). Kalyani Publishers, New Delhi.
5. Singh, P. (2018). *Essentials of Plant Breeding*. (2nd ed.). Kalyani Publishers, New Delhi.
6. Verma, P.S. and Agarwal, V.K. (2021). *Cell Biology, Genetics, Molecular Biology, Evolution and Ecology*. S. Chand Publishing, New Delhi.

C.7 Reference Books & Readings

1. Acquaah, G. (2020). *Principles of Plant Genetics and Breeding*. (3rd ed.). Wiley Blackwell, Hoboken.
2. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K. and Walter, P. (2008). *Molecular Biology of the Cell*. (5th ed.). Garland Science, New York.
3. Allard, R.W. (2010). *Principles of Plant Breeding*. (2nd ed.). John Wiley & Sons, New York.
4. Buchanan, B.B., Gruissem, W. and Jones, R.L. (2015). *Biochemistry and Molecular Biology of Plants*. (2nd ed.). Wiley Blackwell, Chichester.
5. Grierson, D. and Covey, S.N. (2021). *Plant Molecular Biology*. (3rd ed.). Springer Nature, Cham.
6. Griffiths, A.J.F., Wessler, S.R., Carroll, S.B. and Doebley, J. (2020). *An Introduction to Genetic Analysis*. (12th ed.). W.H. Freeman and Company, New York.
7. Lewin, B. (2008). *Genes IX*. (9th ed.). Jones and Bartlett Publishers, Sudbury, Massachusetts
8. Klug, W.S., Cummings, M.R., Spencer, C.A., Palladino, M.A. and Killian, D.J. (2023). *Concepts of Genetics*. (13th ed.). Pearson Education, New York.
9. Pierce, B.A. (2023). *Genetics: A Conceptual Approach*. (8th ed.). W.H. Freeman and Company, New York.

24/07/26

Kalpana Srivastava
Officer on special duty (Judicial)

10. Poehlman, J.M. and Sleper, D.A. (2017). *Breeding Field Crops*. (6th ed.). Wiley Blackwell, Ames.
11. Slater, A., Scott, N.W. and Fowler, M.R. (2018). *Plant Biotechnology: The Genetic Manipulation of Plants*. (3rd ed.). Oxford University Press, Oxford.
12. Snustad, D.P. and Simmons, M.J. (2019). *Principles of Genetics*. (7th ed.). John Wiley & Sons, Hoboken.

C.7 Suggested E-Resources/Digital Repositories

1. SWAYAM/NPTEL: Genetics and Genomics - https://onlinecourses.swayam2.ac.in/e-learning/preview/cec21_bt05
2. SWAYAM/NPTEL: Molecular Biology - https://onlinecourses.nptel.ac.in/e-learning/preview/noc24_bt07
3. SWAYAM/NPTEL: Basics of Crop Breeding and Plant Biotechnology - https://onlinecourses.nptel.ac.in/e-learning/preview/noc24_ag08
4. e-PGPathshala: Eukaryotic Transcription - https://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/S000002BI/P001357/M021480/ET/1501754300EucaryoticTranscriptionE-text.pdf

C.8 Assessment Pattern & Question Paper Design

The **End-Semester examination** shall be conducted as per the following question paper design:

Section A: MCQs/Short Answer Questions (10 × 2 marks = 20 marks) — Covering all Units (mandatory)

Section B: Medium Answer Questions (4 × 5 marks = 20 marks) — Attempt any 4 out of 6 (These 6 questions should cover all Units).

Section C: Long Answer / Essay Questions (3 × 10 marks = 30 marks) — Attempt 3 out of 5 (At least one question from each Unit).

Internal Assessment (30 marks) breakdown:

Written Test(s): 20 marks

Seminar/Assignment/Project: 05 marks

Attendance & Class Participation: 05 marks

24/07/26

Kalpana Srivastava
Officer on special duty (Judicial)

MSBOT-PC204

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSBOT-PC204
Title of the Paper	Core Course IV: Practicals Based on CC-201, 202 & 203
Programme / Subject	M.Sc. — Botany
Semester	Semester II
Nature of Course	Practical Course (PC)
L – T – P	0 – 0 – 4
Credits	4
Maximum Marks	100 (Practical: 70 + Internal Assessment: 30)
Duration of Examination	6 Hours for ESE

C.2 Marks Distribution

Component	Paper IV	Practical	IA	Total (ESE+IA/ESE+PRAC)
End Semester Examination	—	—	—	—
Practical / Lab Work	—	70	—	70
Internal Assessment	—	—	30	30
Maximum Marks	—	**70**	**30**	**100**
Passing Marks	—	**32**	**13**	**45 (45%)**

Note: Internal Assessment shall be evaluated on the basis of attendance, class tests, seminars, assignments, and *viva voce* as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	To develop practical skills in plant collection, identification, herbarium preparation and specimen preservation.
COB 2	To impart experimental knowledge of plant physiological processes through laboratory investigations.
COB 3	To provide hands-on training in the study of reproductive structures, embryological processes used in plant developmental biology.
COB 4	To familiarise students with the principles of classical and molecular genetics, including inheritance patterns, linkage analysis and genetic mapping.
COB 5	To enable students to perform basic molecular biology techniques, analyse experimental data and develop scientific, analytical, and laboratory skills.

24/07/26

Kalpana Srivastava
Officer on special duty (Judicial)

C.4 Course Outcomes (COs)

After completing this course, students will be able to:

CLO No.	Course Learning Outcome
CLO 1	Explain the taxonomic characteristics of locally available plant families, medicinal plants and the significance of plant classification in botanical studies.
CLO 2	Demonstrate skills in plant collection, herbarium preparation, specimen preservation, mounting, cataloguing and the use of taxonomic keys for accurate plant identification.
CLO 3	Analyze the diversity of floral structures, including androecium and inflorescence types and interpret their taxonomic significance in angiosperm classification.
CLO 4	Demonstrate practical knowledge of embryological techniques such as stigma squash preparation and pollen germination studies.
CLO 5	Evaluate physiological processes in plants by conducting experiments on osmosis, plasmolysis, transpiration, photosynthetic pigments, respiration through biochemical estimations.
CLO 6	Analyze Mendelian and non-Mendelian inheritance patterns, linkage relationships, recombination frequencies and construct genetic maps using experimental data.
CLO 7	Develop laboratory competencies in molecular and genetic techniques, including genomic DNA isolation and agarose gel electrophoresis.

C.5 Syllabus — Unit-wise Breakdown

Course Name: Practicals Based on CC-201, 202 & 203 (MSBOT-PC204)		
Unit	**Content**	**Suggested Lectures hours**
I	Taxonomy 1. Family description of some locally available plants. 2. Taxonomy and significance of some important medicinal plants. 3. Compilation of field notes and preparation of herbarium sheets. 4. Study methods of specimen preservation, mounting, and cataloguing. 5. Learn methods of plant identification (including preparation of taxonomic keys).	30
II	Embryology 1. Study of megasporogenesis, megagametogenesis and mature female gametophyte with the help of permanent slides and electron micrographs. 2. Study of stigma by squash method. 3. Study of pollen germination. 4. Mounting and study of the embryo and endosperm. 5. Assessment of pollen fertility and viability.	30

24/07/26

	6. Comparative assessment of viability, germinability and vigor of pollen. 7. Assessment of stigma-receptivity by localizing non-specific esterases, phosphatases and peroxidases. 8. Study of types and structures of stigma and style through sections in selected taxa. 9. Study of the embryo, endosperm and haustorium in selected taxa through dissections.	
III	Plant Physiology 1. Estimation of chlorophyll and carotenoid content in leaves. 2. Experiment on osmosis and plasmolysis. 3. Estimation of total soluble sugars in a plant. 4. Estimation of total proteins in a plant. 5. Study of enzyme activity: amylase/catalase under different pH and temperature. 6. Separation of plant pigments by paper chromatography. 7. Determination of nitrate reductase activity. 8. Bioassays for auxin and gibberellin activity. 9. Study the lipid peroxidation under abiotic stress in plant leaf samples by estimating the malondialdehyde (MDA) content. 10. Study the role of compatible osmolytes for salinity tolerance by estimating the proline content in leaf samples. 11. Study the leaf anatomy of C3 and C4 plants.	30
IV	Genetics 1. Study of Mendelian and non-Mendelian inheritance patterns. 2. Calculation of recombination frequencies. 3. Determination of linkage relationships. 4. Construction of genetic maps from the given data. 5. Isolation of genomic DNA from cauliflower. 6. Visualization of DNA by agarose gel electrophoresis. 7. Polymerase Chain Reaction (PCR) amplification of plant-specific genes. 8. Plasmid DNA isolation and characterization.	30
	Total Suggested Contact Hours For Practical/Field Work Courses	**120 Hours/Semester**

C.6 Recommended Textbooks

1. Bendre, A.M. and Kumar, A. (1984). *A Text Book of Practical Botany*, Vol. I and Vol. II. Rastogi Publications.
2. Dogra, K.R., Kumar, S. and Rahi, L. (2023). *Practical Manual on Plant Breeding & Genetics*. Gyanavi Publishers & Distributors
3. Singh, S., Sharma, H. and Sharma, V. (2025). *A Practical Hand Book of Genetics and Cell Biology*. Walnut Publication.

C.7 Reference Books & Readings

1. Hofmann, A. and Clokie, S. (Eds.) (2018). *Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology*. 8th ed. Cambridge University Press.
2. Moore, S., Stein, W.H. and others (2019 Reprint). *Experimental Methods in Plant Physiology*. Academic Press, London.

KD 24/07/26

Kalpana Srivastava
Officer on special duty (Judicial)

C.7 Suggested E-Resources/Digital Repositories

1. Plant Embryology (Virtual lab simulations): https://www.cuhk.edu.hk/lifesciences/IVFDL/
2. Molecular Biology: https://learn.genetics.utah.edu/content/labs/

C.8 Assessment Pattern & Question Paper Design

The **End-Semester practical examination** shall be conducted as per the following question paper design:

The examinee shall perform any **four** experiments or provide comments on a model, instrument, or specimen from five practicals, with one practical drawn from each unit:

$4 \times 12 = 48$ marks

Spotting: 10 marks

***Viva voce*:** 06 marks

Practical Record: 06 marks

Internal Assessment (30 marks) breakdown:

Two practicals from the syllabus: $10 \times 2 = 20$ marks

Seminar/Assignment/Project: 05 marks

Attendance & Class Participation: 05 marks

24/07/26

Kalpana Srivastava
Officer on special duty (Judicial)

MSBOT-GE205

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSBOT-GE205
Title of the Paper	Elective Course I: Biofertilizer Technology
Programme / Subject	M.Sc. — Botany
Semester	Semester II
Nature of Course	Elective Course (GE)
L – T – P	3 – 1 – 0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours for ESE

C.2 Marks Distribution

Component	Paper I	Practical	IA	Total (ESE+IA)
End Semester Examination	70	—	—	70
Internal Assessment	—	—	30	30
Maximum Marks	**70**	**—**	**30**	**100**
Passing Marks	**32**	**—**	**13**	**45 (45%)**

Note: Internal Assessment shall be evaluated on the basis of attendance, class tests, seminars, assignments, and viva voce as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	To provide a comprehensive understanding of the principles, classification, production and agricultural significance of various biofertilizers.
COB 2	To develop knowledge and practical skills in the isolation, purification, mass multiplication, quality control and application of important biofertilizers.
COB 3	To acquaint students with the biological mechanisms of nitrogen fixation, phosphate solubilization, nutrient mobilisation and mycorrhizal associations.
COB 4	To impart an understanding of integrated nutrient management for promoting sustainable, organic agricultural practices.
COB 5	To familiarize students with the commercial production, policy framework, government support programs and successful applications of biofertilizers in Indian agriculture.

C.4 Course Outcomes (COs)

After completing this course, students will be able to:

CLO No.	Course Learning Outcome
CLO 1	Explain the concepts, classification, and significance of biofertilizers, mycorrhizae, PGPR and compost biofertilizers in sustainable agriculture.
CLO 2	Demonstrate the techniques for isolation, purification, mass multiplication, inoculum preparation and field application of important biofertilizers.
CLO 3	Analyse the mechanisms of biological nitrogen fixation, heterocyst differentiation, phosphate solubilization and mineral mobilisation.
CLO 4	Evaluate the role of mycorrhizal associations, phosphate- and potassium-solubilising microorganisms and other biofertilizers in enhancing nutrient uptake, plant productivity, drought tolerance and soil fertility.
CLO 5	Demonstrate practical knowledge of vermicomposting, biofertilizer formulation, quality control, storage, shelf-life management and commercial production techniques.
CLO 6	Develop integrated strategies by combining biofertilizers with organic and inorganic nutrient sources for improving crop and environmental sustainability.
CLO 7	Evaluate and develop sustainable agricultural approaches by assessing the role of biofertilizers in climate-resilient farming and organic agriculture.

C.5 Syllabus — Unit-wise Breakdown

Course Name: Biofertilizers (MSBOT-GE106)		
Unit	**Content**	**Suggested Lectures hours**
I	**Introduction to Biofertilizers** Introduction, types and classification of biofertilizers - nitrogen fixers, phosphate solubilizers (PSM), Phosphate mobilizing-Mycorrhizae, Mineral-Solubilizing Biofertilizers, Plant growth-promoting rhizobacteria (PGPR) and Compost Biofertilizers; Role of biofertilizers in soil health and organic farming; Advantages of Biofertilizers over chemical fertilizers.	8L + 2T

24/07/26

Kalpana Srivastava
Officer on special duty (Judicial)

II	Symbiotic Nitrogen Fixers: *Rhizobium:* Isolation, purification, mass multiplication, inoculum production and methods of application of *Rhizobium* inoculants. *Frankia*-actinorhizal symbiosis. Asymbiotic Nitrogen Fixers: *Azotobacter, Azospirillum, Clostridium.* Isolation, purification and mass multiplication of *Azospirillum* and *Azotobactercter*, formulation of inoculum and application of inoculants of *Azospirillum* and *Azotobactercter.*	10L + 4L
III	Cyanobacteria: Isolation and purification of Cyanobacteria; Mass multiplication of cyanobacterial bioinoculants- Trough or Tank method, Pit method, Field method; methods of application of cyanobacterial inoculum. *Azolla* - mass cultivation and application in rice fields. Heterocyst differentiation and function.	9L + 3T
IV	Phosphate, Potassium Solubilizing Microorganisms and Mycorrhizae: Phosphate Solubilizers: *Bacillus, Pseudomonas, Aspergillus*, mechanism of organic acid production. Mineral-Solubilizing Biofertilizers: Potassium solubilizing, Silicate and zinc solubilizing Mycorrhizae: Types: Ectomycorrhiza, endomycorrhiza (arbuscular mycorrhiza - AM). Role in nutrient uptake, drought resistance, and plant protection. Mass multiplication and field application techniques. Vermicomposting	10L + 3T
V	Biofertilizers: Storage, shelf life, quality control and marketing Field application techniques: seed treatment, soil application, foliar spray. Integrated Nutrient Management (INM) and biofertilizer combinations. Role of biofertilizers in climate-resilient and organic agriculture. National policies, subsidy schemes, and biofertilizer promotion programs in India. Case studies: Biofertilizer success stories in Indian agriculture.	8L + 3T
	Total Suggested Lectures	**60 (For 4 Credit Course) [45 L+15 T]**

24/07/26

Kalpana Srivastava
Officer on special duty (Judicial)

Suggested Pedagogical Methods

1. SWOT Analysis of Biofertilizers: Students conduct a SWOT analysis of biofertilizers as an agricultural input, comparing them with chemical fertilizers, organic manures, and integrated nutrient management (INM) approaches. They present a comparative report. Develops analytical and comparative skills.
2. Flipped Journal Club – *Frankia* & Actinorhizal Symbiosis: Assign a paper on *Frankia*-actinorhizal symbiosis (e.g., in Casuarina, Alnus). Students present the molecular mechanisms of infection, nodule development, and nitrogen fixation, and discuss its potential for reforestation and agroforestry.
3. Field Method Demonstration – Cyanobacterial Application-Students visit a paddy field (or use a video demonstration) to observe the field method of cyanobacterial application.
4. Field Application Techniques – Demonstration of different biofertilizer application techniques: (a) Seed treatment (coating seeds with inoculant), (b) Soil application (mixing inoculant with soil/compost), (c) Foliar spray (for certain biofertilizers).

C.6 Recommended Textbooks

1. Gupta, M.M., Kumari, A. and Sharma, A. (2025). *Agrifood Waste as Biofertilizer*. 1st ed., CAB International.
2. Patel, V.K., Mahajan, V.L. and Shaikh, V.G. (2024). *Biofertilizers and Biopesticides*. Atharva Publications.
3. Rao, S. (2025). *Bio-fertilizers in Agriculture and Forestry*. 4th ed., Scientific International.
4. Tiwari, V.N. (2025). *Principles & Practices of Natural Farming*. Agrotech Publishing.

C.7 Reference Books & Readings

1. Dufossé, L, Joshi, N.C., Villalobos, S.S. and Kumar, A. (2026). *Microbial Fertilizers: Innovations and Applications for Sustainable Agriculture*. 1st Ed. Elsevier.
2. Fahad, S., Saud, S., Wahid, F. and Adnan, M. (2024). *Biofertilizers for sustainable soil management*. 1st Ed. CRC Press.

C.7 Suggested E-Resources/Digital Repositories

1. SWAYAM/NPTEL: Soil Fertility and Fertilizers - https://nptel.ac.in/courses/126105024

C.8 Assessment Pattern & Question Paper Design

The **End-Semester examination** shall be conducted as per the following question paper design:

Section A: MCQs/Short Answer Questions (10 × 2 marks = 20 marks) — Covering all Units (mandatory)

Section B: Medium Answer Questions (4 × 5 marks = 20 marks) — Attempt any 4 out of 6 (These 6 questions should cover all Units).

Section C: Long Answer / Essay Questions (3 × 10 marks = 30 marks) — Attempt 3 out of 5 (At least one question from each Unit).

Internal Assessment (30 marks) breakdown:

Written Test(s): 20 marks

Seminar/Assignment/Project: 05 marks

Attendance & Class Participation: 05 marks

24/07/26
Kalpana Srivastava
Officer on special duty (Judicial)

MSBOT-GE206

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSBOT-GE205
Title of the Paper	General Elective II: Intellectual Property Rights
Programme / Subject	M.Sc. — Botany
Semester	Semester II
Nature of Course	General Elective (GE)
L – T – P	3 – 1 – 0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours for ESE

C.2 Marks Distribution

Component	Elective Paper I	Practical	IA	Total (ESE+IA)
End Semester Examination	70	—	—	70
Internal Assessment	—	—	30	30
Maximum Marks	**70**	—	**30**	**100**
Passing Marks	**32**	—	**13**	**45 (45%)**

Note: Internal Assessment shall be evaluated on the basis of attendance, class tests, seminars, assignments, and *viva voce* as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	To provide a comprehensive understanding of the concepts, principles, and legal frameworks of Intellectual Property Rights (IPR).
COB 2	To familiarize students with plant variety protection systems, geographical indications, and the regulatory mechanisms of plant genetic resources.
COB 3	To develop an understanding of the criteria, procedures, ethical concerns, and legal issues associated with patenting biological inventions and innovations.
COB 4	To impart knowledge of biodiversity laws, traditional knowledge protection, and national and international measures for preventing biopiracy.

24/07/26

COB 5	To equip students with practical skills in patent searching, patent documentation, intellectual property management, technology transfer, licensing and bio-entrepreneurship for the commercialisation of scientific innovations.

C.4 Course Outcomes (COs)

After completing this course, students will be able to:

CLO No.	Course Learning Outcome
CLO 1	Explain the fundamental concepts, types, and significance of Intellectual Property Rights (IPR), including patents, trademarks and copyrights.
CLO 2	Demonstrate an understanding of national and international IPR frameworks, including TRIPS, WTO, WIPO and their relevance to biological sciences and biotechnology.
CLO 3	Analyze the provisions of the Plant Variety Protection and Farmer's Rights (PPV & FR) Act, 2001, UPOV guidelines and geographical indications.
CLO 4	Analyze the importance of traditional knowledge, biodiversity conservation and the role of national and international regulations in preventing biopiracy and unauthorised exploitation of biological resources.
CLO 5	Evaluate the legal, ethical, and social implications of patenting biological inventions, genetically modified organisms, transgenic crops and microorganisms.
CLO 6	Demonstrate the ability to conduct patent searches, interpret patent documents, and understand the procedures involved in drafting, filing and managing intellectual property applications.
CLO 7	Develop strategies for intellectual property management, technology transfer, licensing, bio-entrepreneurship and commercialisation of innovations.

C.5 Syllabus — Unit-wise Breakdown

Course Name: Intellectual Property Rights (MSBOT-GE206)		
Unit	**Content**	**Suggested Lectures hours**
I	Basic concepts of Intellectual Property: Patents, Trademarks, Copyrights and Trade Secrets; International agreements: TRIPS, WTO, WIPO, and the Berne/Paris Conventions; The role of IPR in scientific research and biological prospecting.	9L + 3T
II	The UPOV (Union for the Protection of New Varieties of Plants) framework; PPV&FR Act, 2001 (India): Protection of plant varieties, essentially derived varieties (EDVs), and registration processes; Farmer's rights, researchers' rights, and benefit-sharing mechanisms;	10L + 3T

24/07/26

Kalpana Srivastava
Officer on special duty (Judicial)

	Geographical Indications (GI) for culturally significant plant products (e.g., Darjeeling Tea, Basmati).	
III	Criteria for patenting biological inventions (novelty, inventive step, industrial applicability); Ethical, legal, and social issues (ELSI) of patenting GMOs, transgenic crops, and gene sequences; Budapest Treaty on the international recognition of the deposit of microorganisms for patent purposes.	8L + 3T
IV	Biological Diversity Act (2002) (India) and the Nagoya Protocol; TKDL (Traditional Knowledge Digital Library) and measures to prevent bio-prospecting and biopiracy (e.g., the Neem and Turmeric patent disputes); The concept of prior informed consent (PIC) and mutually agreed terms (MAT).	9L + 3T
V	Patent search databases (WIPO, Indian Patent Office, Espacenet); Drafting and filing a patent application (provisional vs. complete specifications); Technology transfer, licensing agreements, and bio-entrepreneurship.	9L + 3T
	Total Suggested Lectures	**60 (For 4 Credit Course) [45 L+15 T]**

Suggested Pedagogical Methods

1. Comparative Analysis of types of IPR: Students create a comparative table of Patents, Trademarks, Copyrights, and Trade Secrets. They must: (a) Define each, (b) Provide examples from biological sciences, (c) Discuss the duration of protection, (d) Explain the registration process.
2. Case Study – Biological Prospecting Success and Failure: Present case studies of successful (e.g., the discovery of Taxol from Pacific yew) and controversial (e.g., biopiracy allegations) biological prospecting. Students analyze the IPR issues involved and propose ethical guidelines.
3. Flipped Journal Club – UPOV vs. Smallholder Farmers: Assign a paper on the impact of UPOV on smallholder farmers and biodiversity conservation. Students present the arguments for and against UPOV, discuss the Indian context, and propose alternatives.
4. GI Tagging – Research Project: Students research a GI-tagged agricultural/plant product.
5. Bio-entrepreneurship – Business Plan Development: Students work in groups to develop a business plan for a bio-entrepreneurial venture (e.g., a startup based on a patented biological invention). They must: (a) Describe the technology/product, (b) Analyze the market, (c) Plan IP protection (patents, trademarks), (d) Outline the business model

C.6 Recommended Textbooks

1. Ahuja, V.K. (2023). *Intellectual Property Rights in India.* 4th ed. LexisNexis Butterworths, New Delhi.
2. Basheer, S. and Reddy, P.P. (2022). *Intellectual Property Law and Innovation in India.* Oxford University Press, New Delhi.
3. Ganguli, P. (2021). *Intellectual Property Rights: Unleashing the Knowledge Economy.* McGraw Hill Education, New Delhi.

24/07/26

4. Gopalakrishnan, N.S. and Agitha, T.G. (2021). *Principles of Intellectual Property*. 3rd ed. Eastern Book Company, Lucknow.
5. Jain, M.P. and Jain, S.C. (2023). *Intellectual Property Rights and Information Technology Law*. LexisNexis, New Delhi.
6. Kumar, A. and Singh, P. (2022). *Biodiversity, Traditional Knowledge and Intellectual Property Rights.* Studium Press, New Delhi.
7. Nair, M.D. and Kumar, R. (2021). *Intellectual Property Rights: A Handbook for Researchers and Innovators.* New India Publishing Agency, New Delhi.
8. Narayanan, P. (2022). *Intellectual Property Law.* 5th ed. Eastern Law House, Kolkata.
9. Singh, N.K. and Sharma, R. (2021). *Plant Variety Protection and Farmers' Rights in India.* New India Publishing Agency, New Delhi.
10. Vashishth, V. and Sinha, A.K. (2022). *Intellectual Property Rights and Biodiversity Conservation*. Springer Nature, Singapore.

C.7 Reference Books & Readings

1. Bainbridge, D.I. (2022). *Intellectual Property*. 11th ed. Pearson Education, Harlow.
2. Bently, L., Sherman, B., Gangjee, D. and Johnson, P. (2022). *Intellectual Property Law*. 6th ed. Oxford University Press, Oxford.
3. Blakeney, M. (2021). *Intellectual Property Rights and Food Security*. CABI Publishing, Wallingford.
4. Cornish, W., Llewelyn, D. and Aplin, T. (2023). *Intellectual Property: Patents, Copyright, Trade Marks and Allied Rights*. 10th ed. Sweet & Maxwell, London.
5. Dutfield, G. and Suthersanen, U. (2020). *Global Intellectual Property Law*. 3rd ed. Edward Elgar Publishing, Cheltenham.
6. Khoury, A. and Blakeney, M. (2022). *Research Handbook on Intellectual Property and Biodiversity*. Edward Elgar Publishing, Cheltenham.
7. Matthews, D. and Munoz-Tellez, V. (2023). *Research Handbook on TRIPS and Intellectual Property*. Edward Elgar Publishing, Cheltenham.
8. WIPO (2023). *Understanding Intellectual Property*. World Intellectual Property Organization, Geneva.

C.7 Suggested E-Resources/Digital Repositories

1. SWAYAM/NPTEL: Intellectual Property - https://onlinecourses.nptel.ac.in/e-learning/preview/noc22_hs59
2. SWAYAM PRABHA: https://www.youtube.com/watch?v=F-4cpb3kAfM

C.8 Assessment Pattern & Question Paper Design

The **End-Semester Examination** shall be conducted as per the following question paper design:

Section A: MCQs/Short Answer Questions (10 × 2 marks = 20 marks) — Covering all units (mandatory)

Section B: Medium Answer Questions (4 × 5 marks = 20 marks) — Attempt any 4 out of 6

Section C: Long Answer / Essay Questions (3 × 10 marks = 30 marks) — Attempt 3 out of 5.

Internal Assessment (30 marks) breakdown:

Written Test(s): 20 marks

24/07/26

Kalpana Srivastava
Officer on special duty (Judicial)

Seminar/Assignment/Project: 05 marks

Attendance & Class Participation: 05 marks

24/07/26

Kalpana Srivastava
Officer on special duty (Judicial)

D PART D — GENERAL REGULATIONS & PROVISIONS

D.1 Attendance & Eligibility

5. A student must have a minimum of 75% attendance in each paper to be eligible to appear in the Semester / Annual Examination.
6. Condonation of attendance deficiency shall be governed by the Regulation..
7. A student detained due to shortage of attendance may appear to the examinations of same semester in the next academic session subject to payment of prescribed fees.

D.2 Examination & Promotion Rules

8. A student is required to clear **at least** 60% (4 out of 6) papers of a particular Semester before being promoted to the succeeding Semester.
9. Back / Ex-Student candidates shall be governed by the rules in force at the time of their original admission unless otherwise specifically notified.
10. A candidate who fails in one or more papers shall be required to appear only in the failed paper(s) (Carry Forward System) in subsequent examinations of the same Semester.
11. A candidate is required to clear all his papers within a maximum of **Five Years of duration** to qualify for the degree.

D.3 Grading System (CBCS)

Letter Grade	% Range	Grade Point	Performance Description	Remarks
O	≥90-100	10	Outstanding	Pass
A+	≥80<90	9	Excellent	Pass
A	≥70<80	8	Very Good	Pass
B+	≥60<70	7	Good	Pass
B	≥55<60	6	Above Average	Pass
C	≥50<55	5	Average	Pass
P	≥45<50	4	Pass	Pass
F	<45	0	Fail	Fail
Ab/M	0	0	Absent/Malpractice	Fail / Reappear

24/07/26

Kalpana Srivastava
Officer on special duty (Judicial)

E PART E — ABBREVIATIONS & AUTHENTICATION

E.1 List of Abbreviations

Abbr.	Expansion	Abbr.	Expansion
CC	Core Course	**DSE**	Discipline Specific Elective
GE	Generic Elective	**OE**	Open Elective
AEC	Ability Enhancement Course	**VAC**	Value Added Course
SEC	Skill Enhancement Course	**IKS**	Indian Knowledge System
L	Lecture (hours per week)	**T**	Tutorial (hours per week)
P	Practical (hours per week)	**IA**	Internal Assessment
CCA	Continuous & Comprehensive Assess.	**CLO**	Course Learning Outcome
PLO	Programme Learning Outcome	**GA**	Graduate Attribute
NHEQF	National HE Qualifications Framework	**PROJ**	Project / Dissertation

E.2 Authentication

Subject Expert-1
[Sushil Kr Singh,]
[Professor, Department of Botany A. N. College Patna
Patliputra University Patna]
Date: 29.06.2026

Subject Expert-2
[Dr. Meenu Gupta]
[Department of Botany J. D. Women's College Patna, Patliputra University Patna]
Date: 29.06.26

Subject Expert-3
[Dr. Sumit Kumar]
[Department of Botany Nalanda College Bihar Sharif, Patliputra University Patna]
Date: 29-06-2026

Subject Expert-4 (If applicable)
[Name of the University]
Date: _____

24/07/26
Kalpana Srivastava
Officer on special duty (Judicial)