

**Shiv Chhatrapati Shikshan Sanstha's**  
**Rajarshi Shahu Mahavidyalaya, Latur**  
**Empowered Autonomous Institution**



**Structure and Curriculum of**  
**Undergraduate Programme of Science & Technology**  
**B.Sc. (Honors/Research) in Botany**

**Board of Studies**  
**in**  
**Botany**

**Rajarshi Shahu Mahavidyalaya, Latur**  
**Empowered Autonomous Institution**

**(UG IV Year)**

**w.e.f. June, 2026**

**(In Accordance with NEP-2020)**

## **Review Statement**

The NEP Cell reviewed the Curriculum of **B.Sc. (Honors/Research /Degree) in Botany** Programme to be effective from the **Academic Year 2026-27**. It was found that, the structure is as per the NEP-2020 guidelines of Govt. of Maharashtra.

**Date:** 10/04/2026

**Place:** Latur

**NEP Cell**

Rajarshi Shahu Mahavidyalaya, Latur  
Empowered Autonomous Institution

## **CERTIFICATE**

I hereby certify that the documents attached are the Bonafide copies of the Curriculum of **B.Sc. (Honors/Research) in Botany** Programme to be effective from the **Academic Year 2026-27**.

Date: 10/04/2026

Place: Latur

**(S. N. Shinde)**

Chairman

Board of Studies in Botany

Rajarshi Shahu Mahavidyalaya, Latur

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Shiv Chhatrapati Shikshan Sanstha's

## Rajarshi Shahu Mahavidyalaya, Latur

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### Members of Board of Studies in the Subject Botany Under the Faculty of Science and Technology

Sr. No.	Name	Designation	In position
1.	Shri S. N. Shinde, Head, Department of Botany, Rajarshi Shahu Mahavidyalaya, Latur	Chairperson	HoD
2.	Dr. B. S. Survase, Director, School of Life Sciences, S. R. T. M. U. Nanded	Member	V.C. Nominee
3.	Prof. Dr. A. S. Dhabe, Head, Department of Botany, Dr. B. A.M. University, Chhatrapati Sambhajinagar	Member	Expert from outside for Special Course
4.	Prof. Dr. A. B. Ade, Head, Department of Botany, Savitribai Phule Pune University, Pune	Member	Academic Council Nominee
5.	Dr. C. S. Swami, Head, Department of Botany, Dayanand Science College, Latur	Member	College Alumni
6.	Dr. S.H. Nile, National Agri-Food Biotechnology Institute, Mohali, India	Member	Expert from outside for Special Course
7.	Dr. K. D. Savant, Department of Botany, Rajarshi Shahu Mahavidyalaya, Latur	Member	Member from same Department
8.	Shri. D. R. Awad, Department of Botany, Rajarshi Shahu Mahavidyalaya, Latur	Member	Member from same Department
9.	Ms. P. V. Kumbhar, Department of Botany, Rajarshi Shahu Mahavidyalaya, Latur	Member	Member from same Department
10.	Ms. P. S. Maskepatil, Department of Botany, Rajarshi Shahu Mahavidyalaya, Latur	Member	Member from same Department
11.	Ms. P. B. Gore, Department of Botany, Rajarshi Shahu Mahavidyalaya, Latur	Member	Member from same Department
12.	Ms. N. S. Kamble, Department of Botany, Rajarshi Shahu Mahavidyalaya, Latur	Member	Member from same Department

## From the Desk of the Chairperson...

The Department of Botany is established in 1971. It is one of the leading departments in the field of teaching and student centric activities. After Autonomy, in keeping pace with the advances in various aspects of plant sciences, the department has introduced the courses like Molecular Biology, Cell Biology, Plant Biotechnology, Bioinformatics, Genetics, Instrumentation in Botany, Pharmacognosy, Gardening and Landscaping, Plant Breeding, Biostatistics, Forensic Botany etc. The Department has academic autonomy and has been revising its curriculum regularly. The department has successfully implemented the Choice Based Credit System (CBCS) for grading the students. The Curriculum of the B.Sc. and M.Sc. has been designed by considering NET, SET, GATE and others competitive examinations.

Institution's Motto, *Aroha Tamaso Jyoti* (The Journey from Dark to Light), the Mission, *Pursuit of Excellence*, the Vision, to evolve as a World Class Dynamic Center of Higher Education, and the Core Values have been frequently reflected in the present curriculum.

The Higher Education System in India and all over the world has undergone paradigm shift in both qualitative and quantitative aspects. Its best example is National Education Policy (NEP-2020). The National Education Policy 2020 emphasizes on developing overall personality of students by incorporating Humanitarian and Constitutional values, creativity and critical thinking, harnessing innovation, use of modern technology and interaction with various stakeholders. It recognizes that the pedagogy should evolve to make education more experiential, holistic, integrated, learner-centric, flexible and developing skill, etc. to shape the student that can face the challenges of the future, the new policy also envisages the refinement and improvement in the Learning Outcome based Curriculum Framework.

Botany is one of the most fundamental branches of Life Sciences. It is the broad subject encompassing classical and modern systemic aspects of plant diversity as well as contemporary subjects like Molecular Biology, Bioinformatics, Biotechnology, etc. to foster comprehensive understanding about various aspects of plant sciences. The present learning outcome based curriculum framework for B. Sc. (Honors/Research) in Botany is designed to provide a focused learning outcome based syllabus at the Honors level providing structured teaching-learning experiences catering to needs of the students. The honors course in Botany will prepare the students both academically and in terms of employability. This program also inculcates various attributes like Problem solving, Research skills, Critical thinking etc. These attributes encompass values related to emotional stability, social justice, creative and critical thinking, well-being and various skills required for employability, thus preparing students for continuous learning and sustainability.

As per the Institutional policy it is decided to upgrade the curriculum and syllabi of UG after every three year and PG after two years progressively. Accordingly, the curriculum and syllabi UG-I & PG-I upgraded and UG-IV newly designed keeping in mind the aspirations of the students, changing nature of the subject as well as the learning environment. Minor changes have been introduced in the syllabus of UG-II, UG-III and PG-II as per the need and the suggestions of the stakeholders. Courses of Botany have been designed to incorporate recent advancements, techniques to upgrade the skills of students. The new structure is expected to enhance the level of understanding among students and maintain the standard of Honors Degree in Botany across the country. The efforts have been made to integrate use of recent technology and use of MOOCs to assist teaching-learning process. This framework offers flexibility and

innovation in syllabi designing and in methods adopted for teaching-learning process and learning assessment.

The present structure comprises Discipline specific courses (DSC), Discipline Specific Electives (DSE), Discipline Specific Minor Course (DSM), Generic/Open Electives (GE/OE), Vocational Specific Course (VSC), Skill Enhancement Course (SEC), Major Mandatory Course (MMC). Major Elective Course (MEC) Research Methodology Course (RMC) etc. The discipline specific courses (DSC) and Major Mandatory Course (MMC) are compulsory and the elective courses can be chosen from the given Basket. Most of the courses comprise theory and practicals.

The project work is specially emphasized in this structure. The project will mainly involve experimental work. The students will be asked their choice for project. The Generic Electives will be offered to the students of other departments of the college. The students will have the option to choose one generic elective from the given Basket. The generic elective comprises theory as well as practical. The students will also undertake one Vocational Specific Course (VSC) and one Skill Enhancement Course (SEC) of two credits each. The VSC and SEC also comprise theory and practicals. These courses will be chosen by the students from the concerned basket.

One DSC- Ayurveda and Medicinal Botany is specified for Indian Knowledge Systems (IKS) which is a strong foundation in Indian Medicinal System Culture, Philosophy and Spirituality and have evolved through thousands of years. These knowledge systems are applicable in the modern world in several ways.

These courses offer skills to pursue research and teaching in the field of Botany and thus would produce best minds to meet the demands of society. This curriculum framework for B.Sc. (Honors) in Botany is developed keeping in view of the students centric learning Pedagogy, which is entirely outcome oriented. The curriculum framework focuses on the pragmatist approach whereby practical application of theoretical concepts is covered through Laboratory and Field works.

The new curriculum offers knowledge of wide areas in Botany including Diversity, Plant Systematics, Plant Biotechnology, Cell Biology, Genetics, Environmental Biology, Plant Physiology, Bioinformatics, and Medicinal Plants. Plant disease management etc. This new syllabus has been prepared keeping in view the unique requirement of B.Sc. (Honors) Botany students. The contents of the syllabi have been drawn to accommodate the widening horizons of the Botany discipline and reflect the changing needs of the students. The semester wise course distribution and detailed syllabus for each course is appended with a list of suggested references

The major objective of this curriculum is to elevate the subject knowledge of the students, making them critical thinkers and able to solve problems and issues related to Botany logically and efficiently.



**(S. N. Shinde)**  
Chairman  
Board of Studies in Botany  
Rajarshi Shahu Mahavidyalaya, Latur



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## Rajarshi Shahu Mahavidyalaya, Latur

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### Department of Botany

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### Department of Botany

UG Skeleton in Accordance with NEP-2020

Illustrative Credit Distribution Structure for Four Year B.Sc. Degree (Honors)

Year & Level	Sem	Major		Minor	GE / OE	VSC/ SEC (VSEC)	AEC/ VEC	OJT/FP/ CEP/RP	Credit per Sem.	Cum./Cr. per exit
		DSC	DSE							
1	2	3	4	5	6	7	8	9	10	
IV 6.0	VII	DSC XIII: 04 Cr. DSCXIV: 04 Cr. DSCXV: 04 Cr DSCXVI 02 Cr	DSE- III 04 Cr.	RMC: 4Cr					22	44
	VIII	DSC XVII: 04 Cr. DSCXVIII: 04 Cr. DSCXIX: 04 Cr DSCXX 02 Cr	DSE- IV 04 Cr.				OJT/FP 4Cr	22		
	Cum . Cr.							44		

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## Rajarshi Shahu Mahavidyalaya, Latur

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### Department of Botany UG Skeleton in Accordance with NEP-2020 Illustrative Credit Distribution Structure By Research

Year & Level	Sem	Major		Minor	GE / OE	VSC/ SEC (VSEC)	AEC/ VEC	RP	Credit per Sem.	Cum./Cr. per exit
		DSC	DSE							
1	2	3		4	5	6	7	8	9	10
IV 6.0	VII	DSC XIII: 04 Cr. DSCXIV: 04 Cr. DSCXV: 02 Cr	DSE-III 04 Cr.	RMC: 4Cr				4 Cr RP	22	44
	VIII	DSC XVI: 04 Cr. DSCXVII: 04 Cr. DSCXVIII: 02 Cr	DSE-IV 04 Cr.				8 Cr RP	22		
	Cum. . Cr.								44	

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### Abbreviations:

1. DSC : Discipline Specific Core (Major)
2. DSE : Discipline Specific Elective (Major)
3. DSM : Discipline Specific Minor
4. OE : Open Elective
5. VSEC : Vocational Skill and Skill Enhancement Course
6. VSC : Vocational Skill Course
7. SEC : Skill Enhancement Course
8. AEC : Ability Enhancement Course
9. MIL : Modern Indian Languages
10. IKS : Indian Knowledge System
11. FSRCE: Fostering Social Responsibility & Community Engagement
12. VEC : Value Education Course
13. OJT : On Job Training
14. FP : Field Project
15. CEP : Community Engagement Programme
16. CC : Co-Curricular Course
17. RP : Research Project/Dissertation
18. SES : Shahu Extension Services



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## Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

### Department of Botany

#### UG IV

#### Courses and Credits: Sem-VII

Sr. No.	Course Type	Course Code	Credits	Marks	Hours L/P
1	DSC-XIII	401BOT7101	03	75	45
2	DSC-XIV	401BOT7102	03	75	45
3	DSC-XV	401BOT7103	03	75	45
4	DSC-XVI	401BOT7104	02	50	30
5	DSE -III(A)	401BOT7201	03	75	45
6	DSE-III (B)	401BOT7202	03	75	45
7	RMC	401BOT7301	04	100	60
8	Lab Course-XIII	401BOT7105	01	50	30
9	Lab Course-XIV	401BOT7106	01	50	30
10	Lab Course-XV	401BOT7107	01	50	30
11	Lab Course-III(A)	401BOT7203	01	50	30
12	Lab Course-III (B)	401BOT7204	01	50	30
13	Research Project		4	100	

#### Sem-VIII

Sr. No.	Course Type	Course Code	Credits	Marks	Hours L/P
1	DSC-XVII	401BOT8101	03	75	45
2	DSC-XVIII	401BOT8102	03	75	45
3	DSC-XIX	401BOT8103	03	75	45
4	DSC-XX	401BOT8104	02	50	30
5	DSE -IV (A)	401BOT8201	03	75	45
6	DSE -IV (B)	401BOT8202	03	75	45
7	Lab Course-XVI	401BOT8106	01	50	30
8	Lab Course-XVII	401BOT8107	01	50	30
9	Lab Course-XVIII	401BOT8108	01	50	30
10	Lab Course-IV (A)	401BOT8203	01	50	30
11	Lab Course-IV (B)	401BOT8204	01	50	30
12	Research Project	401BOT8101	06	150	



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## Rajarshi Shahu Mahavidyalaya, Latur

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### Department of Botany

#### UG Program Outcomes:

Programme Outcomes (POs) for B.Sc. Botany	
PO 1	<b>Disciplinary Knowledge</b> Students will acquire comprehensive knowledge of plant sciences, including taxonomy, physiology, genetics, ecology, microbiology, and biotechnology, forming a strong academic foundation.
PO 2	<b>Scientific Temper and Research Skills</b> Students will develop scientific thinking, research aptitude, and the ability to design experiments, analyze data, and interpret results using appropriate methodologies.
PO 3	<b>Practical and Technical Skills</b> Students will demonstrate proficiency in laboratory and field techniques such as microscopy, plant identification, tissue culture, and use of scientific instruments.
PO 4	<b>Critical Thinking and Problem Solving</b> Students will apply logical reasoning and analytical skills to identify, evaluate, and solve problems related to plant sciences and environmental challenges.
PO 5	<b>Communication Skills</b> Students will communicate scientific knowledge effectively through oral presentations, reports, and scientific writing using appropriate terminology.
PO 6	<b>Digital and Data Literacy</b> Students will utilize modern tools, software, and statistical techniques for data analysis, documentation, and presentation in biological sciences.
PO 7	<b>Environment and Sustainability Awareness</b> Students will understand ecological principles, biodiversity conservation, and sustainable use of plant resources to address environmental issues.
PO 8	<b>Ethics and Social Responsibility</b> Students will adhere to ethical principles in scientific practices and demonstrate responsibility towards society, environment, and biodiversity conservation.
PO 9	<b>Entrepreneurship and Innovation</b> Students will explore entrepreneurial opportunities in plant-based industries such as agriculture, horticulture, and biotechnology, fostering innovation and self-employment.
PO 10	<b>Lifelong Learning and Professional Development</b> Students will develop self-directed learning abilities, adaptability, and professional competence to pursue higher education and careers in diverse fields.

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### Department of Botany

#### UG Programme Specific Outcomes:

Programme Specific Outcomes (PSOs) for B.Sc. Botany (Honors/Research)	
PSO No.	Programme Specific Outcomes (PSOs)
PSO 1	<b>Academic Competence</b> Students will acquire comprehensive knowledge of fundamental and advanced concepts in Botany, including plant diversity, physiology, genetics, ecology, and biotechnology. They will develop a strong theoretical foundation along with practical skills to understand plant structure, function, and interactions, enabling them to pursue higher studies and professional careers in plant sciences and related fields.
PSO 2	<b>Scientific Research Competence</b> Students will develop the ability to design and conduct basic scientific investigations in plant sciences, formulate hypotheses, collect and analyze data, and interpret results using appropriate tools and techniques. They will gain exposure to research methodologies, scientific writing, and critical evaluation of literature, enabling them to contribute to research and innovation in botany and allied fields.
PSO 3	<b>Practical Skills</b> Students will acquire hands-on experience in laboratory and field techniques such as microscopy, plant identification, tissue culture, physiological experiments, and data analysis. They will demonstrate proficiency in the use of scientific instruments, sample collection, preservation, and documentation, ensuring accuracy, safety, and reliability in experimental work.
PSO 4	<b>Critical Thinking &amp; Problem Analysis:</b> Students will develop the ability to critically analyze biological problems related to plant sciences, interpret experimental data, and apply scientific reasoning to propose logical and sustainable solutions. They will be able to evaluate ecological, agricultural, and biotechnological issues using evidence-based approaches and demonstrate problem-solving skills in real-life situations
PSO 5	<b>Personal and Professional Competence</b> Students will develop effective communication, teamwork, and leadership skills along with problem-solving and decision-making abilities. They will cultivate lifelong learning habits, adaptability, and professionalism required for careers in education, research, industry, and environmental management.
PSO 6	<b>Ethical Entrepreneurship</b> Students will understand the principles of ethics, sustainability, and environmental responsibility in the application of plant sciences. They will be encouraged to explore entrepreneurial opportunities in areas such as plant nurseries, herbal products, agriculture, and biotechnology, while adhering to ethical practices and contributing to socio-economic development.

**Mapping Scale:**

1 = Low    2 = Moderate    3 = High

PO \ PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
<b>PO1: Advanced Disciplinary Knowledge</b>	3	2	2	1	1	2
<b>PO2: Research Competence &amp; Scientific Inquiry</b>	2	3	2	2	1	1
<b>PO3: Experimental &amp; Technical Expertise</b>	2	2	3	2	1	1
<b>PO4: Critical Thinking &amp; Analytical Skills</b>	1	2	2	3	2	2
<b>PO5: Scientific Communication</b>	1	2	1	2	3	1
<b>PO6: Digital &amp; Computational Skills</b>	1	2	3	2	2	1
<b>PO7: Environmental &amp; Sustainability Awareness</b>	2	2	1	2	2	3
<b>PO8: Ethical Values &amp; Professional Integrity</b>	1	1	1	2	2	3
<b>PO9: Entrepreneurship &amp; Innovation</b>	1	1	1	2	2	3
<b>PO10: Leadership &amp; Lifelong Learning</b>	2	2	1	2	3	2



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## Rajarshi Shahu Mahavidyalaya, Latur

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### Department of Botany

UG IV

#### Major & Major Elective (DSC&DSE):

##### Sem-VII

Sr. No.	Major Course Title/Elective	Course Code	Credits	Marks	Hours L/P
1	DSC-XIII: Advanced Cell Biology	401BOT7101	03	75	45
2	Lab Course-XIII	401BOT7105	01	50	30
3	DSC-XIV: Biodiversity of Microbes and Cryptogams.	401BOT7102	03	75	45
4	Lab Course-XIV	401BOT7106	01	50	30
5	DSC-XV: Biomolecules	401BOT7103	03	75	45
6	Lab Course-XV	401BOT7107	01	50	30
7	<b>DSC-XVI:</b>	<b>401BOT7104</b>	<b>02</b>	<b>50</b>	
8	DSE-III (A): Bioinstrumentation and Biostatistics	401BOT7201	03	75	45
9	Lab Course-III	401BOT7203	01	50	30
10	DSE-III (B): Plant Physiology	401BOT7202	03	75	45
11	Lab Course-III	401BOT7204	01	50	30
	Total		22		

##### Sem-VIII

Sr. No.	Major Course Title/Elective	Course Code	Credits	Marks	Hours L/P
1	DSC-XVII: Diversity of Pteridophytes, Gymnosperms	401BOT8101	03	75	45
2	Lab Course- XVI	401BOT8105	01	50	30
3	DSC-XVIII: Plant Physiology and Metabolism	401BOT8102	03	75	45
4	Lab Course-XVII	401BOT8106	01	50	30
5	DSC-XIX: Plant Structure Development & Reproduction in Angiosperms	401BOT8103	03	75	45
6	Lab Course-XVIII	401BOT8107	01	50	30
7	<b>DSC-XX:</b>	<b>401BOT8104</b>	<b>02</b>	<b>50</b>	
8	DSE-IV(A): Plant Ecology and Evolution	401BOT8201	03	75	45
9	Lab Course-IV (A)	401BOT8203	01	50	30
10	DSE-IV (B): Angiosperms Systematics	401BOT8202	03	75	45
11	Lab Course-IV (B)	401BOT8204	01	50	30
11	Field Project			50	

# Semester - VII

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## Rajarshi Shahu Mahavidyalaya, Latur

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### Department of Botany

UG IV Sem VII

Course Type: DSC-XIII

Course Title: Advanced Cell Biology

Course Code: 401BOT7101

Credits: 03

Maximum Marks: 75

Lectures: 45 Hrs.

#### Learning Objectives:

- LO 1. To differentiate the structural organization of prokaryotic and eukaryotic cells.
- LO 2. To explain the mechanisms of energy generation and utilization in cells.
- LO 3. To analyze the cellular components and molecular mechanisms involved in mitotic and meiotic cell division.
- LO 4. To apply principles of cell biology to interpret changes in cell function due to environmental factors, physiological conditions, or genetic mutations.
- LO 5. To evaluate signal transduction pathways and their significance in cellular responses.

#### Course Outcomes:

After completion of the course, students will be able to-

- CO 1. Analyze fundamental concepts of advanced cell biology.
- CO 2. Apply and integrate knowledge of cellular structure and function.
- CO 3. Demonstrate proficiency in microscopic techniques and interpret ultrastructure from electron micrographs.
- CO 4. Apply knowledge of signal transduction pathways to explain cellular responses under different physiological conditions.

Unit No.	Title of Unit & Contents	Hrs.
I	Cell Organelles-I	12
	<ol style="list-style-type: none"><li>1. Introduction</li><li>2. Cell Wall - Biogenesis, Ultra structure and functions. Growth- primary and secondary wall.</li><li>3. Cell Membrane-Molecular organization, Fluid mosaic model, membrane protein diffusion, transport across membranes- facilitated diffusion, carrier &amp; channel proteins, transporters, active transport, transport of ions and solutes.</li><li>4. Biogenesis of chloroplasts and mitochondria.</li><li>5. Molecular organization of chloroplast and mitochondrial membranes.</li><li>6. Plasmodesmata –Structure and role in movement of molecules.</li><li>7. Vacuoles–Tonoplast membrane biogenesis, transporters,</li></ol>	

	<p>role as storage organelle, transport across vacuolar membrane.</p> <p>8. Correlate significance of bacteria, algae and fungi with human welfare.</p>	
	<p><b>Unit Outcomes:</b></p> <p>UO1. Correlate cell structure using compound microscope and elucidation of Ultra structure from Electron Microphotographs.</p>	
<b>II</b>	<b>Cell Organelles-II</b>	<b>11</b>
	<ol style="list-style-type: none"> <li>1. Nucleus-Structure, organization and regulation of nuclear pore complex. Transport across nuclear membrane.</li> <li>2. Endoplasmic Reticulum- Role in synthesis and transport of secretory proteins.</li> <li>3. Golgi complex–Role in sorting, storage and secretion.</li> <li>4. Lysosomes, membrane integrity and role Glyoxysomes and Peroxisomes structure and functions.</li> <li>5. Ribosome–Structure, assembly and dissociation of subunits, functions.</li> <li>6. Structure and function of Cytoskeleton: Composition and organization of microtubules, micro filaments. Tread milling, role in cell division, signaling and intracellular traffic. Role in motility. Flagella-Structure and organization.</li> </ol>	
	<p><b>Unit Outcome:</b></p> <p>UO1. Apply and integrate the basic concepts of cell biology including structure and functions of organisms.</p>	
<b>III</b>	<b>Cell Signaling and Communication</b>	<b>11</b>
	<p><b>Cell signaling:</b></p> <ol style="list-style-type: none"> <li>1. Introduction</li> <li>2. Hormones and their receptors, cell surface receptor, signaling through G-protein coupled receptors.</li> <li>3. Signal transduction pathways, secondary Messengers.</li> <li>4. Regulation of signaling pathways.</li> <li>5. Bacterial and plant two component systems.</li> <li>6. Light signaling in plants.</li> </ol> <p><b>Cellular communication:</b></p> <ol style="list-style-type: none"> <li>1. Regulation of Hematopoiesis</li> <li>2. General principles of cell communication</li> <li>3. Cell adhesion and roles of different adhesion molecules</li> <li>4. Gap junctions</li> <li>5. Extra cellular matrix and integrin's</li> <li>6. Neurotransmission and it's regulation</li> </ol>	
	<p><b>Unit Outcome:</b></p> <p>UO1. Justify the basic aspects of cell signaling and cellular communication.</p>	
<b>IV</b>	<b>Cell Cycle</b>	<b>11</b>
	<p><b>Cell Cycle</b></p> <ol style="list-style-type: none"> <li>1. Phases of Cell Cycle.</li> <li>2. Functional importance of each phase.</li> </ol>	

	<ol style="list-style-type: none"> <li>3. Molecular events during cell cycle.</li> <li>4. Regulation of cell cycle.</li> <li>5. Cyclins and protein kinases.</li> <li>6. MPF (maturation promoting factor)</li> </ol> <p><b>A) Cell aging and cell senescence:</b></p> <ol style="list-style-type: none"> <li>1. Programmed cell death and its molecular aspects.</li> <li>2. Regulation of cell death.</li> <li>3. PCD in response to stress.</li> </ol> <p><b>B) Apoptosis</b></p> <ol style="list-style-type: none"> <li>1. Role of different genes.</li> <li>2. Cell organelles during apoptosis.</li> <li>3. Genetic control of apoptosis.</li> </ol>	
	<p><b>Unit Outcome:</b>          UO1. Understand the cell Aging and Cell Senescence &amp; Apoptosis.</p>	

### Learning Resources:

1. Modern Methods of Plant Analysis, Vol. I – Paech K and Tracey MV (eds),. Springer-Verlag, Berlin, Germany. 1956.
2. Modern Methods of Plant Analysis, Vol. II – Paech K and Tracey MV (eds),. Springer-Verlag, Berlin, Germany. 1955.
3. Molecular Biology of the Cell (6th edition) – Alberts B, Johnson A, Lewis J, Morgan D, Raff M, Roberts K and Walter P., Garland Science, New York, USA. 2015.
4. Essential Cell Biology (5th edition) – Alberts B, Bray D, Hopkin K, Johnson A, Lewis J, Raff M, Roberts K and Walter P., Garland Science, New York, USA. 2019.
5. Plant Cell Biology – Assmann SM and Liu B (eds),. Springer, New York, USA. 2016.
6. Applied Plant Cell Biology: Cellular Tools and Approaches – Nick P and Opatrny Z (eds),. Springer, Berlin, Germany. 2014.
7. Plant Physiology and Development (6th edition) – Taiz L, Zeiger E, Møller IM and Murphy A., Sinauer Associates, Sunderland, USA. 2018.
8. Cell and Molecular Biology (8th edition) – De Robertis EDP and De Robertis EMF., Lippincott Williams and Wilkins, Philadelphia, USA. 2017.
9. Cell Biology (3rd edition) – Pollard TD, Earnshaw WC and Lippincott-Schwartz J., Elsevier, Philadelphia, USA. 2017.
10. The Cell: A Molecular Approach (8th edition) – Cooper GM and Hausman RE., Sinauer Associates, Sunderland, USA. 2019.
11. Principles and Techniques of Biochemistry and Molecular Biology (8th edition) – Wilson K and Walker J., Cambridge University Press, Cambridge, UK. 2018.
12. Biophysical Chemistry – Upadhyay A, Upadhyay K and Nath N., Himalaya Publishing House, Mumbai, India. 2014.
13. Plant Biochemistry (4th edition) – Heldt HW and Piechulla B., Academic Press, Amsterdam, Netherlands. 2011.
14. Fundamentals of Biochemistry (5th edition) – Voet D, Voet JG and Pratt C., Wiley, Hoboken, USA. 2016.
15. Molecular Cell Biology (9th edition) – Lodish H, Berk A, Kaiser CA, Krieger M, Bretscher A, Ploegh H, Amon A and Scott MP., W.H. Freeman, New York, USA. 2021.
16. The Cell Cycle: Principles of Control – Morgan DO., Oxford University Press, Oxford, UK. 2007.

17. Plant Biotechnology: The Genetic Manipulation of Plants – Slater A, Scott N and Fowler M., Oxford University Press, Oxford, UK. 2008.
18. Introduction to Plant Tissue Culture (2nd edition) – Razdan MK., Science Publishers, Enfield, USA. 2003.
19. Plant Cell Culture: A Practical Approach – Dixon RA., IRL Press, Oxford, UK. 1985.
20. Plant Cytogenetics (3rd edition) – Singh RJ., CRC Press, Boca Raton, USA. 2016.
21. Plant Cell and Tissue Culture – Vasil IK (ed),. Springer, Dordrecht, Netherlands. 2008.

**e-Journals:**

1. <https://onlinelibrary.wiley.com/journal/15824934>
2. <https://juniperpublishers.com/ijcsmb/images/fraction-slider/IJCSMB .jpg>
3. <https://www.sciencedirect.com/journal/journal-of-molecular-biology>
4. <https://www.springer.com/journal/18/>
5. <https://www.mdpi.com/journal/cimb>
6. <https://www.peerreviewcentral.com/ads/image/AJBGMB.png>

**Internal Examination Pattern: Continuous Assessment Test (CAT):**

CAT-I: Book Reading/ Poster presentation/ Woolen model

CAT-II: Open book test/ Surprise test / Descriptive test

❖ **Mapping of Cos with POs & PSOs:**

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	2	1	2	1	2	1	1	0	1	3	2	1	2	1	1
CO2	3	3	1	3	1	2	2	1	0	1	3	2	1	3	2	1
CO3	2	2	3	2	1	2	1	1	0	1	2	2	3	2	1	1
CO4	3	3	1	3	2	2	2	1	0	1	3	3	2	3	2	1

**Scale:** 3 = High, 2 = Moderate, 1 = Low

Rajarshi Shahu Mahavidyalaya,  
Latur (Autonomous)



Shiv Chhatrapati Shikshan Sanstha's

## Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Department of Botany

UG IV Sem VII

Course Type: Lab Course

Course Title: Lab Course –XIII

Course Code: 401BOT7106

Credit: 01

Hours – 30 Hrs.

Maximum Marks – 50

### Learning Objectives:

- LO1. To familiarize students with advanced cell biology techniques, including microscopy and cell fractionation methods.
- LO2. To develop practical skills in cytological techniques, including karyotyping, mitotic index determination, and chiasmata analysis.
- LO3. To prepare reports and interpret electron micrographs for understanding cellular ultrastructure.
- LO4. To perform laboratory techniques including isolation of mitochondria, differential centrifugation, and permeability experiments.

### Course outcomes:

After completion of the course, students will be able to-

- CO1. Understand advanced cell biology techniques.
- CO2. Differentiate karyotyping, mitotic index determination, and chiasmata analysis.
- CO3. Perform laboratory techniques like differential Centrifugation.
- CO4. Describe & interpret electron micrographs for understanding cellular ultrastructure.

Sr. No.	Practicals
1	Demonstration of SEM and TEM (Photocopy).
2	Isolation of mitochondria.
3	Comparative study of normal and banded karyotype.
4	Determination of mitotic index in any plant species
5	Differential centrifugation for isolation of cell fractions –Nuclear fraction.
6	Determination of permeability of living cells to acids and bases.
7-8	Study of different stages of mitosis from Onion root tip.
9-10	Study of different stages of meiosis from suitable plant material.
10-11	Study of G-banding, S -banding using Florescence microscope using suitable plant material (Onion root tip).
12	Study of karyotype from suitable plant material.
13	Study of chiasmata frequency from suitable plant material.
14	Study of electron micrographs of cell organelles.

**N.B:** 1) Any ten Practical from above list

2) Several Short Excursions, field visit and at least one Long Excursion.

### Learning Resources:

1. Cell and Molecular Biology – Gerald Karp – Wiley – 2013

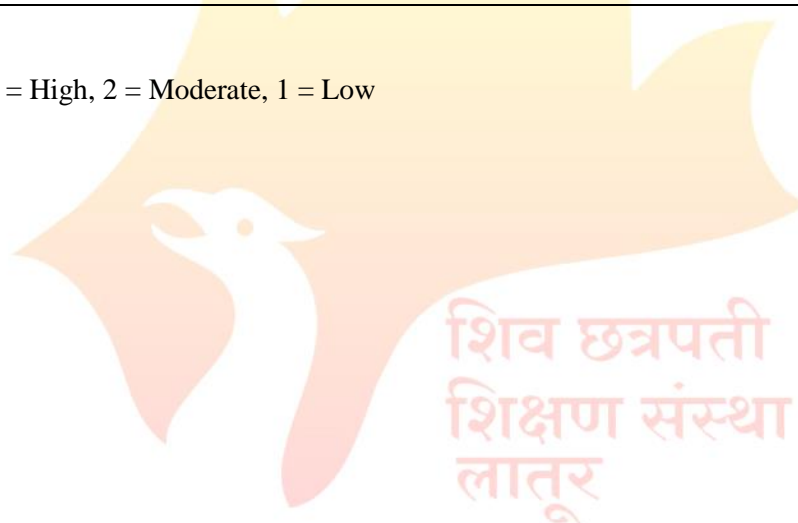
2. Molecular Biology of the Cell – Bruce Alberts, Alexander Johnson, Julian Lewis, et al. – Garland Science – 2015
3. Cell Biology – C. B. Powar – Himalaya Publishing House – 2012
4. Plant Cytogenetics – Ram J. Singh – CRC Press – 2016
5. Practical Cell Biology – C. B. Powar – Himalaya Publishing House – 2011
6. Cell Biology: A Laboratory Handbook – Julio E. Celis – Academic Press – 2006
7. Introduction to Practical Biology – R. C. Dubey & D. K. Maheshwari – S. Chand Publishing – 2013
8. Cytogenetics: Plant Chromosome Analysis – P. K. Gupta – Rastogi Publications – 2012
9. Wilson, K., & Walker, J. Principles and Techniques of Biochemistry and Molecular Biology (8th ed.). Cambridge: Cambridge University Press, 2018.
10. Plummer, D. T. An Introduction to Practical Biochemistry (5th ed.). New Delhi: Tata McGraw-Hill, 2004.
11. Jayaraman, J. Laboratory Manual in Biochemistry. New Delhi: New Age International Publishers, 2011.
12. Sadasivam, S., & Manickam, A. Biochemical Methods (3rd ed.). New Delhi: New Age International Publishers, 2008.
13. Cooper, G. M., & Hausman, R. E. The Cell: A Molecular Approach (8th ed.). Sunderland: Sinauer Associates, 2019.
14. Alberts, B., Johnson, A., Lewis, J., Morgan, D., Raff, M., Roberts, K., & Walter, P. Molecular Biology of the Cell (6th ed.). New York: Garland Science, 2015.
15. De Robertis, E. D. P., & De Robertis, E. M. F. Cell and Molecular Biology (8th ed.). Philadelphia: Lippincott Williams & Wilkins, 2017.
16. Karp, G. Cell and Molecular Biology: Concepts and Experiments (9th ed.). Hoboken: Wiley, 2019.
17. Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A., & Scott, M. P. Molecular Cell Biology (9th ed.). New York: W.H. Freeman, 2021.
18. Bancroft, J. D., & Gamble, M. Theory and Practice of Histological Techniques (7th ed.). Edinburgh: Churchill Livingstone, 2013.
19. Kiernan, J. A. Histological and Histochemical Methods: Theory and Practice (4th ed.). Oxford: Scion Publishing, 2008.
20. Singh, R. J. Plant Cytogenetics (3rd ed.). Boca Raton: CRC Press, 2016.
21. Sharma, A. K., & Sharma, A. Chromosome Techniques: Theory and Practice (3rd ed.). London: Butterworths, 1980.
22. Darlington, C. D., & La Cour, L. F. The Handling of Chromosomes (6th ed.). London: Allen & Unwin, 1976.
23. Ruzin, S. E. Plant Microtechnique and Microscopy. New York: Oxford University Press, 1999.
24. Jensen, W. A. Botanical Histochemistry: Principles and Practice. San Francisco: W.H. Freeman, 1962.
25. Hayat, M. A. Principles and Techniques of Electron Microscopy: Biological Applications (4th ed.). Cambridge: Cambridge University Press, 2000.
26. Bozzola, J. J., & Russell, L. D. Electron Microscopy: Principles and Techniques for Biologists (2nd ed.). Sudbury: Jones & Bartlett, 1999.
27. Griffiths, G. Fine Structure Immunocytochemistry. Berlin: Springer-Verlag, 1993.

28. Palade, G. E. Cell Fractionation Techniques. New York: Academic Press, 1977.

❖ Mapping of Cos with POs & PSOs: Lab Course XIII

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	2	1	2	1	2	1	1	0	1	3	2	1	2	1	1
CO2	3	3	1	3	1	2	2	1	0	1	3	3	2	3	2	1
CO3	2	2	3	2	1	2	1	1	0	1	2	2	3	2	1	1
CO4	3	3	1	3	2	2	2	1	0	1	3	3	2	3	2	1

Scale: 3 = High, 2 = Moderate, 1 = Low



॥ आर्योह तमसो ज्योतिः ॥

Rajarshi Shahu Mahavidyalaya,  
Latur (Autonomous)



Shiv Chhatrapati Shikshan Sanstha's

## Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Department of Botany

UG IV Sem VII

Course Type: DSC-XIV

Course Title: Biodiversity of Microbes and Cryptogams

Course Code: 401BOT7102

Credits: 03

Maximum Marks: 75

Hours: 45

### Learning Objectives:

- LO1. To understand microbial diversity and its significance.
- LO2. To investigate the Ecological impact of antibiotic administration on the cultivable indigenous microbiota.
- LO3. To analyze the alternation of generation of Cryptogams.
- LO4. To develop competencies that provides a strong and practical foundation for future careers.

### Course Outcomes:

After completion of the course, students will be able to-

- CO1. Investigate and explain the ecological role of bryophytes as indicators of pollution
- CO2. Identify the microbes on the basis of their morphological characteristics.
- CO3. Differentiate and correlate algal species based on morphology and pigmentation.
- CO4. Analyze and justify the diversity and significance of Microbes and Cryptogams.

Unit No.	Title of Unit & Contents	Hrs.
I	<b>Viruses, Bacteria and Mycoplasma</b>	10
	<b>1. Viruses:</b> <ul style="list-style-type: none"><li>1. Introduction</li><li>2. General characters,</li><li>3. Types</li><li>4. Ultra structure of plant viruses (TMV and Bacteriophage)</li><li>5. Transmission of plant viruses</li><li>6. Economic importance</li></ul>	
	<b>2. Bacteria:</b> <ul style="list-style-type: none"><li>1. Introduction</li><li>2. General characters,</li><li>3. Types</li><li>4. Ultra structure</li><li>5. Nutrition (Autotrophic, Heterotrophic and Symbiotic),</li><li>6. Reproduction (Binary fission, Transformation and Transduction),</li><li>7. Economic Importance</li></ul>	
	<b>3. Mycoplasma:</b> <ul style="list-style-type: none"><li>1. Introduction</li><li>2. General characters</li><li>3. Types</li></ul>	

	<p>4. Ultra structure</p> <p>5. Economic importance .</p> <p><b>Unit Outcomes:</b>          UO1. Identify the microbes on the basis of their morphology.          UO2. Understand the Microbial Diversity and Classification.</p>	
<b>II</b>	<b>Fungi</b>	<b>10</b>
	<p>1. Introduction</p> <p>2. General characters of Fungi</p> <p>3. Biodiversity and Taxonomy of the Phyla-</p> <p>a) Zygomycota (Rhizopus),</p> <p>b) Ascomycota (Aspergillus),</p> <p>c) Basidiomycota (Polyporus),</p> <p>d) Oomycota (Saprolegnia),</p> <p>e) Dueteromycota (Alternaria)</p> <p>4. Economic importance of Fungi.</p> <p><b>Unit Outcomes:</b>          UO-1 Justify the fungal diversity.          UO2. Understand the Fungal Diversity and Classification.</p>	
<b>III</b>	<b>Algae</b>	<b>12</b>
	<p>1. Thallus organization.</p> <p>2. Cell structure, Reproduction, Pigments, Reserve food, Flagella.</p> <p>3. Salient Features of –a) Chlorophyta (<i>Volvox</i>),</p> <p>b) Bacillariophyta (<i>Pinnularia</i>),</p> <p>c) Pheophyta (<i>Sargasum</i>)</p> <p>d) Rhodophyta (<i>Batrachospermum</i>)</p> <p>4. Economic importance of Algae</p> <p><b>Unit Outcomes:</b>          UO1. Correlate &amp; distinguish algal species on the basis morphology and pigmentation.          UO2. Analyze the Alternation of Generation of Algae.</p>	
<b>IV</b>	<b>Bryophytes</b>	<b>13</b>
	<p>6. Introduction and Origin of Bryophytes.</p> <p>7. Distribution, Habit, Morphology, Reproduction, Phylogeny, and Inter -relationship of the orders :</p> <p>a) Marchantiales (Riccia),</p> <p>b) Anthocerotales (Antheceros),</p> <p>c) Jungermanniales (Porella),</p> <p>d) Sphagnales (Sphagnum)</p> <p>4. Economic importance of Bryophytes</p> <p>5. Bryophytes as indicators of pollution.</p>	

	<p><b>Unit Outcomes:</b>          UO1. Investigate the Ecological impact of Bryophytes as pollution indicators.          UO2. Study morphology, reproductive structure and anatomy of Bryophytes .</p>	
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**Learning Resources:**

1. Textbook of Algae – Kumar HD and Singh HN., Affiliated East-West Press, New Delhi, India. 1971.
2. Textbook of Algae – Sharma OP., Tata McGraw-Hill Publishing Company, New Delhi, India. 1986.
3. Textbook of Botany: Algae – Pandey BP., S Chand and Company Pvt Ltd, New Delhi, India. 1994.
4. Botany for Degree Students: Algae – Vashishta BR., S Chand and Company Pvt Ltd, New Delhi, India. 1995.
5. College Botany, Vol. III – Gangulee HC and Kar AK., New Central Book Agency, Kolkata, India. 1992.
6. Taxonomy and Biology of Blue-Green Algae – Desikachary TV., Indian Council of Agricultural Research, New Delhi, India. 1959.
7. The Structure and Reproduction of Algae, Vol. I & II – Fritsch FE., Cambridge University Press, Cambridge, UK. 1965.
8. Algae: Form and Function – Venkataraman GS et al., Indian Council of Agricultural Research, New Delhi, India. 1974.
9. Textbook of Fungi – Sharma OP., Tata McGraw-Hill Publishing Company, New Delhi, India. 1989.
10. Morphology and Taxonomy of Fungi – Bessey EA., CBS Publishers and Distributors, New Delhi, India. 1967.
11. College Botany, Vol. I – Gangulee HS and Kar AK., New Central Book Agency, Kolkata, India. 1992.
12. The Myxomycetes of India – Thind KS., Indian Council of Agricultural Research, New Delhi, India. 1977.
13. Aquatic Fungi of India – Dayal R., Today and Tomorrow's Printers and Publishers, New Delhi, India. 1995.
14. The Inter-relationships of Bryophytes – Cavers F., Cambridge University Press, London, UK. 1964.
15. Liverworts of Western Himalayas and the Punjab Plains, Part I – Kashyap SR., University of the Punjab, Lahore, Pakistan. 1932.
16. An Introduction to Embryophyta, Vol. I: Bryophyta – Parihar NS., Central Book Depot, Allahabad, India. 1965.
17. Bryology in India – Udar R., Today and Tomorrow's Printers and Publishers, New Delhi, India. 1976.
18. Cryptogamic Botany, Vol. II – Smith GM., McGraw-Hill Book Company, New York, USA. 1955.
19. The Structure and Life of Bryophytes (3rd edition) – Watson EV., Hutchinson University Library, London, UK. 1964.
20. Botany for Degree Students: Bryophyta – Vashishta BR., S Chand and Company Pvt Ltd, New Delhi, India. 1996.
21. Biology of Bryophytes – Chopra RN and Kumra PK., Wiley Eastern Ltd., New Delhi, India. 1988.
22. Virology – Saravanan P., MJP Publishers, Chennai, India. 2010.
23. Textbook of Fungi, Bacteria and Viruses – Dubey HC., Vikas Publishing House Pvt Ltd, New Delhi, India. 2009.

24. Principles of Virology – Flint SJ, Enquist LW, Racaniello VR and Skalka AM,. ASM Press, Washington DC, USA. 2004.
25. Plant Bacteriology – Tripathi DP,. Oxford and IBH Publishing Company, New Delhi, India. 2008.

**Internal Examination Pattern: Continuous Assessment Test (CAT):**

CAT-I: Book Reading/ Assignments/ Collection of Specimens

CAT-II: Open book test/ Surprise test / Descriptive test

❖ **Mapping of Cos with POs & PSOs:**

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	2	1	2	1	1	3	2	0	1	3	2	1	2	2	1
CO2	3	2	2	2	1	1	2	2	0	1	3	2	2	2	2	1
CO3	3	2	2	3	1	2	2	2	0	1	3	3	2	3	2	1
CO4	3	3	2	3	2	2	3	2	0	2	3	3	2	3	3	2

**Scale:** 3 = High, 2 = Moderate, 1 = Low

शिव छत्रपती  
शिक्षण संस्था  
लातूर

॥ आरोग्यं तमसो ज्योतिः ॥

Rajarshi Shahu Mahavidyalaya,  
Latur (Autonomous)



Shiv Chhatrapati Shikshan Sanstha's

## Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

### Department of Botany

UG IV Sem VII

Course Type: Lab Course

Course Title: Lab Course-XIV

Course Code: 401BOT7107

Credits: 01

Maximum Marks: 50

Hours: 30

#### Learning Objectives:

- LO 1. To practically expose students to diverse life forms of microbes and cryptogams.
- LO 2. To study the lifecycles of cryptogams.
- LO 3. To provide hands-on experience in understanding morphological and reproductive structures through practical work.
- LO 4. To analyze the economic importance of Algae, Bryophyte and Fungi.

#### Course outcomes:

After completion of the course, students will be able to-

- CO1. Correlate and interpret the life cycles of algae, bryophytes, and fungi.
- CO2. Examine and describe the morphological and reproductive features of cryptogams.
- CO3. Differentiate and explain the distinguishing characteristics and affinities among various groups of cryptogams.
- CO4. Develop observational and analytical skills through the study of diversity in form, structure, and life cycles of algae, fungi, and bryophytes.

Sr. No.	Practicals
1	Isolation of Algae from soil and water.
2	Study of thallus and reproductive structures of <i>Chara</i> .
3	Study of thallus and reproductive structures of <i>Sargasum</i> .
4	Study of thallus and reproductive structures of <i>Pinnularia</i> .
5	Study of thallus and reproductive structures of <i>Batrachospermum</i> .
6	Study of thallus, internal and reproductive structures of <i>Riccia</i> .
7	Study of thallus, internal and reproductive structures of <i>Anthoceros</i> .
8	Study of thallus, internal and reproductive structures of <i>Polytricum</i> .
9	Study of thallus, internal and reproductive structures of <i>Porella</i> .
10	Study of thallus, internal and reproductive structures of <i>Sphagnum</i> .
11	Study of thallus and reproductive structures of <i>Rhizopus</i> .
12	Study of thallus and reproductive structures of <i>Aspergillus</i> .
13	Study of thallus and reproductive structures of <i>Polyporus</i> .
14	Study of thallus and reproductive structures of <i>Saprolegnia</i> .
15	Study of thallus and reproductive structures of <i>Steminitis</i> .
16	Preparation of culture media: PDA, Czapek, Dox Agar medium.
17	Isolation of Fungi from soil, air, water, and host, their inoculation on culture media.

**N.B:** 1) Any ten Practicals from above list

2) Several Short Excursions, field visit and at least one Long Excursion.

### Learning Resources:

1. Textbook of Algae – Kumar HD and Singh HN,. Affiliated East-West Press, New Delhi, India. 1971.
2. Textbook of Algae – Sharma OP,. Tata McGraw-Hill Publishing Company, New Delhi, India. 1986.
3. The Structure and Reproduction of Algae, Vol. I & II – Fritsch FE,. Cambridge University Press, Cambridge, UK. 1965.
4. Algae: Form and Function – Venkataraman GS et al., Indian Council of Agricultural Research, New Delhi, India. 1974.
5. The Structure and Life of Bryophytes (3rd edition) – Watson EV,. Hutchinson University Library, London, UK. 1964.
6. Botany for Degree Students: Bryophyta – Vashishta BR,. S Chand and Company Pvt Ltd, New Delhi, India. 1996.
7. Biology of Bryophytes – Chopra RN and Kumra PK,. Wiley Eastern Ltd., New Delhi, India. 1988.
8. Introduction to Fungi (3rd edition) – Webster J and Weber R,. Cambridge University Press, Cambridge, UK. 2007.
9. Textbook of Fungi, Bacteria and Viruses – Dubey HC,. Vikas Publishing House Pvt Ltd, New Delhi, India. 2009.
10. An Introduction to Mycology – Mehrotra RS and Aneja KR,. New Age International Publishers, New Delhi, India. 1990.
11. Fundamentals of Mycology – Burnett JH,. Edward Arnold, London, UK. 1976.
12. Fungi of India – Bilgrami KS, Jamaluddin and Rizwi MA,. Today and Tomorrow's Printers and Publishers, New Delhi, India. 1979.
13. Aquatic Fungi of India – Dayal R,. Today and Tomorrow's Printers and Publishers, New Delhi, India. 1995.
14. Experiments in Microbiology, Plant Pathology and Biotechnology (4th edition) – Aneja KR,. New Age International Publishers, New Delhi, India. 2003.

○ Mapping of Cos with POs & PSOs:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	2	2	3	2	1	1	2	1	0	1	3	2	3	2	1	1
CO2	3	2	3	2	1	1	2	1	0	1	3	2	3	2	1	1
CO3	3	2	3	3	1	2	2	1	0	1	3	3	3	3	2	1
CO4	3	3	3	3	2	2	3	2	0	2	3	3	3	3	3	2

Scale: 3 = High, 2 = Moderate, 1 = Low



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**Rajarshi Shahu Mahavidyalaya, Latur**

Empowered Autonomous Institution

**Department of Botany**

UG IV Sem VII

**Course Type: DSC-XV**

**Course Title: Biomolecules**

**Course Code: 401BOT7103**

**Credits: 03**

**Maximum Marks: 75**

**Hours: 45**

**Learning Objectives:**

- LO1. To describe the structure, classification, and functions of major biomolecules
- LO2. To illustrate the biochemical properties and structural organization of macromolecules and their interactions in living systems.
- LO3. To explain the molecular architecture and organization of cells.
- LO4. To summarize the metabolic pathways of carbohydrates, lipids, and proteins, including their dietary and endogenous sources.
- LO5. To evaluate the mechanisms of enzyme action, metabolic regulation, and hormone-mediated molecular signaling.

**Course Outcomes:**

After completion of the course, students will be able to-

- CO1. Analyze the structure and function of biomolecules in cellular processes.
- CO2. Explain the interactions among biomolecules in maintaining cellular organization and function.
- CO3. Analyze metabolic pathways and the role of enzymes in regulating metabolism.
- CO4. Evaluate the principles of metabolic control and hormonal regulation in biological systems.

Unit No.	Title of Unit & Contents	Hrs.
<b>I</b>	<b>Molecules and their Interaction</b>	<b>11</b>
	<ol style="list-style-type: none"><li>1. Structure of atoms, molecules and chemical bonds. (Covalent and Non - covalent bonds) Stabilizing interactions (H- bonding, hydrophobic interactions, electrostatic interactions Van - Der Waals interactions etc.)</li><li>2. Principles of biophysical chemistry Solutions (Percentage, Molar, Normal, PPM and PPB) pH Buffer, Reaction kinetics</li><li>3. Thermodynamics laws (Concept of entropy, Enthalpy, standard free energy, Colligative properties (Osmotic pressure freezing point and boiling point).</li><li>4. Gibb's free Energy</li></ol>	
	<b>Unit Outcome:</b> UO1. Understand the fundamental principles of atomic structure, chemical bonding, biophysical chemistry, and	

	thermodynamics and analyze their relevance in biological systems.	
<b>II</b>	<b>Structure and Functions of Biomolecules</b>	<b>11</b>
	<ol style="list-style-type: none"> <li>1. Composition, structure, types and function of biomolecules: <ol style="list-style-type: none"> <li>a. Carbohydrates</li> <li>b. Lipids</li> <li>c. Amino acids</li> <li>d. Peptide Bonds</li> </ol> </li> <li>2. Proteins (Primary, Secondary tertiary and quaternary structure) <p>Conformation of Protein (Ramachandran plot, Secondary structure, Domains, Motif and Folds.)</p> </li> <li>3. Nucleic acids. Nucleotides Conformation of nucleic acids (A B, Z DNA), RNA.</li> </ol> <p><b>Unit Outcome:</b>  UO1. Understand and explain the composition, structure, types, and biological functions of major biomolecules and nucleic acids and analyze their significance in cellular processes.</p>	
<b>III</b>	<b>Enzymology</b>	<b>12</b>
	<ol style="list-style-type: none"> <li>1. Introduction, Properties, Enzymes classification, vitamins as co-enzymes, Principles of catalysis and Enzyme kinetics (MM equation,)</li> <li>2. Types of Enzymes (Alloenzymes, isoenzymes, Apoenzymes, Ribozymes.)</li> <li>3. Types of Enzyme inhibition, (Competitive, noncompetitive and uncompetitive)</li> <li>4. Allosteric enzyme regulation.</li> </ol> <p><b>Unit Outcome:</b>  UO1. Explain and analyze enzyme classification, structure, catalytic mechanisms, and kinetics (Michaelis–Menten equation), along with different types of enzymes, inhibition mechanisms, and allosteric regulation in metabolic control.</p>	
<b>IV</b>	<b>Metabolism</b>	<b>11</b>
	<ol style="list-style-type: none"> <li>1. Metabolism of Carbohydrates (Gluconeogenesis), nucleotides Biosynthesis (De novo and salvage pathway).</li> <li>2. General pathway of Lipid metabolism.</li> <li>3. General pathway of Amino acid metabolism.</li> </ol> <p><b>Unit Outcome:</b>  UO1. Understand and analyze the major metabolic pathways of carbohydrates, lipids, amino acids, and nucleotides, including their biosynthesis and regulation, and evaluate their significance in cellular metabolism.</p>	

### Learning Resources:

1. A Textbook of Plant Physiology, Biochemistry and Biotechnology – Verma SK and Verma M., S Chand and Company Pvt Ltd, New Delhi, India. 2007.
2. Biochemistry and Molecular Biology of Plants – Buchanan BB, Gruissem W and Jones RL., American Society of Plant Physiologists, Rockville, USA. 2000.
3. Life Processes in Plants – Galston AW., Springer-Verlag, New York, USA. 1989.
4. Biochemistry – Powar CB and Chatwal GR., Himalaya Publishing House, Mumbai, India. 2005.
5. Biochemistry (4th edition) – Naik P., Jaypee Brothers Medical Publishers, New Delhi, India. 2012.
6. Biochemistry – Satyanarayana U and Chakrapani U., Books and Allied Pvt Ltd, Kolkata, India. 2013.
7. Fundamentals of Biochemistry (Revised edition) – Jain JL, Jain S and Jain N., S Chand and Company Pvt Ltd, New Delhi, India. 2007.
8. Fundamentals of Plant Biochemistry and Biotechnology – Gupta NK and Gupta S., Rastogi Publications, New Delhi, India. 2010.
9. Physicochemical and Environmental Plant Physiology (2nd edition) – Nobel PS., Academic Press, San Diego, USA. 1999.
10. Plant Biochemistry – Kilkar JP., Emkay Publications, Pune, India. 2000.
11. Plant Biochemistry – Arunkumar V, Senthilkumar N and Sivakumar K., MJ Publishers, New Delhi, India. 2012.
12. Plant Biochemistry – Nagaraj G., New Age International Publishers, New Delhi, India. 2005.
13. Plant Metabolism (2nd edition) – Dennis DT, Turpin DH, Lefebvre DD and Layzell DB (eds), Longman, Essex, UK. 1997.
14. Plant Physiology (4th edition) – Salisbury FB and Ross CW., Wadsworth Publishing Company, California, USA. 1992.
15. Plant Physiology (2nd edition) – Taiz L and Zeiger E., Sinauer Associates, Sunderland, USA. 1998.
16. Plant Physiology and Biochemistry – Srivastava HS., Academic Press (India), New Delhi, India. 2002.
17. Principles of Biochemistry – Lehninger AL, Nelson DL and Cox MM., CBS Publishers and Distributors (Indian Reprint), New Delhi, India. 2005.

### Internal Examination Pattern: Continuous Assessment Test (CAT):

CAT-I: Book Reading/ Assignment/Poster presentation

CAT-II: Open book test/ Descriptive test

❖ Mapping of Cos with POs & PSOs:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	2	1	2	1	2	1	1	0	1	3	2	1	2	1	1
CO2	3	2	1	3	1	2	1	1	0	1	3	2	2	3	1	1
CO3	3	3	2	3	1	2	2	1	0	1	3	3	2	3	2	1
CO4	2	3	2	3	1	2	2	1	0	1	3	3	2	3	2	1

Scale: 3 = High, 2 = Moderate, 1 = Low



॥ आरोह तमसो ज्योतिः ॥

Rajarshi Shahu Mahavidyalaya,  
Latur (Autonomous)



Shiv Chhatrapati Shikshan Sanstha's

## Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Department of Botany

UG IV Sem VII

Course Type: Lab Course

Course Title: Lab Course-XV

Course Code: 401BOT7108

Credit: 01

Maximum Marks: 50

Hours: 30

### Learning Objectives:

- LO 1. To familiarize students with basic biochemical laboratory techniques, instruments, and safety practices used in biomolecule analysis.
- LO 2. To develop skills to qualitatively and quantitatively estimate major biomolecules
- LO 3. To provide hands-on experience in the isolation, purification, and identification of DNA, RNA, and proteins from biological samples.
- LO 4. To understand the principles behind biochemical assays and analytical techniques.

### Course outcomes:

After completion of the course, students will be able to-

- CO1. Perform standard qualitative and quantitative biochemical tests for identification of biomolecules.
- CO2. Prepare reagents, standard solutions, and buffers accurately for laboratory experiments.
- CO3. Isolate and differentiate DNA, RNA, and proteins using appropriate experimental techniques.
- CO4. Apply principles of biochemical assays to analyze bimolecular composition in samples.

Sr. No.	Practicals
1	Quantitative estimation of protein by Foline -Lowry method.
2	Quantitative estimation of protein by Bradford reagent method.
3	Isolation of DNA from various sources.
4	Isolation of RNA from yeast tablets.
5	Estimation of DNA using Diphenyl Amine reagent.
6	Estimation of RNA by orcinol reagent.
7	Estimation of total Amino acid in Germinating and Non-germinating seeds.
8	Qualitative detection of Amino acid.
9	Estimation of total soluble sugars.
10	Effect of substrate concentration pH on enzyme activity.
11	Effect of pH on enzyme activity.

12	Estimation of Ascorbic acid in ripe and unripe fruits.
13	One Short/ Long Excursion

**N.B:** 1) Any ten Practicals from above list

2) Several Short Excursions, field visit and at least one Long Excursion.

**Learning Recourse:**

1. An Introduction to Practical Biochemistry (5th edition) – Plummer DT., Tata McGraw-Hill Publishing Company, New Delhi, India. 2004.
2. Laboratory Manual in Biochemistry – Jayaraman J., New Age International Publishers, New Delhi, India. 2011.
3. Biochemical Methods (3rd edition) – Sadasivam S and Manickam A., New Age International Publishers, New Delhi, India. 2008.
4. Principles and Techniques of Biochemistry and Molecular Biology (8th edition) – Wilson K and Walker J., Cambridge University Press, Cambridge, UK. 2018.
5. Lehninger Principles of Biochemistry (7th edition) – Nelson DL and Cox MM., W.H. Freeman and Company, New York, USA. 2017.
6. Fundamentals of Biochemistry (5th edition) – Voet D, Voet JG and Pratt C., Wiley, Hoboken, USA. 2016.
7. The Cell: A Molecular Approach (8th edition) – Cooper GM and Hausman RE., Sinauer Associates, Sunderland, USA. 2019.
8. Molecular Cloning: A Laboratory Manual (3rd edition) – Sambrook J and Russell DW., Cold Spring Harbor Laboratory Press, New York, USA. 2001.
9. Gene Cloning and DNA Analysis: An Introduction (7th edition) – Brown TA., Wiley-Blackwell, Oxford, UK. 2016.
10. Experiments in Microbiology, Plant Pathology and Biotechnology (4th edition) – Aneja KR., New Age International Publishers, New Delhi, India. 2003.
11. Biophysical Chemistry – Upadhyay A, Upadhyay K and Nath N., Himalaya Publishing House, Mumbai, India. 2014.
12. Elements of Biotechnology (2nd edition) – Gupta PK., Rastogi Publications, New Delhi, India. 2003.
13. Plant Physiology and Biochemistry – Srivastava HS., Academic Press (India), New Delhi, India. 2002.
14. Plant Physiology and Development (6th edition) – Taiz L, Zeiger E, Møller IM and Murphy A., Sinauer Associates, Sunderland, USA. 2018.
15. Principles of Instrumental Analysis (6th edition) – Skoog DA, Holler FJ and Crouch SR., Thomson Brooks/Cole, Belmont, USA. 2007.
16. Practical Clinical Biochemistry (5th edition) – Varley H, Gowenlock AH and Bell M., Heinemann Medical Books Ltd., London, UK. 1980.
17. Hawk's Physiological Chemistry (14th edition) – Oser BL., McGraw-Hill Book Company, New York, USA. 1965.

Mapping of Cos with POs & PSOs:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	2	2	3	2	1	2	1	1	0	1	3	2	3	2	1	1
CO2	2	2	3	2	1	2	1	1	0	1	3	2	3	2	1	1
CO3	3	3	3	3	1	3	2	1	0	1	3	3	3	3	2	1
CO4	3	3	3	3	2	3	2	1	0	2	3	3	3	3	3	2

Scale: 3 = High, 2 = Moderate, 1 = Low



शिव छत्रपती  
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लातूर

॥ आरोग्यं तमसो ज्योतिः ॥

Rajarshi Shahu Mahavidyalaya,  
Latur (Autonomous)



Shiv Chhatrapati Shikshan Sanstha's

## Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Department of Botany

UG IV Sem VII

**Course Type: DSC-XVI**

**Course Title: Teaching, Communication and Research Aptitude**

**Course Code: 401BOT7104**

**Credits: 02**

**Max. Marks: 50**

**Lectures: 30Hrs.**

### Learning Objectives:

- LO 1 To understand the concepts, objectives and levels of teaching-learning, along with learner characteristics and factors affecting learning.
- LO 2 To comprehend different types of communication, barriers, and methods of effective classroom and group communication.
- LO 3 To gain knowledge of research methodologies, hypothesis formulation, thesis writing and research ethics uses ICT tools.
- LO 4 To develop logical reasoning and data interpretation skills for analyzing arguments, solving problems and interpreting data.

### Course Outcomes

After completion of the course the students will be able to-

- CO 1 Explain and apply teaching-learning principles, instructional strategies, and evaluation techniques in biotechnology education and professional contexts.
- CO 2 Demonstrate effective scientific communication skills (oral, written, and digital) for presenting biological concepts and research findings.
- CO 3 Analyze research problems, design basic experimental methodologies, formulate hypotheses, and follow ethical practices in life sciences.
- CO 4 Apply logical reasoning, quantitative analysis, and data interpretation techniques to solve biological and biotechnological problems.

Rajarshi Shahu Mahavidyalaya,  
Latur (Autonomous)

Unit No.	Title of Unit & Contents	Hrs.
<b>I</b>	<b>Teaching and Learning Aptitude &amp; Research Aptitude</b>	<b>07 Hrs.</b>
	<ol style="list-style-type: none"> <li>Teaching: concept, objectives and levels (Memory, Understanding, Reflective)</li> <li>Learner's characteristics (cognitive, emotional, social)</li> <li>Factors affecting teaching-learning process</li> <li>Teaching methods: teacher-centered vs learner-centered</li> <li>Teaching support systems and evaluation methods</li> </ol> <p>Research: meaning, types and characteristics</p> <ol style="list-style-type: none"> <li>Research methods: experimental, qualitative, quantitative</li> <li>Research process and hypothesis</li> <li>Thesis writing and referencing styles</li> </ol>	
	<p><b>Unit Outcomes:</b></p> <p>UO 1 Explain teaching-learning processes and evaluation systems.</p> <p>UO 2 Apply research principles in scientific writing.</p>	
<b>II</b>	<b>Communication and Comprehension</b>	<b>07 Hrs.</b>
	<ol style="list-style-type: none"> <li>Communication: types, characteristics and barriers</li> <li>Verbal, non-verbal and group communication</li> <li>Classroom and mass communication</li> <li>Reading comprehension (passage-based questions)</li> </ol>	
	<p><b>Unit Outcomes:</b></p> <p>UO 1 Explain communication processes and barriers.</p> <p>UO 2 Apply comprehension and communication skills.</p>	
<b>III</b>	<b>Unit 4: ICT &amp; Higher Education System</b>	<b>08 Hrs.</b>
	<ol style="list-style-type: none"> <li>CT: Basics, E-learning Platforms</li> <li>Digital Initiatives in India (SWAYAM, e-PG Pathshala)</li> <li>Higher Education System in India</li> <li>Regulatory Bodies (UGC, AICTE, NAAC)</li> <li>Policies &amp; Governance (NEP 2020 Overview)</li> </ol>	
	<p><b>Unit Outcomes:</b></p> <p>UO 1 Analyze the significance of e-learning platforms such as SWAYAM and e-PG Pathshala in enhancing access to education.</p> <p>UO 2 Explain the basic concepts of Information and Communication</p>	

Unit No.	Title of Unit & Contents	Hrs.
	Technology (ICT) and its role in higher education.	
<b>IV</b>	<b>Logical Reasoning &amp; Data Interpretation</b>	<b>08 Hrs.</b>
	1. Logical reasoning: series, coding-decoding, analogies 2. Structure of arguments, fallacies, syllogism, Venn diagram 3. Indian logic: Pramanas and inference 4. Data interpretation: tables, graphs and charts	
	<b>Unit Outcomes:</b> UO 1 Analyze logical reasoning and argument structures. UO 2 Interpret data using graphical methods.	

### Learning Resources:

1. Pearson Education. *UGC NET/SET Paper I guide*. 2023 ed. New Delhi: Pearson Education.
2. Kothari CR. *Research methodology: Methods and techniques*. New Delhi: New Age International Publishers; 2004.
3. Kumar R. *Research methodology: A step-by-step guide for beginners*. New Delhi: SAGE Publications; 2011.
4. McQuail D. *Mass communication theory*. New Delhi: SAGE Publications; 2010.
5. IGNOU. *Teaching and research aptitude study materials*. 2022 ed. New Delhi: IGNOU Publications.
6. Government of India. *National education policy (NEP 2020)*. New Delhi: Ministry of Education; 2020.
7. NCBI. *NCBI database*. 2024 ed. Available from: National Center for Biotechnology Information.
8. National Library of Medicine. *PubMed database*. 2024 ed. Available from: NLM.

### Internal Examination Pattern :

CAT – I: Analytical Case Study on Applied Concepts in the Prescribed Syllabus

CAT – II: Critical Review and Analysis of Research Literature Relevant to the Syllabus

### Mapping of Cos with POs & PSOs:

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	2	2	2	3	1	–	2	1	2	3	2	2	2	3	1
CO2	2	2	1	2	3	3	–	1	1	2	2	2	1	2	3	1
CO3	3	3	2	3	2	2	1	3	1	2	3	3	2	3	2	2
CO4	2	3	2	3	1	3	2	1	1	2	2	2	2	3	2	1

Scale: 3 = High, 2 = Moderate, 1 = Low



Shiv Chhatrapati Shikshan Sanstha's

## Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Department of Botany

UG IV Sem VII

Course Type: DSE-III (A)

Course Title: Bioinstrumentation and Biostatistics

Course Code: 401BOT7201

Credits: 03

Maximum Marks: 75

Hours: 45

### Learning Objectives:

- LO1 .To illustrate the principles, working, and applications of microscopy, spectroscopy, and flow cytometry techniques.
- LO2.To perform and demonstrate separation techniques like chromatographic, electrophoretic, and culture techniques used in biological sciences.
- LO3. To learn laboratory safety practices, biochemical concepts (pH, buffers), and microtomy techniques for sample preparation and analysis.
- LO4. To analyze and interpret experimental data using radioactive techniques, biostatistics, and computational tools in biology.

### Course Outcomes:

After completion of the course, students will be able to-

- CO1. Examine principal, working and functions of different Bio- instruments.
- CO2. Understand principal, working and functions of different laboratory techniques.
- CO3. Justify the methods of Biostatistics.
- CO4. Explain the applications of Biostatistics in Biological research.

Unit No.	Title of Unit & Contents	Hrs.
I	<b>Microscopy and Spectroscopy</b>	10
	<b>1. Microscopy:</b> A. Light microscopy: Introduction, Principle and working of a. Compound microscope b. Stereo microscope c. Phase contrast microscope d. Fluorescence microscope B. Electron microscope: Introduction, Principle and working of a. TEM b. SEM, (image processing method and staining techniques). C. Flow cytometry.	
	<b>2. Spectroscopy:</b> Introduction, Principle and working of a. UV-visible spectrophotometry b. IR spectrophotometry c. NMR spectrophotometry	

	d. Mass spectrometry	
	<b>Unit Outcome:</b> UO1.Examine principal, working and functions of different bio- instruments.	
<b>II</b>	<b>Laboratory Techniques-I</b>	<b>12</b>
	<b>Separation Techniques:</b> 1. <b>Centrifugation Techniques:</b> Basic principles of centrifugation, different types rotors, different types of Centrifugations, care and safety aspects of centrifuges, preparative and analytical centrifugation 2. <b>Chromatographic Techniques:</b> Introduction, Principle and working of a. paper Chromatography b. Thin layer chromatography (TLC) c. HPLC d. GC 3. <b>Electrophoretic Techniques:</b> Introduction, Principle and working of a. Electrophoresis of Proteins (SDS PAGE) Agarose electrophoresis Culture Techniques	
	<b>Unit Outcome:</b> UO1.Examine principle, working and functions of different laboratory Techniques used for Separation of different biomolecules.	
<b>III</b>	<b>Laboratory Techniques-II</b>	<b>12</b>
	1. <b>Biochemistry Laboratory:</b> Laboratory discipline, safety and care, experimental report, SI unit, pH and Buffers. 1. <b>Culture Techniques:</b> Principles, types (bacterial, fungal) media preparation, Sterilization and Inoculation. 2. <b>Microtomy:</b> Principle of tissue fixation for microtomy, types of microtome's, Serial sectioning and staining. 3. <b>Radioactive Techniques:</b> Isotopes and their half-life and biological half-life Specific activityof radioisotopes, making radioisotope solutions.	
	<b>Unit Outcome:</b> UO1. Examine principal, working and functions of Microtomy and radioactive techniques.	
<b>IV</b>	<b>Laboratory Techniques-III</b>	<b>11</b>
	1. <b>Computers in Biology:</b> Modern computers, tissue in biological science, Internet	

	<p><b>2. Biostatistics:</b></p> <p>a. Measures of central tendency and dispersal</p> <p>b. Standard Deviation</p> <p>c. Probability distributions (Binomial, Poisson and normal)</p> <p>d. Regression and Correlation</p> <p>e. t-test; Analysis of variance; X</p>	
	<p><b>Unit Outcomes:</b></p> <p>UO1.Explain the applications of biostatistics in biological research.</p> <p>UO2.Understand the limitations and assumption of the T- test.</p>	

### Learning Resources:-

1. Instruments of Chemical Analysis – Kaur H., Pragati Prakashan, New Delhi, India. 2007.
2. Fundamentals of Biochemistry – Jain JL, Jain S and Jain N., S Chand and Company Pvt Ltd, New Delhi, India. 2007.
3. Textbook of Biochemistry – Jeya Shanthi N., New Age International Publishers, New Delhi, India. 2010.
4. Instrumental Methods of Chemical Analysis – Chatwal GR and Anand SK., Himalaya Publishing House, Mumbai, India. 2005.
5. Fundamentals of Biochemistry – Deb AC., New Central Book Agency, Kolkata, India. 2004.
6. Bioinstrumentation – Veera Kumari L., MJP Publishers, New Delhi, India. 2009.
7. Biological Instrumentation and Methodology – Bajpai PK., S Chand and Company Pvt Ltd, New Delhi, India. 2006.
8. Fundamentals of Biochemistry for Medical Students – Shanmugam A., Wolters Kluwer, Chennai, India. 2012.
9. Principles and Techniques of Biochemistry and Molecular Biology – Wilson K and Walker J., Cambridge University Press, Cambridge, UK. 2000.
10. Biomedical Instrumentation and Measurements – Cromwell L, Weibell FJ and Pfeiffer EA., Prentice Hall of India Pvt Ltd, New Delhi, India. 2006.
11. Methods in Experimental Biology – Ralph R., Blackie and Son Ltd., London, UK. 1975.
12. An Introduction to Biometry – Mungikar AM., Saraswati Printing Press, Aurangabad, India. 1997.
13. Fundamentals of Biostatistics – Khan IA and Khanum A., Ukaaz Publications, New Delhi, India. 2004.
14. Analytical Quantitative Methods in Microscopy – Meek GA and Elder HY., Cambridge University Press, Cambridge, UK. 1978.
15. Microscope Photometry – Piller H., Springer-Verlag, Berlin, Germany. 1977.
16. Biological Ultrastructure – Engstrom A and Finean JB., Academic Press, London, UK. 1963.

17. Techniques in Photomicrography – Brain EB and Ten Cate AR,. Butterworths, London, UK. 1969.
18. Photomicrography: A Comprehensive Treatise – Loveland RP,. John Wiley and Sons, New York, USA. 1970.
19. Laboratory Techniques in Botany – Purvis MJ, Collier DC and Wallis D,. Butterworths, London, UK. 1964.
20. Techniques and Methods in Biology – Ghatak KL,. PHI Learning Pvt Ltd, New Delhi, India. 2011.

**Internal Examination Pattern: Continuous Assessment Test (CAT):**

CAT-I: Book Reading/ Poster presentation/ Woolen model

CAT-II: Open book test/ Surprise test / Descriptive test

**Mapping of Cos with POs & PSOs:**

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	2	3	2	2	1	3	1	1	0	1	2	3	2	2	1	1
CO2	2	3	2	2	1	3	1	1	0	1	2	3	2	2	1	1
CO3	3	3	1	3	2	3	1	1	0	2	3	3	1	3	2	1
CO4	3	3	1	3	2	3	2	1	0	2	3	3	1	3	2	1

**Scale:** 3 = High, 2 = Moderate, 1 = Low

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॥ आरोह तमसो ज्योतिः॥

Rajarshi Shahu Mahavidyalaya,  
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Shiv Chhatrapati Shikshan Sanstha's

## Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

### Department of Botany

UG IV Sem VII

Course Type: Laboratory Course

Course Title: Laboratory Course-III

Course Code: 401BOT7203

Credit: 01

Maximum Marks: 50

Hours: 30

#### Learning Objectives:

- LO 1. To prepare biological samples using microtomy and staining techniques for microscopic observation.
- LO 2. To perform and demonstrate analytical techniques such as UV-Vis spectrophotometry, chromatography, and electrophoresis.
- LO 3. To learn the principles and working of advanced instruments such as HPTLC, NMR, GC, HPLC, SEM, TEM, X-ray diffraction, fluorescence microscopy, and radioactive counters.
- LO 4. To prepare standard solutions of different concentrations and perform accurate biochemical calculations.

#### Course outcomes:

After completion of the course, students will be able to-

- CO 1. Explain and evaluate the working principles and applications of advanced analytical and imaging instruments.
- CO 2. Demonstrate skills in sample preparation, microtomy, and staining for biological studies.
- CO 3. Analyze and interpret experimental data using statistical methods and computational tools.
- CO 4. Perform and evaluate separation and analytical techniques used for biomolecules.

Sr. No.	Practicals
1	Preparation of Standard solutions, %, M, N, PPM, PPB
2	Determination of Absorption spectra using UV-VIS spectrophotometer. (Protein / Nucleic acid)
3	Separation of Nucleic acid using Agarose gel Electrophoresis
4	Separation of Amino acid using paper Chromatography
5	Separation of plant pigments using thin layer chromatography
6	Separation of proteins using SDS-PAGE (Demonstration)
7	Demonstration and working of HPTL
8	Study the principle and working of compound Microscope
9	Study the principle and working of pH meter / colorimeter / spectrophotometer and centrifuge
10	Preparation of permanent double stained slides of plant material with the help of microtomy

11	Problems based on $X^2$ – Test
12	ANOVA use of computers
13	pH – measurements and preparation of buffers
14	Verification of Beer and Lamberts law
15	Study of instruments – Radioactive counters, X-ray diffraction, NMR, GC, HPLC, SEM, TEM, Fluorescence microscopy
16	Short/ Long Excursion

**N.B:** 1) Any Ten Practicals from above list.

2) Several Short Excursions, Field visits and at least one Long Excursion

### Learning Resources:

1. Principles and Techniques of Biochemistry and Molecular Biology (8th edition) – Wilson K and Walker J., Cambridge University Press, Cambridge, UK. 2018.
2. Principles of Instrumental Analysis (6th edition) – Skoog DA, Holler FJ and Crouch SR., Thomson Brooks/Cole, Belmont, USA. 2007.
3. Instrumental Methods of Chemical Analysis – Chatwal GR and Anand SK., Himalaya Publishing House, Mumbai, India. 2005.
4. Analytical Chemistry (6th edition) – Christian GD., John Wiley and Sons, New York, USA. 2004.
5. Quantitative Chemical Analysis (9th edition) – Harris DC., W.H. Freeman and Company, New York, USA. 2016.
6. Instrumental Methods of Analysis (7th edition) – Willard HH, Merritt LL, Dean JA and Settle FA., CBS Publishers and Distributors, New Delhi, India. 1986.
7. Molecular Cloning: A Laboratory Manual (3rd edition) – Sambrook J and Russell DW., Cold Spring Harbor Laboratory Press, New York, USA. 2001.
8. Gene Cloning and DNA Analysis: An Introduction (7th edition) – Brown TA., Wiley-Blackwell, Oxford, UK. 2016.
9. An Introduction to Practical Biochemistry (5th edition) – Plummer DT., Tata McGraw-Hill Publishing Company, New Delhi, India. 2004.
10. Laboratory Manual in Biochemistry – Jayaraman J., New Age International Publishers, New Delhi, India. 2011.
11. Biochemical Methods (3rd edition) – Sadasivam S and Manickam A., New Age International Publishers, New Delhi, India. 2008.
12. Biochemistry Laboratory: Modern Theory and Techniques (2nd edition) – Boyer RF., Pearson Education, Boston, USA. 2012.
13. Experiments in Microbiology, Plant Pathology and Biotechnology (4th edition) – Aneja KR., New Age International Publishers, New Delhi, India. 2003.
14. Theory and Practice of Histological Techniques (7th edition) – Bancroft JD and Gamble M., Churchill Livingstone, Edinburgh, UK. 2013.

15. Histological and Histochemical Methods: Theory and Practice (4th edition) – Kiernan JA., Scion Publishing Ltd., Oxford, UK. 2008.
16. Plant Microtechnique and Microscopy – Ruzin SE., Oxford University Press, New York, USA. 1999.
17. Microbiology – Pelczar MJ, Chan ECS and Krieg NR., Tata McGraw-Hill Publishing Company, New Delhi, India. 2005.
18. Statistics and Chemometrics for Analytical Chemistry (6th edition) – Miller JN and Miller JC., Pearson Education, Harlow, UK. 2010.
19. Biostatistics: A Foundation for Analysis in the Health Sciences (10th edition) – Daniel WW., John Wiley and Sons, New York, USA. 2013.
20. Biostatistical Analysis (5th edition) – Zar JH., Pearson Education, New Delhi, India. 2010.
21. Biochemistry (8th edition) – Stryer L, Berg JM and Tymoczko JL., W.H. Freeman and Company, New York, USA. 2015.
22. Outlines of Biochemistry (5th edition) – Conn EE, Stumpf PK, Bruening G and Doi RH., John Wiley and Sons, New York, USA. 1987.
23. Principles and Techniques of Electron Microscopy: Biological Applications (4th edition) – Hayat MA., Cambridge University Press, Cambridge, UK. 2000.
24. Electron Microscopy: Principles and Techniques for Biologists (2nd edition) – Bozzola JJ and Russell LD., Jones and Bartlett Publishers, Sudbury, USA. 1999.
25. Introduction to Modern Liquid Chromatography (3rd edition) – Snyder LR, Kirkland JJ and Dolan JW., Wiley, Hoboken, USA. 2010.

**Mapping of Cos with POs & PSOs:**

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	2	2	3	2	1	3	1	1	0	1	2	3	3	2	1	1
CO2	2	2	3	2	1	2	1	1	0	1	2	2	3	2	1	1
CO3	3	3	2	3	2	3	2	1	0	2	3	3	2	3	2	1
CO4	3	3	3	3	2	3	2	1	0	2	3	3	3	3	3	2

**Scale:** 3 = High, 2 = Moderate, 1 = Low



Shiv Chhatrapati Shikshan Sanstha's

## Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Department of Botany

UG IV Sem VII

Course Type: DSE-III (B)

Course Title: Plant Physiology

Course Code: 401BOT7202

Credits: 03

Maximum Marks: 75

Hours: 45

### Learning Objectives:

- LO1. To learn the principles of plant water relations.
- LO2. To illustrate the role of mineral nutrition and nitrogen metabolism.
- LO3. To study the seed biology, fruit development, defense mechanisms, and the role of secondary metabolites in plants.
- LO4. To analyze photoreceptors and their role in plant responses to light and environmental Signals.

### Course Outcomes:

After completion of the course, students will be able to-

- CO1. Analyze and evaluate plant water relations.
- CO2. Understand plant responses to abiotic stresses (drought, oxidative stress)
- CO3. Explain and assess the physiological and molecular basis of mineral nutrition and nitrogen metabolism in plants.
- CO4. Examine the role of plant hormones in physiological processes of plants.

Unit No.	Title of Unit & Contents	Hrs.
<b>I</b>	<b>Plant Water Relation</b>	<b>13</b>
	<ol style="list-style-type: none"><li>1. Soil and plant water uptake, water and its role in plants, properties and functions of water in the cell water relations, water potential of plant cells.</li><li>2. Mechanism of water uptake by root, transport in root, aquaporins, movements of water in plants, Micorrhizal association on water uptake.</li><li>3. Water loss from plants: Evapo-transpiration. Transpiration, driving force for transpiration, Plant factors influencing transpiration rate.</li><li>4. Stomata: Structure and function, mechanism of stomatal movement and antitranspirants.</li><li>5. The role of mineral nutrition in plant metabolism: Essential elements, classification based on functions of elements in plants.</li></ol>	
	<b>Unit Outcomes:</b> UO1. Explain the different mechanism used for water transport. UO2. Understanding concepts like water potential, osmotic pressure and water transpiration.	
<b>II</b>	<b>Nitrogen Metabolism and Respiration</b>	<b>10</b>
	<ol style="list-style-type: none"><li>1. Nitrate and ammonium assimilation; amino acid biosynthesis.</li><li>2. Nif gene, nod gene-Structure, function and regulation.</li><li>3. Enzymes-Structure, function and kinetics.</li><li>4. Glycolysis, Citric acid cycle; electron transport and ATP synthesis; alternate oxidase</li></ol>	
	<b>Unit Outcomes:</b> UO1. Justify the various physiological processes of plant.	

	UO2. Understand the Nitrogen Metabolism and Respiration.	
<b>III</b>	<b>Plant Hormones</b>	<b>11</b>
	<ol style="list-style-type: none"> <li>1. Biosynthesis, storage, breakdown and transport; physiological effect and mechanisms (Mode) of action.</li> <li>2. Post-Harvest Technology: Physiological changes during ripening, fruit preservation and role of Ethylene in post-harvest technology.</li> <li>3. Senescence: Factors influencing senescence, ripening and post life of flower, vegetables and seeds. Molecular mechanism of senescence and ageing, senescence associated genes.</li> <li>4. Importance of seed, seed structure and function, physiological and biochemical changes during seed and fruit development and abortion.</li> <li>5. Defense mechanism and secondary metabolites</li> <li>6. Structure, function and mechanisms of action of <ol style="list-style-type: none"> <li>a. Phytochromes.</li> <li>b. Cryptochromes.</li> <li>c. Phototropins.</li> </ol> </li> </ol>	
	<p><b>Unit Outcomes:</b></p> <p>UO1. Correlate the plant defense and secondary metabolites.</p> <p>UO2. Understands the importance of Plant hormones in the plant growth.</p>	
<b>IV</b>	<b>Sensory and Stress Biology</b>	<b>11</b>
	<ol style="list-style-type: none"> <li>1. Stomatal movement.</li> <li>2. Photoperiodism and biological clocks.</li> <li>3. Vernalization</li> <li>4. Drought- characteristic features, water potential in the soil- Plant air continuum, Development of water deficits, energy balance concept.</li> <li>5. Molecular response to water deficit: stress perception, Expression of regulatory genes and significance of gene products.</li> <li>6. Stress and hormones: ABA as a signaling molecule, Cytokinin as a negative signal.</li> <li>7. Oxidative stress: Oxidative stress- ROS, Role of scavenging system</li> </ol>	
	<p><b>Unit Outcomes:</b></p> <p>UO1. Examine the Photoperiodism, biological clocks and stress biology.</p> <p>UO2. Understand the structure of stomata and their role in transpiration.</p>	

**Learning Resources:**

1. Plant Physiology and Development (6th edition) – Taiz L, Zeiger E, Møller IM and Murphy A., Sinauer Associates, Sunderland, USA. 2018.
2. Plant Physiology (4th edition) – Salisbury FB and Ross CW., Wadsworth Publishing Company, California, USA. 1992.
3. Physicochemical and Environmental Plant Physiology (2nd edition) – Nobel PS., Academic Press, San Diego, USA. 1999.
4. Introduction to Plant Physiology (4th edition) – Hopkins WG and Hüner NPA., John Wiley and Sons, New York, USA. 2009.
5. Plant Physiology and Biochemistry – Srivastava HS., Academic Press (India), New Delhi, India. 2002.
6. A Textbook of Plant Physiology, Biochemistry and Biotechnology – Verma SK and Verma M., S Chand and Company Pvt Ltd, New Delhi, India. 2007.
7. Fundamentals of Plant Physiology – Jain VK., S Chand and Company Pvt Ltd, New Delhi, India. 2006.

8. Introductory Plant Physiology (2nd edition) – Noggle GR and Fritz GJ., Prentice Hall of India Pvt Ltd, New Delhi, India. 1983.
9. Biochemistry and Molecular Biology of Plants – Buchanan BB, Grissem W and Jones RL., American Society of Plant Physiologists, Rockville, USA. 2000.
10. Plant Biochemistry (4th edition) – Heldt HW and Piechulla B., Academic Press, Amsterdam, Netherlands. 2011.
11. Plant Hormones: Physiology, Biochemistry and Molecular Biology (2nd edition) – Davies PJ (ed), Kluwer Academic Publishers, Dordrecht, Netherlands. 1995.
12. Biochemistry and Physiology of Plant Hormones – Moore TC., Springer-Verlag, New York, USA. 1989.
13. Photosynthesis: Metabolism, Control and Physiology (3rd edition) – Lawlor DW., Pearson Education, Harlow, UK. 2001.
14. Plant Physiology (2nd edition) – Taiz L and Zeiger E., Sinauer Associates, Sunderland, USA. 1998.
15. Physiological Plant Ecology (4th edition) – Larcher W., Springer-Verlag, Berlin, Germany. 2003.
16. Water Relations of Plants and Soils – Kramer PJ and Boyer JS., Academic Press, San Diego, USA. 1995.
17. Seeds: Physiology of Development and Germination (2nd edition) – Bewley JD and Black M., Plenum Press, New York, USA. 1994.
18. Plant Physiology (4th edition) – Devlin RM and Witham FH., CBS Publishers and Distributors, New Delhi, India. 1983.

**Internal Examination Pattern: Continuous Assessment Test (CAT):**

CAT-I: Book Reading/ Poster presentation/ Assignment

CAT-II: Open book test/ Surprise test / Descriptive test

**Mapping of Cos with POs & PSOs:**

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	2	1	3	1	2	3	1	0	1	3	2	1	3	2	1
CO2	3	2	1	3	1	2	3	1	0	1	3	2	1	3	2	1
CO3	3	3	1	3	1	2	3	1	0	1	3	3	1	3	2	1
CO4	3	3	1	3	2	2	3	1	0	1	3	3	1	3	2	1

**Scale:** 3 = High, 2 = Moderate, 1 = Low



Shiv Chhatrapati Shikshan Sanstha's

## Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

### Department of Botany

UG IV Sem VII

Course Type: Laboratory Course

Course Title: Laboratory Course-III

Course Code: 401BOT7204

Credit: 01

Maximum Marks: 50

Hours: 30

#### Learning Objectives:

- LO1. To understand the concepts of seed viability and Methods of seed dormancy.
- LO2. To study the effect of photosynthetic rate using various wavelengths of light.
- LO3. To understand knowledge of effect of light intensity on oxygen evolution in photosynthesis.
- LO4. To know the practical applications of growth regulators.

#### Course outcomes:

After completion of the course, students will be able to-

- CO1. Explain the concepts of seed viability and dormancy.
- CO2. Correlate the effect of photosynthetic rate using various wavelengths of light.
- CO3. Justify the effect of light intensity on oxygen evolution in photosynthesis.
- CO4. Examine the role of growth regulators on development of plant.

Sr. No.	Practicals
1	Preparation of stock solutions
2	Measurement of transpiration by Ganong's photometer.
3	Measurement of transpiration by Cobalt chloride method
4	Measurement of photosynthetic rate using various wavelengths of light.
5	Determination of stomatal index and stomatal frequency in leaves.
6	Determination of seed viability and vigour test
7	Study of methods of breaking seed dormancy.
8	Demonstration of the effect of auxins on rooting.
9	Demonstration of Hills reaction.
10	Demonstration of root respiration
11	Determination the osmotic potential of cell sap by plasmolysis method
12	Study of effect of light intensity and bicarbonate concentration on oxygen evolution in photosynthesis
13	Short / Long Excursion

**N.B:** 1) Any Ten Practical from above list.

2) Several Short Excursions, Field visits and at least one Long Excursion.

#### Learning Resources:

1. Biochemical Methods (3rd edition) – Sadasivam S and Manickam A., New Age International Publishers, New Delhi, India. 2008.
2. An Introduction to Practical Biochemistry (5th edition) – Plummer DT., Tata McGraw-Hill Publishing Company, New Delhi, India. 2004.
3. Laboratory Manual in Biochemistry – Jayaraman J., New Age International Publishers, New Delhi, India. 2011.
4. Plant Physiology and Development (6th edition) – Taiz L, Zeiger E, Møller IM and Murphy A., Sinauer Associates, Sunderland, USA. 2018.
5. Plant Physiology (4th edition) – Salisbury FB and Ross CW., Wadsworth Publishing Company, California, USA. 1992.
6. Plant Physiology and Biochemistry – Srivastava HS., Academic Press (India), New Delhi, India. 2002.
7. Introduction to Plant Physiology (4th edition) – Hopkins WG and Hüner NPA., John Wiley and Sons, New York, USA. 2009.
8. Plant Physiology (4th edition) – Devlin RM and Witham FH., CBS Publishers and Distributors, New Delhi, India. 1983.
9. Plant Physiology – Pandey SN and Sinha BK., Vikas Publishing House Pvt Ltd, New Delhi, India. 2006.
10. Introductory Plant Physiology (2nd edition) – Noggle GR and Fritz GJ., Prentice Hall of India Pvt Ltd, New Delhi, India. 1983.
11. Water Relations of Plants and Soils – Kramer PJ and Boyer JS., Academic Press, San Diego, USA. 1995.
12. Seeds: Physiology of Development and Germination (2nd edition) – Bewley JD and Black M., Plenum Press, New York, USA. 1994.

**Mapping of Cos with POs & PSOs:**

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
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CO2	2	2	3	2	1	2	2	1	0	1	3	2	3	2	1	1
CO3	3	3	3	3	2	3	2	1	0	2	3	3	3	3	2	1
CO4	3	3	3	3	2	3	3	1	0	2	3	3	3	3	3	2

**Scale:** 3 = High, 2 = Moderate, 1 = Low



Shiv Chhatrapati Shikshan Sanstha's  
**Rajarshi Shahu Mahavidyalaya, Latur**

Empowered Autonomous Institution

**Department of Botany**

UG IV Sem VII

Course Type: RMC

Course Title: Research Methodology

Course Code: 401BOT7301

Credits: 04

Maximum Marks: 100

Hours: 60

**Learning Objectives:**

- LO1: To describe the fundamental concepts, types, research process, research problems, and hypothesis formulation.
- LO2: To explain research design, variables, experimental designs, and sampling methods.
- LO3: To apply methods of data collection, processing, and basic statistical analysis.
- LO4: To evaluate research findings and demonstrate skills in report writing, referencing, and research ethics.

**Course Outcomes:**

After completion of the course, students will be able to-

- CO1: Explain the basic concepts, types, and processes of research
- CO2: Apply appropriate research designs, variables, and sampling techniques in scientific studies.
- CO3: Analyze and interpret data using suitable data collection methods and statistical tools.
- CO4: Prepare and evaluate research reports using scientific writing, referencing tools, and ethical practices.

Unit No.	Title of Unit & Contents	Hrs.
<b>I</b>	<b>Introduction and Methods of Research</b>	<b>15</b>
	<ol style="list-style-type: none"><li>1. Meaning of research, Objectives of research, Types of research,</li><li>2. Research approaches, Significance of research, Research methods versus methodology, Research and scientific methods,</li><li>3. Research processes, Criteria for good research</li><li>4. Research problem, Selecting the problem, Necessity of defining the problem, Techniques involved in defining a problem.</li><li>5. Hypothesis: types and formulation</li></ol>	
	<b>Unit Outcomes:</b> UO1. To examine the research problem. UO2. Develop the clear, measurable research questions and hypothesis.	
<b>II</b>	<b>Research Design and Sampling</b>	<b>15</b>
	<ol style="list-style-type: none"><li>1. Meaning and need for research design, features of a good design.</li><li>2. Important concepts relating to research design: Dependent and independent variables, Extraneous variables, Control, Research hypothesis, Experimental and non-experimental hypothesis –Testing research, Experimental and control group</li><li>3. Different research designs: Research design in case of exploratory research studies, Research design in case of hypothesis- testing research studies, basic</li></ol>	

	<p>principles of experimental designs, Important Experimental Designs</p> <p>4. Sampling Design, steps in sample design, criteria of selecting a sampling procedure, characteristics of a good sample design, different types of sample design</p>	
	<p><b>Unit Outcomes:</b></p> <p>UO1.To learn important concepts relating to research design.</p> <p>UO2.Analyze the strengths and weaknesses of different sampling methods.</p>	
<b>III</b>	<b>Data Collection and Data Processing</b>	<b>15</b>
	<p>1. Measurements in Research, Measurement Scales, Sources of errors in measurement.</p> <p>2. Collection of primary data: Observation Method, Interview Method, through questionnaires, through schedules, difference between questionnaire and schedule</p> <p>3. Collection of secondary data, Selection of appropriate methods for data collection, Case study method</p> <p>4. Data processing, processing operations: editing, coding, classification, tabulation, graphical representation, types of analysis, Statistical tools and techniques of data analysis-measures of central tendency, dispersion</p> <p>5. Hypothesis testing (t-test, chi-square, ANOVA basics)</p>	
	<p><b>Unit Outcomes:</b></p> <p>UO1. To data collection and processing operations.</p> <p>UO2.Explain the principles and importance of data collection and data processing in the research .</p>	
<b>IV</b>	<b>Report writing and evaluations</b>	<b>15</b>
	<p>1. Principles of report writing and guide lines according to style manuals.</p> <p>2. Writing and presentation of preliminary, main body and reference section of report.</p> <p>3. Evaluation of research report.</p> <p>4. Methods to search required information effectively, Reference Management Software like Zotero/ Mendeley, Software for paper formatting like LaTeX/ MS Office.</p> <p>5. Ethics in research and publication</p> <p>6. Software for detection of Plagiarism.</p>	
	<p><b>Unit Outcome:</b></p> <p>UO1.To search required information effectively and Software for detection of Plagiarism.</p>	

### Learning Recourses:

1. Research Methodology: Methods and Techniques – Kothari CR., New Age International Publishers, New Delhi. 2004.
2. Research Methodology: A Step-by-Step Guide for Beginners – Kumar R., Sage Publications, New Delhi. 2011.
3. Fundamentals of Research Methodology and Statistics – Singh YK., New Age International Publishers, New Delhi. 2006.
4. Scientific Method and Social Research – Goode WJ and Hatt PK., McGraw-Hill, New York. 1952.

5. The Craft of Research – Booth WC, Colomb GG and Williams JM,. University of Chicago Press, Chicago. 2008.
6. Designing Scientific Research – Babbie E,. Wadsworth Publishing, Belmont. 2010.
7. Biostatistics: A Foundation for Analysis in the Health Sciences – Daniel WW,. Wiley India Pvt Ltd, New Delhi. 2013.
8. Biostatistical Analysis – Zar JH,. Pearson Education, New Delhi. 2010.
9. Statistics for Biology and Health – Rosner B,. Springer, New York. 2011.
10. Practical Statistics for Medical Research – Altman DG,. Chapman and Hall, London. 1991.
11. Fundamentals of Biostatistics – Khan IA and Khanum A,. Ukaaz Publications, Hyderabad. 2004.
12. Experimental Design for the Life Sciences – Ruxton GD and Colegrave N,. Oxford University Press, Oxford. 2010.
13. Methods in Biostatistics – Mahajan BK,. Jaypee Brothers Medical Publishers, New Delhi. 2010.
14. Introduction to Biostatistics – Prasad S,. Prentice Hall of India, New Delhi. 2005.
15. Research Methods in Life Sciences – Dawson C,. Routledge, London. 2009.
16. Data Analysis in Biology – Whitlock MC and Schluter D,. Roberts and Company Publishers, Colorado. 2009.
17. Statistics for Experimenters: Design, Innovation and Discovery – Box GEP, Hunter JS and Hunter WG,. Wiley, New York. 2005.
18. An Introduction to Biometry – Mungikar AM,. Saraswati Printing Press, Aurangabad. 1997.
19. Principles of Scientific Research – Chawla D and Sondhi N,. Vikas Publishing House, New Delhi. 2011.
20. Essentials of Research Methodology for Life Sciences – Panneerselvam R,. PHI Learning Pvt Ltd, New Delhi. 2014.

**Internal Examination Pattern: Continuous Assessment Test (CAT):**

CAT-I: Book Reading/ Poster presentation/ Assignment

CAT-II: Open book test/ Surprise test / Descriptive test

**Mapping of Cos with POs & PSOs:**

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	2	3	1	2	3	2	1	2	0	3	2	3	1	2	3	1
CO2	2	3	1	3	3	2	1	2	1	3	2	3	1	3	3	2
CO3	2	3	1	3	3	3	1	2	1	3	2	3	1	3	3	2
CO4	2	3	1	3	3	3	1	2	2	3	2	3	1	3	3	3

**Scale:** 3 = High, 2 = Moderate, 1 = Low

# Semester - VIII



शिव छत्रपती  
शिक्षण संस्था  
लातूर

॥ आर्योह तमसो ज्योतिः ॥

Rajarshi Shahu Mahavidyalaya,  
Latur (Autonomous)



Shiv Chhatrapati Shikshan Sanstha's

## Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Department of Botany

UG IV Sem VIII

Course Type: DSC-XVII

Course Title: Biodiversity of Pteridophytes, Gymnosperms, and Fossil Plants

Course Code: 401BOT8101

Credits: 03

Maximum Marks:- 75

Hours: 45

### Learning Objectives:

- LO1. To study evolutionary trends of cryptogams and Gymnosperms.
- LO2. To understand the connecting links between Pteridophytes and Gymnosperms
- LO3. To study the morphology, anatomy and of Pteridophytes & gymnosperms.
- LO4. To illustrate the conceptual knowledge about fossil plants to the students.
- LO5. To know the importance Pteridophytes & gymnosperms

### Course Outcomes:

After completion of the course, students will be able to-

- CO1. Differentiate between the characteristics of Pteridophytes & Gymnosperms living forms.
- CO2. Examine the stellar evolution, heterospory and seed habit.
- CO3. Compare the life form, structure, reproduction and significance of Pteridophyte, Gymnosperm and Fossil Plants etc.
- CO4. Explain the Principles of Paleobotany and Paleopalynological techniques.

Unit No.	Title of Unit & Contents	Hrs.
I	<b>Pteridophytes-I</b>	10
	<ol style="list-style-type: none"><li>1. Introduction and characteristic features. Diversity of Pteridophytes in India and their migration to land. Affinities of Pteridophyte with Bryophyte and Algae</li><li>2. Recent systems of classification of Pteridophytes</li><li>3. Comparative morphology, reproduction and phylogeny of following orders with reference to the forms mentioned against each: Psilotales (<i>Tmesipteris</i>), Lycopodiales (<i>Lycopodium</i>), Filicales (<i>Adiantum</i>), Equisetales (<i>Equisetum</i>), Salviniales (<i>Salvinia</i>)</li></ol>	
	<b>Unit Outcome:</b> UO1. Differentiate between the characteristics of Pteridophytes & Gymnosperms living forms.	
II	<b>Pteridophytes -II</b>	12
	<ol style="list-style-type: none"><li>1. Apogamy and Apospory</li><li>2. Telome concept</li><li>3. Stellar evolution</li><li>4. Soral evolution</li></ol>	

	<p>5. Gametophyte evolution</p> <p>6. Heterospory and seed habit</p> <p>7. Economic importance of Pteridophytes</p> <p><b>Unit Outcome:</b>            UO1.Examine the stellar evolution, heterospory and seed habit.            UO2. Analyze the Telome concept and it's role in understanding of evolution of plant structures.</p>	
<b>III</b>	<b>Gymnosperms</b>	<b>11</b>
	<p>1. Characteristic features of Gymnosperms</p> <p>2. Recent system of classification (S.P. Bhatnagar and Alok Moitra)</p> <p>3. Study of morphology and reproduction Cycadales (<i>Zamia</i>), Coniferales (<i>Pinus</i>), Gnetales (<i>Gnetum</i>), Ephedrales (<i>Ephedra</i>)</p> <p>4. Gymnosperms as prospective ancestor of Angiosperms</p> <p>5. Economic importance of gymnosperms</p> <p><b>Unit Outcome:</b>            UO1. Compare the life form, structure, reproduction and significance of Pteridophyte, Gymnosperm and Fossil Plants etc.</p>	
<b>IV</b>	<b>Paleobotany</b>	<b>12</b>
	<p>1. Introduction Evolution time scale</p> <p>2. Principles of Paleobotany: Petrification, Impression and Compression</p> <p>3. Indian fossil flora –Glossopteris flora, Rajmahal hill flora and Deccan Intertrappean flora</p> <p>4. Paleopalynological techniques- Coal maceration and Lignite maceration</p> <p>5. Study of morphology and evolutionary trends of:</p> <p>a. Bennettitales</p> <p>b. Cycadales</p> <p>c. Coniferales</p> <p>6. Economic importance</p> <p><b>Unit Outcomes:</b>            UO1.Explain the Principles of Paleobotany and Paleopalynological techniques.</p>	

### Learning Recourses:

1. A Textbook of Bryophytes, Pteridophytes, Gymnosperms and Paleobotany – Mohanty C., Kalyani Publishers, New Delhi. 2012.
2. Advances in Pteridology – Trivedi AN., Pointer Publishers, Jaipur. 2002.
3. An Introduction to Paleobotany – Arnold CA., McGraw-Hill Book Company, New York. 1972.
4. An Introduction to Pteridophyta – Parihar NS., Central Book Depot, Allahabad. 1959.
5. An Introduction to Pteridophytes – Rashid A., Vikas Publishing House Pvt Ltd, New Delhi. 1978.
6. Biology and Morphology of Pteridophytes – Parihar NS., Central Book Depot, Allahabad. 1996.
7. Botany for Degree Students: Pteridophyta – Vashishta BR., S Chand and Company Pvt Ltd, New Delhi. 1996.

8. Comparative Morphology of Vascular Plants – Eames AJ and Gifford EM., McGraw-Hill, New York. 1950.
9. Diversity of Pteridophytes, Gymnosperms and Elementary Paleobotany – Kumar S., Rastogi Publications, Meerut. 2010.
10. Gymnosperms – Bhatnagar SP and Moitra A., Pragati Prakashan, Meerut. 1996.
11. Gymnosperms – Vashishta PC, Sinha AR and Kumar A., S Chand and Company Pvt Ltd, New Delhi. 2006.
12. Indian Fossil Pteridophytes – Surange KR., CSIR Publications, New Delhi. 1968.
13. Introduction to Paleobotany – Arnold CA., McGraw-Hill Book Company, New York. 1947.
14. Morphology of Gymnosperms – Kakkar RK and Kakkar BR., Central Book Depot, Allahabad. 1995.
15. Morphology of Pteridophytes – Sporne KR., Hutchinson University Library, London. 1966.
16. Morphology of Vascular Plants – Bierhorst DW., Macmillan Company, New York. 1971.
17. Principles of Paleobotany – Darrah WC., Ronald Press Company, New York. 1968.
18. Pteridophytes and Gymnosperms – Agashe SN., Springer-Verlag, New York. 1995.
19. Palaeobotany – Agashe SN., Oxford and IBH Publishing Company, New Delhi. 1995.
20. Pteridophytes – Vashishta PC., S Chand and Company Pvt Ltd, New Delhi. 2006.

### **Journals**

1. - An Introduction to Paleobotany-Arnold, C. A. (1972)
2. - Principles of Paleobotany- Darroh, W.C. (1960) Surange, K. R. (1968) - Indian Fossil Pteridophytes.
3. American Fern Journal.
4. Comparative morphology of vascular plants -Foster, A. S. and Gifford, E. M. (1959)
5. Essentials of Paleobotany. Shukla, A.C. and Mishra, S.D. (1975) Bhatnagar, S.P. and MoitraAlok (1975) - The Gymnosperms.
6. Gymnosperms, Structure and Evolution-Chamberlein, C.J. (1966)
7. Indian Gymnosperms in Time and Space- Ramanujan, C.G.K. (1979)
8. International Journal of plant sciences.
9. Morphology of Gymnosperms-Coulter and Chumberlein, J. M.
10. Morphology of Gymnosperms-Sporne, K.R. (1967)
11. Morphology of vascular plants- Bierhorst, D.W. (1971)
12. Studies in Paleobotany.-Andrews, H.N. (1961)

13. The Gymnosperms-Vasishtha, P.C. (1976) Bhatnagar, S.P. and MoitraAlok (1996)- The Gymnosperms.

**Internal Examination Pattern: Continuous Assessment Test (CAT):**

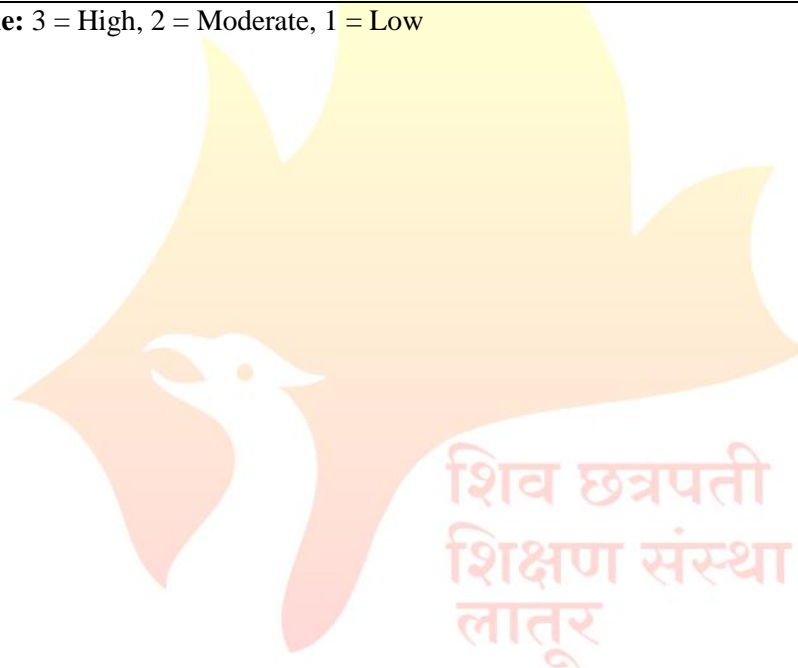
CAT-I: Book Reading/ Poster presentation/ Assignment

CAT-II: Open book test/ Surprise test / Descriptive test

**Mapping of Cos with POs & PSOs:**

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	2	1	2	1	1	2	1	0	1	3	2	1	2	1	1
CO2	3	2	1	2	1	1	2	1	0	1	3	2	1	2	1	1
CO3	3	2	1	3	1	2	2	1	0	1	3	2	1	3	2	1
CO4	3	3	1	3	2	2	2	1	0	2	3	3	1	3	2	2

**Scale:** 3 = High, 2 = Moderate, 1 = Low



॥ आरोग्यं तमसो ज्योतिः ॥

Rajarshi Shahu Mahavidyalaya,  
Latur (Autonomous)



Shiv Chhatrapati Shikshan Sanstha's

## Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Department of Botany

UG IV Sem VIII

**Course Type: Laboratory Course**

**Course Title: Laboratory Course-XVI**

**Course Code: 401BOT810**

**Credits: 01**

**Maximum Marks: 50**

**Hours: 30**

### Learning Objectives:

- LO1: To describe the morphology, anatomy, and reproductive structures of pteridophytes and gymnosperms.
- LO2: To explain the structural organization of vegetative and reproductive parts using permanent slides and microscopic observations.
- LO3: To apply laboratory techniques such as slide preparation and maceration for anatomical studies.
- LO4: To analyze and compare structural features of different plant groups to understand their diversity and evolution.

### Course outcomes:

After completion of the course, students will be able to-

- CO1: Identify and describe the morphological, anatomical, and reproductive features of pteridophytes and gymnosperms.
- CO2: Demonstrate skills in preparation and observation of double-stained permanent slides.
- CO3: Apply maceration and microscopic techniques for detailed anatomical study of plant materials.
- CO4: Analyze and differentiate plant groups based on structural and reproductive characteristics.

Sr. No.	Practicals
1	Study of morphological, anatomical (double stained slide permanent slide) and reproductive structures of <i>Tmesipteris</i>
2	Study of morphological, anatomical (double stained slide permanent slide) and reproductive structures of <i>Lycopodium</i>
3	Study of morphological, anatomical (double stained slide permanent slide) and reproductive structures of <i>Adiantum</i>
4	Study of morphological, anatomical (double stained slide permanent slide) and reproductive structures of <i>Equisetum</i>
5	Study of morphological, anatomical (double stained slide permanent slide) and reproductive structures of <i>Salvinia</i>
6	Study of the morphology and anatomy (double stained slide permanent slide) of the vegetative and reproductive structures of <i>Gnetum</i>
7	Study of the morphology and anatomy (double stained slide permanent slide) of the vegetative and reproductive structures of <i>Zamia</i> .
8	Study of the morphology and anatomy of the vegetative and reproductive structures of <i>Pinus</i> .

9	Study of the morphology and anatomy (double stained slide permanent slide) of the vegetative and reproductive structures of <i>Ephedra</i> .
10	Study of Maceration Techniques.
11	Study of Fossils specimens (Any two as per available material)
12	Short/ Long Excursion

**N.B:** 1) Any Ten Practicals

2) Several Short Excursions and at least one Long Excursion.

**Learning Resources:**

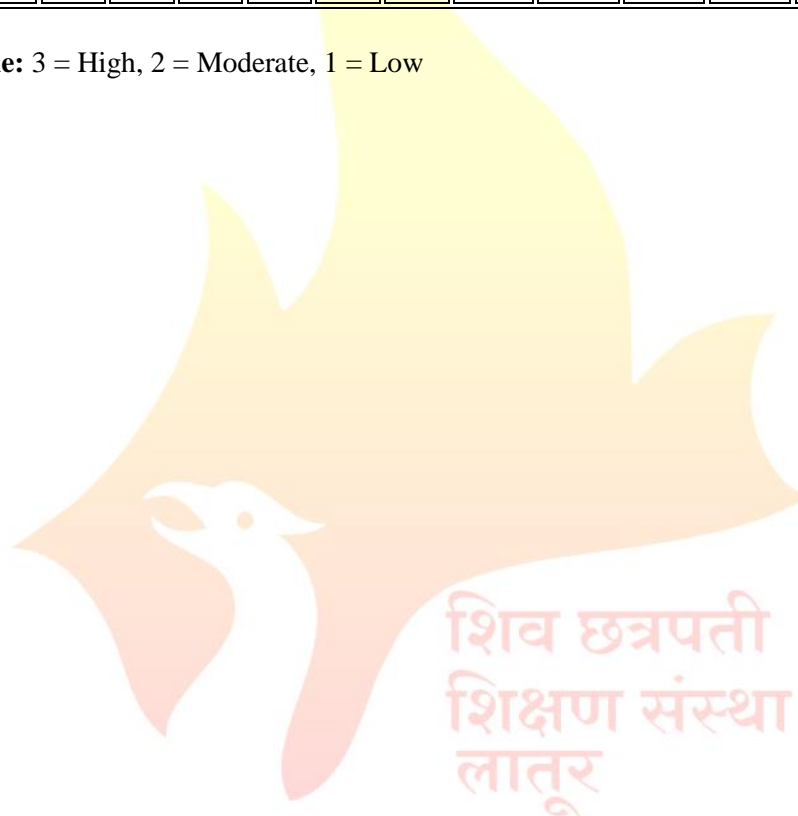
1. An Introduction to Pteridophyta – Parihar NS., Central Book Depot, Allahabad. 1959.
2. An Introduction to Pteridophytes – Rashid A., Vikas Publishing House Pvt Ltd, New Delhi. 1978.
3. Biology and Morphology of Pteridophytes – Parihar NS., Central Book Depot, Allahabad. 1996.
4. Morphology of Pteridophytes – Sporne KR., Hutchinson University Library, London. 1966.
5. The Ferns – Bower FO., Cambridge University Press, Cambridge. 1963.
6. Comparative Morphology of Vascular Plants – Eames AJ and Gifford EM., McGraw-Hill, New York. 1950.
7. Morphology of Vascular Plants – Bierhorst DW., Macmillan Company, New York. 1971.
8. Botany for Degree Students: Pteridophyta – Vashishta BR., S Chand and Company Pvt Ltd, New Delhi. 1996.
9. Gymnosperms – Vashishta PC, Sinha AR and Kumar A., S Chand and Company Pvt Ltd, New Delhi. 2006.
10. Gymnosperms – Bhatnagar SP and Moitra A., New Age International Publishers, New Delhi. 1996.
11. Morphology of Gymnosperms – Kakkar RK and Kakkar BR., Central Book Depot, Allahabad. 1995.
12. The Gymnosperms – Biswas C and Johri BN., Narosa Publishing House, New Delhi. 2004.
13. The Gymnosperms (Fossils and Living) – Sharma OP., Central Publishing House, Allahabad. 2002.
14. Pteridophytes and Gymnosperms – Agashe SN., Springer-Verlag, New York. 1995.
15. Plant Microtechnique and Microscopy – Ruzin SE., Oxford University Press, New York. 1999.
16. Theory and Practice of Histological Techniques – Bancroft JD and Gamble M., Churchill Livingstone, Edinburgh. 2013.
17. Laboratory Techniques in Botany – Purvis MJ, Collier DC and Wallis D., Butterworths, London. 1964.
18. Techniques and Methods in Biology – Ghatak KL., PHI Learning Pvt Ltd, New Delhi. 2011.
19. Introduction to Paleobotany – Arnold CA., McGraw-Hill Book Company, New York. 1947.
20. Principles of Paleobotany – Darrah WC., Ronald Press Company, New York. 1968.
21. Indian Fossil Pteridophytes – Surange KR., CSIR Publications, New Delhi. 1968.
22. Palaeobotany – Agashe SN., Oxford and IBH Publishing Company, New Delhi. 1995.

23. Paleobotany: The Biology and Evolution of Fossil Plants – Taylor TN, Taylor EL and Krings M., Academic Press, Burlington. 2009.

**Mapping of Cos with POs & PSOs:**

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	2	2	3	2	1	1	2	1	0	1	3	2	3	2	1	1
CO2	3	2	3	2	1	1	2	1	0	1	3	2	3	2	1	1
CO3	3	2	3	3	1	2	2	1	0	2	3	3	3	3	2	1
CO4	3	3	3	3	2	2	3	1	0	2	3	3	3	3	3	2

**Scale:** 3 = High, 2 = Moderate, 1 = Low



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Rajarshi Shahu Mahavidyalaya,  
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Shiv Chhatrapati Shikshan Sanstha's  
**Rajarshi Shahu Mahavidyalaya, Latur**

Empowered Autonomous Institution

**Department of Botany**  
**UG IV Sem VIII**

**Course Type: DSC- XVIII**

**Course Title: Plant Physiology and Metabolism**

**Course Code: 401BOT8102**

**Credits: 03**

**Maximum Marks: 75**

**Hours: 45**

**Learning Objectives:**

- LO1. To increase awareness and appreciation for plants in your environment, as well as to understand their diverse physiological functions.
- LO2. To demonstrate ways to measure environmental services accomplished by plants.
- LO3. To propose ways of using plants to preserve and improve urban, agricultural, rural, and wilderness environments.
- LO4. To explain and provide examples of how plants interact with light, water, soil and other organisms and how humans can optimize those interactions.

**Course Outcomes:**

After completion of the course, students will be able to-

- CO1. Explain the various metabolic, physiological paths in plants.
- CO2. Justify the regulation of growth, development and influence of environment.
- CO3. Examine the soil plant relationship with reference to environmental factors and plant physiology.
- CO4. Correlate the function of secondary metabolite and plant hormones

Unit No.	Title of Unit & Contents	Hrs.
<b>I</b>	<b>Transport and Translocation Mechanism</b>	<b>11</b>
	<b>1. Solute transport and photo assimilates translocation:</b> Uptake, transport and translocation of water, ions, solutes and macromolecules from soil, through cells, across membranes, through xylem and phloem, nutrient uptake through root microbe interaction; membrane transport proteins	
	<b>2. Nitrogen metabolism:</b> i) Root nodulation and nitrogen fixation ii) Nitrogen uptake iii) NOD factor	
	<b>Unit Outcome:</b> UO-1 Explain the various physiological paths in plants.	
<b>II</b>	<b>Stress Physiology and Senescence</b>	<b>11</b>
	<b>1. Stress physiology:</b> – Responses of plants to biotic (pathogen and insects) and abiotic (water, temperature and salt) stresses	
	<b>2. Senescence: Mechanism,</b> physiology of senescence; role of hormones, biochemical aspects, significance in fruit ripening	
	<b>Unit Outcome:</b> UO1 Examine the soil plant relationship with reference to environmental	

	factors and plant physiology	
<b>III</b>	<b>Photosynthesis</b>	<b>12</b>
	<ol style="list-style-type: none"> <li><b>Photosynthesis:</b> Evolution of photosynthetic apparatus, photooxidation of water, Hills reaction, two-pigment system, mechanism of electron and proton H<sup>+</sup> transport</li> <li><b>Carbon assimilation pathways</b> in C<sub>3</sub>, C<sub>4</sub> and CAM plants. Photosynthetic productivity in these plants, and significance <b>Photorespiration:</b> Glycolate pathway, Glyoxylate pathway, biochemical basis of photorespiration, significance</li> </ol>	
	<b>Unit Outcome:</b> UO1. Explain the various metabolic paths in plants.	
<b>IV</b>	<b>Plant Metabolism</b>	<b>11</b>
	<ol style="list-style-type: none"> <li><b>Secondary metabolites:</b> Biosynthesis of terpenes, phenols and nitrogenous compounds and their roles</li> <li><b>Phytohormones:</b> Biosynthesis and mechanism of action of Phytohormones auxin, gibberellin, cytokinin, ethylene and ABA. Brassinosteroids, Jasmoic acids, Polyamines, salicylic acid.</li> </ol>	
	<b>Unit Outcome:</b> UO1. Correlate the function of secondary metabolite and plant hormones	

#### Learning Recourses:

- Biochemistry and Molecular Biology of Plants – Buchanan BB, Gruissem W and Jones RL., American Society of Plant Physiologists, Maryland, USA. 2000.
- Life Processes in Plants – Galston AW., Scientific American Library, Springer-Verlag, New York, USA. 1989.
- Biochemistry and Molecular Biology of Plant Hormones – Hooykaas PJJ, Hall MA and Libbenga KR (eds), Elsevier, Amsterdam, The Netherlands. 1999.
- Introduction to Plant Physiology – Hopkins WG., John Wiley and Sons Inc., New York, USA. 1995.
- Molecular Cell Biology (4th edition) – Lodish H, Berk A, Zipursky SL, Matsudaira P, Baltimore D and Darnell J., W.H. Freeman and Company, New York, USA. 2000.
- Biochemistry and Physiology of Plant Hormones (2nd edition) – Moore TC., Springer-Verlag, New York, USA. 1989.
- Physicochemical and Environmental Plant Physiology (2nd edition) – Nobel PS., Academic Press, San Diego, USA. 1999.
- Plant Physiology (4th edition) – Salisbury FB and Ross CW., Wadsworth Publishing Company, California, USA. 1992.
- Concepts in Photobiology: Photosynthesis and Photomorphogenesis – Singhal GS, Renger G, Sopory SK, Irrgang KD and Govindjee., Narosa Publishing House, New Delhi, India. 1999.
- Plant Physiology (2nd edition) – Taiz L and Zeiger E., Academic Press, San Diego, USA. 1998.

11. Molecular Plant Development: From Gene to Plant – Westhoff P., Oxford University Press, Oxford, UK. 1998.
12. An Introduction to Practical Biochemistry – Plummer DT., Tata McGraw Hill Publishing Company Ltd., New Delhi, India. 1988.
13. A Biologist's Guide to Principles and Techniques of Practical Biochemistry (3rd edition) – Wilson K and Goulding KH (eds),. Foundation Books, New Delhi, India. 1992.
14. Biochemical Methods (2nd edition) – Sadasivam S and Manickam A., New Age International Publishers, New Delhi, India. 1996.
15. Modern Plant Physiology (2nd edition) – Sinha RK., Narosa Publishing House, New Delhi, India. 2002.
16. Plant Physiology (2nd edition) – Kumar P and Purohit SS., Agrobios Publications, Jodhpur, India. 2003.
17. Plant Physiology and Metabolism – Dhumal KN, Kadam VK, Sayyad I and Deshmukh RN., Nirali Prakashan, Pune, India. 2010.
18. Basics of Plant Physiology and Metabolism (4th edition) – Joshi A., MJP Publishers, Chennai, India. 2012.

**Internal Examination Pattern: Continuous Assessment Test (CAT):**

CAT-I: Book Reading/ Poster presentation/ PPT Presentation

CAT-II: Open book test/ Surprise test / Descriptive test

**Mapping of Cos with POs & PSOs**

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	2	1	3	1	2	3	1	0	1	3	2	1	3	2	1
CO2	3	2	1	3	1	2	3	1	0	1	3	2	1	3	2	1
CO3	3	3	1	3	1	2	3	1	0	1	3	3	1	3	2	1
CO4	3	3	1	3	2	2	3	1	0	1	3	3	1	3	2	1

**Scale:** 3 = High, 2 = Moderate, 1 = Low



Shiv Chhatrapati Shikshan Sanstha's

## Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

### Department of Botany UG IV Sem VIII

**Course Type: Laboratory Course**

**Course Title: Laboratory Course- XVII**

**Course Code: 401BOT8106**

**Credit: 01**

**Maximum Marks: 50**

**Hours: 30**

#### Learning Objective:

- LO1: To describe the principles of biochemical techniques used for estimation and analysis of biomolecules.
- LO2: To apply chromatographic and spectrophotometric methods for identification and separation of primary and secondary metabolites.
- LO3: To perform biochemical experiments to analyze physiological processes.
- LO4: To analyze and interpret experimental data related to plant biochemical composition and metabolic changes.

#### Course outcomes:

After completion of the course, students will be able to-

- CO1: Explain and perform quantitative estimation of biomolecules.
- CO2: Apply chromatographic techniques and identification of plant metabolites.
- CO3: Demonstrate laboratory skills in isolation of chloroplasts and analysis of enzyme activity and stress-induced metabolites.
- CO4: Analyze biochemical changes in plants and interpret results obtained from experimental studies.

Sr. No.	Practicals
1	Estimation of soluble proteins in germinating and non-germinating seeds by Lowry/Bradford's method
2	Estimation of total amino acids in germinating and non-germinating seeds
3	The identification of sugar in Fruit juices by TLC
4	Isolation of Chloroplast from spinach leaves
5	study biochemical changes during leaf senescence
6	Effect of time and enzyme concentration on the rate of enzyme action(Any one)
7	Estimation of stress induced amino acid (Proline)
8	Estimation of total fats in fatty seeds
9	Separation of Alkaloids/Phenols by TLC
10	Estimation of Phenols by chemical method

11	Qualitative analysis of secondary metabolites
12	Sugar/ amino acids analysis with paper chromatography
13	Estimation of Chlorophylls

**N.B:1) Any Ten Practicals**

**2) Several Short Excursions and at least one Long Excursion**

**Learning Resources:**

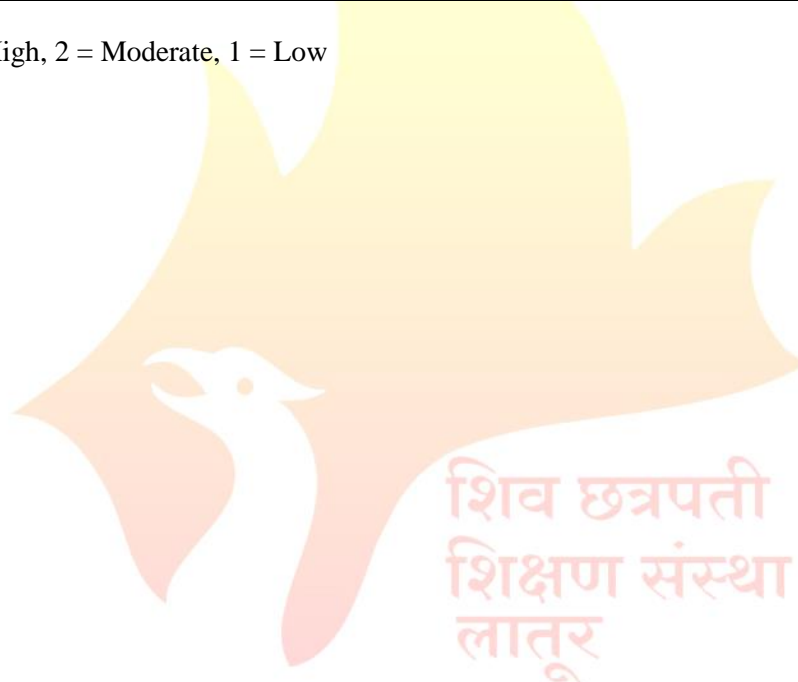
1. Biochemical Methods (3rd edition) – Sadasivam S and Manickam A., New Age International Publishers, New Delhi, India. 2008.
2. An Introduction to Practical Biochemistry – Plummer DT., Tata McGraw Hill Publishing Company Ltd., New Delhi, India. 2004.
3. Laboratory Manual in Biochemistry – Jayaraman J., New Age International Publishers, New Delhi, India. 2011.
4. Principles and Techniques of Biochemistry and Molecular Biology (8th edition) – Wilson K and Walker J., Cambridge University Press, Cambridge, UK. 2018.
5. Biochemistry Laboratory: Modern Theory and Techniques (2nd edition) – Boyer RF., Pearson Education, Boston, USA. 2012.
6. Molecular Cloning: A Laboratory Manual (3rd edition) – Sambrook J and Russell DW., Cold Spring Harbor Laboratory Press, New York, USA. 2001.
7. Gene Cloning and DNA Analysis: An Introduction (7th edition) – Brown TA., Wiley-Blackwell, Oxford, UK. 2016.
8. Experiments in Microbiology, Plant Pathology and Biotechnology (4th edition) – Aneja KR., New Age International Publishers, New Delhi, India. 2003.
9. Plant Physiology and Biochemistry – Srivastava HS., Academic Press (India), New Delhi, India. 2002.
10. Plant Physiology and Development (6th edition) – Taiz L, Zeiger E, Møller IM and Murphy A., Sinauer Associates, Sunderland, USA. 2018.
11. Plant Biochemistry (4th edition) – Heldt HW and Piechulla B., Academic Press, Amsterdam, Netherlands. 2011.
12. Fundamentals of Biochemistry (5th edition) – Voet D, Voet JG and Pratt C., Wiley, Hoboken, USA. 2016.
13. Biochemistry (8th edition) – Berg JM, Tymoczko JL and Stryer L., W.H. Freeman, New York, USA. 2015.
14. Outlines of Biochemistry (5th edition) – Conn EE, Stumpf PK, Bruening G and Doi RH., John Wiley and Sons, New York, USA. 1987.
15. Hawk's Physiological Chemistry (14th edition) – Oser BL., McGraw-Hill, New York, USA. 1965.
16. Practical Clinical Biochemistry (5th edition) – Varley H, Gowenlock AH and Bell M., Heinemann, London, UK. 1980.
17. Secondary Metabolites – Harborne JB., Academic Press, London, UK. 1998.
18. Phytochemical Methods (3rd edition) – Harborne JB., Chapman and Hall, London, UK. 1998.
19. Introduction to Plant Physiology (4th edition) – Hopkins WG and Hüner NPA., John Wiley and Sons, New York, USA. 2009.

20. Plant Physiology (4th edition) – Salisbury FB and Ross CW, Wadsworth Publishing Company, California, USA. 1992.

**Mapping of Cos with POs & PSOs**

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	2	2	3	2	1	2	1	1	0	1	3	2	3	2	1	1
CO2	2	2	3	2	1	2	1	1	0	1	3	2	3	2	1	1
CO3	3	3	3	3	2	3	2	1	0	2	3	3	3	3	2	2
CO4	3	3	3	3	2	3	2	1	0	2	3	3	3	3	2	2

**Scale:** 3 = High, 2 = Moderate, 1 = Low



शिव छत्रपती  
शिक्षण संस्था  
लातूर

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Rajarshi Shahu Mahavidyalaya,  
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## Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

### Department of Botany UG IV Sem VIII

Course Type: DSC- XIX

Course Title: Plant Structure, Development & Reproduction in Angiosperms

Course Code: 401BOT8103

Credits: 03

Maximum Marks: 75

Hours: 45

#### Learning Objectives:

- LO1. To describe reproductive structure of a plant and compare male and female gametophytes and explain how they form in Angiosperms.
- LO3. To compare and contrast life cycles of angiosperms, gymnosperms.
- LO4. To describe the structure and function of the flower within the angiosperm life cycle.
- LO6. To explain significance of features or steps of seed maturation, dormancy, and germination.

#### Course Outcomes:

After completion of the course, students will be able to-

- CO1. Examine anatomy in relation to basic structure of plants and their developmental structure.
- CO2. Acquire knowledge about leaf, shoot and root development.
- CO3. Justify basic anatomical concept of primary structure of root stem and flower.
- CO4. Explain the principles of Palynology and its branches.

Unit No.	Title of Unit & Contents	Hrs.
<b>I</b>	<b>Process of Plant Development</b>	<b>10</b>
	<ol style="list-style-type: none"><li>1. Plant development- concept, definitions and unique features</li><li>2. Processes of development, cell growth, organization of cells, tissues and tissue system to whole plant. Cell- cell interaction</li><li>3. Factors for development- intrinsic and extrinsic</li><li>4. Vegetative development – structure and organization of seed embryo</li><li>5. Seed formation and germination – Embryonal axis- meristems, establishment of seedling organ</li><li>6. Phenomenon of development, meristems as dynamic centers of cell regeneration, organ development, primordium to organ, juvenility – characteristics, transition to adult phase.</li></ol>	
	<b>Unit Outcome:</b> UO1.Acquire knowledge about leaf, shoot and root development.	
<b>II</b>	<b>Embryological aspects of Development</b>	<b>12</b>
	<ol style="list-style-type: none"><li>1. Transition - vegetative to reproductive phase, morphological and histochemical changes in vegetative plant body</li><li>2. Gametophyte development, microsporogenesis and male gametophyte megasporogenesis and female gametophyte</li></ol>	

	<ol style="list-style-type: none"> <li>3. Fertilization – process and its significance abnormalities in fertilization</li> <li>4. Embryo development - Development of embryo in dicots and monocot, unclassified or abnormal embryos, unorganized or reduced embryo</li> <li>5. Polyembryony – concept and classification of polyembryony, special cases and causes of polyembryony, apomixes- concept, categories- agamospermy and vegetative reproduction apospory, parthenogenesis.</li> </ol>	
	<p><b>Unit Outcome:</b> UO1.Examine anatomy in relation to basic structure of plants and their developmental structure.</p>	
<b>III</b>	<b>Molecular Basis of Plant Development</b>	<b>11</b>
	<ol style="list-style-type: none"> <li>1. Plant hormones– Biosynthesis, storage, breakdown and transport; physiological effects and mechanisms of action</li> <li>2. Organization of shoot and root apical meristem, shoot and root development, leaf development and Phyllotaxy</li> <li>3. Molecular basis of plant development - Embryogenesis and seedling development, root, shoot and leaf development, gene expression during transition to flowering and flower development molecular genetics of gametophytes development, expression of cell incompatibility</li> <li>4. Transition to flowering and flower development-ABC Model</li> </ol>	
	<p><b>Unit Outcome:</b> UO1. Justify basic anatomical concept of primary structure of root stem and flower.</p>	
<b>IV</b>	<b>Palynology</b>	<b>12</b>
	<ol style="list-style-type: none"> <li>1. <b>Palynology:</b> Scope and branches with special suggested readings</li> <li>2. <b>Palynotaxonomy:</b> Pollen morphology and plant taxonomy with suggested readings: to Gymnosperms and Angiosperms</li> <li>3. <b>Paleopalynology:</b> Principles, microfossil recovery theory and techniques, microfossil groups and oil exploration</li> <li>4. <b>Aeropalynology:</b> Principles, techniques, pollen analysis, pollen and spore allergy, allergic properties of pollen, pollen calendar and importance</li> <li>5. <b>Aeropalynology:</b> Pollen viability, pollen germination, pollen storage and them Significance</li> <li>6. <b>Melitopalynology:</b> Bee colony, foraging behavior of bees Unfloral multifloral honey, application in crop productivity</li> </ol>	
	<p><b>Unit Outcome:</b> UO1.Explain the principles of Palynology and its branches</p>	

**Learning Recourses:**

1. Bhojwani S. S. and Bhatnagar S. P. (1999). The embryology of angiosperms. Vikas Pub. House.

2. Bhojwani S.S. and Soh W.Y. (2001). Current Trends in Embryology of Angiosperms. Kluwer Academic Publishers.
3. Fahn A (1989) plant anatomy (Third edition) Pergamon Press.
4. Gilbert (2006). Developmental biology (8th Edition). Sinauer Associates, Inc., Publishers, Sunderland, Massachusetts, USA.
5. Graham C.F. and Wareing P.F. (1984). Developmental Controls in Animals and Plants. Blackwell Scientific Publications.
6. Jermy Burgess (1985) An Introduction to Plant Cell Development. Cambridge University Press.
7. Krishnamurthy. (1988) Methods in Plant Histochemistry.
8. Lewis Wolpert (2002), Principles of Development (2<sup>nd</sup> edition). Oxford University Press.
9. Lyndon R.F. (1990) Plant Development the Cellular Basis. UNWIN HYMAN.
10. Raghavan V. (2000) Developmental Biology of Flowering Plants. Springer Verlag.
11. Razdan M.K. (2003) Plant Tissue Culture, Oxford IBH.
12. Wareing P. F. and Philips I. D. J. (1981) Growth and Differentiation in plants. Pergamon Press.
13. Wada M., Shimazaki K., Iino M. (2005). Light sensing in plants. Springer.

**Internal Examination Pattern: Continuous Assessment Test (CAT):**

CAT-I: Book Reading/ Seminar/ PPT presentation/Journal reading

CAT-II: Open book test/ Surprise test / Descriptive test

**Mapping of Cos with POs & PSOs:**

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
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CO3	3	2	1	2	1	1	2	1	0	1	3	2	1	2	1	1
CO4	3	3	1	3	1	2	2	1	0	2	3	3	1	3	2	1

**Scale:** 3 = High, 2 = Moderate, 1 = Low

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Rajarshi Shahu Mahavidyalaya,  
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## Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

### Department of Botany UG IV Sem VIII

**Course Type: Laboratory Course**

**Course Title: Laboratory Course- XVII**

**Course Code: 401BOT8107**

**Credit: 01**

**Maximum Marks: 50**

**Hours: 30**

#### Learning Objective:

- LO1: To describe the structure, origin, and development of plant tissues.
- LO2: To explain the processes of microsporogenesis, megasporogenesis, and development of male and female gametophytes.
- LO3: To apply histological and dissection techniques for studying plant anatomy, embryology and reproductive structures.
- LO4: To analyze developmental stages of endosperm, embryo, and pollen viability, and correlate structural and functional aspects.

#### Course outcomes:

After completion of the course, students will be able to-

- CO1: Identify and describe the structure and development of plant tissues, meristems, and secondary growth.
- CO2: Explain and demonstrate the stages of gametophyte development and embryogenesis in plants.
- CO3: Perform histological techniques, staining, and dissection for detailed anatomical and embryological studies.
- CO4: Analyze and interpret observations on pollen viability, germination, and developmental stages of endosperm and embryo.

Sr. No.	Practicals
1	Isolation of vegetative and reproductive apical meristem
2	Tracing the course of stomatal development and observations on stomatal types
3	Anatomical studies on secondary growth (wood)
4	Origin and development of epidermal structures (Trichomes, glands and lenticels) and study of secretory structures (nectarines and laticifers)
5	Histochemical comparison between vegetative SA and reproductively induced SA
6	Observations on Microsporogenesis and development of male gametophyte (pollen)
7	Observations on. Megasporogenesis and development of female gametophyte
8	Observations on types of endosperm, dissection and isolation of endosperm
9	Observations on stages of embryo development, dissection and isolation of developing embryo (3 stages)
10	In vitro germination of spore/pollen, Correlation between fertility (stain ability),

	viability (TTC and FDA staining) and germinability (in vitro) of pollen grains
11	Histological analysis of secondary growth (Primary or secondary axis)
12	Dissection of haustorial endosperm
13	Dissection of an embryo of dicot and monocot

**N.B:** 1) Any ten Practicals form the above list.

2) Several Short Excursions, field visits and at least one Long Excursion.

### Learning Resources:

1. Plant Anatomy (3rd edition) – Fahn A., Pergamon Press, Oxford, UK. 1989.
2. Plant Microtechnique and Microscopy – Ruzin SE., Oxford University Press, New York, USA. 1999.
3. Theory and Practice of Histological Techniques (7th edition) – Bancroft JD and Gamble M., Churchill Livingstone, Edinburgh, UK. 2013.
4. Laboratory Techniques in Botany – Purvis MJ, Collier DC and Wallis D., Butterworths, London, UK. 1964.
5. Techniques and Methods in Biology – Ghatak KL., PHI Learning Pvt Ltd, New Delhi, India. 2011.
6. Methods in Plant Histochemistry – Krishnamurthy KV., S. Viswanathan Printers and Publishers, Madras, India. 1988.
7. An Introduction to Plant Cell Development – Burgess J., Cambridge University Press, Cambridge, UK. 1985.
8. Developmental Biology of Flowering Plants – Raghavan V., Springer-Verlag, New York, USA. 2000.
9. The Embryology of Angiosperms – Bhojwani SS and Bhatnagar SP., Vikas Publishing House Pvt Ltd, New Delhi, India. 1999.
10. Reproductive Biology of Plants – Johri BM and Srivastava PS., Narosa Publishing House, New Delhi, India. 2001.
11. Plant Development: The Cellular Basis – Lyndon RF., Unwin Hyman Ltd., London, UK. 1990.
12. Growth and Differentiation in Plants – Wareing PF and Phillips IDJ., Pergamon Press, Oxford, UK. 1981.
13. Introduction to Plant Physiology – Hopkins WG and Hüner NPA., John Wiley and Sons Inc., New York, USA. 2009.
14. Plant Physiology and Development (6th edition) – Taiz L, Zeiger E, Møller IM and Murphy A., Sinauer Associates, Sunderland, USA. 2018.
15. Plant Tissue Culture – Razdan MK., Oxford and IBH Publishing Company, New Delhi, India. 2003.
16. Fundamentals of Palynology – Erdtman G., Munksgaard, Copenhagen, Denmark. 1969.
17. Pollen Analysis – Faegri K and Iversen J., Blackwell Scientific Publications, Oxford, UK. 1989.
18. Embryology of Angiosperms – Maheshwari P., McGraw-Hill Book Company, New York, USA. 1950.
19. Plant Anatomy (5th edition) – Esau K., John Wiley and Sons, New York, USA. 1977.
20. Anatomy of Seed Plants (2nd edition) – Esau K., John Wiley and Sons, New York, USA. 1977.

Mapping of Cos with POs & PSOs:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	2	2	3	2	1	1	2	1	0	1	3	2	3	2	1	1
CO2	3	2	3	2	1	1	2	1	0	1	3	2	3	2	1	1
CO3	3	3	3	3	1	2	2	1	0	2	3	3	3	3	2	2
CO4	3	3	3	3	2	2	3	1	0	2	3	3	3	3	3	2

Scale: 3 = High, 2 = Moderate, 1 = Low



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Rajarshi Shahu Mahavidyalaya,  
Latur (Autonomous)



Shiv Chhatrapati Shikshan Sanstha's

## Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Department of Botany

UG IV Sem VIII

Course Type: DSC-XX

Course Title: Analytical, Quantitative and Scientific Aptitude

Course Code: 401BOT8104

Credits: 02

Max. Marks: 50

Lectures: 30 Hrs.

### Learning Objectives:

- LO 1 To cultivate and demonstrate logical reasoning, pattern recognition, and analytical thinking to solve complex problems efficiently.
- LO 2 To apply and compute quantitative aptitude concepts, including arithmetic, algebra, and time-based problem-solving techniques in real-life contexts.
- LO 3 To analyze and integrate advanced mathematical concepts such as geometry, permutation, combination, and probability for scientific applications.
- LO 4 To interpret, evaluate, and correlate data using statistical tools, graphical methods, and general science concepts with emphasis on environmental sustainability.

### Course Outcomes:

After completion of course the student will be able to-

- CO 1 Analyze and solve problems involving logical reasoning, pattern recognition, sequences, coding–decoding, and relationships.
- CO 2 Compute, apply, and solve numerical and arithmetic problems involving ratios, percentages, profit & loss, time-work, and algebraic concepts.
- CO 3 Analyze, evaluate, and apply geometrical concepts, permutation and combination, and probability in real-world and scientific problem-solving.
- CO 4 Interpret, analyze, and evaluate data using statistical tools, graphical representations, and apply scientific and environmental concepts for sustainable development.

Rajarshi Shahu Mahavidyalaya,  
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Unit No.	Title of Unit & Contents	Hrs.
<b>I</b>	<b>Logical Reasoning and Mental Ability</b>	<b>07 Hrs.</b>
	<ol style="list-style-type: none"> <li>1. Observational skills and pattern recognition Logical deductions and analytical reasoning</li> <li>2. Sequence and series</li> <li>3. Coding-decoding, analogies and relationships</li> </ol>	
	<b>Unit Outcomes:</b> UO 1 Analyze reasoning and deduction patterns. UO 2 Apply logical reasoning techniques.	
<b>II</b>	<b>Quantitative Aptitude</b>	<b>08 Hrs.</b>
	<ol style="list-style-type: none"> <li>1. Numerical ability and arithmetic</li> <li>2. Ratio, percentage, averages</li> <li>3. Profit and loss</li> <li>4. Time, work and speed</li> <li>5. Quadratic equations</li> <li>6. Clock, calendar, years, weeks and days</li> </ol>	
	<b>Unit Outcomes:</b> UO 1 Apply quantitative techniques in problem solving. UO 2 Analyze mathematical relationships.	
<b>III</b>	<b>Advanced Mathematics and Probability</b>	<b>08 Hrs.</b>
	<ol style="list-style-type: none"> <li>1. Geometry of shapes and measurement</li> <li>2. Directional geometry</li> <li>3. Moving object dynamics (basic)</li> <li>4. Permutation and combination</li> <li>5. Probability</li> </ol>	
	<b>Unit Outcomes:</b> UO 1 Apply mathematical and probabilistic concepts. UO 2 Analyze problem-solving strategies.	
<b>IV</b>	<b>Data Interpretation and General Science</b>	<b>07/ Hrs.</b>
	<ol style="list-style-type: none"> <li>1. Data analysis and graphical interpretation</li> <li>2. Statistical tools (mean, variation)</li> <li>3. General science (basic concepts and applications)</li> <li>4. Environmental issues and sustainable development</li> </ol>	
	<b>Unit Outcomes:</b> UO 1 Interpret data using statistical and graphical tools. UO 2 Evaluate scientific and environmental concepts.	

**Learning Resources:**

1. Pathfinder Academy. *CSIR-NET life sciences*. 2024 ed. New Delhi: Pathfinder Publication.

2. Aggarwal RS. *Quantitative aptitude for competitive examinations*. 2024 ed. New Delhi: S. Chand Publishing.
3. Verma R, Sharma S. *Logical reasoning and data interpretation*. 2023 ed. New Delhi: Arihant Publications.
4. NCERT. *Mathematics textbooks (Class XI & XII)*. 2023 ed. New Delhi: NCERT.
5. Lucent Publications. *Lucent's general science*. 2024 ed. New Delhi: Lucent Publications.
6. Made Easy Editorial Board. *GATE life sciences guide*. 2024 ed. New Delhi: Made Easy Publications.
7. Verma R. *Fast track objective arithmetic*. 2023 ed. New Delhi: Arihant Publications.
8. Pandey MK. *Analytical reasoning*. 2023 ed. New Delhi: BSC Publishing.
9. Various authors. *Previous years' question papers (CSIR-NET / SET / DBT-JRF / JAM)*. 2024 ed.
10. Government of India. *Scientific and environmental policy documents*. 2023 ed. New Delhi: Government of India.

### Internal Examination Pattern :

CAT – I: Analytical Case Study on Applied Concepts in the Prescribed Syllabus

CAT – II: Critical Review and Analysis of Research Literature Relevant to the Syllabus

### Mapping of Cos with POs & PSOs:

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	1	3	1	3	1	2	–	–	1	2	1	2	1	3	2	–
CO2	2	2	1	3	1	3	–	–	1	2	2	2	2	3	2	–
CO3	2	2	1	3	1	2	1	–	1	2	2	2	1	3	2	1
CO4	3	3	2	3	2	3	3	2	1	2	3	3	2	3	2	2

Scale: 3 = High, 2 = Moderate, 1 = Low

Rajarshi Shahu Mahavidyalaya,  
Latur (Autonomous)



Shiv Chhatrapati Shikshan Sanstha's

## Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

### Department of Botany UG IV Sem VIII

Course Type: DSE-III (A)

Course Title: Plant Ecology and Evolution

Course Code: 401BOT8201

Credits: 03

Maximum Marks: 75

Hours: 45

#### Learning Objectives:

- LO1. To create awareness among students about bio resource conservation.
- LO2. To provide scientific basis for aims of environmentalism.
- LO3. To understand trend of evolution among living organisms.
- LO4. To provide students with an understanding of the basics of plant-environment and their interaction with other organisms.

#### Course Outcomes:

After completion of the course, students will be able to-

- CO1. Justify the concept if niche and species interaction.
- CO2. Explain the mechanism of genetic drift, adaptive radiation and species isolation.
- CO3. Correlate the Characteristics of population, Community and ecological succession.
- CO4. Examine the trend of evolution among living organisms.

Unit No.	Title of Unit & Contents	Hrs.
<b>I</b>	<b>Environmental Ecology</b>	<b>12</b>
	<ol style="list-style-type: none"><li>1. <b>Habitat and Niche:</b> Concept of habitat and niche; (niche width and overlap; fundamental and realized niche; resource partitioning; character displacement)</li><li>2. <b>Interaction types:</b> Plant interaction with abiotic factors such as climatic, edaphic, and topographic factors Plant-plant interaction concept of allelopathy. Species interaction: mutualism, commensalism, competition, parasitism and predation</li><li>3. <b>Conservation Biology:</b><ol style="list-style-type: none"><li>i. Principles of conservation, major approach to management</li><li>ii. Organisms of conservation concern: Rare, endangered species</li></ol></li></ol>	
	<b>Unit Outcome:</b> UO1. Justify the concept if niche and species interaction.	
<b>II</b>	<b>Population and Community Ecology</b>	<b>10</b>
	<ol style="list-style-type: none"><li>1. <b>Population Ecology:</b> Characteristics of a population; population growth curves; population regulation, life history strategies (r and K selection); concept of metapopulation-demes and dispersal, age structure populations</li><li>2. <b>Community Ecology:</b> Nature of communities; community</li></ol>	

	<p>structure and attributes; level of species diversity and its measurement</p> <p>3. <b>Diversity types and levels:</b> Alpha, Beta, Gamma</p> <p>4. <b>Ecological Succession:</b> Types; mechanisms; changes involved in succession, concept of climax.</p>	
	<p><b>Unit Outcome:</b> UO1 Correlate the Characteristics of population, Community and ecological succession.</p>	
<b>III</b>	<b>Evolutionary Biology</b>	<b>11</b>
	<p>1. <b>Emergence of evolutionary thoughts:</b> Lamarck; Darwin-concepts of variation, adaptation struggle, fitness and natural selection; Spontaneity of mutations; the evolutionary synthesis</p> <p>2. <b>Origin of cells and unicellular revolution:</b> Origin of basic biological molecules; Abiotic synthesis of organic monomers and polymers; Concept of Oparone and Haldane; Experiment of Miller (1953); The first cell; Evolution of prokaryotes; Origin of eukaryotic cells; Evolution of unicellular eukaryotes</p> <p>3. <b>Paleontology and Evolutionary History:</b> The evolutionary time scale; Eras, Periods and epoch; Major events in the evolutionary time scale</p>	
	<p><b>Unit Outcome:</b> UO1. Examine the trend of evolution among living organisms</p>	
<b>IV</b>	<b>Molecular Evolutionary Biology</b>	<b>12</b>
	<p>1. <b>Molecular Evolution:</b> Concepts of neutral evolution, molecular divergence and molecular clocks; origin of new genes and proteins</p> <p>2. <b>The Mechanisms:</b> Population genetics- Populations, Gene pool, Gene frequency; Hardy- Weinberg Law; concepts and rate of change in gene frequency through natural selection, Migration and random genetic drift, Adaptive radiation.</p> <p>3. Isolating mechanisms; Speciation, Allopatric and Sympatric; Convergent evolution; Sexual selection, Co-evolution</p>	
	<p><b>Unit Outcome:</b> UO1. Explain the mechanism of genetic drift, adaptive radiation and species isolation.</p>	

#### Learning Resources:

1. Patterns of Primary Production in the Biosphere – Lieth HFW., Springer-Verlag, New York, USA. 1978.
2. Fundamentals of Ecology – Agarwal SK., Ashish Publishing House, New Delhi, India. 1992.
3. The Biosphere – Bradbury IK., Academic Press, London, UK. 1990.
4. Handbook of Limnology and Water Pollution with Practical Methodology – Das SM., South Asian Publishers, New Delhi, India. 1989.
5. Environment and Plant Ecology – Etherington JR., John Wiley and Sons, London, UK. 1975.
6. Deterministic Mathematical Models in Population Ecology – Freedman HI., Marcel Dekker Inc., New York, USA. 1980.
7. Quantitative Plant Ecology – Greig-Smith P., Blackwell Scientific Publications, Oxford, UK. 1983.
8. Comparative Plant Ecology – Grime JP, Hodgson JG and Hunt R., Unwin Hyman Ltd., London, UK. 1988.
9. Quantitative and Dynamic Ecology – Kershaw KA., Edward Arnold, London, UK. 1964.
10. Concepts of Ecology – Kormondy EJ., Prentice Hall, New Jersey, USA. 1966.

11. Ecology – Krebs CJ,. Harper and Row Publishers, New York, USA. 1978.
12. Manual of Plant Ecology – Misra KC,. Oxford and IBH Publishing Company, New Delhi, India. 1989.
13. Proceedings of the School of Plant Ecology – Misra R and Das RR,. Banaras Hindu University Press, Varanasi, India. 1971.
14. Ecology – Odum EP,. Holt, Rinehart and Winston, New York, USA. 1971.
15. Fundamentals of Ecology (3rd edition) – Odum EP,. Saunders College Publishing, Philadelphia, USA. 1996.
16. Fundamentals of Ecology (6th edition) – Odum EP and Barrett GW,. Brooks/Cole, Belmont, USA. 2010.
17. Principles of Environmental Science – Pandeya SC et al.,. Vikas Publishing House Pvt Ltd, New Delhi, India. 1963.
18. On the Origin of Species – Darwin C,. John Murray, London, UK. 1859.
19. Genetics and the Origin of Species – Dobzhansky T,. Columbia University Press, New York, USA. 1937.
20. The Genetical Theory of Natural Selection – Fisher RA,. Oxford University Press, Oxford, UK. 1930.
21. Phylogenetic Systematics – Hennig W,. University of Illinois Press, Urbana, USA. 1966.
22. Systematics and the Origin of Species – Mayr E,. Columbia University Press, New York, USA. 1942.
23. Factors of Evolution – Schmalhausen II,. Blakiston Company, Philadelphia, USA. 1949.
24. Tempo and Mode of Evolution – Simpson GG,. Columbia University Press, New York, USA. 1944.
25. A Textbook of Plant Ecology Including Ethnobotany and Soil Science – Shukla RS and Chandel PS,. S Chand and Company Pvt Ltd, New Delhi, India. 2005.
26. A Textbook of Plant Ecology (15th edition) – Ambasht RS and Ambasht NK,. CBS Publishers and Distributors, New Delhi, India. 2017.

**Internal Examination Pattern: Continuous Assessment Test (CAT):**

CAT-I: Book Reading/Collection of Specimens

CAT-II: Open book test/ Surprise test / Descriptive test

❖ Mapping of Cos with POs & PSOs:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	2	1	3	1	2	3	2	0	1	3	2	1	3	2	1
CO2	3	3	1	3	1	2	3	2	0	1	3	3	1	3	2	1
CO3	3	2	1	3	1	2	3	2	0	1	3	2	1	3	2	1
CO4	3	3	1	3	2	2	3	2	0	2	3	3	1	3	2	2

**Scale:** 3 = High, 2 = Moderate, 1 = Low



Shiv Chhatrapati Shikshan Sanstha's

## Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

### Department of Botany UG IV Sem VIII

Course Type: Lab Course

Course Title: Lab Course- IV

Course Code: 401BOT8203

Credits: 01

Maximum Marks: 50

Hours: 30

#### Learning Objective:

LO1: To describe the structure and components of aquatic and terrestrial ecosystems.

LO2: To explain methods for assessing abiotic and biotic factors.

LO3: To apply ecological techniques for sampling, data collection, and analysis of soil, water and plant communities.

LO4: To analyze ecological data to evaluate environmental conditions.

#### Course outcomes:

After completion of the course, students will be able to-

CO1: Identify and describe ecological components.

CO2: Perform estimation of abiotic and biotic factors.

CO3: Apply field and laboratory techniques to assess soil properties, population dynamics, and community structure.

CO4: Analyze ecological data and prepare reports to interpret environmental conditions and impacts of pollution.

Sr. No.	Practicals
1	Study of Phytoplankton
2	Evaluation of Abiotic components of Aquatic ecosystem (pH, temperature and Transparency).
3	Determination of Phytomass
4	Study of species diversity index
5	Study of Population dynamics
6	Determination of field capacity of Soil
7	Estimation of primary productivity of an Aquatic ecosystem
8	Determination of residual chlorine from water sample
9	Determination of frequency, Density, Abundance, Dominance and IVI of the Plant Community
10	Estimation of DO and free CO <sub>2</sub>
11	Study of morphological and anatomical characteristics of plants under pollution stages
12	Allelopathic analysis of the plants
13	Determination of Palmers algal index
14	Ecological reports based on tour or analysis

**N.B:** 1) Any Ten Practical.

2) Several Short Excursions and at least one Long Excursion

### Learning Resources:

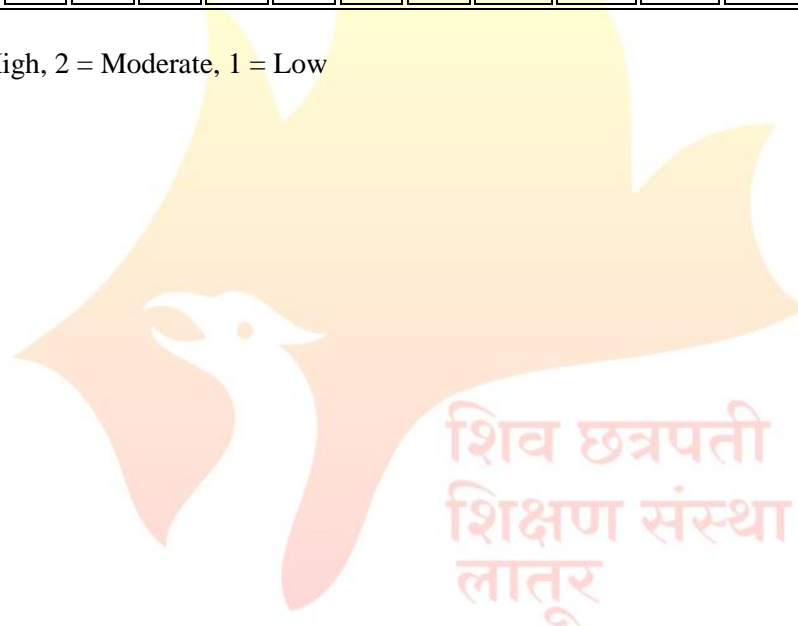
1. Practical Ecology – Misra R., Oxford and IBH Publishing Company, New Delhi, India. 1968.
2. Manual of Plant Ecology – Misra KC., Oxford and IBH Publishing Company, New Delhi, India. 1989.
3. Fundamentals of Ecology (6th edition) – Odum EP and Barrett GW., Brooks/Cole, Belmont, USA. 2010.
4. Ecology – Krebs CJ., Harper and Row Publishers, New York, USA. 1978.
5. Quantitative Ecology and the Evolution of Ecological Systems – Pielou EC., Macmillan Publishing Company, New York, USA. 1977.
6. Plant Ecology – Weaver JE and Clements FE., McGraw-Hill Book Company, New York, USA. 1938.
7. Methods in Plant Ecology – Greig-Smith P., Blackwell Scientific Publications, Oxford, UK. 1983.
8. A Textbook of Plant Ecology Including Ethnobotany and Soil Science – Shukla RS and Chandel PS., S Chand and Company Pvt Ltd, New Delhi, India. 2005.
9. A Textbook of Plant Ecology (15th edition) – Ambasht RS and Ambasht NK., CBS Publishers and Distributors, New Delhi, India. 2017.
10. Limnology – Welch PS., McGraw-Hill Book Company, New York, USA. 1952.
11. Freshwater Biology – Edmondson WT., John Wiley and Sons, New York, USA. 1992.
12. Standard Methods for the Examination of Water and Wastewater – APHA., American Public Health Association, Washington DC, USA. 2017.
13. Environmental Chemistry – Sawyer CN, McCarty PL and Parkin GF., McGraw-Hill, New York, USA. 2003.
14. Water Pollution and Its Control – Trivedy RK and Goel PK., Karad Environmental Publications, Karad, India. 1986.
15. Introduction to Environmental Engineering and Science – Masters GM and Ela WP., Pearson Education, New Delhi, India. 2008.
16. Soil Science – Brady NC and Weil RR., Pearson Education, New Delhi, India. 2002.
17. Methods of Soil Analysis – Black CA., American Society of Agronomy, Madison, USA. 1965.
18. Primary Productivity in Aquatic Ecosystems – Vollenweider RA., IBP Handbook, Blackwell Scientific Publications, Oxford, UK. 1974.
19. Phytoplankton Ecology – Reynolds CS., Cambridge University Press, Cambridge, UK. 2006.
20. Algal Ecology: Freshwater Benthic Ecosystems – Stevenson RJ, Bothwell ML and Lowe RL., Academic Press, San Diego, USA. 1996.
21. Environmental Biology – Odum EP., Saunders College Publishing, Philadelphia, USA. 1971.

22. Air Pollution and Plant Life – Bell JNB and Treshow M., John Wiley and Sons, New York, USA. 2002.
23. Ecological Methods (2nd edition) – Southwood TRE and Henderson PA., Blackwell Science, Oxford, UK. 2000.

❖ Mapping of Cos with POs & PSOs:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	2	2	3	2	1	2	3	1	0	1	3	2	3	2	1	1
CO2	2	2	3	2	1	2	3	1	0	1	3	2	3	2	1	1
CO3	3	3	3	3	2	3	3	2	0	2	3	3	3	3	2	2
CO4	3	3	3	3	2	3	3	2	0	2	3	3	3	3	3	2

Scale: 3 = High, 2 = Moderate, 1 = Low



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Rajarshi Shahu Mahavidyalaya,  
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## Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

### Department of Botany UG IV Sem VIII

Course Type: DSE-III (B)

Course Title: Taxonomy of Angiosperms

Course Code: 401BOT8202

Credits: 03

Maximum Marks: 75

Hours: 45

#### Learning Objectives:

- LO1. To study the Principles and tools of Taxonomy
- LO2. To study the different classification systems.
- LO3. To learn Origin, evolution of agriculture and Plant domestication.
- LO4. To know the characteristic, classification and economic importance of some families of Angiosperms.

#### Course Outcomes:

After completion of the course, students will be able to-

- CO1. Examine the principles and tools of Angiosperms
- CO2. Correlate the different classification systems.
- CO3. Explain Origin, evolution of agriculture and Plant domestication.
- CO4. Justify the characteristic, interrelationships, classification and economic importance of some families of Angiosperms.

Unit No.	Title of Unit & Contents	Hrs.
<b>I</b>	<b>Principles and tools of Taxonomy</b>	<b>12</b>
	<ol style="list-style-type: none"><li>1. Introduction, Botanical Nomenclature: Brief history, Scientific names, ICN, Principles</li><li>2. Adaptation and morphological peculiarities in Angiosperms</li><li>3. Tools of taxonomy: Floras, monographs, Herbarium and botanical gardens, their role in research and conservation. Important herbaria and botanic gardens of the World.</li><li>4. Floristics: Need and significance. History of botanical exploration in India and recent works with special emphasis on Maharashtra.</li><li>5. Morphological features used in identification. Artificial dichotomous keys Biodiversity, Types, Importance and methods of conservation</li></ol>	
	<b>Unit Outcome:</b> UO1 Examine the principles and tools of Angiosperms	
<b>II</b>	<b>Classification Systems</b>	<b>10</b>
	<ol style="list-style-type: none"><li>1. Importance and need for classification. Criteria used for classification; phases of plant classification. Overview on pre and post-Darwinian systems of classification.</li><li>2. Artificial systems of classification –Theophrastus.</li><li>3. System of classification: Engler and Prantl's system, Hutchinson's system</li><li>4. Phylogenetic systems of classification - Cronquist</li><li>5. APG system of classification</li></ol>	
	<b>Unit Outcome:</b> UO1 Correlate the different classification systems.	

<b>III</b>	<b>Evolution</b>	<b>11</b>
	<p>1. Origin and evolution of agriculture: Introduction, food crops, centers of plant domestication of major crops, crop dispersal and distribution.</p> <p>2. Plant domestication: Introduction, Evolution of farming, changes during domestication, genetic regulation of domestication syndromes.</p> <p>3. Evolution of weeds, genetic diversity and domestication. Centers and threats to diversity.</p> <p>4. Crop plants and their wild relatives: Cereal grains, legumes, starch plants, fruits, vegetables, fibers, cordage, medicinal plants, poisonous plants.</p>	
	<p><b>Unit Outcome:</b>            UO1. Explain Origin, evolution of agriculture and Plant domestication.</p>	
<b>IV</b>	<b>Families of Angiosperms</b>	<b>12</b>
	<p>1. Major clades in APG-IV: characteristic features, interrelationships, classification (APG-IV) and economic importance of families of angiosperms:            Anagrade: Amborellaceae, Nymphaeaceae            Magnoliids: Magnoliaceae            Monocots: Araceae            Commelinoids: Arecaceae            Probable Sister of Eudicots: Ceratophyllaceae            Eudicots: Ranunculaceae            Core Eudicots: Amaranthaceae            Eurosids-I: Leguminosae            Euasterids-I: Apocynaceae            Euasterid-II: Asteraceae</p>	
	<p><b>Unit Outcome:</b>            UO1. Justify the characteristic, interrelationships, classification and economic importance of some families of Angiosperms</p>	

### Learning Resources:

1. Plant Systematics: A Phylogenetic Approach – Judd WS, Campbell CS, Kellogg EA, Stevens PF and Donoghue MJ., Sinauer Associates, Sunderland, USA. 2016.
2. Plant Taxonomy – Singh G., Oxford and IBH Publishing Company, New Delhi, India. 2010.
3. An Introduction to Plant Taxonomy – Jeffrey C., Cambridge University Press, Cambridge, UK. 1982.
4. Taxonomy of Angiosperms – Vashishta PC., S Chand and Company Pvt Ltd, New Delhi, India. 2014.
5. Plant Taxonomy – Pandey BP., S Chand and Company Pvt Ltd, New Delhi, India. 2005.
6. Modern Plant Taxonomy – Stace CA., Cambridge University Press, Cambridge, UK. 2010.
7. Principles of Angiosperm Taxonomy – Davis PH and Heywood VH., Oliver and Boyd, Edinburgh, UK. 1963.
8. Taxonomy of Vascular Plants – Lawrence GHM., Oxford and IBH Publishing Company, New Delhi, India. 1951.

9. The Families of Flowering Plants – Hutchinson J., Oxford University Press, London, UK. 1959.
10. Flowering Plants: Evolution Above the Species Level – Stebbins GL., Harvard University Press, Cambridge, USA. 1974.
11. Systematic Botany – Rendle AB., Cambridge University Press, Cambridge, UK. 1952.
12. Plant Systematics – Simpson MG., Academic Press, Burlington, USA. 2010.
13. Angiosperm Phylogeny Group Classification of Flowering Plants – APG IV., Botanical Journal of the Linnean Society, London, UK. 2016.
14. Botanical Nomenclature: Principles and Practice – McNeill J., Koeltz Scientific Books, Koenigstein, Germany. 1990.
15. International Code of Nomenclature for Algae, Fungi and Plants (Shenzhen Code) – Turland NJ et al., Koeltz Botanical Books, Glashütten, Germany. 2018.
16. Flora of British India – Hooker JD., L Reeve and Company, London, UK. 1872.
17. Flora of Maharashtra State – Almeida MR., Orient Press, Mumbai, India. 1996.
18. Flora of the Presidency of Bombay – Cooke T., Botanical Survey of India, Kolkata, India. 1908.
19. Indian Plant Taxonomy – Nayar MP., Today and Tomorrow Printers and Publishers, New Delhi, India. 1996.
20. Experimental Taxonomy of Flowering Plants – Solbrig OT., Columbia University Press, New York, USA. 1970.

**Internal Examination Pattern: Continuous Assessment Test (CAT):**

CAT-I: Book Reading/ Preparation of Herbaria/ Collection of Specimens

CAT-II: Open book test/ Surprise test / Descriptive test

**Mapping of Cos with POs & PSOs:**

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	2	1	2	1	1	2	1	0	1	3	2	1	2	1	1
CO2	3	2	1	2	1	1	2	1	0	1	3	2	1	2	1	1
CO3	3	2	1	3	1	2	3	2	0	1	3	2	1	3	2	1
CO4	3	3	1	3	2	2	3	2	0	2	3	3	1	3	2	2

**Scale:** 3 = High, 2 = Moderate, 1 = Low



Shiv Chhatrapati Shikshan Sanstha's

## Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

### Department of Botany UG IV Sem VIII

Course Type: Lab Course

Course Title: Lab Course Based on DSE-III (B)

Course Code: 401BOT8204

Credit: 01

Maximum Marks: 50

Hours: 30

#### Learning Objective:

- LO1: To describe the classification of angiosperms based on Bentham and Hooker's system and recognize key plant families.
- LO2: To explain morphological and anatomical features of selected plant families and their diagnostic characters.
- LO3: To apply techniques for identification of plant specimens.
- LO4: To analyze structural adaptations of plants to different ecological conditions.

#### Course outcomes:

After completion of the course, students will be able to-

- CO1: Identify and classify plant specimens based on Bentham and Hooker's system using morphological characters.
- CO2: Describe distinguishing features of major angiosperm families and their economic importance.
- CO3: Construct and use artificial keys for identification of unknown plant specimens and demonstrate herbarium techniques.
- CO4: Analyze and compare morphological and anatomical adaptations of plants under different environmental conditions.

Sr. No.	Practicals
1-10	Studies on the following Classes as per Bentham and Hooker's system of classification using any 3 type specimens and preparation of artificial keys for identification of any two unknown specimens: Dicotyledonae: a) Amborellaceae, Nymphaeaceae, Hydatellaceae; b) Magnoliaceae; c) Araceae; d) Arecaceae; e) Ceratophyllaceae; f) Ranunculaceae; g) Amaranthaceae; h) Leguminosae; i) Apocynaceae, j) Asteraceae.
11-12.	Comparative study of morphological and structural adaptations of hydrophytes, mesophytes, xerophytes, halophytes.
13	Demonstration of tool used in herbarium preparation.

**N.B: 1) Any Ten Practicals.**

**2) Several Short Excursions and at least one Long Excursion**

**Learning Recourses**

1. The Genera of Flowering Plants – Bentham G and Hooker JD., L Reeve and Company, London, UK. 1862.
2. Plant Systematics: A Phylogenetic Approach – Judd WS, Campbell CS, Kellogg EA, Stevens PF and Donoghue MJ., Sinauer Associates, Sunderland, USA. 2016.
3. Plant Taxonomy – Singh G., Oxford and IBH Publishing Company, New Delhi, India. 2010.
4. Taxonomy of Angiosperms – Vashishta PC., S Chand and Company Pvt Ltd, New Delhi, India. 2014.
5. Plant Taxonomy – Pandey BP., S Chand and Company Pvt Ltd, New Delhi, India. 2005.
6. An Introduction to Plant Taxonomy – Jeffrey C., Cambridge University Press, Cambridge, UK. 1982.
7. Modern Plant Taxonomy – Stace CA., Cambridge University Press, Cambridge, UK. 2010.
8. The Families of Flowering Plants – Hutchinson J., Oxford University Press, London, UK. 1959.
9. Flowering Plants: Evolution Above the Species Level – Stebbins GL., Harvard University Press, Cambridge, USA. 1974.
10. Systematic Botany – Rendle AB., Cambridge University Press, Cambridge, UK. 1952.
11. Plant Systematics – Simpson MG., Academic Press, Burlington, USA. 2010.
12. Flora of British India – Hooker JD., L Reeve and Company, London, UK. 1872.
13. Flora of the Presidency of Bombay – Cooke T., Botanical Survey of India, Kolkata, India. 1908.
14. Flora of Maharashtra State – Almeida MR., Orient Press, Mumbai, India. 1996.
15. Botanical Nomenclature: Principles and Practice – McNeill J., Koeltz Scientific Books, Koenigstein, Germany. 1990.
16. International Code of Nomenclature for Algae, Fungi and Plants (Shenzhen Code) – Turland NJ et al., Koeltz Botanical Books, Glashütten, Germany. 2018.
17. Plant Anatomy (3rd edition) – Fahn A., Pergamon Press, Oxford, UK. 1989.
18. Plant Ecology – Weaver JE and Clements FE., McGraw-Hill Book Company, New York, USA. 1938.
19. A Textbook of Plant Ecology Including Ethnobotany and Soil Science – Shukla RS and Chandel PS., S Chand and Company Pvt Ltd, New Delhi, India. 2005.
20. Practical Botany – Bendre AM and Kumar A., Rastogi Publications, Meerut, India. 2004.
21. Laboratory Techniques in Botany – Purvis MJ, Collier DC and Wallis D., Butterworths, London, UK. 1964.
22. Techniques and Methods in Biology – Ghatak KL., PHI Learning Pvt Ltd, New Delhi, India. 2011.
23. Herbarium Techniques – Bridson D and Forman L., Royal Botanic Gardens, Kew, UK. 1998.

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Mapping of Cos with POs & PSOs:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	2	2	3	2	1	1	2	1	0	1	3	2	3	2	1	1
CO2	3	2	3	2	1	1	2	1	0	1	3	2	3	2	1	1
CO3	3	3	3	3	1	2	2	1	0	2	3	3	3	3	2	2
CO4	3	3	3	3	2	2	3	1	0	2	3	3	3	3	3	2

Scale: 3 = High, 2 = Moderate, 1 = Low



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## Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

UG Forth Year

### Extra Credit Activities

Sr. No.	Course Title	Credits	Marks	Hours T/P
1	MOOCs	Min. of 02 credits	Min. of 30 Hrs.	1
2	Certificate Courses	Min. of 02 credits	Min. of 30 Hrs.	2
3	IIT Spoken Tutorial Courses	Min. of 02 credits	Min. of 30 Hrs.	3

#### Guidelines:

##### Extra -academic activities

1. All extra credits claimed under this heading will require sufficient academic input/ contribution from the students concerned.
2. Maximum 04 extra credits in each academic year will be allotted.
3. These extra academic activity credits will not be considered for calculation of SGPA/CGPA but will be indicated on the grade card.

##### Additional Credits for Online Courses:

1. Courses only from SWAYAM and NPTEL platform are eligible for claiming credits.
2. Students should get the consent from the concerned subject Teacher/Mentor/Vice Principal and Principal prior to starting of the course.
3. Students who complete such online courses for additional credits will be examined/ verified by the concerned mentor/internal faculty member before awarding credits.
4. Credit allotted to the course by SWAYAM and NPTEL platform will be considered as it is.

##### Additional Credits for Other Academic Activities:

1. One credit for presentation and publication of paper in International/National/State level seminars/workshops.
2. One credit for measurable research work undertaken and field trips amounting to 30 hours of recorded work.
3. One credit for creating models in sponsored exhibitions/other exhibits, which are approved by the concerned department.
4. One credit for any voluntary social service/Nation building exercise which is in collaboration with the outreach center, equivalent to 30 hours
5. All these credits must be approved by the College Committee.

### **Additional Credits for Certificate Courses:**

1. Students can get additional credits (number of credits will depend on the course duration) from certificate courses offered by the college.
2. The student must successfully complete the course. These credits must be approved by the Course Coordinators.
3. Students who undertake summer projects/ internships/ training in institutions of repute through a national selection process, will get 2 credits for each such activity. This must be done under the supervision of the concerned faculty/mentor.

### **Note:**

1. The respective documents should be submitted within 10 days after completion of Semester End Examination.
2. No credits can be granted for organizing or for serving as office bearers/ volunteers for Inter-Class / Associations / Sports / Social Service activities.
3. The office bearers and volunteers may be given a letter of appreciation by the respective staff coordinators. Besides, no credits can be claimed for any services/activities conducted or attended within the college.
4. All claims for the credits by the students should be made and approved by the mentor in the same academic year of completing the activity.
5. Any grievances of denial/rejection of credits should be addressed to Additional Credits Coordinator in the same academic year.
6. Students having a shortage of additional credits at the end of the third year can meet the Additional Credits Coordinator, who will provide the right advice on the activities that can help them earn credits required for graduation.

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**Rajarshi Shahu Mahavidyalaya, Latur**

Empowered Autonomous Institution

**Examination Framework**

**Theory:**

40% Continuous Assessment Tests (CATs) and 60% Semester End Examination (SEE)

**Practical:**

50% Continuous Assessment Tests (CATs) and 50% Semester End Examination (SEE)

Course	Marks	CAT & Mid Term Theory				CAT Practical		Best Scored CAT & Mid Term	SEE	Total
		Att.	CAT I	CAT II	CAT III	Att.	CAT			
1	2	3				4		5	6	5 + 6
Research Methodology	100	10	10	10	20	-	-	40	60	100
MMC/MEC	75	05	10	10	15	-	-	30	45	75
Lab Course	50	-	-	-	-	05	20	-	25	50
Field Project	100	10	10	10	20	-	-	40	60	100

**Note:**

1. All Internal Exams are compulsory
2. Out of 02 CATs best score will be considered
3. Mid Term Exam will be conducted by the Exam Section
4. Mid Term Exam is of Objective nature (MCQ)
5. Semester End Exam is of descriptive in nature (Long & Short Answer)
6. CAT Practical (20 Marks): Lab Journal (Record Book) 10 Marks, Overall Performance 10 Marks

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## Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Semester End Examination Paper Pattern

Pattern - I

Course: Theory

Max. Marks: 45

Times: 2 Hrs.

**Q.1 Answer the following questions (3 Marks each) 12**

**Marks**

- Based on Unit - I
- Based on Unit - II
- Based on Unit - III
- Based on Unit - IV

**Q.2 Answer any THREE of the following (5 Marks each) 15**

**Marks**

- Based on Unit - I
- Based on Unit - II
- Based on Unit - III
- Based on Unit - IV

**Q.3 Answer any ONE of the following 08**

**Marks**

- Based on Unit - I
- Based on Unit - II

**Q.4 Answer any ONE of the following 10**

**Marks**

- Based on Unit - III
- Based on Unit - IV

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**Sadashiv N. Shinde**  
Chairman

Board of Studies in Botany  
Rajarshi Shahu Mahavidyalaya, Latur  
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