2-YEARS NEP PG CURRICULUM

M.Sc. BOTANY PROGRAMME

SUBJECT CODE = BOT

FOR POSTGRADUATE COURSES UNDER RANCHI UNIVERSITY, RANCHI

Implemented w.e.f.
Academic Session 2025-26 Onwards

Members of the Board of Studies of NEP PG Syllabus of Botany
As per Guidelines of the Ranchi University, Ranchi

1. Chairman –

Dr. Anita Mehta
Associate Professor & Head
University Department of Botany, Ranchi University, Ranchi

2. External Members –

i. **Prof. Md. Anwar Mallick**
Retd. University Professor
Department of Botany
Vinoba Bhave University, Hazaribagh

ii. **Prof. Jyoti Kumar**
Retd. University Professor
University Department of Botany
Ranchi University, Ranchi

iii. **Prof. Manoj Kumar**
Professor & Head
Department of Life Sciences
Central University of Jharkhand, Ranchi

3. Internal Members –

i. **Dr. Ladly Rani**
Assistant Professor
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ii. **Dr. Smrity Prabha**
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v. **Dr. Shweta Nag**
Assistant Professor
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vi. **Dr. Binod Kumar Mahto**
Assistant Professor
University Department of Botany, Ranchi University, Ranchi

4. Special Invited Members –

i. **Dr. Ajay Kumar Shrivatava**
Associate Professor
Department of Botany, Xavier College, Ranchi

ii. **Dr. Malay Bharti**
Assistant Professor
Department of Botany, Doranda College, Ranchi

iii. **Dr. Shalini Mehta**
Assistant Professor
Department of Botany, Ranchi Womens College, Ranchi

5. **Invited NEP Expert Members –**

   i. **Dr. Raj Kumar Singh**
   Assistant Professor
   University Department of Physics, Ranchi University, Ranchi
   cum NEP Nodal Officer, R. U.

   ii. **Dr. Neeraj**
   Assistant Professor
   University Department of Chemistry Ranchi University, Ranchi
   cum Member, NEP Implementation & Monitoring Committee, R.U.

6. **Invited IKS Expert Members –**

   I. **Dr. Smriti Singh**
   Assistant Professor
   University Department of Chemistry, Ranchi University, Ranchi
   cum U.G.C.-IKS Master Trainer

7. **Student Alumni Member –**

   i. **Ms. Aditi Shyamanita**
   M. Sc. (2020-2022)
   University Department of Botany, Ranchi University, Ranchi

8. **Student Representative –**

   i. **Mr. Mitesh Kumar**
   Class Roll No.: 46
   M. Sc. Semester-IV (2023-2025)
   University Department of Botany, Ranchi University, Ranchi

   ii. **Mr. Divyanshu Kumar**
   Class Roll No.: 17
   M. Sc. Semester-I (2024-2026)
   University Department of Botany, Ranchi University, Ranchi

Approval by the Members of the NEP Implementation and Monitoring Committee of Ranchi University, Ranchi

The prepared Curriculum of the Master's Degree has been approved by the NEP Implementation and Monitoring Committee of R.U., duly forwarded by the Head of the Department; it will be offered to the Students of the 1-year and 2-year Postgraduate Programme. It is implemented from the 1st Semester of the Academic Session 2025-26 and onwards.

Member Secretory

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HIGHLIGHTS OF NEP PG CURRICULUM

CREDIT OF COURSES

The term 'credit' refers to the weightage given to a course, usually in terms of the number of instructional hours per week assigned to it. The workload relating to a course is measured in terms of credit hours. It determines the number of hours of instruction required per week over a semester (minimum 15 weeks).

a) One hour of teaching/ Lectures or two hours of laboratory /practical work will be assigned per class/interaction.
   One credit for Theory = 15 Hours of Teaching
   One credit for Practicum = 30 Hours of Practical work
   One credit for Internship = 02 Weeks of Practical experience

b) For credit determination, instruction is divided into three major components:
   Hours (L) – Classroom Hours of one hour duration.
   Tutorials (T) – Special, elaborate instructions on specific topics of one hour duration
   Practical (P) – Laboratory or field exercises in which the student has to do experiments or other practical work of a two-hour duration.

   Internship – For the Exit option after 1st year of the 2-year P.G. Programme for the award of P.G. Diploma, Level 6.5, Students can either complete two 4-week internships worth 2 credits each or one 8-week internship for all 4 credits. This practical experience connects academic learning with real-world applications, offering valuable exposure to professional environments in their fields of study

PG CURRICULUM

1. The PG Curriculum will be either of 1-year duration for students who studied the four-year UG Programme (FYUGP) or a 2-year duration for students who studied a three-year UG programme from a CBCS/LOCF/FYUGP Curriculum.
2. There is a flexible mode in the PG programme offered to the students of Ranchi University, Ranchi. The total credit for any semester will be 20 credits.
3. **Two-year PG curriculum:** The First year of the PG curriculum offers coursework only. There will be 3 courses at level 400 and 2 courses at level 500 in the first and the second semesters of any 2-year PG programme.
4. **One-year PG curriculum:** The Courses in the 1-year PG programme and the second year of the 2-year PG programme are the same.
   a. **Course work only**: There will be 5 courses at level 500 of 4 credits each in every semester for the coursework offered in the programme.
   b. **Course work and Research**: There will be 5 courses at the level 500 bearing 4 credits each in the first semester of a 1-year PG or in the third semester of a 2-year PG. There will be Research work offered in the next semester for this mode offered in the programme. The eligibility for this mode is available in the NEP PG curriculum of Ranchi University, Ranchi.
   c. **Research work only**: The eligible student will be offered this mode to conduct extensive research under the supervision of a guide. Each semester will be equivalent to 20 credits. The selection of a candidate for the research mode will depend upon the eligibility of the student, availability of the guide and seat in the department/institution of Ranchi University, Ranchi.

PROMOTION CRITERIA

Two Years Post-graduation programme having coursework only:

i. Each course shall be of **100 marks** having two components: **30 marks for Sessional Internal Assessment (SIA), conducted by the Department/College and 70 marks shall be assigned to the End Semester University Examination (ESUE), conducted by the University**.
ii. The marks of SIA shall further break into, 20 for Internal Written Examinations, 05 for Written Assignment/ Seminar presentation and 05 for overall performance of a student including regularity in the class room lectures and other activities of the Department/College.

iii. The Requisite Marks obtained by a student in a particular subject will be the criteria for promotion to the next Semester.

iv. There shall be two written internal examinations, each of 1 hour duration and each of 20 marks, in a semester out of which the '**Better One out of Two**' shall be taken for computation of marks under SIA.

v. If a student failed to secure pass marks in Mid Semester, he/she has to reappear in Mid & End Semester Examinations.

vi. In case a student is fail to secure pass marks in End Semester Examination, then he/she has to appear only in End Semester Examination of following Sessions within period of Upper Limit of Four Years and the Marks of Mid Semester will be carried for the preparation of result.

vii. Students' final marks and the result will be based on the marks obtained in Mid Semester and End Semester Examination organized taken together.

viii. The pass marks in the programme will be 45% of the total marks obtained in each Core/ Elective/ Other Courses offered.

ix. In absolute terms of marks obtained in a course, **a minimum of 28 marks is essential in the ESUE** and **a minimum of 17 marks is to be secured in the SIA** to clear the course. In other words, a student shall have to pass separately in the ESUE and in the SIA by securing the minimum marks prescribed here.

x. Every candidate seeking to appear in the ESUE shall be issued an Admit Card by the University. **No candidate will be permitted to appear in the examination without a valid admit card.**

xi. A candidate shall be permitted to proceed in next Semester (2^{nd}, 3^{rd} and 4^{th}) **provided he/she has passed at least in 3 courses out of 5 courses** in the respective semester in theory and practical/ project courses taken together.

xii. A student will have to clear all his papers within maximum of Four Years of duration to qualify for the degree.

However, it will be necessary to procure pass marks in each of the papers before completion of the programme.

VALUE ADDED COURSES

1. The Value added course will be of **2 credits** to be covered during the first semester.
2. There will be objective-type questions asked in the End Semester University Examination (ESUE).
3. There will be OMR-based examination and the correct answer is to be marked by a black ballpoint pen only on the OMR sheet provided by the University.
4. For **50 Marks Examination** the student will be provided **Two hours** for marking their responses.
5. Students are not allowed to choose or repeat courses already undergone at the undergraduate level in the proposed major and minor streams.
6. The performance in this course will not influence the SGPA or CGPA of the PG Programme where the student is registered to obtain the Master's Degree. However, it will be mandatory to secure minimum pass marks in the course before exit from the PG Programme.
7. If the student fails to secure the minimum pass marks in the Value added course in the first semester, he may appear in the examination of the said course with the following batch of the next session.
8. The student may appear in the examination of the said course further if could not clear the course in the following attempt, subject to the date of validation of the Registration.

The Regulations related to any concern not mentioned above shall be guided by the existing Regulations of the PG Curriculum of Ranchi University, Ranchi.

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COURSE STRUCTURE FOR PG **'PG DIPLOMA/ COURSEWORK ONLY/ COURSEWORK WITH RESEARCH/ RESEARCH ONLY '**

Table 1: Credit Framework for One Year Postgraduate Programme (PG) [Total Credits = 80]

Academic Level	Level of Courses	Semester	Coursework Level 400	Coursework Level 500	Research Preparedness	Research thesis/ Project/ Patent	Total Credits
YEAR 1							
Level 6.5	**Coursework**	**I**	**4+4+4**	**4+4**	**---**	**---**	**20**
		II	**4+4+4**	**4+4**	**---**	**---**	**20**
YEAR 2:	**Exit Point: Having Internship of 4 credits Exit allowed with PG Diploma Certificate**						
Level 6.5	**Coursework**	**III**	**---**	**4+4+4+4+4**	**---**	**---**	**20**
		IV	**---**	**4+4+4+4+4**	**---**	**---**	**20**
OR							
Level 6.5	**Coursework + Research**	**III**	**---**	**4+4+4+4+4**	**---**	**---**	**20**
		IV	**---**	**---**	**20**		**20**
OR							
Level 6.5	**Research**	**III**	**---**	**---**	**20**	**---**	**20**
		IV	**---**	**---**	**---**	**20**	**20**
							Total credits of P.G. Programme = **80**

Note: **Having Internship of 4 credits 'Exit' is allowed with awarding the PG Diploma Certificate**.

Implemented from Academic Session 2025-26 & Onwards

AIMS OF MASTER'S DEGREE PROGRAMME IN BOTANY

The aim of the Master's degree programme in Botany is to provide:

The Master's Degree Programme in Botany is designed to provide students with advanced knowledge, technical skills, and research aptitude in the diverse areas of plant science. The programme aims to build a strong foundation in classical botany while integrating modern concepts and technologies to address contemporary challenges in plant biology, agriculture, environment, and biotechnology.

1. Academic and Knowledge Advancement

- To deepen understanding of plant morphology, anatomy, taxonomy, physiology, genetics, ecology, and evolution.
- To impart up-to-date knowledge of emerging fields such as molecular biology, plant biotechnology, genomics, bioinformatics, and climate change biology.
- To encourage critical thinking and analytical skills for interpreting scientific data and concepts.

2. Research Competence and Innovation

- To train students in designing, conducting, and presenting independent research projects in various branches of botany.
- To develop expertise in modern laboratory techniques, instrumentation, and fieldwork methodologies.
- To cultivate problem-solving abilities for addressing issues related to plant productivity, biodiversity conservation, and sustainable resource management.

3. Environmental and Societal Relevance

- To enhance understanding of the role of plants in ecosystem services, environmental balance, and human welfare.
- To promote awareness of biodiversity conservation, sustainable agriculture, and mitigation strategies for environmental degradation.
- To integrate botanical knowledge into policy-making, community development, and industrial applications.

4. Professional and Career Development

- To prepare students for diverse career opportunities in academia, research institutions, botanical gardens, environmental organisations, agriculture, forestry, pharmaceuticals, and biotechnology industries.
- To strengthen communication, teamwork, and leadership skills for professional success.
- To encourage ethical conduct and a responsible approach in scientific research and environmental stewardship.

5. Lifelong Learning and Global Perspective

- To instill a commitment to continuous learning and adaptability in the rapidly evolving field of plant sciences.
- To foster a global outlook by connecting local plant science issues to international research and conservation efforts.

PROGRAMME LEARNING OUTCOMES

The broad aims of Master's degree programme in Botany are:
The Postgraduate Programme in Botany equips students with advanced theoretical knowledge, practical skills, and research competencies to excel in plant sciences. Upon successful completion of the programme, graduates will be able to:

1. Knowledge and Understanding

- Demonstrate comprehensive knowledge of plant biology, covering taxonomy, anatomy, physiology, ecology, genetics, evolution, and biodiversity.
- Explain advanced concepts in molecular biology, plant biotechnology, bioinformatics, environmental science, and plant pathology.
- Correlate traditional botanical knowledge with modern interdisciplinary approaches to address scientific and societal challenges.

2. Research Skills and Scientific Temper

- Design and execute independent research projects, including formulation of hypotheses, experimental design, data collection, and statistical analysis.
- Apply advanced laboratory techniques, field survey methods, and modern instrumentation relevant to plant sciences.
- Critically evaluate scientific literature, synthesize information, and present research outcomes effectively in oral and written formats.

3. Problem-Solving and Application

- Develop innovative solutions for issues in agriculture, forestry, biodiversity conservation, and environmental sustainability.
- Integrate knowledge of plant sciences in biotechnology, pharmaceuticals, and industrial applications.
- Address plant-related problems in the context of climate change, habitat loss, and resource management.

4. Professional and Ethical Competence

- Exhibit professional integrity, ethical research practices, and respect for biodiversity and intellectual property rights.
- Demonstrate leadership, teamwork, and communication skills in multidisciplinary and multicultural environments.
- Apply botanical knowledge for societal benefit, policy-making, and public awareness.

5. Lifelong Learning and Global Perspective

- Engage in continuous professional development to adapt to evolving scientific advancements.
- Relate local and regional botanical issues to global environmental and conservation contexts.
- Contribute to the advancement of plant sciences through collaborative national and international research initiatives.

Through these outcomes, the programme aims to produce highly skilled, research-oriented, and socially responsible botanists capable of contributing to academia, industry, environmental management, and policy formulation, thereby addressing both local and global challenges in plant science.

The Courses in One Year P.G. Programme and in the Second year of Two years P.G. Programme are Common.

Table 2: **Semester-wise Course Code and Credit Points**

Sem	Core, AE/ GE/ DC/ EC & Compulsory FC Courses				Examination Structure		
	Paper	Paper Code	Credit	Name of Paper	Mid Semester Evaluation (F.M.)	End Semester Evaluation (F.M.)	End Semester Practical/ Viva (F.M.)
I	Foundation Course	FCBOT101	4	Diversity and Biology of Lower Plants, Microorganisms and Plant Pathology	30	70	----
	Core Course	CCBOT102	4	Advanced Molecular Biology	30	70	----
	Core Course	CCBOT103	4	Research Methodology	30	70	----
	Core Course	CCBOT104	4	Biological Instrumentation	30	70	----
	Practicals on Core	CPBOT105	4	Practical-I	----	----	100
II	Core Course	CCBOT201	4	Plant Anatomy, Embryology, And Taxonomy	30	70	----
	Core Course	CCBOT202	4	Applied Botany	30	70	----
	Core Course	CCBOT203	4	Integrative Botany	30	70	----
	Core Course	CCBOT204	4	Cytogenetics and Cell Biology	30	70	----
	Practicals on Core	CPBOT205	4	Practical-II	----	----	100
III	Core Course	CCBOT301	4	IKS in Botany	30	70	----
	Skill Enhancement Course	ECBOT302	4	A. Biofertilizers/ B. Mushroom Cultivation	30	70	----
	Core Course	CCBOT303	4	Plant Physiology and Biochemistry	30	70	----
	Core Course	CCBOT304	4	Fundamental and Applied Ecology	30	70	----
	Practicals on Core	CPBOT305	4	Practical-III	----	----	100
IV	Elective	ECBOT401	4	A. Algal Biotechnology-I/ B. Microbiology and Plant Pathology-I/ C. Cytogenetics, Plant Breeding, Molecular Biology and Biotechnology-I/ D. Plant Physiology, Biotechnology and Molecular Biology-I/ E. Plant Taxonomy, Ethnobotany and Medicinal Plants-I	30	70	----
	Elective	ECBOT402	4	A. Algal Biotechnology-II/ B. Microbiology and Plant Pathology-II/ C. Cytogenetics, Plant Breeding, Molecular Biology and Biotechnology-II/ D. Plant Physiology, Biotechnology and Molecular Biology-II/ E. Plant Taxonomy, Ethnobotany and Medicinal Plants-II	30	70	----

	Core Course	CCBOT403	4	Laboratory Safety, Regulations and Research Ethics	30	70	----
	Practicals on Elective	EPBOT404	4	A. Practical-IVA B. Practical-IVB C. Practical-IVC D. Practical-IVD E. Practical-IVE	----	----	100
	PROJECT	PRBOT405	4	Dissertation/ Project/ Teaching Aptitude	----	----	100

*** Either One Internship of 4 credits or Two Internships of 2 credits each is required before opting for the 'Exit' option after First year of the P.G. Programme.**

FORMAT OF QUESTION PAPER FOR MID/ END SEMESTER EXAMINATIONS

Question format for **20 Marks**:

Subject/ Code

F.M. =20 **Time**=1Hr. Exam Year

General Instructions:

i. **Group A** carries very short answer type compulsory questions.
ii. **Answer 1 out of 2** subjective/ descriptive questions given in **Group B**.
iii. Answer in your own words as far as practicable.
iv. Answer all sub parts of a question at one place.
v. Numbers in right indicate full marks of the question.

Group A

1. [5x1=5]
   i. ....
   ii. ....
   iii. ....
   iv. ....
   v. ....
2. .... [5]

Group B

3. .... [10]
4. .... [10]

Note: There may be subdivisions in each question asked in Theory Examination.

Question format for **70 Marks**:

Subject/ Code

F.M. =70 **Time**=3HrS. Exam Year

General Instructions:

i. **Group A** carries very short answer type compulsory questions.
ii. **Answer 4 out of 6** subjective/ descriptive questions given in **Group B**.
iii. Answer in your own words as far as practicable.
iv. Answer all sub parts of a question at one place.
v. Numbers in right indicate full marks of the question.

Group A

1. [5x1=5]
   i. ....
   ii. ....
   iii. ....
   iv. ....
   v. ....
2. .... [5]

Group B

3. .... [15]
4. .... [15]
5. .... [15]
6. .... [15]
7. .... [15]
8. .... [15]

Note: There may be subdivisions in each question asked in Theory Examination.

SEMESTER I

I. FOUNDATION COURSE [FCBOT102]

DIVERSITY AND BIOLOGY OF LOWER PLANTS, MICROORGANISMS AND PLANT PATHOLOGY

Marks: 30 (MSE: 20 Th. 1Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE :28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

1. To understand the diversity, classification, structure, reproduction, and economic importance of lower plants (Algae to Gymnosperms).
2. To impart advanced knowledge of microbiology including viruses, bacteria, and archaea.
3. To develop comprehensive understanding of plant-microbe interactions and plant disease mechanisms.
4. To enable students to identify plant diseases and suggest appropriate control measures.
5. To expose students to applied and modern research trends in the subject areas.

Course Learning Outcomes:

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

1. Describe the classification, life cycles, and economic importance of lower plant groups and microbes.
2. Analyse the anatomical and reproductive adaptations of bryophytes, pteridophytes, and gymnosperms.
3. Interpret microbial structures and their role in environment and industry.
4. Diagnose major plant diseases and recommend suitable management practices.
5. Integrate molecular and ecological tools in understanding plant-microbe interactions and host defence mechanisms.

Course Content:

Unit I: Algae and Fungi **(12 Lectures)**

Algae: Classification (Fritsch and modern), thallus organisation, life cycles (Cyanophyta, Chlorophyta, Charophyta, Phaeophyta and Rhodophyta), role in biotechnology (biofuels, biofertilizers).

Fungi: Modern classification (Ainsworth), life cycles of *Phytophthora*, *Aspergillus*, *Agaricus*, lichen biology, fungal biotechnology (enzymes, antibiotics, mycoremediation).

Unit II: Bryophytes and Pteridophytes **(10 Lectures)**

Bryophytes: Classification, alternation of generations, Life cycle of *Marchantia*, *Anthoceros*, *Funaria*; evolution of gametophyte and sporophyte.

Pteridophytes: Telome theory, heterospory and seed habit, Life cycle of *Lycopodium*, *Selaginella*, *Equisetum*, *Marsilea*; ecological role and phytoremediation potential.

Unit III: Gymnosperms and Fossils **(8 Lectures)**

Comparative morphology and anatomy of *Pinus*, *Taxus* and *Gnetum*.

Reproductive biology and fossil gymnosperms (Cycadales, Bennettitales, Cordaitales); living fossils- *Ginkgo*.

Fossils: Types, Fossilization and Geological Time Period.

Recent advances in gymnosperm phylogeny using molecular tools.

Unit IV: Microbiology **(14 Lectures)**

Bacteria: Structure, asexual reproduction and genetic recombination: transformation, conjugation, and transduction; nitrogen fixation and microbial genetics.

Viruses and Viroids: Structure, replication, lytic and lysogenic cycles (e.g., T4, λ-phage), plant viral diseases (TMV, Yellow vein mosaic).

Archaea: Extremophiles and their ecological importance.

Mycoplasma: General account and its role in causing plant diseases.

Unit V: Plant Pathology **(16 Lectures)**

General Principles: Infection, penetration, colonization, pathogenesis, symptomology, Koch's postulates.

Disease Management: Cultural, biological, chemical and integrated disease management (IDM).

Important Diseases: Distribution, symptoms, etiology, disease cycle and management: Late blight of potato, Red rot of sugarcane, Wilt of pigeon pea, Rust of wheat, Bacterial blight of rice, Leaf curl of papaya, leaf curl of tomato.

Recent advances in molecular plant pathology and host-pathogen interaction.

Reference Books:

1. Alexopoulos, C.J., Mims, C.W. & Blackwell, M. (1996). *Introductory Mycology*. Wiley.
2. Kumar, H.D. (1999). *Introductory Phycology*. Affiliated East-West Press.
3. Pandey, B.P. (2021). *Bryophyta, Pteridophyta and Gymnosperms*. S. Chand & Co.
4. Pelczar, M.J., Chan, E.C.S. & Krieg, N.R. (2001). *Microbiology: Concepts and Applications*. Tata McGraw-Hill.
5. Agrios, G.N. (2005). *Plant Pathology*, 5th Ed. Elsevier Academic Press.
6. Dubey, H.C. (2021). *A Textbook of Fungi, Bacteria and Viruses*. S. Chand & Co.
7. Mehrotra, R.S. & Aggarwal, A. (2013). *Plant Pathology*. Tata McGraw-Hill.
8. Sambamurty, A.V.S.S. (2005). *A Textbook of Algae*. IK International Publishing.
9. Sharma, O.P. (2014). *Pteridophyta and Gymnosperms*. Tata McGraw-Hill.
10. Webster, J. & Weber, R. (2007). *Introduction to Fungi*. Cambridge University Press.

II. CORE COURSE [CCBOT102]
ADVANCED MOLECULAR BIOLOGY

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

1. To familiarise the students with the fundamental principles of molecular tools and techniques, and various potential application of molecular biology.

Course Learning Outcomes:

1. Use the techniques, skills, and modern tools necessary for imbalances in various life processes, design a molecular cell biology research project, collect and analyse data, and interpret results.

Course Content:

Unit 1: Introduction to Molecular Cloning (14 Lectures)

Vectors: Characteristics of cloning vectors, Plasmids (pBR322, pUC18/I9) and Ti plasmid. Shuttle vectors and Expression vectors: *E. coli lac* and T7 promoter-based vectors.

Enzymes used in Molecular Cloning: Restriction enzymes. Types I, II and III, nomenclature, use of Type II restriction enzymes in cloning. Reverse transcriptase.

Methods used in Molecular Cloning: Agarose gel electrophoresis of DNA, Southern, Northern and Western blotting. RFLP (Restriction Fragment Length Polymorphism). Molecular probes: cDNA probes – RNA probes

Unit 2: PCR Techniques (9 lectures)

Principle of Polymerase Chain Reaction, RT-PCR, Real-Time PCR and their applications.

Unit 3: Gene Expression (16 lectures)

Regulation of gene expression in Prokaryotes: various models - operon - details of lac operon-negative and positive control lac operon. Regulation gene expression in eukaryotes: Regulation of transcription - regulation of RNA processing and translation. Microarray and gene expression analysis.

Unit 4: DNA Sequencing (7 lectures)

DNA sequencing: Maxam Gilbert chemical method - Sanger's enzymatic chain termination method – foot printing.

Unit 5: Gene Silencing and Genome Editing (6 lectures)

Introduction4 to gene silencing (RNAi)/ post-transcriptional gene silencing (PTGS) and its mechanism.
Introduction and Principle of genome editing.

Unit 6: Applied Cytogenetics and Molecular Biology (8 lectures)

Applied Plant Cytology: Advanced chromosome staining: G-banding, C-banding, NOR-banding; Fluorescent In Situ Hybridisation (FISH) and its applications; **DNA fingerprinting** and **barcoding** for plant variety protection; **Molecular and Cytogenetic Diagnostics in Plant Health:** Applications in seed certification, tissue culture fidelity, and conservation.

Reference Books:

1. Brown TA. (2010) Gene Cloning and DNA Analysis. 6th edition. Blackwell Publishing, Oxford, U.K.
2. Primrose SB and Twyman RM. (2006) Principles of Gene Manipulation and Genomics, 7th edition. Blackwell Publishing, Oxford, U.K.
3. Sambrook J and Russell D. (2001) Molecular Cloning-A Laboratory Manual. 3rd edition. Cold Spring Harbor Laboratory Press.
4. Walker J M and Gringold EB, Molecular Biology and Biotechnology. Panima.
5. Benjamin Lewin. Genes 1X. John Wiley.
6. Hartwell L H et al., Genetics: From Genes to Genome. Mc Graw Hill.
7. Watson J D et al., Molecular Biology of the Gene. The Benjamin / Cummings.
8. Lodish H et al., Molecular Cell Biology. Scientific American Books. W H Freeman.
9. David Freid felder, Molecular Biology. Narosa.
10. Adrin J Harwood, Methods in Molecular Biology, Vol.58, Basic DNA and RNA protocols. Humana Press.
11. Chris R Calladine et al., Understanding DNA. Elsevier.
12. Micklos D A et al., DNA Science. Cold Spring Harbour.
13. Cox et al, Molecular Biology, Principles and Practice, Freeman
14. Tropp, Molecular Biology, Genes to proteins, Jones and Bartlett
15. Allison, Fundamental Molecular Biology, Wiley.
16. Ernst L Winnacker, from genes to clones, Panim
17. Alberts B, Johnson A, Lewis J, et al. (2015) Molecular Biology of the Cell. 6th edition. Garland Science, New York, U.S.A.
18. Sharma AK, Sharma A. (2014) Plant Cytogenetics. 2nd edition. CRC Press, Boca Raton, FL, U.S.A.
19. Murray BG, Young A (eds.). (2021) Plant Cytogenetics: Methods and Protocols. 2nd edition. Humana Press, New York, U.S.A.

III. CORE COURSE [CCBOT103]
RESEARCH METHODOLOGY

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:
1. Understand some basic concepts of research and its methodologies.
2. Identify appropriate research topics and, select and define appropriate research problem and parameters.

Course Learning Outcomes:
1. Demonstrate the ability to choose methods appropriate to research aims and objectives.
2. Understand the limitations of particular research methods.
3. Develop skills in qualitative and quantitative data analysis and presentation.
4. 4 Develop advanced critical thinking skills.

Course Content:

Unit 1: Basic concepts of research (10 lectures)

Research-definition and types of research (Descriptive vs analytical; applied vs fundamental; quantitative vs qualitative; conceptual vs empirical). Research methods vs methodology. Literature-review and its consolidation; Library research; field research; laboratory research.

Unit 2: General laboratory practices (12 lectures)

Common calculations in botany laboratories. Understanding the details on the label of reagent bottles. Molarity and normality of common acids and bases. Preparation of solutions. Dilutions. Percentage solutions. Molar, molal and normal solutions. Technique of handling micropipettes; Knowledge about common toxic chemicals and safety measures in their handling.

Unit 3: Data collection and documentation of observations (6 lectures)

Maintaining a laboratory record; Tabulation and generation of graphs. Imaging of tissue specimens and application of scale bars. The art of field photography.

Unit 4: Overview of Biological Problems (6 lectures)

History; Key biology research areas, Model organisms in biology (A Brief overview): Geneties, Physiology, Biochemistry, Molecular Biology, Cell Biology, Genomics, Proteomics Transcriptional regulatory network.

Unit 5: Methods to study plant cell/tissue structure (6 lectures)

Whole mounts, peel mounts, squash preparations, clearing, maceration and sectioning: Tissue preparation: living vs fixed, physical vs chemical fixation, coagulating fixatives, non-coagulant fixatives; tissue dehydration using graded solvent series; Paraffin and plastic infiltration; Preparation of thin and ultrathin sections.

Unit 6: Plant microtechniques (12 lectures)

Staining procedures, classification and chemistry of stains. Staining equipment. Reactive dyes and fluorochromes (including genetically engineered protein labeling with GFP and other tags). Cytogenetic techniques with squashed plant materials.

Unit 7: The art of scientific writing and its presentation (8 lectures)

Numbers, Units, abbreviations and nomenclature used in scientific writing. Writing references. Powerpoint presentation. Poster presentation. Scientific writing and ethics, Introduction to copyright- academic misconduct/plagiarism.

Reference Books:

1. Dawson, C. (2002). Practical research methods. UBS Publishers, New Delhi.
2. Stapleton, P., Yondeowei, A., Mukanyange, J., Houten, H. (1995). Scientific writing for agricultural research scientists – a training reference manual. West Africa Rice Development Association, Hong Kong.
1. Ruzin, S.E. (1999). Plant micro technique and microscopy. Oxford University Press, New York, USA

IV. CORE COURSE [CCBOT104]
BIOLOGICAL INSTRUMENTATION

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objective

1. Understand the Principles of microscopy.
2. Understand the structure and functioning of various biological instruments.
3. Get enlighten their knowledge in various biochemical methods

Course Learning Outcomes

3. Skill in operating laboratory equipment, their upkeep, and adept at various biological techniques. Ability to prepare molar, molal, normal solutions and solutions of different dilutions. Interpreting scientific results, and ability to present results in a scientific way through graphs, photographs, poster presentations and power point presentations.

Course Content:
Biological Instrumentation
Unit 1: Imaging and related techniques: (15 lectures)
Principles of microscopy; Light microscopy; Fluorescence microscopy; Electron Microscopy (a) Flow cytometry (b) Applications of fluorescence microscopy: Chromosome banding, FISH, chromosome painting; Transmission and Scanning electron microscopy – sample preparation for electron microscopy, cryofixation, negative staining, shadow casting, freeze fracture, freeze etching.

Unit 2: pH and Centrifugation: (10 lectures)
pH meter: Principles and instrumentation, Centrifugation: Principles, types of centrifuges, types of rotors, differential and density gradient centrifugation, application. Sonication, Freeze drying.

Unit 3: Spectrophotometry: (15 lectures)
Principle involved in Spectrophotometer; Spectrophotometric techniques, Instrumentation: ultraviolet and visible spectrophotometry (single and double beam, double wavelength spectrophotometers), Infrared spectrometers - Luminometry and densitometry – principles and their applications - Mass Spectroscopy-principles of analysis, application in Biology.

Unit 4: Chromatography: (10 lectures)
Chromatographic techniques: Principle and applications – Column - thin layer –paper, affinity and gas chromatography - Gel filtration - Ion exchange and High-performance liquid chromatography techniques– Examples of application for each chromatographic system - Basic principles of electrophoresis.

Unit 5: Preparation of molar, molal and normal solutions, buffers, the art of scientific writing: (10 lectures)
Understanding the details on the label of reagent bottles. Molarity and normality of common acids and bases. Preparation of solutions. Dilutions. Percentage solutions. Molar, molal and normal solutions. Technique of handling micropipettes; Knowledge about common toxic chemicals and safety measures in their handling. The art of scientific writing and presentation of scientific matter. Scientific writing and ethics. Writing references. PowerPoint presentation. Poster presentation. Introduction to copyright-academic misconduct/plagiarism in scientific writing.

Reference Books:

1. Dawson, C. (2002). Practical research methods. UBS Publishers, New Delhi.
2. Stapleton, P., Yondeowei, A., Mukanyange, J., Houten, H. (1995). Scientific writing for agricultural research scientists – a training reference manual. West Africa Rice Development Association, Hong Kong.
3. Ruzin, S.E. (1999). Plant micro technique and microscopy. Oxford University Press, New York, U.S.A.
4. Bajpai, P.K. 2006. Biological Instrumentation and methodology. S. Chand & Co. Ltd.
5. K. Wilson and J. Walker Eds. 2005. Biochemistry and Molecular Biology. Cambridge University Press.
6. K. Wilson andKHGoulding. 1986. Principles and techniques of Practical Biochemistry. (3 edn) Edward Arnold, London.
7. Stapleton, P., Yondeowei, A., Mukanyange, J., Houten, H. (1995). Scientific writing for agricultural research scientists – a training reference manual. West Africa Rice Development Association, Hong Kong.
8. Ruzin, S.E. (1999). Plant micro technique and microscopy. Oxford University Press, New York, U.S.A.

V. CORE COURSE [CPBOT105]
PRACTICAL-I

Marks: 100 (ESE Pr: 6 Hrs) = 100	Pass Marks = 45

(Credits: Practical-04, 120 Hours)

Course Objectives:

1. To provide hands-on training in modern experimental techniques used in plant sciences.
2. To develop proficiency in handling and analysis of microorganisms, algae, fungi, and bryophytes.
3. To understand and apply molecular biology techniques in plant research.
4. To familiarise students with the operation and application of essential biological instruments.
5. To inculcate scientific methodology including data analysis, documentation, and research ethics.

Course Learning Outcomes:

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

1. Demonstrate skills in microscopy, culturing, molecular assays, and plant pathology.
2. Isolate, culture, and characterize microbial organisms and lower plants.
3. Apply basic and advanced techniques of molecular biology in experimental setups.
4. Analyse and interpret experimental data with statistical and bioinformatics tools.
5. Operate and understand the working principles of key biological instruments.

Course Content:

I: Research Methodology

Preparation of research proposal: Hypothesis framing, objectives, and methodology design
Literature review using PubMed, Scopus, Google Scholar
Data collection, tabulation, and graphical representation
Basics of scientific writing and referencing (APA/MLA styles)
Introduction to statistical software: SPSS/R

II: Diversity and Biology of Lower Plants

Microscopic study of representative genera: Algae, Bryophytes, and Pteridophytes
Field collection and herbarium preparation techniques
Study of reproductive structures and life cycles
Cultivation of freshwater algae
Comparative study of thallus organisation

III: Microorganisms and Plant Pathology

Isolation and culture of bacteria and fungi from soil/plant surfaces
Gram staining and fungal staining techniques
Koch's postulates demonstration
Preparation and use of PDA and NA media
Identification of plant diseases (samples and slides)
Study of symptoms caused by *Alternaria*, *Fusarium*, *Pythium*, etc.

IV: Advanced Molecular Biology

PCR demonstration (basic primer design concepts)
Bioinformatics tools: NCBI BLAST, sequence alignment, gene annotation

V: Biological Instrumentation

Operation and principles of:
- Compound and phase-contrast microscope
- Spectrophotometer and colorimeter
- pH meter, centrifuge, laminar airflow

Agarose gel electrophoresis and Gel documentation system
Calibration and maintenance of lab instruments
Safety guidelines for laboratory work

Reference Books:

1. Kothari, C.R. – *Research Methodology: Methods and Techniques* (New Age International)
2. Pelczar, M.J., Chan, E.C.S., & Krieg, N.R. – *Microbiology* (McGraw-Hill)
3. Sharma, O.P. – *Textbook of Algae/Bryophyta/Pteridophyta* (Tata McGraw-Hill)
4. Maloy, S.R., Cronan, J.E., & Freifelder, D. – *Microbial Genetics* (Jones & Bartlett)
5. Sambrook, J. & Russell, D.W. – *Molecular Cloning: A Laboratory Manual* (Cold Spring Harbor)
6. Wilson, K. & Walker, J. – *Principles and Techniques of Biochemistry and Molecular Biology* (Cambridge University Press)
7. Dubey, R.C. & Maheshwari, D.K. – *A Textbook of Microbiology* (S. Chand & Co.)
8. Sawhney, S.K. & Randhir Singh – *Introductory Practical Biochemistry* (Narosa Publishing).

SEMESTER II

I. CORE COURSE [CCBOT201]

PLANT ANATOMY, EMBRYOLOGY, AND TAXONOMY

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

1. To impart advanced knowledge of internal plant structures and their functional relevance.
2. To understand plant development from gametogenesis to seed formation and embryological innovations.
3. To explore classical and modern approaches in plant taxonomy for scientific classification.
4. To build skills in comparative anatomy and identification of taxa using morphology and molecular markers.
5. To provide field and lab-based knowledge useful for botanical research and biodiversity documentation.

Course Learning Outcomes:

After completing this course, students will be able to:

1. Explain internal organisation of plant tissues and interpret secondary growth patterns.
2. Analyse reproductive development and apply embryological knowledge to breeding and biotechnology.
3. Identify and classify angiosperms using morphological and molecular tools.
4. Use herbarium and taxonomy methods in biodiversity conservation and ecological studies.
5. Integrate anatomy, embryology and taxonomy to solve taxonomic problems and apply in research.

Course Content:

Unit I: Advanced Plant Anatomy (14 Lectures)

Plant Tissue: Introduction; Types of tissues (Meristematic tissues and Permanent) and their functions.
Meristems: Types, organisation, shoot and root apex theory, origin and maintenance of stem cell niches.
Secondary growth: Cambium- origin, Structure and function, seasonal activity, anomalous secondary growth in dicot and monocot (e.g., *Boerhaavia*, *Dracaena*).
Wood Anatomy: Heartwood vs sapwood, types of wood (porous/non-porous), dendrochronology.
Secretory Tissues: Laticifers, resin ducts, oil glands.
Leaf and Stem Anatomy: Kranz anatomy, ecological adaptations (Xerophytes and Hydrophytes).
Application of anatomy in systematics, pharmacognosy, and forensic botany.

Unit II: Reproductive Biology and Embryology (14 Lectures)

Microsporogenesis, Microgametogenesis, Megasporogenesis and Mega gametogenesis: Types of embryo sacs.
Pollination Biology: Adaptations, compatibility mechanisms, self-incompatibility, pollen-pistil interaction.
Fertilisation: Double fertilisation, post-fertilisation changes.
Endosperm & Embryo Development: Types of endosperm (nuclear, cellular, helobial), development of dicot and monocot embryos.
Apomixis and Polyembryony: Types, mechanisms, significance in plant breeding.
Recent techniques: Embryo rescue, in vitro fertilisation, applications in biotechnology.

Unit III: Plant Taxonomy – Principles and Concepts (16 Lectures)

Taxonomic Hierarchy: Species concepts (biological, morphological, phylogenetic), infra-specific categories.
Systems of Classification: Bentham & Hooker (natural), Engler & Prantl (phylogenetic), APG-IV system (molecular).
Identification Tools: Botanical keys (dichotomous), field and herbarium methods, floras, monographs.
Nomenclature: ICN rules, priority, typification or types method, valid publication, changes in codes.
Modern Taxonomy: Role of anatomy, embryology, palynology, phytochemistry and molecular techniques (DNA barcoding, RAPD, ITS).

Unit IV: Angiosperm Families and Phylogeny (16 Lectures)

Detailed study of selected families with emphasis on diagnostic features, diversity, and economic importance:
Dicot Families: Fabaceae, Asteraceae, Brassicaceae, Euphorbiaceae, Solanaceae.
Monocot Families: Poaceae, Orchidaceae, Liliaceae, Zingiberaceae.
Phylogenetic trends and cladistics.
Herbarium preparation, digital herbarium and recent trends in plant systematics.

Reference Books:

1. Esau, K. (2006). *Plant Anatomy*, Wiley Eastern Ltd.
2. Fahn, A. (1990). *Plant Anatomy*, Pergamon Press.
3. Cutter, E.G. (1971). *Plant Anatomy: Experiments and Observations*, Edward Arnold.
4. Bhojwani, S.S. & Bhatnagar, S.P. (2018). *The Embryology of Angiosperms*, Vikas Publishing House.
5. Raghavan, V. (2000). *Developmental Biology of Flowering Plants*, Springer.
6. Shivanna, K.R. (2003). *Pollination Biology and Biotechnology*, Oxford & IBH.
7. Singh, G. (2016). *Plant Systematics: Theory and Practice*, Oxford & IBH.
8. Jain, S.K. & Rao, R.R. (1997). *A Handbook of Field and Herbarium Methods*, Today & Tomorrow Printers.
9. Heywood, V.H., Brummitt, R.K., Culham, A., & Seberg, O. (2007). *Flowering Plant Families of the World*, Royal Botanic Gardens, Kew.
10. Simpson, M.G. (2019). *Plant Systematics*, 3rd Ed., Academic Press.
11. Taxonomy of Vascular plants by George H. M. Lawrence
12. Advance Plant Taxonomy by A. K. Mondal
13. Modern Plant Taxonomy by N S Subrahmanyam

II. CORE COURSE [CCBOT202]
APPLIED BOTANY

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objective:

1. **To build an integrated, application-oriented understanding of modern botany** that links ecology, molecular biology, microbiology, taxonomy, cytology, phycology, and plant anatomy/embryology.
2. **To master hands-on and digital research competencies**—from CRISPR genome editing, diagnostics and chemotaxonomic profiling to GIS-based species-distribution modelling and remote-sensing analytics.
3. **To critically evaluate and deploy plant-based biotechnological solutions** for current challenges in food security, climate change mitigation, sustainable agriculture, bioremediation and the circular bio-economy.
4. **To design, execute and interpret multidisciplinary experiments** that combine laboratory, field and in-silico approaches while adhering to good laboratory practice, statistical rigour and biosafety/ethical guidelines.

Course Learning Outcome:

1. **Ability to explain** the conceptual framework of applied ecology in the Anthropocene and **evaluate** plant-based climate-smart solutions for urban and agro-ecosystems.
2. **Application of** remote sensing, GIS and species-distribution modelling to **predict** plant responses to environmental change and to guide ecological restoration projects.
3. **Ability to demonstrate** proficiency in advanced molecular techniques and **interpret** resulting data for plant improvement and diagnostics.
4. **Construction of** DNA-fingerprinting profiles and chemotaxonomic matrices to **differentiate** plant varieties, trace crop evolution and authenticate herbal raw materials.
5. **Analysis of** plant–microbe interactions, innate immunity pathways and endophyte functions, and **design** integrated disease- and pest-management protocols that emphasise biocontrol agents.
6. **Ability to perform** microscopic, histochemical and cytogenetic investigations to **assess** genetic stability, developmental stages and taxonomic relationships.
7. **Designing of** algal cultivation/harvesting workflows and **evaluate** their techno-economic and environmental feasibility for biofertilisers, biofuels, phycoremediation and carbon capture.

Course Content:

Unit 1: Applied Phycology **(10 lectures)**

1. **Algal Biotechnology:** Genetic engineering in microalgae and its applications in algal systems.
2. **Algae in Agriculture and Soil Health:** Algal biofertilizers (*Nostoc*, *Anabaena*, *Azolla-Anabaena* complex); Algal amendments for improving soil fertility and crop productivity.
3. **Algae in Wastewater Treatment and phycoremediation:** Phycoremediation of heavy metals, nitrates, phosphates; Algal biofilms and biosorption; Algae-based integrated waste management systems.
4. **Algae in Climate Change Mitigation:** Carbon sequestration by macro- and microalgae; algae-based carbon credits; Role in restoring degraded aquatic ecosystems.

Unit 2: Applied Microbiology and Pathology **(10 lectures)**

1. **Plant-Microbe Interactions and Molecular Basis of Plant Immunity:** Molecular signaling in symbiotic associations (e.g., nodulation genes); Endophytes and their role in stress tolerance; Effector triggered immunity (ETI); Pathogen triggered immunity (PTI): PAMP-triggered; Hypersensitive response (HR), systemic acquired resistance (SAR); Resistance genes (R genes) and their biotechnological applications.
2. **Soil and Rhizosphere Microbiology:** Microbes diversity in the rhizosphere; Plant growth promoting rhizobacteria; Application in organic farming and soil health restoration.
3. **Industrial Applications of Plant-Associated Microbes:** Microbes in bioproduct synthesis: biofertilizers, biopesticides, phytohormones; Fermentation technology in plant-based products (enzymes, antibiotics); Biotransformation and biodegradation by plant-associated microbes.
4. **Integrated Disease and Pest Management (IDM & IPM):** Concept and components of IDM/ IPM; Use of cultural, biological, mechanical, and chemical strategies; Biocontrol agents: *Trichoderma*, *Pseudomonas*, *Bacillus* spp.; Commercial formulations and their field applications.

Unit 3: Applied Morphology, Anatomy, Embryology and Forensic Botany **(10 lectures)**

1. **Morphology and Palynology:** General morphology; Morphological markers in plant breeding and varietal identification. Different types and methods of gathering data based on morphological markers.
2. **Plant Anatomy and Embryology:** Developmental embryogeny, general anatomy; Histochemical staining and micro technique tools and its applications in plant pathology, plant tissue culture, and systematics. Apomixis and its biotechnological applications; Experimental embryology.
3. **Forensic Botany:** Introduction and application of forensic botany.

Unit 4: Applied Taxonomy (10 lectures)

1. **Phytochemistry:** Phytochemistry of pharmacognostically important plants and identification of the major classes of the pharmaceutically important phytochemicals from *Withania sominifera*, *Tinospora cordifolia*, *Ocimum sanctum*, *Moringa oleifera*, *Curcuma longa* (phenolics, steroids, terpenoids glycosides and alkaloids).
2. **Chemotaxonomy:** History, general chemical and chemotaxonomic characters, types of data, methods of gathering data; Phytochemical databases.
3. **Numerical and Molecular taxonomy:** Introduction to numerical taxonomy and its application; Molecules and genomes in plant systematics, techniques used in molecular taxonomy, molecular systematics in crop evolution; Serology in relation to plant taxonomy- Methods, role of serology in taxonomy.

Unit 5: Applied Plant Physiology (10 lectures)

1. **Pharmaceutically important bioactive compounds of some medicinal plants through plant cell and tissue culture**
2. **Environmental signals in flowering:** Floral meristem identity genes; The ABC model of flower development.
3. **Molecular aspects of Plant Movement, Growth and Development:** Role and molecular aspects of phytohormones and phytochromes in plant movement, growth and development.
4. Hydroponics and Aeroponics Techniques.

Unit 6: Applied Ecology and Environmental Biology (10 lectures)

1. **Fundamentals of Applied Ecology:** Conceptual framework of applied ecology in the Anthropocene; Role of botany in solving real-world ecological problems.
2. **Urban Ecology and Plant-Based Solutions:** Urban ecosystems: Characteristics and challenges; Role of green roofs, vertical gardens, urban forestry; Climate-resilient agriculture and ecological restoration.
3. **Ecological Modeling and Predictive Tools**: Basics of ecological modeling and simulation; Species distribution modeling (SDM) under climate change; Remote sensing and GIS in vegetation ecology.

Reference Book:

1. Slater A, Scott NW, Fowler MR. (2014) Plant Biotechnology: The Genetic Manipulation of Plants. 2nd edition.Oxford University Press, Oxford, U.K.
2. Birchler JA, Han F (eds.). (2018) Genome Engineering for Plant Improvement. Springer, Cham, Switzerland.
3. Odum EP, Barrett GW. (2005) Fundamentals of Ecology. 5th edition. Brooks/Cole, Belmont, CA, U.S.A.
4. Grimm NB, Faeth SH, Golubiewski NE (eds.). (2008) Urban Ecology: An International Perspective. Springer, New York, U.S.A.
5. Pickett STA, Cadenasso ML, McGrath BP (eds.). (2013) Resilience in Ecology and Urban Design. Springer, New York, U.S.A.
6. Agrios GN. (2012) Plant Pathology. 5th edition. Elsevier Academic Press, San Diego, CA, U.S.A.
7. Rangaswami G, Bagyaraj DJ. (2005) Agricultural Microbiology. 2nd edition. Prentice Hall of India, New Delhi, India.
8. Gnanamanickam SS (ed.). (2006) Biological Control of Crop Diseases. CRC Press, Boca Raton, FL, U.S.A.
9. Van Loon LC (ed.). (2007) Plant Innate Immunity. Springer, Berlin, Germany.
10. Kloepper JW, Lifshitz R, Zhang C. (2013) Plant Growth-Promoting Rhizobacteria. Springer, Berlin, Germany.
11. Stace CA. (2010) Plant Taxonomy and Biosystematics. 3rd edition. Cambridge University Press, Cambridge, U.K.
12. Bhojwani SS, Bhatnagar SP. (2015) The Embryology of Angiosperms. 6th edition. Vikas Publishing House, New Delhi, India.
13. Punt W, Hoen PP, Blackmore S, Nilsson S, Le Thomas A. (2007) Glossary of Pollen and Spore Terminology. Elsevier, Amsterdam, Netherlands.
14. Richmond A, Hu Q (eds.). (2013) Handbook of Microalgal Culture: Applied Phycology and Biotechnology. 2nd edition. Wiley-Blackwell, Oxford, U.K.
15. Lee RE. (2018) Phycology. 6th edition. Cambridge University Press, Cambridge, U.K.
16. Vashishta BR, Sinha AK. (2008) Botany for Degree Students: Algae. Revised edition. S. Chand & Company, New Delhi, India.
17. Sharma PD. (2020) Ecology and Environment. 12th edition. Rastogi Publications, Meerut, India.
18. Cooke BM, Jones DG, Kaye B (eds.). (2006) The Epidemiology of Plant Diseases. 2nd edition. Springer, Dordrecht, Netherlands.
19. Taiz, L., Zeiger, E., MØller, I.M. and Murphy, A (2015). Plant Physiology and Development. Sinauer Associates Inc. USA. 6th edition.
20. Campbell, MK (2012) Biochemistry, 7th ed., Published by Cengage Learning.
21. Nelson DL and Cox MM (2008) Lehninger Principles of Biochemistry, 5th Edition., W.H. Freeman and Company

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III. CORE COURSE [CCBOT203]
INTEGRATIVE BOTANY

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objective

1. To familiarise the students with the fundamental principles of Nanobiotechnology, various potential application of Nanobiotechnology.
2. To apply the cutting-edge computational and statistical tools to genomic, transcriptomic and proteomic datasets.
3. To analyse molecular, biochemical and physiological responses of photosynthetic organisms to environmental stresses to design sustainable, innovative solutions for agriculture, bio-products and ecosystem resilience.

Course Learning Outcomes

1. Ability to describe and differentiate major classes of nanomaterials used in agriculture and evaluate their regulatory and biosafety frameworks.
2. **Ability to select, operate and interpret data** from principal characterization platforms for nanoparticle analysis.
3. **Execution of genomic, transcriptomic and proteomic workflows**—including genome annotation, RNA-seq analysis, homology modelling and molecular docking—using current bioinformatics software.
4. **Application of statistical reasoning** (probability distributions, hypothesis tests, t-tests, one- & two-way ANOVA) and use SPSS / Excel to analyse and visualize biological data sets.
5. **Ability to critically compare abiotic stress–response pathways** and relate omics-level changes to physiological adaptation.
6. **Designing of integrated biotechnological strategies**—such as nano-enabled agrichemicals or gene-edited, stress-tolerant crops—by synthesizing knowledge from all three units.

Course Content:

Unit 1: NANO-BIOTECHNOLOGY (15 lectures)

1. Introduction of Nanobiotechnology and its applications. Various types of nanomaterial utilized in agriculture.
2. Synthesis of nanoparticle: Physical, Chemical and Biological.
3. Structural characterization techniques: X-ray diffraction (XRD) technique; Electron Microscopy; Spectroscopic Techniques.
4. Application of plant-based nanoparticles as biofertilizer and drugs.
5. Regulatory and safety measures for nanotechnology-based agriculture products.

Unit 2: ADVANCE BIOINFORMATICS AND BIOSTATISTICS (25 lectures)

1. **Genomics and Genome Annotation:** Structural and functional annotation; Gene prediction tools (GENSCAN); Genome browsers (Emsembl, NCBI).
2. **Transcriptomics and RNA-seq Analysis:** Introduction to transcriptomics, Microarray and RNA-seq workflow and differential gene expression; Use of tools: HISAT2 and DESeq2.
3. **Proteomics and Protein Structure Prediction:** Overview of proteomics; Protein structure databases (PDB, InterPro); Homology modeling.
4. **Probability Distributions and Sampling:** Normal, binomial, and Poisson distributions; Sampling techniques and sampling error
5. **Hypothesis Testing:** Null and alternative hypotheses; Type I and II errors; student t-test.
6. **Analysis of Variance:** One-way and two-way ANOVA; Assumptions and interpretations.
7. **Statistical Software:** Introduction to Excel and SPSS for biostatistics.

Unit 3: STRESS BIOLOGY (20 lectures)

1. Distribution of extremophiles, cyanobacteria and plant across environmental gradients.
2. Biotic and abiotic stress tolerance: Bacterial, fungal, nematode, drought, salinity, light and temperature and its impact on physiological, biochemical and molecular level with reference to stress responsive gene/proteins in Rice, Wheat, *Arabidopsis*, Tomato and Soybean.
3. Concept of gene mining from plant model system for the development of stress tolerant crops.
4. Gene chemistry using photosynthetic organisms for production of biofuels and bioactive compounds.
5. Application of stress biology and its significance.

Reference Books:

1. Bhushan B (ed.). (2017) *Springer Handbook of Nanomaterials.* 2nd edition. Springer, Berlin, Germany.
2. Rai M, Ribeiro C (eds.). (2015) *Nanotechnology and Plant Sciences: Nanoparticles and Their Impact on Plants.* 1st edition. Springer, Cham, Switzerland.
3. Prasad R, Kumar V, Kumar M (eds.). (2014) *Nanotechnology in Sustainable Agriculture.* 1st edition. Springer, Cham, Switzerland.
4. Cullity BD, Stock SR. (2014) *Elements of X-ray Diffraction.* 3rd edition. Pearson, Boston, U.S.A.

5. Goldstein JI, Newbury DE, Michael JR, et al. (2018) *Scanning Electron Microscopy and X-ray Microanalysis*. 4th edition. Springer, New York, U.S.A.
6. Egerton RF. (2016) *Physical Principles of Electron Microscopy.* 2nd edition. Springer, Cham, Switzerland.
7. Skoog DA, Holler FJ, Crouch SR. (2018) *Principles of Instrumental Analysis.* 7th edition. Cengage Learning, Boston, U.S.A.
8. Mount DW. (2020) *Bioinformatics: Sequence and Genome Analysis.* 3rd edition. Cold Spring Harbor Laboratory Press, New York, U.S.A.
9. Rosner B. (2015) *Fundamentals of Biostatistics.* 8th edition. Cengage Learning, Boston, U.S.A.
10. Field A. (2018) *Discovering Statistics Using IBM SPSS Statistics.* 5th edition. Sage Publications, London, U.K.
11. Gill SS, Tuteja N (eds.). (2010) *Reactive Oxygen Species and Antioxidant Machinery in Abiotic Stress Tolerance in Crop Plants.* 1st edition. Springer, Berlin, Germany.
12. Hasegawa PM (ed.). (2013) *Plant Abiotic Stress.* 2nd edition. Wiley-Blackwell, Oxford, U.K.
13. Ahmad P, Rasool S (eds.). (2014) *Emerging Technologies and Management of Crop Stress Tolerance.* 1st edition. Academic Press, London, U.K.
14. Shanker AK, Shanker C (eds.). (2016) *Abiotic Stress in Plants: Mechanisms and Adaptations.* 1st edition. InTechOpen, London, U.K.
15. Castenholz RW (ed.). (2012) *Ecology of Cyanobacteria II: Their Diversity in Space and Time.* 2nd edition. Springer, Dordrecht, Netherlands.
16. Hall RD (ed.). (2015) *Plant Metabolomics.* 2nd edition. Springer, Dordrecht, Netherlands.
17. Henry RJ (ed.). (2013) *Plant Genomics.* 2nd edition. Wiley-Blackwell, Oxford, U.K
18. Barrangou R, van der Oost J (eds.). (2015) *CRISPR-Cas Systems: RNA-Mediated Adaptive Immunity in Bacteria and Archaea.* 1st edition. Springer, Berlin, Germany.

IV. CORE COURSE [CCBOT204]
CYTOGENETICS AND CELL BIOLOGY

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objective:
1. To provide an in-depth understanding of chromosome biology, cell structure-function relationships, and genome organisation.
2. To explore the molecular basis of heredity and genome dynamics.
3. To integrate applied concepts of cytogenetics in plant breeding, diagnostics, and biotechnology.
4. To expose students to recent advances in genome editing, chromosome engineering, and cancer biology.

Course Learning Outcomes:
After completing this course, students will be able to:
1. Analyse chromosomal behaviour and genetic inheritance mechanisms at the molecular level.
2. Apply cytogenetic tools in crop improvement and cytodiagnostics.
3. Understand genome organisation, chromosome variation, and epigenetics.
4. Use recent technologies like CRISPR, karyotyping, FISH, and polyploidy induction.

Course Contents:
1. Structure and functions of cell organelles: nucleus, mitochondria, chloroplast, ER, Golgi, lysosomes.
2. Cytoskeleton: microtubules and microfilaments in mitosis and intracellular transport
3. Membrane structure and models (fluid mosaic, lipid rafts)
4. Cell signaling: types of signaling, receptors, secondary messengers, MAPK cascade
5. Chromatin Organisation, Chromosome structure and packaging of DNA, Histones, Heterochromatin.
6. Cell division and cell cycle: Mitosis, Meiosis, their regulation, Overview of cell cycle, control mechanism: role of cyclins and cyclin dependent kinases.
7. Protein sorting: Targeting of proteins to organelles.
8. Mutations: Types, Detection, Molecular basis of mutation, Physical and Chemical Mutagenesis.
9. DNA damage and repair mechanism.
10. Structure and numerical alterations in chromosomes: Origin, Occurrence and production of haploid. Introduction and characterization of monosomics, trisomics, Origin and production of autopolyploids, allopolyploids.
11. Cytogenetic basis of cancer and apoptosis; oncogenes and tumor suppressor genes
12. Applications in biotechnology: chromosome engineering, gene tagging, marker-assisted breeding

Reference Books:
1. Verma, P.S. & Agarwal, V.K. – *Cell Biology, Genetics, Molecular Biology* (S. Chand)
2. Gupta, P.K. – *Cytogenetics* (Rastogi Publications)
3. Snustad, D.P. & Simmons, M.J. – *Principles of Genetics* (Wiley)
4. Alberts, B. et al. – *Molecular Biology of the Cell*, 7th Ed. (Garland Science, 2022)
5. De Robertis, E.D.P. & De Robertis, E.M.F. – *Cell and Molecular Biology*, 8th Ed.
6. Lodish, H. et al. – *Molecular Cell Biology*, 9th Ed. (W.H. Freeman, 2021)
7. Hartl, D.L. & Jones, E.W. – *Genetics: Analysis of Genes and Genomes* (Jones & Bartlett)
8. Primrose, S.B. & Twyman, R.M. – *Principles of Gene Manipulation and Genomics*.

V. CORE COURSE [CPBOT205]
PRACTICAL-II

Marks: 100 (ESE Pr: 6 Hrs) = 100	Pass Marks = 45

(Credits: Practical-04, 120 Hours)

Course Objectives:
1. To provide practical exposure to the structural, developmental, and taxonomic aspects of plants.
2. To enhance applied botanical skills relevant to agriculture, horticulture, and industry.
3. To foster interdisciplinary thinking and integration of plant sciences with traditional knowledge.
4. To appreciate and apply the principles of the Indian Knowledge System (IKS) in plant biology and ecology.

Course Learning Outcomes:
By the end of this course, students will be able to:
1. Perform microscopic analysis of plant tissues and developmental structures.
2. Identify and classify plant specimens using botanical keys and nomenclature.
3. Apply knowledge in areas like herbal medicine, plant-based industries, and sustainable practices.
4. Interpret the relevance of traditional plant knowledge in contemporary scientific context.
5. Integrate classical and modern perspectives of plant science in practical applications.

Course Content:

I: Plant Anatomy, Embryology, and Taxonomy

Study of permanent slides and preparation of temporary mounts:
T.S. of dicot and monocot stem/root/leaf
Anomalous secondary growth (e.g., *Boerhaavia*, *Achyranthes*)
Microscopic study of embryo sac, pollen grains, and fertilisation stages
Collection, identification, and herbarium preparation of angiosperms (10 local species)

II: Applied Botany

Seed germination and viability testing
Preparation of biofertilizers using Rhizobium/Azospirillum cultures
Extraction of essential oils (e.g., from *Ocimum*, *Cymbopogon*)
Analysis of medicinal plant parts (e.g., *Withania*, *Rauvolfia*, *Tinospora*)
Preparation of herbal formulations (churna/asava/oil) based on traditional recipes
Visit/report on a botanical garden, herbal garden, or local industry

III: Integrative Botany

Comparative anatomical and morphological study across plant groups (algae to angiosperms)
Observation of developmental stages in seed plants
Interdisciplinary experiment: Photosynthesis rate measurement and relation to anatomy,
Comparative seed morphology with ecological adaptation
Integration of field knowledge, taxonomy, and physiology in plant ID and usage

IV: Indian Knowledge System (IKS)

Study of traditional plant classification systems (e.g., *Vrikshayurveda*, *Charaka Samhita*).
Documentation of 5 ethnobotanical plants and associated traditional uses.
Preparation of a local traditional herbarium with vernacular names.
Comparative study: Traditional vs modern pharmacognosy.
Field documentation of folk practices or indigenous agricultural techniques.
Group project: Poster/chart on "Contributions of Indian Botanists/IKS to Plant Sciences".

Reference Books:

1. Esau, K. – *Plant Anatomy* (Wiley Eastern)
2. Bhojwani, S.S. & Bhatnagar, S.P. – *The Embryology of Angiosperms* (Vikas Publishing)
3. Sharma, O.P. – *Plant Taxonomy* (Tata McGraw-Hill)
4. Kochhar, S.L. – *Economic Botany in the Tropics* (Macmillan)
5. Purohit, S.S. & Vyas, S.P. – *Medicinal Plant Cultivation* (Agrobios)
6. Jain, S.K. – *Manual of Ethnobotany* (Scientific Publishers)
7. Pandey, B.P. – *Botany for Degree Students – Plant Anatomy, Embryology & Economic Botany*
8. Vashishta, P.C. – *Botany series (Plant Groups & Physiology)* (S. Chand)
9. Dash, B. & Sharma, R.K. – *Charaka Samhita* (Chaukhamba Sanskrit Series)
10. Sen, S. & Chakraborty, R. – *Revival, Modernization and Integration of Indian Traditional Herbal Medicine* (Elsevier)
11. NITI Aayog – *Indian Knowledge Systems: Perspectives and Applications*

SEMESTER III

I. CORE COURSE [CCBOT301]

INDIAN KNOWLEDGE SYSTEM (IKS) IN BOTANY

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objective:
1. To explore classical and indigenous knowledge of plants in Indian traditions.
2. To apply IKS concepts in agriculture, herbal medicine, environmental conservation, and sustainable living.
3. To bridge classical knowledge with contemporary scientific research and technologies.
4. To equip students with critical tools for integrating IKS into policy, innovation, and entrepreneurship.

Course Learning Outcomes:
After completing this course, students will be able to:
1. Identify and interpret key IKS-based botanical knowledge.
2. Translate IKS concepts into real-world solutions in agriculture, health, and conservation.
3. Critically assess traditional vs modern plant science applications.
4. Build interdisciplinary and culturally-sensitive research models.

Course Outlines:

Unit I: Traditional Botanical Systems in Ancient India

Historical roots of Botany in Indian scriptures and treatises. Study of *Vrikshayurveda*, *Charaka Samhita*, *Sushruta Samhita*, *Nighantus*, and *Samhitas*. Indian plant classification: morphological, medicinal, and ecological bases.
Sanskrit terminologies of botanical relevance.

Unit II: Ethnobotany and Indigenous Plant Knowledge

Regional and tribal plant knowledge systems across India. Ethnopharmacology and ethnomedicine. Cultural and spiritual associations with plants. IPR, TKDL (Traditional Knowledge Digital Library), and legal protections.

Unit III: Medicinal Plants and Ayurvedic Applications

Medicinal plant classification in Ayurveda (Rasa, Guna, Virya, Vipaka).
Ayurvedic pharmacognosy and pharmacodynamics. Role of plants in Panchakarma, Rasayana, and daily health.
Comparison of Ayurvedic formulations with modern phytomedicine.

Unit IV: Traditional Agriculture and Sustainable Practices

Indigenous farming techniques: Rishi Krishi, Homa farming, Vedic agriculture. Organic inputs: Panchagavya, Jeevamrutha, biofertilizers. Climate-resilient crops and seed conservation. Water harvesting and soil health in ancient systems.

Unit V: Sacred Groves, Conservation Ethics, and Modern Integration

Sacred groves as community-based biodiversity reserves. Ritual and temple gardens: ecosystem ethics.
Biocultural conservation models. Integration of IKS with AI, GIS, and environmental policy frameworks.

Unit V: Economic Botany related to IKS

Fibre yielding plants: Timber yielding plants; Oil Yielding plants and Drug yielding plants.
Role of IKS in textile industry.

Reference Books:

1. Vrikshayurveda by Surapala – Translated by Nalini Sadhale (Agri-History Foundation)
2. Indian Medicinal Plants – K.M. Nadkarni
3. Dravyaguna Vigyana – P.V. Sharma (Vol. 1 & 2)
4. The Cultural History of Plants – Ghani, A.
5. Ethnobotany: Principles and Applications – C.M. Cotton
6. The Sacred Groves of India – M.D. Subash Chandran
7. Biology in the Vedas – B.G. Matapurkar
8. Vedic Botany – N. Sivarajan
9. Textbook of Pharmacognosy – Trease & Evans

II. SKILL ENHANCEMENT COURSE - A [ECBOT302A]
BIOFERTILIZERS

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:
1. To impart fundamental and advanced knowledge of biofertilizers and their role in sustainable agriculture.
2. To understand the biology, production, and application of different microbial inoculants.
3. To evaluate the significance of microbial interactions in soil fertility and plant growth promotion.
4. To develop practical understanding of biofertilizer formulation, quality control, and field application.
5. To equip students with skills for research and entrepreneurship in the biofertilizer industry.

Course Learning Outcomes:
Upon successful completion of this course, students will be able to:
1. Explain the role of various beneficial microbes in nutrient cycling and plant productivity.
2. Identify and characterize key microbial groups used as biofertilizers.
3. Demonstrate knowledge of biofertilizer formulation, quality control, and field-level application.
4. Evaluate the benefits and limitations of biofertilizers in sustainable farming systems.
5. Apply the acquired knowledge in research, extension, and agri-based entrepreneurship.

Course Contents:

Unit I: Introduction to Biofertilizers and Soil Microbial Ecology (12 Lectures)

Definition, scope, and history of biofertilizers.
Types and classification: nitrogen fixers, phosphate solubilizers, potassium solubilizers, and plant growth-promoting rhizobacteria (PGPR). Soil microbial ecology: Rhizosphere, phyllosphere, symbiotic endophytic associations; Rhizospheric engineering. Role of biofertilizers in soil health and organic farming. Comparative advantages over chemical fertilizers.

Unit II: Nitrogen Fixing Microorganisms (14 Lectures)

Symbiotic Nitrogen Fixers: *Rhizobium*: Mechanism of nodule formation, nitrogenase enzyme, leghaemoglobin. *Frankia*-actinorhizal symbiosis.
Non-Symbiotic Nitrogen Fixers: *Azotobacter*, *Azospirillum*, *Clostridium*.
Cyanobacteria: Role of *Anabaena*, *Nostoc* in paddy fields; heterocyst differentiation and function.
Molecular basis of nitrogen fixation (nif genes, regulation).
Biofertilizer production and application techniques for nitrogen-fixing microbes.

Unit III: Phosphate, Potassium Solubilizing Microorganisms and Mycorrhizae (12 Lectures)

Phosphate Solubilizers: *Bacillus*, *Pseudomonas*, *Aspergillus*, mechanism of organic acid production.
Potassium Solubilizers: Role of silicate-solubilizing bacteria and fungi in agriculture.
Mycorrhizae:Types: Ectomycorrhiza, endomycorrhiza (arbuscular mycorrhiza - AMF).
Role in nutrient uptake, drought resistance, and plant protection.
Mass multiplication and field application techniques.

Unit IV: Biofertilizer Technology and Quality Control (10 Lectures)

Isolation, identification, and characterization of microbial inoculants.
Carrier materials and formulation techniques. Liquid vs carrier-based biofertilizers. Quality standards (BIS norms), shelf life, contamination testing. Role of biotechnology in strain improvement and biofertilizer development.
Pilot plant setup and commercialization strategies.

Unit V: Applications and Policy Perspectives (12 Lectures)

Field application techniques: seed treatment, soil application, foliar spray.
Integrated Nutrient Management (INM) and biofertilizer combinations.
Role of biofertilizers in climate-resilient and organic agriculture.
National policies, subsidy schemes, and biofertilizer promotion programs in India.
Challenges and future prospects in biofertilizer research and entrepreneurship.
Case studies: Biofertilizer success stories in Indian agriculture (Jharkhand focus).

Reference Books:

1. Subba Rao, N.S. (2000). *Soil Microorganisms and Plant Growth*. Oxford & IBH Publishing.
2. Dubey, R.C. & Maheshwari, D.K. (2013). *A Textbook of Microbiology*. S. Chand & Co.
3. Kannaiyan, S. (2002). *Biofertilizers for Sustainable Agriculture and Forestry*. Scientific Publishers.
4. Vessey, J.K. (2003). *Plant Growth Promoting Rhizobacteria as Biofertilizers*. Plant and Soil Journal.
5. Smith, S.E. & Read, D.J. (2008). *Mycorrhizal Symbiosis*. Academic Press.
6. Directorate of Extension, Ministry of Agriculture, Govt. of India. *Manual on Biofertilizer Production and Use*.
7. Bagyaraj, D.J. & Ashwin R. (2017). *Microbial Biotechnology for Sustainable Agriculture*. I.K. International Publishing.
8. BIS Standards IS 13641:1993 and IS 14846:2000 for Rhizobium, Azotobacter, PSB, etc..

OR SKILL ENHANCEMENT COURSE - B [ECBOT302B]

MUSHROOM CULTIVATION

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	**Pass Marks: (MSE: 17 + ESE: 28) = 45**

(Credits: Theory-04, 60 Hours)

Course Objectives:

1. To provide theoretical and practical knowledge of edible and medicinal mushroom cultivation.
2. To understand fungal biology, taxonomy, and physiology of economically important mushrooms.
3. To develop skills in spawn production, substrate preparation, and post-harvest management.
4. To explore the nutritional, medicinal, and biotechnological applications of mushrooms.
5. To promote entrepreneurship and rural employment through mushroom technology.

Course Learning Outcomes:

After successful completion of this course, students will be able to:

1. Identify and differentiate important edible and medicinal mushroom species.
2. Understand the biology, physiology, and ecological roles of fungi.
3. Demonstrate techniques for spawn preparation, substrate handling, and mushroom cropping.
4. Apply post-harvest and value addition techniques for product development.
5. Design small-scale mushroom cultivation units and apply knowledge for entrepreneurship.

Course Contents:

Unit I: Introduction to Mushroom Science and Fungal Biology (10 Lectures)

History, scope and significance of mushroom cultivation in India and Jharkhand.
General characteristics and classification of fungi.
Morphology and anatomy of mushrooms (basidiocarps and ascomycetes).
Life cycle and reproductive structures of edible mushrooms (*Agaricus*, *Pleurotus*, *Volvariella*).
Ecological role of fungi and their importance in biodegradation and nutrient cycling.

Unit II: Cultivable Mushrooms and Their Biology (14 Lectures)

Edible Mushrooms: *Agaricus bisporus* (Button mushroom), *Pleurotus spp.* (Oyster mushroom), *Volvariella volvacea* (Paddy straw mushroom), *Calocybe indica* (Milky mushroom)
Medicinal Mushrooms: *Ganoderma lucidum* (Reishi), *Lentinula edodes* (Shiitake), *Cordyceps militaris*
Nutritional and medicinal value: proteins, polysaccharides, antioxidants, immunomodulators.

Unit III: Mushroom Cultivation Techniques (14 Lectures)

Infrastructure: spawn lab, cropping room, compost yard, sterilization setup.
Substrate preparation: composting, pasteurization, sterilization methods.
Spawn types: grain spawn, sawdust spawn, liquid spawn.
Cultivation process of major species: substrate selection, spawning, cropping conditions (temperature, humidity, light).
Harvesting, yield optimization and crop cycles. Organic and indoor mushroom production techniques.

Unit IV: Post-Harvest Technology and Value Addition (10 Lectures)

Drying, preservation, packaging and storage of fresh mushrooms.
Processing: pickles, soup powders, nuggets, snacks. Quality control, shelf life, and safety standards.
Food safety and HACCP in mushroom processing units. Value chain management and market trends.

Unit V: Mushroom Industry, Research and Entrepreneurship (12 Lectures)

Economics of mushroom production: cost-benefit analysis. Training, extension and entrepreneurship opportunities.
Government schemes and subsidies (NABARD, RKVY, SFAC).
Common pests and diseases (green mold, mites, flies), their control and organic solutions.
Recent advances: mushroom biotechnology, genetic improvement, mycoremediation.
Case studies: successful mushroom farmers and startups in Jharkhand and India.

Reference Books:

1. Chang, S.T. & Miles, P.G. (2004). *Mushrooms: Cultivation, Nutritional Value, Medicinal Effect, and Environmental Impact*. CRC Press.
2. Kumar, S. & Sharma, S.R. (2018). *Mushroom Cultivation in India*. DIPA, ICAR, New Delhi.
3. Singh, M., Vijay, B., Kamal, S. & Wakchaure, G.C. (2011). *Mushroom Cultivation Technology*. National Research Centre for Mushrooms (ICAR), Solan.
4. Sharma, V.P. (2021). *Textbook of Mushroom Production Technology*. Daya Publishing House.
5. Nita Bahl (2000). *Handbook of Mushrooms*. Oxford & IBH.
6. Verma, R.N. (2016). *Technical Manual on Mushroom Cultivation*. ICAR-NRCP, Solan.
7. Zied, D.C. & Pardo-Giménez, A. (2017). *Edible and Medicinal Mushrooms: Technology and Applications*. Wiley.
8. Directorate of Mushroom Research (DMR), Solan – Technical Bulletins.

III. CORE COURSE [CCBOT303]
PLANT PHYSIOLOGY AND BIOCHEMISTRY

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:
1. To understand the fundamental physiological and biochemical processes in plants.
2. To explore metabolic pathways, enzymology, and molecular interactions in plant metabolism.
3. To examine plant responses to abiotic and biotic stresses and mechanisms of stress tolerance.
4. To relate physiological and biochemical processes to applications in agriculture, biotechnology, and climate resilience.

Course Learning Outcomes:
After completing this course, students will be able to:
1. Comprehend and interpret the physiological and biochemical mechanisms regulating plant growth and metabolism.
2. Analyse the role of macromolecules, enzymes, and secondary metabolites in plant development and stress responses.
3. Explore the physiological adaptations of plants to abiotic and biotic stresses.
4. Apply knowledge of plant physiology in crop improvement and stress management strategies.

Course Contents:
GROUP-A: Plant Physiology **(25 Lectures)**
1. **Transpiration**: Types of Transpiration, Evaporation and Transpiration, Mechanism of Transpiration and Stomatal, Physiology, Factors Affecting the Rate of Transpiration, Significance of Transpiration, Antitranspirant, Measurement of Transpiration.
2. **Translocation in Plant**: Phloem Transport; Phloem Sap Composition, Movement in Plant, Direction of Movement, Bidirectional Movement, Lateral Movement, Source – Sink relationship, Phloem loading, Phloem Unloading, Mechanism of Phloem Transport – Electro-osmosis, Protoplasmic, Streaming, Contractile Protein Variants, Mass Flow Hypothesis, Factors Affecting Translocation.
3. **Phytohormone**: History, Structure, Biosynthesis Physiological Response and Mechanism of Action of Auxins.
4. **Physiology of Flowering**: Photoperiodism and Vernalization.
5. **Seed Dormancy and Germination**: Definition, Types, Mechanism and Methods of Breaking the Dormancy.

GROUP-B: Plant Biochemistry **(25 Lectures)**
6. **Photosynthesis**: The Pigment System, Light Reaction, Dark (C_3 Cycle), Hatch and Slack Pathway (C_4 Cycle), Photorespiration and Factors Affecting Rate of Photosynthesis and molecular mechanism.
7. **Respiration**: Glycolysis, Fermentation, Krebs Cycle, Electron Transport System, Hexose Monophosphate Shunt, Theories of Phosphorylation – The Chemical Coupling Theory, Conformational Coupling Theory, Chemiosmotic Theory, Factors Affecting the Rate of Respiration.
8. **Enzymes**: Nomenclature and Classification, Nature, Properties, Enzyme Energetic, Mode and Mechanism of Action, Factors Affecting Enzyme Activities.
9. **Nitrogen Metabolism**: Nitrogen Fixation; Non-biological Fixation; Biological Fixation – Symbiotic Nitrogen Fixers, Non-symbiotic Nitrogen Fixers, Biochemistry of Nitrogen Fixation.
10. **Lipid Metabolism**: Simple Lipids, Complex Lipid, Neutral Fats, Β-Oxidation of Fatty Acid and Biosynthesis of Fatty Acids.
11. **Secondary Metabolites:** Types, Biosynthesis pathway and role in defence mechanism.

GROUP-C
Stress Physiology and Adaptation **(10 Lectures)**
12. Abiotic stresses: drought, salinity, high and low temperature, heavy metals
13. Biotic stress: pathogens and herbivory – systemic acquired resistance (SAR) and induced systemic resistance (ISR)
14. Oxidative stress and antioxidant defence mechanisms (ROS, SOD, catalase, peroxidase)
15. Role of phytohormones (ABA, SA, JA, ethylene) in stress signaling
16. Molecular and genetic approaches to improve stress tolerance
17. Use of omics (transcriptomics, proteomics, metabolomics) in stress physiology

Reference Books:

1. Taiz, L., Zeiger, E., Møller, I.M., & Murphy, A. – Plant Physiology and Development (Sinauer/ Oxford University Press)
2. Buchanan, B.B., Gruissem, W., & Jones, R.L. – Biochemistry & Molecular Biology of Plants (Wiley)
3. Hopkins, W.G. & Hüner, N.P.A. – Introduction to Plant Physiology (Wiley)
4. Jain, V.K. – Fundamentals of Plant Physiology (S. Chand)
5. Levitt, J. – Responses of Plants to Environmental Stresses
6. Ahmad, P. & Prasad, M.N.V. – Abiotic Stress Responses in Plants (Springer)
7. Parida, A. & Das, A.B. – Salt Tolerance and Salinity Effects in Plants
8. Hirt, H. & Shinozaki, K. – Plant Responses to Abiotic Stress (Springer)

IV. CORE COURSE [CCBOT304]

FUNDAMENTAL AND APPLIED ECOLOGY

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objective:

1. To understand core principles of ecological organisation and processes across biotic and abiotic systems.
2. To integrate ecological knowledge with advanced tools and applied strategies in restoration, conservation, climate resilience, and industry.
3. To enable the application of ecological models, indicators, and technologies in natural resource management, urban ecology, agriculture, and biotechnology.

Course Learning Outcomes:

After completing this course, students will be able to:

1. Analyse ecological interactions, ecosystem functions, and biogeochemical cycles.
2. Apply modern tools like GIS, remote sensing, and ecological modeling.
3. Understand ecological responses to climate change, invasive species, pollution, and habitat loss.
4. Design solutions for conservation, ecosystem restoration, and ecological entrepreneurship.

Course Contents:

1. Ecological factors; Climatic, Topographic, Edaphic and Biotic.
2. Population and Community ecology: population characteristics, Population dynamics, Community characteristics, composition, structure, origin and development of a community, methods of study of community.
3. Ecological succession: Types and mechanisms of ecological successions (Hydrosere and Xerosere); Changes in ecological properties during succession.
4. Ecosystem organisation: Types, Structure and Function, Flow of energy; Bio-geochemical cycles of C, N, P, S; mineral cycles (Pathway, Processes); Primary production, Decomposition and Feed chain, Food web of different types of ecosystems; Terrestrial (Forest and Grassland) and Aquatic (Freshwater); and Ecological pyramids.
5. Ecological adaptations: Hydrophytes, Xerophytes and Halophytes.
6. Phytogeography: Major plant communities of the world; Phytogeographic regions of the world; Floristic regions of India, vegetation of India.
7. Air, Water, Soil, Sound and Radiation Pollutions: Kinds, Sources, Quality parameters, Effects on plants & Ecosystem and control measures.
8. Climate Change (Global Environmental Problems): Global warming, Green house Gases (CO_2, CH_4, O_3, CFC_5, N_2O), Sources, Trends & Role); Environmental effects of Global warming, Ozone depletion, Damage to the Ozone layer & Hole, Health effects of Ozone depletion and increased UV Radiation, Saving the Ozone layer.
9. Non-conventional source of energy: Solar, Wind, Nuclear, Biogas and Petroplants.
10. Strategies of Plant conservation: *In situ* conservation – Sanctuaries, National parks and sacred groves and *Ex situ* conservation – Botanical gardens, Gene bank, Seed banks and tissue culture techniques.
11. Natural resources and their Managements: Land resource, water resource, Air resource, agriculture and forestry resources and their management.
12. Indian Biological Diversity Act. Convention of Biological Diversity (CBD), People's Biodiversity Register, Green Book, Red Book, Blue Book.
13. Bioremediation: Definition need and scope of bioremediation Phytoremediation, Microremediation.
14. **Industrial, Environmental and Climate Applications: Industrial ecology**: Circular economy, green technologies, ecological engineering; **Climate change ecology**: Impacts on biodiversity, ecosystems, and phenology; **Carbon sequestration**, REDD+, CDM, net-zero ecology; **Pollution ecology**: Bioindicators and biomonitoring (algae, lichens, macroinvertebrates); **Policy and governance**: Biodiversity Act 2002, Ramsar Convention, CBD, Environmental Impact Assessment (EIA)

Suggested Reference Books:

1. Odum, E.P. – *Fundamentals of Ecology*
2. Smith, R.L. & Smith, T.M. – *Elements of Ecology*
3. Begon, M., Townsend, C.R., & Harper, J.L. – *Ecology: From Individuals to Ecosystems*
4. Singh, J.S., Singh, S.P. & Gupta, S.R. – *Ecology, Environment and Resource Conservation*
5. Dasmann, R. – *Environmental Conservation*
6. Sodhi, N.S., & Ehrlich, P.R. – *Conservation Biology for All*
7. Krebs, C.J. – *Ecological Methodology*
8. Withgott, J. & Laposata, M. – *Environment: The Science Behind the Stories*

V. CORE COURSE [CPBOT305]
PRACTICAL-III

Marks: 100 (ESE Pr: 6 Hrs) = 100	Pass Marks = 45

(Credits: Practical-04, 120 Hours)

Course Objectives:
1. To impart hands-on experience in physiological and biochemical processes in plants.
2. To understand chromosome behaviour, and genetic principles through experimentation.
3. To analyse ecological interactions, environmental parameters, and their influence on plant communities.
4. To develop critical laboratory skills in plant experimentation, data recording, and environmental assessments.

Course Learning Outcomes:
Upon successful completion of the course, students will be able to:
1. Measure and interpret physiological responses of plants under various conditions.
2. Understand mitosis and chromosomal behaviours.
3. Perform ecological sampling and evaluate biodiversity and productivity.
4. Use analytical techniques in plant biochemistry and cytogenetics.
5. Conduct experiments and interpret scientific results in the context of plant-environment interactions.

Course Content:
I: Plant Physiology and Biochemistry
Estimation of chlorophyll and carotenoid content in leaves.
Experiment on osmosis and plasmolysis.
Estimation of total soluble sugars in a plant.
Estimation of total proteins in a plant.
Study of enzyme activity: amylase/catalase under different pH and temperature.
Separation of amino acids or plant pigments by paper chromatography.

II: Cytogenetics
Study of mitosis from root tips (e.g., *Allium cepa*).
Study of polyploidy using colchicine-treated root tips.

III: Fundamental and Applied Ecology
Quadrat method for studying vegetation; Measurement of frequency, density, and abundance of plant species.
Analysis of soil pH, moisture content
Estimation of dissolved oxygen and pH in water samples
Biodiversity index calculation (Shannon-Weiner index)
Visit to a forest, grassland, or wetland and preparation of field report
Study of ecological adaptations in hydrophytes and xerophytes.

Reference Books:

1. Taiz, L., Zeiger, E., Møller, I. M., & Murphy, A. – *Plant Physiology and Development* (Oxford University Press)
2. Sadasivam, S. & Manickam, A. – *Biochemical Methods* (New Age International)
3. Plummer, D.T. – *An Introduction to Practical Biochemistry* (Tata McGraw-Hill)
4. Sharma, A.K. & Sharma, A. – *Chromosome Techniques: Theory and Practice* (Butterworth-Heinemann)
5. Singh, R.J. – *Plant Cytogenetics* (CRC Press)
6. Glick, B.R. & Pasternak, J.J. – *Molecular Biotechnology* (ASM Press)
7. Odum, E.P. & Barrett, G.W. – *Fundamentals of Ecology* (Cengage Learning)
8. Kormondy, E.J. – *Concepts of Ecology* (Pearson)
9. Trivedi, R.K. & Goel, P.K. – *Chemical and Biological Methods for Water Pollution Studies* (Environmental Publications)
10. Mishra, R. – *Ecology Workbook* (Oxford & IBH)

SEMESTER IV

I. ELECTIVE COURSE-A [ECBOT401A]
ALGAL BIOTECHNOLOGY-I

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:
1. To provide a detailed understanding of algal taxonomy, systematics, and principles of classification, especially Fritsch and Chapman systems.
2. To explore the structural and reproductive biology of major algal groups including Cyanophyceae, Chlorophyceae, Phaeophyceae, and Rhodophyceae.
3. To study the role of algae in ecosystem dynamics, including their contributions to pollution, diseases, and environmental monitoring.
4. To highlight the economic importance of algae in food, feed, biofertilizer, aquaculture, agriculture, and industry.
5. To introduce students to advanced culturing techniques and the use of algae as experimental systems in biotechnology.
6. To understand the molecular and biotechnological applications of cyanobacteria in producing fine chemicals and bioactive molecules.

Course Learning Outcomes:
After successful completion of the course, students will be able to:
1. Explain and compare classical classification systems of algae by Fritsch and Chapman.
2. Describe the cellular structure, reproduction, and life cycles of Cyanophyceae and Chlorophyceae.
3. Analyse alternation of generations in Phaeophyceae and Rhodophyceae with appropriate life cycle diagrams.
4. Understand heterocyst and akinete development in Cyanobacteria and their ecological roles.
5. Recognise algal species involved in plant and animal diseases and their pathological impact.
6. Evaluate the role of algae in water pollution, perform physico-chemical water analysis, and use algae as pollution indicators.
7. Discuss the utility of cyanobacteria in producing bioactive compounds, pigments, polysaccharides, and lipids.
8. Assess the economic potential of algae in various industries including agriculture, aquaculture, and biofertilizer production.
9. Understand molecular tools and gene manipulation techniques related to blue-green algae (cyanobacteria).

Course Contents:
1. Principles and systems of classification by Fritsch (1935), Chapman and Chapman (1973).
2. Cyanophyceae: Cell structure and thallus organisation, heterocyst and akinete development and their role chromatic adaptation and reproduction.
3. Chlorophyceae: Range of thallus organisation, methods of reproduction & perennation and life cycle.
4. Life cycle patterns and alternation of generation with particulars reference to Phaeophyceae and Rhodophyceae.
5. Nuclear characteristics of green algae & blue-green algae.
6. A detailed idea of algae causing diseases of plants and animals.
7. Algae and water pollution: Physico-chemical analysis of water bodies, pollution indices and pollution indicators and steps to control pollution.
8. Cyanobacteria in human welfare: Production of fine chemicals, polysaccharides, bioactive molecules, pigments and lipids.
9. Recent Biotechnological developments with algae as an experimental material.
10. Culture of algae: Media preparation.
11. Methods of collection, isolation and culture procedure for green algae and blue-green algae.
12. Economic importance of Algae as:
    a) Food b) Feed c) Bio-fertiliser d) Aquaculture e) Agriculture and industry.
13. Molecular biotechnology with special reference to blue green algae.

Reference Books:

1. Fritsch, F.E. – *The Structure and Reproduction of the Algae* (Cambridge University Press)
2. Chapman, V.J. & Chapman, D.J. – *The Algae* (Macmillan)
3. Bold, H.C. & Wynne, M.J. – *Introduction to the Algae: Structure and Reproduction* (Prentice-Hall)
4. Lee, R.E. – *Phycology* (Cambridge University Press)
5. Rao, B.D. – *A Textbook of Algae* (S. Chand & Co.)
6. Kaushik, B.D. – *Algal Biotechnology* (Chand Publishing)
7. Richmond, A. & Hu, Q. – *Handbook of Microalgal Culture: Applied Phycology and Biotechnology* (Wiley-Blackwell)
8. Subramanian, G. – *Cyanobacterial Biotechnology* (Science Publishers)
9. Sharma, O.P. – *Textbook of Algae* (Tata McGraw-Hill)
10. Trivedi, R.K. & Goel, P.K. – *Chemical and Biological Methods for Water Pollution Studies* (Environmental Publications)
11. Prescott, G.W. – *Algae of the Western Great Lakes Area* (Wm. C. Brown)

OR ELECTIVE COURSE-B [ECBOT401B]

MICROBIOLOGY AND PLANT PATHOLOGY-I

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

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

1. Understand and identify the general symptoms of plant diseases caused by bacteria, fungi, and viruses.
2. Explain Koch's Postulates and its importance in the identification of causal organisms of plant diseases.
3. Classify plant pathogenic bacteria based on Gram staining, and distinguish between Gram-positive and Gram-negative bacteria.
4. Describe the microbial mechanisms of pathogenicity, including strategies employed by microbes to invade and colonise host tissues.
5. Analyse the mechanical forces used by pathogens to breach plant surfaces and establish infection.
6. Elaborate on the chemical weapons used by plant pathogens, including: Enzymes involved in degrading plant cell walls. Toxins, their types, and role in disrupting host cellular functions.
7. Examine plant defence mechanisms, focusing on:
    - Structural barriers that prevent pathogen entry.
    - Chemical defences produced during or after infection.
    - The role of phenolic compounds in inhibiting pathogen activity.
    - The production and role of phytoalexins as antimicrobial compounds.

Learning Outcomes:

After successful completion of this module, students will be able to:

1. Identify and diagnose plant diseases based on visible symptoms caused by microbial pathogens.
2. Apply Koch's postulates to experimentally determine the causal agents of plant diseases.
3. Differentiate between Gram-positive and Gram-negative bacteria based on their structural and staining characteristics.
4. Demonstrate understanding of how plant pathogens initiate infection and colonise host plants.
5. Assess and explain the mechanical and chemical tools employed by pathogens to overcome plant defences.
6. Interpret the roles of specific enzymes and toxins in the pathogenesis of plant diseases.
7. Evaluate the effectiveness of plant defence mechanisms including structural reinforcements, chemical responses, and biosynthesis of protective compounds like phytoalexins.

Course Contents:

Unit I: Principles of Plant Pathology: 10 Lectures

History and development of plant pathology. Classification of plant diseases. Pathogenesis: infection, colonization, symptom expression. Disease cycle and survival of pathogens. Koch's Postulates and disease diagnosis, modification of Koch's. Postulates, its application and limitations, relationship between pathogens and diseases.

General symptoms of Plant Disease caused by Bacteria, fungi and Virus.

Classification of Gram +ve and gram -ve bacteria.

Unit II: Pathogens and Disease Mechanisms: 22 Lectures

Bacterial, viral, fungal, and mycoplasma plant pathogens. Mechanism of Attack: Pathogens attack on host:

Mechanisms of pathogenicity:

a) Enzymes: Role of Enzymes in pathogenesis

b) Toxins: Types of toxins and their role in pathogenesis.

c) Effector proteins

d) Mycotoxins, Aflatoxins, major types and their importance

Compatible and incompatible interactions. Molecular basis of plant-pathogen interaction (gene-for-gene theory)

Unit III: Defence Mechanisms: 12 Lectures

Structural or morphological defence mechanism. Biochemical defence mechanism

Phenolic compounds and its role in defence. Phytoalexins. Concept of Phytoncides

Unit IV: Microbial Genetics and Applications: 16 Lectures

Horizontal gene transfer: transformation, conjugation, transduction

Plasmids, transposons, and their role in evolution

Basic recombinant DNA techniques: gene cloning, vectors, PCR

Resistance and susceptibility

Reference Books:

1. "General Microbiology" – *Roger Y. Stanier, John L. Ingraham, Mark L. Wheelis, Page R.*
2. "Microbiology" – *Pelczar, Chan, and Krieg*
3. "Bergey's Manual of Systematic Bacteriology" – *Various Authors*
4. "A Textbook of Microbiology" – *R.C. Dubey and D.K. Maheshwari*

5. “Introduction to Modern Virology” – *Dimmock, Easton, and Leppard*
6. “Essentials of Virology” – *Luria and Darnell*
7. “Introductory Mycology” – *C.J. Alexopoulos, Charles W. Mims, M. Blackwell*
8. “Industrial Microbiology” – *L.E. Casida*
9. “Biotechnology” – *U. Satyanarayan*
10. “Plant Pathology” – *George N. Agrios* (Highly Recommended)
11. “Plant Pathology” – *R.S. Mehrotra & Ashok Aggarwa*
12. “Plant Diseases” – *Singh, R.S.*
13. “Introductory Plant Pathology” – *K.S. Bilgrami & H.C. Dube*
14. “Plant Pathology Techniques and Protocols” – *B. Foster*
15. “Laboratory Manual of Microbiology and Plant Pathology” – *D.K. Maheshwari*
16. “Molecular Genetics of Bacteria” by *Larry Snyder and Wendy Champness*
17. **“Microbial Genetics” by *S.R. Maloy, J.E. Cronan & D. Freifelder***
18. “Genetics” by *P.K. Gupta*
19. “Principles of Genetics” by *Gardner, Simmons & Snustad*
20. “A Textbook of Biotechnology” by *R.C. Dubey*
21. “Biotechnology” by *U. Satyanarayana*
22. “Recombinant DNA” by *Watson et al.*
23. Aflatoxins: Biochemistry and Molecular Biology by *Mehdi Razzaghi-Abyaneh*
24. Fungal Diseases and Mycotoxins in Crops by *K.S. Bilgrami, R. Prasad*

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OR ELECTIVE COURSE-C [ECBOT401C]

CYTOGENETICS, PLANT BREEDING, MOLECULAR BIOLOGY AND BIOTECHNOLOGY-I

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

1. To provide foundational and advanced knowledge in classical and applied cytogenetics.
2. To build conceptual understanding of molecular mechanisms involved in the regulation of gene expression in plants.
3. Introduce students to cutting-edge tools in molecular biology.
4. To develop an understanding of genomic techniques used in modern plant cytogenetics and their relevance to plant breeding and biotechnology.
5. Enable students to appreciate the integration of cytogenetics with genomics and systems biology, promoting interdisciplinary scientific literacy.

Course Learning Outcomes:

1. Ability to explain the fundamentals of cytogenetic techniques and chromosomal behaviour during cell division and recombination.
2. Analyse classical genetic principles, such as Mendelian inheritance, and interpret exceptions like linkage and epistasis.
3. Will be able to describe the structure, organisation, and molecular biology of DNA, RNA, and chromosomes in plant systems.
4. Distinguish various chromosomal aberrations, polyploidy, and aneuploidy, and their applications in plant improvement.
5. Apply knowledge of molecular biology tools such as PCR, DNA sequencing, molecular markers, and gene cloning.
6. Interpret gene expression regulation mechanisms in plants, including operon models and RNA-based regulation.
7. Understand and evaluate the utility of cytogenetic mapping, chromosomal banding, and integration of cytogenetics with proteomics and metabolomics.
8. Critically assess applications of transgenic technology, CRISPR, and molecular diagnostics in modern agriculture and plant health.

Course Content:

Unit I: Cytogenetics **(20 Lectures)**

1. Introduction to cytogenetics and cytogenetic techniques (Pretreatment, fixation, staining and preservation)
2. Mendelian and Non-Mendelian Genetics
3. Cell division and molecular mechanism of the cell cycle.
4. Structure and organisation of chromosomes; Chromosome types; C-value paradox
5. Linkage, Chromosome pairing, Crossing Over and Recombination.
6. Karyotype analysis and evolution, chromosomal aberrations (deletion, duplication, inversion, translocation).
7. Polyploidy: types, induction methods, significance.
8. Aneuploidy: monosomics, trisomics, nullisomics and their cytological identification.

Unit II: Plant Molecular Biology **(20 Lectures)**

1. DNA structure, types and replication (Prokaryotes and Eukaryotes)
2. RNA types, transcription and post-transcriptional modifications
3. Transposable Elements
4. Genetic code, translation and protein targeting
5. Mutation and detection
6. Gene regulation: operon models, transcription factors, enhancers
7. RNAi and epigenetics in plants
8. Study of model genetic plant

Unit III: Applied Molecular Biology **(10 Lectures)**

1. Molecular markers (RAPD, SSR, SNP) and genotyping
2. Gene cloning, vector systems (Ti plasmid, binary vectors)
3. PCR, qPCR, and DNA sequencing
4. CRISPR/Cas systems in plants; DNA Microarray (DNA chip or Biochip)
5. Molecular diagnostics for plant pathogens
6. Transgenic plants

Unit IV: Applied Cytogenetics **(10 Lectures)**

1. Cytogenetic mapping and chromosome banding techniques
2. Cytogenetics in relation to genomics, proteomics and metabolomics

Reference Books:

1. Sharma AK, Sharma A. (1980). *Chromosome Techniques: Theory and Practice.* Butterworth-Heinemann.
2. Singh RJ. (2006). *Plant Cytogenetics.* 2nd edition. CRC Press, USA.
3. Gardner EJ, Simmons MJ, Snustad DP. (2008). *Principles of Genetics.* 8th edition. Wiley.
4. Strickberger MW. (2005). *Genetics.* 3rd edition. Pearson Education India.
5. Klug WS, Cummings MR, Spencer CA. (2015). *Concepts of Genetics.* 11th edition. Pearson Education.
6. Brown TA. (2010). *Gene Cloning and DNA Analysis.* 6th edition. Wiley-Blackwell, Oxford, UK.
7. Primrose SB, Twyman RM. (2006). *Principles of Gene Manipulation and Genomics.* 7th edition. Blackwell Publishing.
8. Sambrook J, Russell DW. (2001). *Molecular Cloning: A Laboratory Manual.* 3rd edition. Cold Spring Harbor Laboratory Press.
9. Buchanan BB, Gruissem W, Jones RL. (2015). *Biochemistry & Molecular Biology of Plants.* 2nd edition. Wiley Blackwell.
10. Watson JD et al. (2017). *Molecular Biology of the Gene.* 7th edition. Pearson Education.
11. Karp G. (2013). *Cell and Molecular Biology: Concepts and Experiments.* 7th edition. Wiley.
12. Lewin B. (2008). *Genes IX.* Jones and Bartlett Publishers.
13. Gupta PK. (2019). *Biotechnology and Genomics.* Rastogi Publications.
14. Chawla HS. (2011). *Introduction to Plant Biotechnology.* 3rd edition. Oxford & IBH Publishing.
15. Lodish H et al. (2016). *Molecular Cell Biology.* 8th edition. W.H. Freeman.

OR ELECTIVE COURSE-D [ECBOT401D]

PLANT PHYSIOLOGY, BIOTECHNOLOGY AND MOLECULAR BIOLOGY-I

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

1. To develop a thorough understanding of physiological processes in plants at cellular, molecular, and whole-plant levels.
2. To explore the biochemical and molecular mechanisms involved in plant responses and adaptation to environmental stresses.
3. To provide conceptual and applied knowledge on stress physiology in plants with reference to crop productivity and resilience.
4. To prepare students for research and innovation in plant physiology with relevance to climate change and agriculture.

Course Learning Outcomes:

1. After completing this course, students will be able to:
2. Explain advanced concepts in plant water relations, mineral nutrition, and growth regulation.
3. Analyse how plants perceive and respond to various abiotic and biotic stresses.
4. Demonstrate knowledge of stress tolerance mechanisms and their molecular basis.
5. Evaluate the roles of hormones, signalling pathways, and gene regulation under stress conditions.
6. Apply the understanding of plant physiology in improving stress tolerance in crops.

Course Contents:

1. Basic concept of growth, development and differentiation.
2. Plant Movement: Types of movement, Tropism (Geotropism and Phototropism) and Nastic Movement, and role of phytohormones in plant movement.
3. Photomorphogenesis.
4. Circardian Rythm.
5. Growth regulators (Phythormones): History, structure, biosynthesis, physiological responses and mechanism of action of Auxins, Gibberellins, Cytokinins, Ethylene, Abscisic acid, Brassinosteroids and Jasmonic acid.
6. Apical dominance and various theories.
7. Transport of phytohormones.
8. Polarity: definition, theories and molecular mechanism.
9. Phytochrome: History of its discovery, isolation, purification and its biological roles.
10. Physiology of flowering: Photoperiodism and Vernalization (Biochemical and Molecular mechanism).
11. Seed dormancy: Definition, types, mechanism and method of breaking the dormancy.
12. Seed Germination: factors, biochemical and molecular basis.

Stress Physiology and Adaptation

13. Abiotic stresses: drought, salinity, high and low temperature, heavy metals
14. Biotic stress: pathogens and herbivory – systemic acquired resistance (SAR) and induced systemic resistance (ISR)
15. Oxidative stress and antioxidant defence mechanisms (ROS, SOD, catalase, peroxidase)
16. Role of phytohormones (ABA, SA, JA, ethylene) in stress signalling
17. Molecular and genetic approaches to improve stress tolerance, Use of omics (transcriptomics, proteomics, metabolomics) in stress physiology

Reference Books :

1. Taiz, L., Zeiger, E., Møller, I.M., & Murphy, A. – Plant Physiology and Development (Sinauer/ Oxford University Press)
2. Buchanan, B.B., Gruissem, W., & Jones, R.L. – Biochemistry & Molecular Biology of Plants (Wiley)
3. Hopkins, W.G. & Hüner, N.P.A. – Introduction to Plant Physiology (Wiley)
4. Jain, V.K. – Fundamentals of Plant Physiology (S. Chand)
5. Levitt, J. – Responses of Plants to Environmental Stresses
6. Ahmad, P. & Prasad, M.N.V. – Abiotic Stress Responses in Plants (Springer)
7. Parida, A. & Das, A.B. – Salt Tolerance and Salinity Effects in Plants
8. Hirt, H. & Shinozaki, K. – Plant Responses to Abiotic Stress (Springer)

OR ELECTIVE COURSE-E [ECBOT401E]

PLANT TAXONOMY, ETHNOBOTANY AND MEDICINAL PLANTS-I

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

1. To understand the concept of species and the taxonomic hierarchy from species to higher categories.
2. To study classical systems of classification (Bentham & Hooker, Hutchinson), their basis, merits, and limitations.
3. To explore recent trends in taxonomy including anatomical, cytological, embryological, phytochemical, and molecular approaches.
4. To impart knowledge of the International Code of Nomenclature and rules for effective plant naming and classification.
5. To identify and describe key angiosperm families of regional importance in Jharkhand along with their economic uses.
6. To introduce ethnobotany as a science, emphasizing traditional medicinal practices of ethnic communities.
7. To teach herbarium techniques, including both classical and digital methods of plant documentation.
8. To explore the role of traditional knowledge in plant conservation and sustainable resource use.

Course Learning Outcomes*:*

After completing this course, students will be able to:

1. Critically compare Bentham & Hooker and Hutchinson systems of classification and understand their historical significance.
2. Integrate modern taxonomic tools such as anatomy, embryology, phytochemistry, and cytology into plant identification and classification.
3. Apply the principles and rules of botanical nomenclature (ICN) including typification, priority, and valid publication.
4. Understand the scope of ethnobotany and document traditional plant-based knowledge from tribal and ethnic communities.
5. Prepare and maintain classical and digital herbarium specimens with correct scientific documentation.
6. Recognise and describe conservation methods for ethnobotanically valuable and endangered plant species.

Course Content:

1. The species concept: Taxonomic hierarchy, species, genus family and other categories principles used in assessing relationship, delimitation of taxa.
2. Outline of classification: Bentham & Hooker and Hutchinson system. Merits and demerits.
3. Recent trends in taxonomy with special reference to: Morphology, Anatomy, Phytochemistry, Cytology and Embryology.
4. Botanical nomenclature: International code of nomenclature for algae, fungi and plants, Principles, Rules and Recommendations, Priority, Typification, Rules of effective and valid publications, Retention and choice of names.
5. Taxonomical features and economic importance of the dominant Angiospermic families of Jharkhand: Magnoliaceae, Apocynaceae, Rubiaceae, Verbenaceae, Convolvulaceae, Asclepiadaceae, Scrophulariaceae, Acanthaceae, Bignoniaceae, Lamiaceae, Euphorbiaceae, Orchidaceae, Zingiberaceae, Araceae, Cyperaceae and Poaceae.
6. Definition, scope and method of study of ethnobotany.
7. Contribution of ethnic communities on traditional medicinal knowledge.
8. Preparation of herbarium, including-digital herbarium.
9. Methods of conservation of valuable plants.
10. Ethnomedicinal plants used in the following diseases:

a) Diabetes b) Jaundice c) Malaria d) Skin diseases e) Gynaecological Problems

Reference Books:

1. Lawrence, G.H.M. – *Taxonomy of Vascular Plants* (Oxford & IBH)
2. Rendle, A.B. – *The Classification of Flowering Plants*
3. Stace, C.A. – *Plant Taxonomy and Biosystematics* (Cambridge University Press)
4. Radford, A.E. – *Vascular Plant Systematics*
5. Jain, S.K. & Rao, R.R. – *A Handbook of Field and Herbarium Methods* (Today and Tomorrow's Printers)
6. Heywood, V.H. & Moore, D.M. – *Current Concepts in Plant Taxonomy*
7. Turland, N.J. et al. (editors) – *International Code of Nomenclature for Algae, Fungi and Plants (Shenzhen Code)* (Koeltz Botanical Books)
8. Jain, S.K. – *Manual of Ethnobotany* (Scientific Publishers)
9. Sinha, R.K. – *Ethnobotany: The Renaissance of Traditional Herbal Medicine*
10. Purohit, S.S. & Vyas, S.P. – *Medicinal Plant Cultivation: A Scientific Approach* (Agrobios)
11. Nadkarni, K.M. – *Indian Materia Medica* (Popular Prakashan)
12. Bridson, D. & Forman, L. – *The Herbarium Handbook* (Royal Botanic Gardens, Kew)
13. Chopra, G.L. – *Plant Systematics: An Integrated Approach*
14. Samant, S.S. et al. – *Plant Biodiversity of Western Himalaya: A Source Book of Important Plants* (GBPIHED)

II. ELECTIVE COURSE-A [ECBOT402A]
ALGAL BIOTECHNOLOGY-II

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:
1. To explore traditional, ecological, and commercial uses of inland algae and cyanobacteria in India.
2. To study the ecological roles of microalgae in wastewater treatment and phytoplankton dynamics in aquatic ecosystems.
3. To understand the genetic and physiological basis of photobiological nitrogen fixation in cyanobacteria.
4. To investigate photoprotective mechanisms, habitat diversity, and physiological adaptations in microalgae.
5. To evaluate causes and consequences of eutrophication and algal blooms, along with monitoring techniques.
6. To study techniques and industrial applications of large-scale cultivation of algae such as Spirulina, Scenedesmus, and Chlorella.

Course Learning Outcomes:
By the end of the course, students will be able to:
1. Document and explain traditional uses of inland algae by local communities.
2. Isolate and identify filamentous algae up to the genus level using local freshwater samples.
3. Evaluate the role of microalgae in liquid waste remediation and nutrient cycling.
4. Explain the genetics of nitrogen fixation, including heterocyst differentiation and nitrogen assimilation in cyanobacteria.
5. Understand and analyse algal biochemical responses to abiotic stresses such as UV, desiccation, and extreme temperatures.
6. Describe photoprotective adaptations of cyanobacteria in diverse habitats.
7. Understand the nature of genetic material in cyanobacteria and basic genetic techniques.
8. Apply knowledge of algal cultivation methods for research and industry (e.g., Spirulina, Chlorella).

Course Contents:
1. Traditional use of inland algae.
2. Isolation and identification of filamentous algae from local samples (upto Genus level).
3. Mass cultivation of cyanobacteria used as biofertilizer.
4. Phytoplankton sampling and identification from local pond.
5. The role of microalgae in liquid waste treatment and reclamation.
6. Photo-biological nitrogen fixation:
   Introduction, genetic structure of N_2 fixation system, heterocyst differentiation nitrate, nitrite and ammonia assimilation.
7. Biochemical and molecular aspects of abiotic stresses:
   a) UV radiation
   b) Temperature and desiccation stress
8. Photo-protective Mechanisms-Habitat diversity and significant physiological properties.
9. Cyanobacterial Genetics: nature of genetic material.
10. Common methods for mass cultivation of micro-algae.
11. Eutrophication: Causal factor, algae blooms.
12. Commercial production of *Spirulina, Scenedesmus, Chlorella.*

Reference Books:

1. Lee, R.E. – *Phycology* (Cambridge University Press)
2. Bold, H.C. & Wynne, M.J. – *Introduction to the Algae* (Prentice Hall)
3. Sharma, O.P. – *Textbook of Algae* (Tata McGraw Hill)
4. Fritsch, F.E. – *The Structure and Reproduction of the Algae* (Cambridge)
5. Subramanian, G. – *Cyanobacterial Biotechnology* (Science Publishers)
6. Rao, B.D. – *A Textbook of Algae* (S. Chand & Co.)
7. Richmond, A. & Hu, Q. – *Handbook of Microalgal Culture: Biotechnology and Applied Phycology* (Wiley-Blackwell)
8. Kaushik, B.D. – *Algal Biotechnology* (Chand Publishing)
9. Trivedi, R.K. & Goel, P.K. – *Chemical and Biological Methods for Water Pollution Studies* (Environmental Publications)
10. Venkataraman, G.S. – *Algal Biofertilizer and Sustainable Agriculture* (Toda)

OR ELECTIVE COURSE-B [ECBOT402B]

MICROBIOLOGY AND PLANT PATHOLOGY-II

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

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

1. Understand and explain the characteristic features of plant pathogenic bacteria, including their structure and modes of infection.
2. Describe the general characteristics of plant viruses, including:
   - Classification of plant viruses
   - Structure and chemical composition
   - Mechanisms of viral replication in host cells
3. Understand various modes of transmission of plant viruses (e.g., insect vectors, mechanical, seed-borne).
4. Gain basic knowledge of antigen-antibody interactions and the immune response in the context of plant pathology.
5. Learn the mode of action of antibiotics and their use in controlling microbial pathogens.
6. Understand the principles and methods of plant disease management, including:
   - Cultural practices to prevent disease spread
   - Chemical control through fungicides/bactericides
   - Quarantine regulations to stop disease introduction
   - Biological control using antagonistic microbes
7. Identify, describe, and analyse the symptoms, etiology, and control methods of major plant diseases caused by fungi, bacteria, and viruses, including:
   - Fungal diseases like downy mildew, powdery mildew, smuts, rust, wilt, tikka disease, early blight, red rot, etc.
   - Bacterial diseases like bacterial blight, citrus canker, stalk rot, and black rot.
   - Viral diseases like bunchy top of banana, rice tungro, sugarcane mosaic, yellow vein mosaic, etc.

Course Learning Outcomes:

After successful completion of this course, students will be able to:

1. Identify and describe the morphological and physiological characteristics of plant pathogenic bacteria.
2. Classify plant viruses and explain their structure, replication, and transmission mechanisms.
3. Illustrate the basic concepts of antigen-antibody interactions and explain the immune responses relevant to plant health.
4. Explain the general action of antibiotics and evaluate their effectiveness in disease management.
5. Compare and contrast various plant disease management strategies, including cultural, chemical, quarantine, and biological methods.
6. Recognise and diagnose symptoms of major plant diseases in economically important crops.
7. Analyse disease etiology and suggest appropriate control measures for:
   - Fungal diseases: e.g., Downy mildew of maize, Loose smut of wheat, Tikka disease of groundnut, etc.
   - Bacterial diseases: e.g., Citrus canker, Tundu disease of wheat, Leaf spot of tomato, Bacterial stalk rot of maize, etc.
   - Viral diseases: e.g., Tobacco mosaic, Rice tungro, Sugarcane mosaic, Leaf curl of papaya, etc.
8. Apply theoretical knowledge to practical field diagnosis and propose effective plant protection practices based on symptoms and pathogen biology.

<u>Course Contents</u>

Unit I: Applied Microbiology and Virology **12 Lectures**

1. Application of microbes in the field of agriculture, biofertilizers, biopesticides, GMOs, and microbial bioremediation, fermented foods and dairy products, industry and bio-waste management, Characteristics features of plant pathogenic bacteria.
2. General characteristics of plant Viruses:
3. a) Classification of plant virus.
4. b) Structure, physical and chemical properties of Plant virus.
5. c) Virus replication.
6. Transmission of plant viruses.
7. Recent trends in viral diagnostics (ELISA, RT-PCR)

Unit II: Immunology and Medical Microbiology **10 Lectures**

1. Antigen and antibody- Innate and acquired immunity, Humoral and cell-mediated immunity, antigen, Antigen: types, determinants (epitopes), haptens, Antibodies, the immune response.
2. Cells and organs of the immune system (T cells, B cells, macrophages, dendritic cells, NK cells)
3. Antibiotics and their general mode of action: an overview.
4. Antibiotic resistance: Intrinsic resistance (natural), Acquired resistance (mutation, gene transfer).

Unit III: Plant Disease Management **10 Lectures**

1. Principles of disease management
2. Chemical control: fungicides (types, mode of action)
3. Biological control: biocontrol agents and PGPRs

4. Cultural and mechanical control, quarantine and legislative measures
5. Integrated Disease Management (IDM) approach, Integrated Pest Management (IPM), Biopesticides: Bacterial, viral and fungal biopesticides and their and applications

Unit IV: Study of Major Plant Diseases **28 Lectures**

Detailed study of Distribution, Symptoms, Etiology, Disease cycle, and Disease Management (Control measures) of following diseases:

1. Downy mildew of Maize
2. Powdery mildew of Pea (Pisusm sativum)
3. Loose smut of Wheat
4. Covered smut / Bunt of Wheat
5. Black stem rust of Wheat
6. Tikka disease of Groundnut
7. Red rot of Sugarcane
8. Early blight of Potato
9. Bacterial blight of Paddy
10. Tundu disease of Wheat
11. Angular Leaf spot of Cotton
12. Citrus Canker
13. Bacterial stalk rot of Maize
14. Black rot / bacterial wilt of Crucifers
15. Yellow vein mosaic of Bhindi
16. Rice tungro disease
17. Sugarcane mosaic disease
18. Bunchy Top of Banana
19. Little leaf of Brinjal

Reference Books:

1. R.S. Mehrotra & A. Aggarwal – *Plant Pathology*
2. R.S. Singh – *Plant Diseases*
3. George N. Agrios – *Plant Pathology*
4. K.S. Bilgrami & H.C. Dube – *A Textbook of Modern Plant Pathology*
5. B.N. Pandey – *Virology*
6. Roger Hull – *Plant Virology*
7. Dimmock, Easton & Leppard – *Introduction to Modern Virology*
8. R.S. Mehrotra – *Plant Pathology*
9. Agrios – *Plant Pathology*
10. C.K. Kokare – *Pharmaceutical Microbiology*
11. R.C. Dubey & D.K. Maheshwari – *Microbiology*
12. Tortora, Funke & Case – *Microbiology: An Introduction*
13. Prescott's Microbiology – Willey, Sherwood, Woolverton
14. A.H. Patel – *Industrial Microbiology*
15. R.C. Dubey – *Microbial Biotechnology*
16. Casida – *Industrial Microbiology*
17. S.S. Chahal – *Principles of Plant Disease Management*
18. Rangaswami & Mahadevan – *Diseases of Crop Plants in India*
19. P. Sudha Gangal - *A Textbook of Immunology*
20. K. Sambamurthy - *Immunology*
21. Kenneth Murphy, Casey Weaver - *Janeway's Immunobiology*
22. Jenni Punt, Sharon Stranford, Patricia Jones, Judith Owen - *Kuby Immunology*

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OR ELECTIVE COURSE-C [ECBOT402C]

CYTOGENETICS, PLANT BREEDING, MOLECULAR BIOLOGY AND BIOTECHNOLOGY-II

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

1. To equip students with an in-depth understanding of classical and modern plant breeding methods, including cytogenetic and molecular techniques.
2. To provide hands-on theoretical knowledge of tissue culture, gene transfer, and genomic tools used in plant biotechnology.
3. To familiarise students with the concepts of GM crops, biofortification, and functional genomics applied to crop improvement.
4. To introduce essential concepts in biostatistics to analyse, interpret, and present scientific data using appropriate statistical tools.
5. To encourage critical thinking on ethical, regulatory, and social implications of advanced plant biotechnology.

Course Learning Outcomes:

1. Explain the objectives, history, and genetic foundations of plant breeding, domestication, and varietal development.
2. Distinguish between reproductive modes, and explain their implications in breeding programs.
3. Apply selection methods, mutation breeding, and cytogenetic tools to develop improved plant varieties.
4. Use knowledge of genetic markers, marker-assisted selection (MAS), and QTL mapping for crop improvement.
5. Demonstrate understanding of next-generation sequencing (NGS), GBS, and their applications in developing climate-resilient and biofortified crops.
6. Describe various plant tissue culture techniques, protoplast fusion, and transgenic technologies.
7. Understand the statistical basis of biological data, conduct analyses using t-tests, ANOVA, regression, and multivariate statistics.
8. Assess the impact and potential of applied biotechnology in agriculture, including vaccine/enzyme production, and engage in informed debates on biosafety and ethics in GM crops.

Course Content:

Unit I: Conventional and Specialized Plant Breeding (12 Lectures)

1. Introduction, objective and Centre of Origin of species, Domestication, genetic resources and hybridisation
2. Modes of reproduction and breeding implications, Apomixis, Self-Incompatibility and Male Sterility
3. Selection methods: mass, pureline, recurrent selection (Breeding for Self and Cross Pollinated plants)
4. Inbreeding and heterosis. Induced Mutation and Ploidy Breeding
5. Resistance Breeding to biotic and abiotic stress adaptation
6. Cytogenetic aspects of wide hybridisation and introgression
7. Breeding maintenance and Variety release

Unit II: Molecular Breeding (12 Lectures)

1. Genetic markers. Marker-assisted breeding: MAS for qualitative, quantitative and QTL detection
2. NextGen Molecular Breeding: NGS, Genotype by sequencing (GBS), genetic maps, physical maps.
3. Genomics Assisted Plant Breeding Development of biofortified and climate-resilient crops
4. Case studies: Rice, Wheat, *Brassica* and cotton improvement programs

Unit III: Plant Biotechnology (12 Lectures)

1. History and scope of plant biotechnology
2. Tissue culture techniques: callus induction, micropropagation, somatic embryogenesis
3. Protoplast culture, isolation and fusion; Anther culture and somatic hybridisation
4. Agrobacterium-mediated and direct gene transfer methods
5. Cryopreservation and synthetic seeds

Unit IV: Biostatistics (10 Lectures)

1. Data types and representation
2. Mean, median, mode, standard deviation
3. t-test, correlation, regression analysis
4. ANOVA: one-way and two-way
5. Introduction to Multivariate statistics and Cluster analysis
6. Application of statistical software (Excel/SPSS basics etc.)

Unit V: Applied Biotechnology (14 Lectures)

1. GM crops: development, biosafety, regulatory issues
2. Biotechnological approaches for biofortification (Golden Rice, iron-fortified crops)
3. Functional genomics and transcriptomics in plant science
4. Plant-based production of vaccines and enzymes
5. Ethical, legal, and social issues (ELSI) in plant biotechnology

Reference Books:

1. Chahal GS and Gosal SS. (2002). *Principles and Procedures of Plant Breeding*. Narosa Publishing House.
2. Singh BD. (2020). *Plant Breeding: Principles and Methods*. 11th edition. Kalyani Publishers.
3. Acquaah G. (2012). *Principles of Plant Genetics and Breeding*. 2nd edition. Wiley-Blackwell.
4. Poehlman JM and Sleper DA. (1995). *Breeding Field Crops*. 4th edition. Blackwell Publishing.
5. Bhojwani SS and Razdan MK. (1996). *Plant Tissue Culture: Theory and Practice*. Elsevier.
6. Chawla HS. (2011). *Introduction to Plant Biotechnology*. 3rd edition. Oxford & IBH Publishing.
7. Brown TA. (2010). *Gene Cloning and DNA Analysis: An Introduction*. 6th edition. Wiley-Blackwell.
8. Primrose SB and Twyman RM. (2006). *Principles of Gene Manipulation and Genomics*. 7th edition. Blackwell Publishing.
9. Sokal RR and Rohlf FJ. (2012). *Biometry: The Principles and Practice of Statistics in Biological Research*. 4th edition. W.H. Freeman.
10. Khan IN. (2018). *Biostatistics Simplified*. 2nd edition. Jaypee Brothers Medical Publishers.
11. Gomez KA and Gomez AA. (1984). *Statistical Procedures for Agricultural Research*. 2nd edition. John Wiley & Sons.
12. Zar JH. (2010). *Biostatistical Analysis*. 5th edition. Pearson Education.
13. Dubey RC. (2014). *Advanced Biotechnology*. S. Chand Publishing.
14. Slater A, Scott NW, Fowler MR. (2008). *Plant Biotechnology: The Genetic Manipulation of Plants*. 2nd edition. Oxford University Press.
15. Lewin B. (2008). *Genes IX*. Jones & Bartlett Learning.
16. Buchanan BB, Gruissem W, Jones RL. (2015). *Biochemistry and Molecular Biology of Plants*. 2nd edition. Wiley Blackwell.

OR ELECTIVE COURSE-D [ECBOT402D]

PLANT PHYSIOLOGY, BIOTECHNOLOGY AND MOLECULAR BIOLOGY-II

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:
1. To provide comprehensive knowledge on the principles, techniques, and applications of plant tissue culture in research and industry.
2. To impart understanding of cellular totipotency, morphogenesis pathways, and their applications in plant propagation and breeding.
3. To introduce students to molecular tools and techniques, including recombinant DNA technology and gene transfer methods.
4. To explore the development and application of transgenic plants for biotic/abiotic stress resistance and metabolic engineering.
5. To familiarise students with the use of molecular markers, DNA-based diagnostics, and gene editing tools for crop improvement.
6. To integrate knowledge of traditional and modern biotechnological approaches for sustainable agriculture and pharmaceutical industries.

Course Learning Outcomes:
After completing the course, students will be able to:
1. Explain the historical development, concepts, and milestones of plant tissue culture and its industrial relevance, especially in India.
2. Describe the pathways of somatic embryogenesis and organogenesis, and assess factors affecting in vitro morphogenesis.
3. Interpret and explain advanced molecular techniques such as PCR, DNA fingerprinting, and blotting for gene detection and analysis.
4. Understand the mechanism of recombinant DNA technology, types of vectors, and gene cloning tools (enzymes, plasmids).
5. Compare different gene transfer techniques (Agrobacterium-mediated, biolistic, electroporation, etc.) and their application in transgenic plant development.
6. Critically analyse the role of transgenic plants in imparting resistance to biotic and abiotic stresses with real-world examples.
7. Apply knowledge of molecular markers and secondary metabolite production techniques for crop improvement and bioresource utilisation.
8. Understand and evaluate modern genome editing tools (e.g., RNA interference, CRISPR-Cas) and their agricultural applications.

Course Contents:
1. History of plant tissue culture, significance and industrial application, and its present status in India.
2. Pathway of differentiation: Somatic Embryogenesis and Organogenesis.
3. *In vitro* pollination, fertilisation, and their significance.
4. Suspension culture and single cell culture.
5. Haploidy: Anther culture, Pollen culture, Ovary culture, and its significance.
6. Endosperm culture and its significance.
7. Protoplast culture and Somatic hybridisation technique, cybridization, factors, limitation and its role in crop improvement.
8. Micropropagation: Technique, factors, limitations and its significance.
9. Recombinant DNA technology – Plasmid, Vector, Types of gene cloning principle and techniques. Enzymes used for recombinant DNA technology.
10. Blotting techniques (Southern, Northern and Western), DNA fingerprinting, polymerase chain reaction.
11. Genetics of *Agrobacterium tumefaciens* and *A. rhizogenes*.
12. Methods of Gene transfer: Physical (Direct) and biological (Indirect) methods and production of transgenic plants.
13. Transgenic plants: Biotic and abiotic stress resistance.
14. Secondary metabolite enhancement through tissue culture technique.
15. Molecular markers and its application. Industrial application of plant tissue culture.
16. Crop improvement: RNAi and Genome editing (Introduction, types, mechanism and its application with example).

Reference Books:

1. Taiz, L., Zeiger, E., Moller, I. M., & Murphy, A. (2018). Plant Physiology and Development (6th ed.). Sinauer Associates.
2. Buchanan, B. B., Gruissem, W., & Jones, R. L. (2015). Biochemistry and Molecular Biology of Plants. Wiley Blackwell.
3. Slater, A., Scott, N. W., & Fowler, M. R. (2008). Plant Biotechnology: The Genetic Manipulation of Plants. Oxford University Press.
4. Heldt, H. W., & Piechulla, B. (2021). Plant Biochemistry (5th ed.). Academic Press.
5. Glick, B. R., & Pasternak, J. J. (2010). Molecular Biotechnology: Principles and Applications of Recombinant DNA. ASM Press.
6. Lewin, B. (2017). Genes XII. Jones and Bartlett.
7. Lodish, H. et al. (2021). Molecular Cell Biology. W.H. Freeman.
8. Chawla, H. S. (2009). Introduction to Plant Biotechnology. Oxford & IBH.

OR ELECTIVE COURSE-E [ECBOT402E]

PLANT TAXONOMY, ETHNOBOTANY AND MEDICINAL PLANTS-II

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

1. To introduce various systems of angiosperm classification with an emphasis on modern phylogenetic approaches.
2. To understand the evolutionary trends and origin of angiosperms through both morphological and molecular perspectives.
3. To familiarise students with molecular taxonomy and the use of DNA markers in plant identification and phylogeny.
4. To explore the diversity, nutritional and medicinal value of under-utilized plants used by indigenous communities, especially in Jharkhand.
5. To gain practical insight into phytochemistry, herbal drug standardization, and pharmacognostic profiling.
6. To prepare students for research and development in the field of ethnomedicine, taxonomy, and conservation.

Course Learning Outcomes**:**

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

1. Critically compare traditional and modern systems of angiosperm classification, including Cronquist and APG systems.
2. Apply molecular tools like DNA markers in the taxonomy and phylogenetic study of angiosperms.
3. Understand the basics of remote sensing and GIS in plant biodiversity mapping and conservation.
4. Identify major Indian organisations, botanical gardens, herbariums, and national parks involved in plant research and conservation.
5. Explain phytochemical constituents, bioactive compounds, and standardization techniques used in herbal drug development.
6. Conduct field-based and lab-based ethnobotanical studies with respect to traditional plant usage and conservation.

Course Contents:

1. Outline of classification of angiosperms with their merits and demerits:
   (a) Cronquist system of classification
   (b) All phylogenic groups (APG) system of classification.
2. Origin and evolution of Angiosperms.
3. Molecular approaches in plant taxonomy: Application of DNA markers in angiosperm taxonomy, molecular phylogeny.
4. Remote sensing – GIS.
5. Ethnic community of world. Biological conservation of ethnic society of world.
6. Role of Government and some other organisation involved in the promotion of ethnobotany in India.
7. National Botanical Gardens, National Parks and Herbarium Centers of India
8. Phytochemistry and standardization of herbal drugs.
9. Study of the following Nutraceutical and Under – utilized plants used by ethnic communities of Jharkhand state: Nutritional and medicinal values;
   Centella asiatica, Moringa oleifera, Eleusine coracana, Madhuca indica, Psidium guajava, Syzygium cumini, Annona squamosa, Carica papaya, Emblica officinalis, Boerhavia diffusa, Aegle marmelos, Cassia tora, Ficus glabella, Dolichos biflorus, Cucumis sativus.
10. Detailed study of the following ethnomedicinal plants used by ethnic communities with floral formula, floral diagram, mode of drug preparation, dose and bioactive compounds.
    Andrographis paniculata, Asparagus racemosus, Rauwolfia serpentina, Azadirachta indica, Achyranthes aspera, Catharanthus roseus, Tinospora cordifolia, Mimosa pudica, Acorus calamus, Ocimum sanctum, Curcuma longa, Stevia spp., Gymnema sylvestre, Bacopa monneri, Vitex negundo, Calotropis procera.

Reference Books:

1. Heywood, V.H. – *Plant Taxonomy* (Edward Arnold)
2. Cronquist, A. – *An Integrated System of Classification of Flowering Plants* (Columbia University Press)
3. Judd, W.S. et al. – *Plant Systematics: A Phylogenetic Approach* (Sinauer Associates)
4. Stace, C.A. – *Plant Taxonomy and Biosystematics* (Cambridge University Press)
5. Henry, R.J. – *Practical Applications of Plant Molecular Biology* (Chapman & Hall)
6. Harborne, J.B. – *Phytochemical Methods* (Springer)
7. Mukherjee, P.K. – *Quality Control of Herbal Drugs* (Business Horizons)
8. Jain, S.K. – *Manual of Ethnobotany* (Scientific Publishers)
9. Sinha, R.K. – *Ethnobotany: The Renaissance of Traditional Herbal Medicine* (Indus Publishing)
10. Purohit, S.S. & Vyas, S.P. – *Medicinal Plant Cultivation* (Agrobios)
11. Nayar, M.P. – *Plant Diversity in India* (NBT)
12. Lillesand, T.M., Kiefer, R.W. & Chipman, J.W. – *Remote Sensing and Image Interpretation* (Wiley)
13. Burrough, P.A. & McDonnell, R.A. – *Principles of Geographical Information Systems* (Oxford University Press)

III. CORE COURSE [CCBOT403]

LABORATORY SAFETY, REGULATIONS AND RESEARCH ETHICS

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

1. To provide comprehensive understanding of laboratory safety protocols and risk assessment in biological research.
2. To familiarise students with biosafety levels, hazardous materials handling, and disposal methods.
3. To educate students about national and international guidelines for biological research and ethical conduct.
4. To instill scientific integrity, good laboratory practices (GLP), and responsible authorship in research.
5. To prepare students for safe and ethical handling of biological materials in research and industrial laboratories.

Course Learning Outcomes:

After successful completion of this course, students will be able to:

1. Demonstrate knowledge of laboratory safety protocols and emergency response.
2. Identify and mitigate biological, chemical, and environmental hazards in lab settings.
3. Apply biosafety and containment practices in handling microorganisms and GMOs.
4. Practice scientific integrity and follow ethical guidelines in botanical research.
5. Comply with national and international regulations concerning life science research.

Course Content:

Unit I: Laboratory Safety and Hazard Management **(14 Lectures)**

Principles of laboratory safety: fire, chemical, electrical, and mechanical safety.
Identification of physical, chemical, and biological hazards.
Safe handling and storage of reagents and lab equipment.
First aid in laboratory and emergency response planning.
Use of personal protective equipment (PPE).
Lab safety signs, labeling, and hazard communication.

Unit II: Biosafety and Containment Practices **(12 Lectures)**

Introduction to Biosafety Levels (BSL-1 to BSL-4).
Primary and secondary containment, biosafety cabinets, HEPA filters.
Guidelines for handling genetically modified organisms (GMOs).
Safe practices for working with microbes, plants, and recombinant DNA.
Institutional Biosafety Committees (IBSC) and approval protocols.
Fieldwork safety in botanical and ecological research.

Unit III: Waste Management and Environmental Safety **(10 Lectures)**

Classification of biological and chemical waste.
Waste minimisation and segregation protocols.
Treatment and disposal of solid, liquid, and sharps waste.
Autoclaving, incineration, and chemical neutralization.
Environmental regulations and green lab practices.
National and CPCB guidelines for laboratory waste management.

Unit IV: Research Ethics and Scientific Integrity **(12 Lectures)**

Ethical principles in scientific research: honesty, objectivity, and accountability.
Plagiarism: detection tools, penalties, and prevention.
Fabrication, falsification, and misconduct in science.
Bioethics: Animal and plant research ethics (CPCSEA and NBA guidelines).
Informed consent and benefit sharing in ethnobotanical research.
Authorship ethics, citation practices, and conflict of interest.

Unit V: Regulatory Framework and National/International Guidelines **(12 Lectures)**

National Guidelines: DBT, DST, ICAR, NBPGR.
Guidelines for biosafety, genetic engineering, and research funding.
International Frameworks: OECD, WHO, Cartagena Protocol, Nagoya Protocol, UNESCO declarations.
GLP (Good Laboratory Practices), GMP (Good Manufacturing Practices).
Laboratory accreditation: NABL and ISO standards.
Case studies on ethical violations and biosafety breaches.

Reference Books:

1. NIH Guidelines for Research Involving Recombinant DNA Molecules (2020).
2. Manual on Laboratory Biosafety – WHO (4th Edition, 2020).
3. Guidelines for Safety in Microbiological and Biomedical Laboratories – CDC, USA.
4. Glick, B.R. & Patten, C.L. (2017). *Molecular Biotechnology: Principles and Applications of Recombinant DNA*. ASM Press.
5. Krimsky, S. (2000). *Science in the Private Interest: Has the Lure of Profits Corrupted Biomedical Research?* Rowman & Littlefield.
6. Day, R.A. & Gastel, B. (2011). *How to Write and Publish a Scientific Paper*, Cambridge University Press.
7. Indian National Science Academy (INSA). (2019). *Ethics in Science Education, Research and Governance*.
8. Ministry of Environment, Forest and Climate Change (MoEF&CC). *National Biodiversity Action Plan*, Government of India.

IV. ELECTIVE COURSE-A [EPBOT404A]
PRACTICAL-IVA

Marks: 100 (ESE Pr: 6 Hrs) = 100	Pass Marks = 45

(Credits: Practical-04, 120 Hours)

Course Objectives:
1. To train students in the collection, identification, and preparation of permanent and temporary slides of freshwater algae of Ranchi region.
2. To develop skills in using ocular and stage micrometers for accurate calibration and microscopic measurements.
3. To teach accurate scientific drawing of algal structures using camera lucida with appropriate scale magnification.
4. To provide practical knowledge in cytological techniques such as pretreatment, fixation, staining, and squash preparation of chromosomes.
5. To impart laboratory skills in basic biochemical analysis, including chromatography, protein estimation, and sugar determination.
6. To introduce techniques for preparing culture media relevant to algal biotechnology and environmental studies.

Course Learning Outcomes:
After successful completion of the course, students will be able to:
1. Identify freshwater algae up to genus or species level from Ranchi and prepare permanent and temporary slides.
2. Use ocular and stage micrometers to measure cell structures accurately and calibrate the microscope accordingly.
3. Draw scientifically accurate sketches of vegetative and reproductive algal structures using camera lucida, with correct magnification.
4. Carry out pigment separation using paper chromatography/TLC and identify photosynthetic pigments.
5. Estimate protein content using the Lowry method and determine soluble sugars or carbohydrates from plant material.

Course Contents:
1. Taxonomy of freshwater algae of Ranchi. Identification & slide preparation of the given material.
2. Ocular and micrometer: Measurement and calibration.
3. Draw camera lucida sketches of vegetative and reproductive structure of given material. Measure and draw the scale of magnification.
4. Study of the chromosome structure: Pretreatment fixation, Staining, squash technique and preparation of a temporary mount of the supplied material/Development, location and identification of components/pigments by paper chromatography/ TLC./Estimation of protein by Lowry's method/determination of soluble sugar/carbohydrates.
5. Environmental Biotech: Preparation of pure culture medium (Pringsheem/molisch).

Reference Books:
1. Sharma, O.P. – *Textbook of Algae* (Tata McGraw Hill)
2. Bold, H.C. & Wynne, M.J. – *Introduction to the Algae: Structure and Reproduction* (Prentice Hall)
3. Fritsch, F.E. – *Structure and Reproduction of Algae* (Cambridge University Press)
4. Trivedi, R.K. – *Microscopy Techniques in Botany* (Scientific Publishers)
5. Sharma, A.K. & Sharma, A. – *Chromosome Techniques – Theory and Practice* (Butterworths)
6. Plummer, D.T. – *An Introduction to Practical Biochemistry* (McGraw-Hill)
7. Sadasivam, S. & Manickam, A. – *Biochemical Methods* (New Age International)
8. Venkataraman, G.S. – *Algal Biofertilizers and Sustainable Agriculture*
9. Richmond, A. & Hu, Q. – *Handbook of Microalgal Culture: Biotechnology and Applied Phycology* (Wiley-Blackwell)
10. Kaushik, B.D. – *Algal Biotechnology* (Chand Publishing)

OR ELECTIVE COURSE-B [EPBOT404B]

PRACTICAL-IVB

Marks: 100 (ESE Pr: 6 Hrs) = 100	Pass Marks = 45

(Credits: Practical-04, 120 Hours)

Course Objectives:

The primary objectives of this course are to:

1. Provide hands-on training in the isolation, staining, and identification of plant pathogenic microorganisms.
2. Develop practical skills in diagnostic microscopy, including ocular micrometry and temporary slide preparation.
3. Familiarise students with Gram staining and its application in bacterial classification.
4. Train students in standard microbiological techniques such as culture handling, spore measurement, and identification of diseases based on symptoms.
5. Enable students to interpret host-pathogen relationships through morphological and symptomatic studies.
6. Introduce the structure, working principles, and use of basic microbiological laboratory equipment.

Course Learning Outcomes:

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

1. Prepare and interpret stained microscopic slides of infected plant tissues to identify pathogens using morphological features and diagrams.
2. Calibrate the ocular micrometer and accurately measure microbial spores and cells, determining their average size.
3. Differentiate plant pathogens using temporary slide preparations and draw suitable conclusions regarding host-pathogen interactions.
4. Perform Gram staining of bacterial specimens and determine Gram reaction (positive/negative) to assist in classification.
5. Isolate plant pathogenic microbes from infected material using culture plates, and follow sterile techniques.
6. Recognise common plant diseases by observing preserved or fresh specimens and accurately name the causal organisms.
7. Understand and explain the structure and working principle of essential microbiological equipment used in pathogen identification and analysis.

Course Contents:

1. Make suitable stained preparations of material “A”. Study the symptoms of the disease and comment upon the host parasite relationship. Identify the pathogen giving suitable diagrams and reasons. Leave your preparation for examination.
2. Determine the value of one small division of the ocular micrometer in microns. Measure three spores of the given material “B”. Find out the average size of the material given.
3. Make suitable stained temporary preparations of materials “C” to exhibit the structure of the pathogen in it. Identify the pathogen giving suitable diagrams and reasons. Leave your preparation for examination.
4. Prepare slide of bacterial specimen “D” stain it with the Gram stain and state whether it is gram positive or gram negative.
5. Isolate the pathogen from the given material “E” from the culture plate.
6. Describe the structure, make an illustrative diagram of the given apparatus and describe its principle of working and applications.
7. Give the name of the disease and the causal organism of the specimen 1-5.

Reference Books:

1. Laboratory Manual in Plant Pathology – Rangaswami
2. Plant Pathology Techniques and Protocols – B. Foster (Springer)’
3. “Practical Manual of Microbiology” – R.C. Dubey & D.K. Maheshwari
4. “Laboratory Manual of Plant Pathology” – Rangaswami & Mahadevan
5. “Practical Plant Pathology” - K.P. Srivastava
6. “Microbiological Methods” - Collins and Lyne
7. Staining and pathogen study-Aneja, Dubey & Maheshwari, APS Lab Manual
8. Micrometry and spore measurement -Aneja, Collins & Lyne
9. Temporary mounts of pathogens -K.P. Srivastava, T.S. Thind
10. Gram staining, Dubey & Maheshwari, Aneja
11. Isolation from culture plates, -T.S. Thind, APS Lab Manual
12. Apparatus structure and principle, -Aneja, Srivastava
13. Disease specimen identification, -K.P. Srivastava, APS Lab Manual

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OR ELECTIVE COURSE-C [EPBOT404C]

PRACTICAL-IVC

Marks: 100 (ESE Pr: 6 Hrs) = 100	**Pass Marks = 45**

(Credits: Practical-04, 120 Hours)

Course Objectives:

1. To equip students with hands-on laboratory experience in classical and modern plant cytogenetics and plant breeding techniques.
2. To train students in molecular biology methods.
3. To develop proficiency in plant tissue culture techniques and biotechnological tools used in plant improvement and propagation.
4. Introduce students to the application of biostatistical tools and bioinformatics for experimental data analysis and phylogenetic studies.
5. To enhance student skills in field-based assessment, including emasculation, hybrid selection, and ploidy determination.

Course Learning Outcomes:

1. Prepare and analyse mitotic and meiotic chromosome spreads, karyotypes, and detect chromosomal abnormalities under stress or mutagen treatments.
2. Determine polyploidy through stomatal measurement and chromosome count and evaluate pollen viability and fertility indices.
3. Apply hybridisation and emasculation techniques in field-based plant breeding and Recognise naturally occurring mutants or polyploid variants.
4. Perform DNA, RNA, and protein extraction and quantification, and analyse gene expression using PCR and electrophoresis.
5. Evaluate metabolite levels and stress indicators like proline content under various biotic and abiotic conditions.
6. Execute plant tissue culture protocols , including callus induction, explant culture, synthetic seed development, and greenhouse management.
7. Apply statistical analyses using software tools like MS Excel and SPSS.
8. Use bioinformatics platforms such as Phytozome, TAIR, and tools like MEGA and Clustal X for gene alignment and phylogenetic analysis.

Course Contents:

1. **Plant Cytogenetics**
   a. Stain preparation; Reagent preparation (Pre-treatment, fixative and preservative)
   b. Preparation of mitotic (*Allium cepa*, *Allium sativum* and *Vicia faba*) and meiotic chromosome spreads
   c. Karyotyping; effect and analysis of chromosomal aberrations with different mutagens and stress
   d. Determination of LC50 doses of selected abiotic stresses in plant.
   e. Study of polyploidy using stomatal size and chromosome count
   f. Pollen viability; Pollen sterility and fertility index
2. **Plant Breeding**
   a. Emasculation technique
   b. Field visits for hybridisation techniques and selection of naturally mutated/ vigorous/ ploidy plants
3. **Molecular Biology**
   a. DNA/RNA/protein extraction from plant tissues
   b. Quantification, PCR amplification and agarose gel electrophoresis
   c. Protein/ Metabolite quantification under different biotic and abiotic stress condition.
4. **Plant Biotechnology**
   a. Media preparation for tissue culture
   b. Inoculation of explants
   c. Callus induction and organogenesis; Growth in Green House Chamber
   d. Field trials and analysis of ploidy level
5. **Biostatistics (Lab Component)**
   a. Application of t-test, ANOVA, and regression using MS Excel/SPSS
   b. Interpretation of experimental data
   c. Bioinformatics approach to construct a hierarchy through DNA and pollen biology
   d. Demonstration on Phytozome, TAIR and retrieving of gene sequences for multiple sequence alignment for candidate gene for making phylogenetic tree using (MEGA, CLUSTAL X etc.).
   e. Estimation of proline content under different biotic and abiotic stress condition.

Reference Books:

1. Sharma AK, Sharma A. (1980). *Chromosome Techniques: Theory and Practice.* Butterworth-Heinemann.
2. Singh RJ. (2006). *Plant Cytogenetics.* 2nd edition. CRC Press, USA.
3. Sambrook J, Russell DW. (2001). *Molecular Cloning: A Laboratory Manual.* 3rd edition. Cold Spring Harbor Laboratory Press.
4. Brown TA. (2010). *Gene Cloning and DNA Analysis.* 6th edition. Wiley-Blackwell, Oxford, UK.
5. Chawla HS. (2011). *Introduction to Plant Biotechnology.* 3rd edition. Oxford & IBH Publishing.
6. Glick BR, Pasternak JJ. (2017). *Molecular Biotechnology: Principles and Applications.* 5th edition. ASM Press.
7. Bhojwani SS, Razdan MK. (1996). *Plant Tissue Culture: Theory and Practice.* Elsevier.
8. Kumar U. (2020). *Plant Tissue Culture and Transformation Techniques.* Ane Books.
9. Slater A, Scott NW, Fowler MR. (2008). *Plant Biotechnology: The Genetic Manipulation of Plants.* Oxford University Press.
10. Zar JH. (2010). *Biostatistical Analysis.* 5th edition. Pearson Education.
11. Sokal RR, Rohlf FJ. (2012). *Biometry: The Principles and Practice of Statistics in Biological Research.* 4th edition. W.H. Freeman.
12. Gomez KA, Gomez AA. (1984). *Statistical Procedures for Agricultural Research.* 2nd edition. Wiley.
13. Mount DW. (2004). *Bioinformatics: Sequence and Genome Analysis.* 2nd edition. Cold Spring Harbor Laboratory Press.
14. Lesk AM. (2019). *Introduction to Bioinformatics.* 5th edition. Oxford University Press.

OR ELECTIVE COURSE-D [EPBOT404D]
PRACTICAL-IVD

Marks: 100 (ESE Pr: 6 Hrs) = 100	Pass Marks = 45

(Credits: Practical-04, 120 Hours)

Course Objectives:
1. To impart hands-on training in the preparation and handling of plant tissue culture media and explants.
2. To develop skills in bioassays for identifying plant hormones and understanding their physiological effects.
3. To enable students to isolate, purify, and analyse plasmid and genomic DNA using molecular biology techniques.
4. To teach separation and estimation of chlorophyll pigments using chromatographic and spectrophotometric methods.
5. To provide knowledge on gene identification from databases, primer designing, PCR amplification, and gel-based analysis.
6. To introduce the preparation of synthetic seeds and analyse the effects of light and salt stress on germination.

Course Learning Outcomes:
After successful completion of the course, students will be able to:
1. Prepare Murashige and Skoog (MS) medium and supplement it with appropriate phytohormones (auxins, cytokinins, gibberellins).
2. Inoculate and maintain aseptic cultures of explants under controlled environmental conditions.
3. Perform classical bioassays to identify plant hormones like auxin (IAA), cytokinin (kinetin), and gibberellins.
4. Separate and quantify chlorophyll a, b, and carotenoids using chromatography (TLC/Paper) and UV-Vis spectroscopy.
5. Isolate plasmid DNA from bacteria and assess its quality and size using agarose gel electrophoresis; perform transformation.
6. Search GenBank to identify genes involved in stress resistance and design primers using basic bioinformatics tools.
7. Perform PCR amplification of stress-resistance genes and analyse the results via gel electrophoresis.
8. Prepare and evaluate synthetic seeds using alginate encapsulation techniques.
9. Examine the physiological effects of light and salinity on seed germination

Course Contents:
1. Preparation of MS medium supplemented with phytohormones.
2. Inoculation of explants into prepared medium.
3. Identify Auxin/Cytokinin/Gibberellin through proper Bioassay.
4. Isolation of bacterial culture by the streaking method.
5. Separation and estimation of chlorophyll pigments by paper chromatography/TLC and spectroscopy.
6. Isolation of Plasmid DNA and analysis by agarose gel electrophoresis; Transformation of isolated plasmid DNA into bacteria.
7. Isolation of plant genomic DNA by using Doyle and Doyle (1990) methods and analysis of isolated DNA by agarose gel electrophoresis.
8. Identification of Biotic/Abiotic stress resistance gene (one) from database GenBank and primer designing of the identified gene.
9. PCR amplification of the identified gene and analysed by using agarose gel electrophoresis.
10. Preparation of synthetic seeds.
11. Effect of Light and salt in seed germination.

Reference Books:

1. George, E.F., Hall, M.A., & De Klerk, G.-J. – *Plant Propagation by Tissue Culture* (Springer)
2. Bhojwani, S.S. & Razdan, M.K. – *Plant Tissue Culture: Theory and Practice* (Elsevier)
3. Srivastava, L.M. – *Plant Growth and Development* (Academic Press)
4. Sambrook, J. & Russell, D.W. – *Molecular Cloning: A Laboratory Manual* (Cold Spring Harbor)
5. Glick, B.R., Pasternak, J.J. – *Molecular Biotechnology: Principles and Applications* (ASM Press)
6. Brown, T.A. – *Gene Cloning and DNA Analysis* (Wiley-Blackwell)
7. Sadasivam, S. & Manickam, A. – *Biochemical Methods* (New Age International)
8. Plummer, D.T. – *An Introduction to Practical Biochemistry* (McGraw-Hill)
9. Mount, D.W. – *Bioinformatics: Sequence and Genome Analysis* (Cold Spring Harbor Laboratory Press)
10. Lesk, A.M. – *Introduction to Bioinformatics* (Oxford University Press)

OR ELECTIVE COURSE-E [EPBOT404E]

PRACTICAL-IVE

Marks: 100 (ESE Pr: 6 Hrs) = 100	**Pass Marks = 45**

(Credits: Practical-04, 120 Hours)

Course Objectives:

1. To enable students to identify flowering plants using floral characters and taxonomic keys with the aid of floras and herbarium specimens.
2. To train students in the microscopic preparation and analysis of leaf anatomical features, especially stomatal types and indices.
3. To develop competency in preparing identification keys and understanding diagnostic features of plant specimens.
4. To expose students to the microscopic examination of plant tissues using macerated material and anatomical techniques.
5. To enhance student familiarity with medicinal and ethnomedicinal plants, their families, and active principles.
6. To cultivate the ability to correctly identify and classify angiosperms using field and laboratory-based evidence.

Course Learning Outcomes:

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

- Use regional and national floras to correctly identify unknown flowering plant specimens up to family and species level.
- Prepare slides for stomatal observation, calculate stomatal index, and interpret their ecological significance.
- Construct dichotomous keys for plant identification and Recognise the importance of active compounds in medicinal plants.
- Identify key cell types (e.g., vessels, fibers, sclereids, tracheids) from macerated plant tissues and describe their functions.
- Accurately identify and classify herbarium specimens of medicinal and ethnomedicinal value.
- Recognise and classify angiosperms from their vegetative and reproductive characters (botanical name and family).
- Understand the medicinal and ethnobotanical significance of commonly used plant species and document their traditional uses.

Course Contents:

1. Work on Specimen A and identify the family and botanical name of the specimen with the help of flora.
2. Prepare a suitable preparation of Specimen B and find out the stomatal index. Draw suitable diagram and comment on your observation.
3. Prepare a key with a suitable diagram for identification of specimens C, D and E. /Comment on active principles of specimens F, G and H.
4. Identify at least two different cell tissues from the macerated material I supplied to you. Comment on your observation. Spotting - Identify herbarium 1-5 (Plants of medicinal value).
5. Identify the angiospermic plants on spots 6-10 (only botanical names and family).
6. Give botanical name, family and uses of Specimens 11-15 (Plants of Ethnomedicinal Values).

Reference Books:

1. Jain, S.K. & Rao, R.R. – *A Handbook of Field and Herbarium Methods* (Today & Tomorrow's Printers)
2. Nair, N.C. & Henry, A.N. – *Flora of Tamil Nadu* (Botanical Survey of India)
3. Bentham, G. & Hooker, J.D. – *Genera Plantarum*
4. Lawrence, G.H.M. – *Taxonomy of Vascular Plants* (Macmillan)
5. Radford, A.E. – *Vascular Plant Systematics* (Harper & Row)
6. Jain, S.K. – *Manual of Ethnobotany* (Scientific Publishers)
7. Purohit, S.S. & Vyas, S.P. – *Medicinal Plant Cultivation* (Agrobios)
8. Nadkarni, K.M. – *Indian Materia Medica* (Popular Prakashan)
9. Sharma, P.V. – *Dravyaguna Vijnana (Materia Medica and Pharmacology)*
10. Esau, K. – *Plant Anatomy* (Wiley Eastern)
11. Pandey, B.P. – *Plant Anatomy* (S. Chand & Company)
12. Johansen, D.A. – *Plant Microtechnique* (McGraw-Hill)

V. PROJECT [PRBOT405]
DISSERTATION/ PROJECT/ TEACHING APTITUDE

Marks: 100 (ESE Pr: 6 Hrs) = 100	Pass Marks: = 45

(Credits: 04, 120 Lectures)

Guidelines to Examiners for
End Semester Examination (ESE):

The evaluation of the dissertation will be done in 100 marks (70 marks + 30 marks of the session). The sessional component will be evaluated by the concerned supervisor.

The end term evaluation (70 marks) will be done by a board of examiners. The end term evaluation in 70 marks will include the literary and scientific presentation of the dissertation and the performance in the viva-voce.

Overall project dissertation may be evaluated under the following heads:
- *Motivation for the choice of topic*
- *Project dissertation design*
- *Methodology and Content depth*
- *Results and Discussion*
- *Future Scope & References*
- *Participation in Internship programme with reputed organisation*
- *Application of Research technique in Data collection*
- *Report Presentation*
- *Presentation style*
- *Viva-voce*

Course Objectives:
1. To develop research skills and scientific inquiry through independent investigations of a BOTchological topic of problem.

Course Outcomes:
On successful completion of this course, the student should know:
1. About conducting a research with approve stages of research methodology in Botany. Dissertation will enable student to further investigate and navigate different aspects and events of life through research.

PROJECT WORK
Each student has to submit three copies of hard-bound dissertation work (along with the raw data), duly forwarded by the HOD of the Department concerned. The forwarded copies will be submitted in the Department of Botany, Ranchi University, for evaluation (one month before the viva voce examination).

The paper may involve:
- (a) Laboratory research/ Field work/ Lab work related to the project.
- (b) Survey research, Case Study or any other type of Botanical research
- (c) One Large study/ Experiment or several studies/ Experiments, depending on the objectives of the research.
- (d) The writing of the dissertation must be within 80 to 100 pages, including references and appendices.
- (e) Content must be typed in Font: Times New Roman with Line Spacing: 1.5 and Font Size 14 points.

Presentation of project work in the seminar on the assigned topic in the P.G. Department of Botany, Ranchi University, Ranchi & open viva there on.

Topics: As decided by the Supervisor/Guide

Teaching Aptitude: Only selected candidates, in alternative to the Dissertation, may be provided duty to teach the assigned topics in selected colleges. The performance may be evaluated based on the organized feedback for the candidate.
