



SNDT Women's University, Mumbai

**Undergraduate Degree / UG
Programme (Syllabus as Per NEP) -
Faculty of Science & Technology**

**Bachelor of Science
(Botany)**

B.Sc. In Botany

As Per NEP – 2020

Semester – V & VI

**Syllabus
(W.E.F. Academic Year 2025-26)**

Terminologies

Vertical	Full-Form/Definition	Remarks	Related To Major And Minor Courses
Major (Core)	Subject Comprising Mandatory and Elective Courses, Major Specific IKS, Vocational Skill Courses, Internship/ Apprenticeship, Field Projects, Research Projects Connected to Major	Minimum 50% Of Total Credits Corresponding to Three/Four - Year UG Degree- Mandatory Courses	Related To The Major
Minor Course	Course From Same Or Different Faculty	Minimum 18-20 Credits to Be Completed in The First Three Years of UG Programme	Related To the Minor
OEC	Open Elective Courses/ Generic Courses	10-12 Credits to Be Offered in I And/Or II Year. Faculty-Wise Baskets of OEC To Be Prepared	OEC Is to Be Chosen Compulsorily from Faculty Other Than That of the Major
VSC	Vocational Skill Courses, Including Hands On Training Corresponding To The Major And/Or Minor Subject	8-10 Credits, To Be Offered in First Three Years, Wherever Applicable Vocational Courses Will Include Skills Based on Advanced Laboratory Practical's of Major	Related To the Major or Minor
SEC	Skill Enhancement Courses	06 Credits, To Be Offered in I And II Year, To Be Selected from The Basket of Skill Courses Approved by University	Related To the Major or Minor Any Relevant Skill
AEC	Ability Enhancement Courses	08 Credits, To Be Offered in I And II Year, English: 04 Credits to Be Earned in Sem - I, Modern Indian Language Of 04 Credits to Be Offered in II Year	NA
VEC	Value Education Courses	Understanding India, Environmental Science/Education, Digital	NA

		and Technological Solutions, Health & Wellness, Yoga Education, Sports, And Fitness	
IKS	Indian Knowledge System	Generic IKS Course: Basic Knowledge Of The IKS To Be Offered At First Year Level	Major-Specific IKS Courses: Advanced Information About the Major, Part of the Major Credit to Be Offered at Second- Or Third-Year Level
OJT	On-Job Training (Internship / Apprenticeship)	Corresponding To the Major Subject	Related To The Major
FP	Field Projects	Corresponding To the Major Subject	Related To the Major
CC	Co-Curricular Courses	Health And Wellness, Yoga Education Sports, And Fitness, Cultural Activities, NSS/NCC And Fine/ Applied/Visual/ Performing Arts	NA
CE	Community Engagement and Service		Related To Major
RP	Research Project	Corresponding To the Major Subject	Related To Major

Programme Template

Degree		B.Sc.
Programme		BOTANY
Preamble		<p>The objective of a B.Sc. Botany programme is to prepare its students for the society.</p> <p>The current pattern is designed to provide a focused learning outcome- based syllabus providing structured teaching-learning experiences catering to the needs of the students.</p> <p>The course will prepare the students both academically and in terms of employability.</p> <p>The curriculum based on learning outcomes of BSc Botany offers knowledge of areas including Plant Systematics, Plant Biotechnology, Resource Botany, Genetics, Ecology, Conservation biology, Physiology and Bioinformatics, Medicinal plants, Plant diseases management etc.</p> <p>The courses define clearly the objectives and the learning outcomes, enabling students to choose the elective subjects broadening their skills in the field of Botany.</p> <p>The course also offers skills to pursue research and teaching in the field of Botany and thus would produce best minds to meet the demands of society.</p> <p>The students will get employment in Research Institutions, Ayurvedic and Herbal companies and Academics.</p> <p>The course will equip students to start their entrepreneurial ventures.</p> <p>The course is designed to equip students to take up competitive examinations with Botany as major.</p>
Programme Specific Outcomes (PSOs)		After completing this programme, Learners will be able to
	1	Apply the field-based and the in-class knowledge of Botany to identify and classify Plants in their natural habitat
	2	Identify the various types of interactions and the economic importance of the plants related with the various ecosystem
	3	Students will get the skillsets and its applications in the specialized fields such as Biochemistry, Molecular Biology, Plant Biotechnology, developmental biology, economic and applied biology
	4	Design the research activity that involves application of critical thinking and experimental skills
	5	Acquaintance with Research Publications, scientific writing and documentation of research while conducting the research

		projects
	6	Demonstrate effective communication skills in both writing and speaking across a variety of professional contexts.
	7	Function effectively in both single-discipline and multidisciplinary teams.
	8	Apply critical thinking to design strategies for life- long learning, recognizing the essential need for continuous self-directed education.
Eligibility Criteria for Programme		10+2 with Biology and Mathematics or its equivalent
Intake (For SNTD WU Departments and Conducted Colleges)		

Structure with Course Titles**B.Sc. In Botany****Semester – V**

Sr. No.	Course	Type of Course	Credits	Marks	Int Marks	Ext Marks
	Semester – V					
50132611	Plant Morphology and Anatomy (Th+Pr) (2+2)	Major (Core)	4	100	50	50
50132612	Plant Taxonomy (Th+Pr) (2+2)	Major (Core)	4	100	50	50
51032611	Botanical Garden and Landscaping (Th)	IKS (Major Specific)	2	50	0	50
50232611	Molecular Biology (Th+Pr) (2+2)	Major (Elective) (Any One)	4	100	50	50
50232612	Plant Pathology (Th+Pr) (2+2)					
50332611	Biostatistics (Th+Pr) (2+2)	Minor Stream	4	100	50	50
50632601	Algal Technology (Pr)	VSC-4	2	50	50	0
51332601	Field Project (Pr)	FP	2	50	50	0
			22	550	300	250

Semester – VI

Sr. No.	Course	Type of Course	Credits	Marks	Int Marks	Ext Marks
	Semester - IV					
60132611	Embryology (Th+Pr) (2+2)	Major (Core)	4	100	50	50
60132612	Genetics (Th+Pr) (2+2)	Major (Core)	4	100	50	50
60232611	Plant Breeding (Th+Pr) (2+2)	Major (Elective) (Any One)	4	100	50	50
60232612	Ecology (Th+Pr) (2+2)					
60332611	Bioinformatics (Th)	Minor Stream	2	50	0	50
60332612	Plant Biotechnology (Th+Pr) (2+2)	Minor Stream	4	100	50	50
61232621	On-the-Job Training	OJT	4	100	50	50
			22	550	250	300

Exit with Degree (3-year)

Course Syllabus

Semester – V

.5.1 Major (Core)

Course Titles	Plant Morphology And Anatomy (Th+Pr)
Course Credits	4 Credit's (2 Th + 2 Pr)
Course Outcomes	After going through the course, learners will be able to
	1. Understand the morphology and anatomy of plants.
	2. Learn the classification of plants and identify different plant species.
	3. Know the basic concepts of gardening and the role of botanical gardens.
	4. Gain a preliminary understanding of biostatistics and molecular biology.
5. Appreciate the importance of algae for economic and environmental development.	
Module 1 (Credit 1) – Plant Morphology	
Learning Outcomes	After learning the module, learners will be able to understand
	<ol style="list-style-type: none">1. Observe variations in plants and plant groups.2. Understand the various levels of organization in a plant body and the relationship between structure and function.
Content Outline	<ul style="list-style-type: none">• Root - Types of root systems and modifications of roots and functions• Stem - Aerial, sub-aerial and underground stem modifications and functions of stem modifications• Leaf - Parts of leaf, types of leaves and phyllotaxy, venation and leaf modifications• Inflorescence, Flower and Fruit - Types of inflorescence, structure of flower, types of fruits and seeds and floral formula and floral diagram (basic idea)
Module 2 (Credit 1) – Plant Anatomy	
Learning Outcomes	After learning the module, learners will be able to understand
	1. Understand the structure, organization, and function of plant tissues and organs.
	2. Differentiate between primary and secondary growth in roots, stems, and leaves.
	3. Identify and classify plant tissues through microscopic observation and sectioning.
4. Correlate anatomical features with plant adaptation, function,	

	and development.
	5. Develop skills in preparing, observing, and accurately sketching plant anatomical structures.
Content Outline	<ul style="list-style-type: none"> • Tissue and tissue systems: meristematic tissue, permanent tissue, and secretory cells. • Classification of meristems: apical, intercalary, and lateral; primary and secondary meristems. • Normal and secondary growth in dicotyledonous and monocotyledonous stems and roots. • Anomalous secondary growth in stems. • Structure of dicot leaves.
Module 3 (Credit 1) – Practicals	
Learning Outcomes	After learning the module, learners will be able to understand
	1. Examine and describe the structure and modifications of roots, stems, and leaves.
	2. Identify types of inflorescences, flower parts, and fruits, and construct floral diagrams and formulas.
	3. Develop practical skills in observation, dissection, and accurate botanical sketching.
Content Outline	<p>Practical's</p> <ul style="list-style-type: none"> • To study the structure and modifications of root, stem, and leaf. • To observe and classify different types of inflorescences. • To examine flowers and their parts. • To study different types of fruits. • To construct floral diagrams and interpret floral formulas.
Module 4 (Credit 1) – Practicals	
Learning Outcomes	After learning the module, learners will be able to understand
	1. Examine and describe normal secondary growth in dicot stems and roots (e.g., sunflower).
	2. Study and identify anomalous secondary growth in dicot stems (Bignonia, Boerhaavia) and monocot stems (Dracaena).
	3. Develop skills in microscopic observation, sectioning, and accurate sketching of plant anatomical structures.
Content Outline	<p>Practical's</p> <ul style="list-style-type: none"> • To study the normal secondary growth in dicot stem (Sunflower). • To study the normal secondary growth in dicot root (Sunflower). • To study secondary growth anomalies in Boerhaavia stem.

	<ul style="list-style-type: none">• To study secondary growth in monocot stem (Dracaena) and note its differences from dicots.• To develop practical skills in sectioning, observation, and sketching of plant anatomical structures.
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Assignments/Activities towards Comprehensive Continuous Evaluation (CCE)

- Microscopic observation and labeled sketches of root, stem, and leaf tissues.
- Dissection of flowers and fruits; construction of floral diagrams and formulas.
- Study of normal and anomalous secondary growth in stems and roots.
- Collection and description of plant specimens for morphological and anatomical features.
- Comparative analysis of monocot and dicot structures, with mini-reports or presentations.

References:

1. Plant Systematics: A Phylogenetic Approach – Walter S. Judd et al., 4th Edition (2015) (covers morphology in systematics context)
2. Plant Anatomy – James D. Mauseth, 6th Edition (2021) (includes morphological aspects linked to anatomy)
3. Plant Anatomy – Katherine Esau, 2nd Edition (1977)
4. Plant Structure and Development: A Practical Approach – Brian J. Davies, 1st Edition (1995)
5. Plant Anatomy – Katherine Esau, 2nd Edition (1977)
6. Plant Anatomy – James D. Mauseth, 6th Edition (2021)
7. Anatomy of Seed Plants – Richard C. Sporne, 2nd Edition (1974)

Semester – V**.5.2 Major (Core)**

Course Titles	Plant Taxonomy (Th+Pr)
Course Credits	4 Credit's (2 Th + 2 Pr)
Course Outcomes	After completing the course, learners will be able to:
	1. Understand the principles and importance of plant taxonomy and nomenclature.
	2. Identify and classify plants using taxonomic keys and morphological characters.
	3. Analyze and interpret plant diversity at family, genus, and species levels.
	4. Recognize the structure and diagnostic features of major plant families.
	5. Appreciate the significance of herbarium, botanical gardens, and modern tools in plant identification and classification.
Module 1 (Credit 1) – Plant Systematics and Description	
Learning Outcomes	After learning the module, learners will be able to understand
	1. Understand different classification systems and their applications.
	2. Describe plants accurately using standard botanical terminology.
Content Outline	<ul style="list-style-type: none">• Systems of classification: Artificial, Natural, and Phylogenetic.• Brief account of Bentham & Hooker and Engler & Prantl systems.• Merits and demerits of these classification systems.• Plant descriptions: Common terminologies for vegetative and reproductive parts.
Module 2 (Credit 1) – Angiosperm Families and Taxonomic Evidences	
Learning Outcomes	After learning the module, learners will be able to understand
	1. Understand the structure, organization, and function of plant tissues and organs.
	2. Differentiate between primary and secondary growth in roots, stems, and leaves.
	3. Identify and classify plant tissues through microscopic observation and sectioning.
	4. Correlate anatomical features with plant adaptation, function, and development.
	5. Develop skills in preparing, observing, and accurately sketching plant anatomical structures.

Content Outline	<ul style="list-style-type: none"> • Study of diagnostic features of angiosperm families: Annonaceae, Brassicaceae, Malvaceae, Fabaceae (with sub-families), Apiaceae, Cucurbitaceae, Rubiaceae, Asteraceae, Apocynaceae, Solanaceae, Lamiaceae, Euphorbiaceae, Orchidaceae, Liliaceae, Poaceae. • Plant taxonomic evidences from palynology, embryology, cytology, phytochemistry, and molecular data.
Module 3 (Credit 1) – Practical's	
Learning Outcomes	After learning the module, learners will be able to understand
	1. Identify and describe root, stem, and leaf morphology.
	2. Examine internal floral structures through V.S. of flowers.
	3. Construct and interpret floral diagrams.
Content Outline	<p>Practical's</p> <ul style="list-style-type: none"> • To observe and describe root, stem, and leaf morphology using botanical terminology. • To prepare and study vertical sections of flowers. • To construct floral diagrams. • To write floral formulae. • To determine the systematic position of plants using Bentham & Hooker's system.
Module 4 (Credit 1) – Practicals	
Learning Outcomes	After learning the module, learners will be able to understand
	1. Identify diagnostic features and diagram Annonaceae and Brassicaceae.
	2. Describe floral structures and diagram Malvaceae and Fabaceae.
	3. Observe and record features of Apiaceae and Cucurbitaceae.
	4. Examine flowers and record floral formulae of Asteraceae, Apocynaceae, Solanaceae.
Content Outline	<p>Practical's</p> <ul style="list-style-type: none"> • To study diagnostic features of Annonaceae and Brassicaceae and make labeled diagrams. • To study Malvaceae and Fabaceae, including floral sections and diagrams. • To examine Apiaceae and Cucurbitaceae for morphological and reproductive features. • To study Asteraceae, Apocynaceae, and Solanaceae, and prepare technical descriptions. • To identify Lamiaceae, Euphorbiaceae, Orchidaceae, Liliaceae,

	and Poaceae, recording floral formulae.
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Assignments/Activities towards Comprehensive Continuous Evaluation (CCE)

- Prepare and sketch slides of flowers, ovary sections, and plant organs.
- Collect and identify plants; prepare herbarium sheets with descriptions.
- Classify plants using Bentham & Hooker's system and compare classification methods.
- Study diagnostic features of angiosperm families with at least two examples each.
- Maintain a lab journal with observations, diagrams, and reflections.
- Participate in quizzes, oral presentations, and mini-projects on plant families.

References:

1. Plant Systematics: A Phylogenetic Approach – Walter S. Judd, Christopher S. Campbell, Elizabeth A. Kellogg, Peter F. Stevens, Michael J. Donoghue, 4th Edition (2015)
2. Plant Taxonomy: The Systematic Evaluation of Comparative Data – Tod F. Stuessy, 2nd Edition (2009)
3. Botany in a Day: The Patterns Method of Plant Identification – Thomas J. Elpel, 5th Edition (2020)
4. Genera Plantarum – George Bentham & Joseph Dalton Hooker, 3 Volumes (1862–1883)
5. Principles of Angiosperm Taxonomy – K.S. Irwin & J.W. Barneby, 2nd Edition (1982)
6. Plant Identification Terminology: An Illustrated Glossary – James G. Harris & Melinda Woolf Harris, 2nd Edition (2001)
7. Plant Families: A Guide to Identification and Natural History – L. Watson & M.J. Dallwitz, 2nd Edition (2007)
8. Manual of Vascular Plants of Northeastern United States and Adjacent Canada – Henry A. Gleason & Arthur Cronquist, 2nd Edition (1991)

Semester – V

.5.3 Indian Knowledge System (IKS) (Major Specific)

Course Titles	Botanical Garden and Landscaping (Th)
Course Credits	2 Credit's
Course Outcomes	After completing the course, learners will be able to:
	1. Apply the basic principles and components of gardening.
	2. Design various types of gardens.
	3. Establish and maintain special types of gardens for outdoor and indoor landscaping.
	4. Establish and maintain Botanical Gardens.
5. Design various types of gardens.	
Module 1 (Credit 1) – Principles of Gardening and Landscape Design	
Learning Outcomes	After learning the module, learners will be able to understand
	1. Explain fundamental principles of gardening and landscape design.
	2. Identify and describe various garden components and adornments.
	3. Plan and design lawns, rockeries, and water features effectively.
	4. Distinguish between formal, informal, and freestyle garden styles.
5. Design a basic layout for different types of gardens, considering aesthetics and functionality.	
Content Outline	<ul style="list-style-type: none"> • Principles of gardening – objectives, aesthetic and functional aspects. • Garden components and adornments – pathways, flower beds, fountains, statues. • Lawn making – types, preparation, and maintenance. • Methods of designing rockeries and water gardens. • Landscape design principles – planning, layout, and composition. • Styles of gardens – formal, informal, freestyle. • Types of gardens – residential, public, terrace, roof, heritage gardens.
Module 2 (Credit 1) – Special Gardens, Bio-Aesthetic Planning, and Botanical Gardens	
Learning Outcomes	After learning the module, learners will be able to understand
	1. Explain the design and functional elements of special types of

	gardens.
	2. Apply bio-aesthetic principles in planning urban and public landscapes.
	3. Select suitable planting materials for various functional areas.
	4. Outline the objectives, principles, and styles of botanical gardens.
	5. Prepare a conceptual plan for botanical gardens or public landscapes.
Content Outline	<ul style="list-style-type: none"> • Special types of gardens – their features, walk-paths, bridges, and constructed elements. • Bio-aesthetic planning – definition, need, principles. • Urban and public landscaping – avenues, schools, villages, stations, dam sites, hydroelectric projects, colonies, riverbanks. • Planting material selection for playgrounds and public spaces. • Botanical gardens – principles, objectives, and styles. • Practical considerations in planning and managing botanical gardens.

Assignments/Activities towards Comprehensive Continuous Evaluation (CCE)

- Field visit: Identify garden components and adornments.
- Lawn design sketch with plant selection.
- Rockery/water garden layout on paper.
- Mini presentation of garden design.
- Field survey of special/urban gardens.
- Bio-aesthetic planning: layout for roadsides or campuses.
- Playground planting plan.
- Conceptual plan of a botanical garden.
- Poster presentation on urban/public green spaces.

References:

1. Floriculture and Landscaping — T. K. Bose, R. G. Maiti, R. S. Dhua & P. Das, 1999, Naya Prokash.
2. Design Elements of Landscape Gardening — K. M. P. Nambisan, 1992, Oxford & IBH.
3. Floriculture in India — G. S. Randhawa & A. Mukhopadhyay, 1986, Allied Publishers.
4. Home Gardening — P. P. Trivedi, 1983, Statesman Press, New Delhi.
5. Ornamental Plants for Gardens — G. T. Sabina & K. V. Peter, 2008, New India Publishing Agency.
6. Gardening in India — M. G. Woodrow, 1999, Biotech Books.
7. Introduction to Ornamental Horticulture — J. S. Arora, 1999, Kalyani Publishers, Ludhiana.

Semester – V

.5.4 Major (Elective)

Course Titles	Molecular Biology (Th+Pr)
Course Credits	4 Credit's (2 Th + 2 Pr)
Course Outcomes	After completing the course, learners will be able to:
	1. Explain DNA and RNA structure and modes of DNA replication.
	2. Identify enzymes involved in replication and gene cloning.
	3. Perform and interpret DNA extraction, electrophoresis, and cloning experiments.
	4. Understand recombinant DNA technology and its applications in GM crops.
	5. Discuss ethical and biosafety issues in biotechnology.
Module 1 (Credit 1) – DNA Replication	
Learning Outcomes	After learning the module, learners will be able to understand
	1. Explain the structure of DNA and its role in replication.
	2. Describe and differentiate the three modes of DNA replication.
	3. Identify key enzymes and their roles in DNA replication.
	4. Compare replication mechanisms in prokaryotes and eukaryotes.
	5. Understand the importance of fidelity and regulation in DNA replication.
Content Outline	<ul style="list-style-type: none"> • DNA structure recap – double helix, antiparallel strands. • Modes of DNA replication: <ul style="list-style-type: none"> ○ Conservative ○ Semi-conservative ○ Dispersive • Enzymes involved in DNA replication: DNA polymerase, helicase, primase, ligase, topoisomerase. • Replication in prokaryotes vs eukaryotes – origin of replication, replication forks. • Regulation of DNA replication – checkpoints, proofreading.
Module 2 (Credit 1) – Recombinant DNA Technology and Applications	
Learning Outcomes	After learning the module, learners will be able to understand
	<ol style="list-style-type: none"> 1. Explain the concept and process of gene cloning. 2. Identify enzymes and vectors used in recombinant DNA technology.

	3. Describe the steps involved in cloning a gene.
	4. Illustrate applications of recombinant DNA technology in crop improvement.
Content Outline	<ul style="list-style-type: none"> • Concept of gene cloning and recombinant DNA technology. • Enzymes in gene cloning: <ul style="list-style-type: none"> • Restriction endonucleases <ul style="list-style-type: none"> ○ DNA ligase ○ Reverse transcriptase • Vectors used in gene cloning: <ul style="list-style-type: none"> ○ Plasmid vectors: pBR322, pUC18 ○ Plant-based vector: Ti-plasmid • Steps in gene cloning: isolation, insertion, transformation, screening. • Applications in agriculture: <ul style="list-style-type: none"> ○ Crop modification – genetically modified crops (Bt cotton, Golden Rice). ○ Disease resistance, herbicide tolerance. • Ethical and biosafety considerations.
Module 3 (Credit 1) – Practical's	
Learning Outcomes	After learning the module, learners will be able to understand
	1. Extract and handle DNA from biological material.
	2. Interpret DNA bands in gel electrophoresis.
	3. Differentiate DNA structures in prokaryotes and eukaryotes.
Content Outline	<p>Practical's</p> <ul style="list-style-type: none"> • Extraction of DNA from plant material (e.g., spinach or onion) – wet lab. • Visualization of DNA using agarose gel electrophoresis (demonstration). • Study of photomicrographs of DNA (prokaryotic vs eukaryotic). • Study of photomicrographs of RNA (mRNA, tRNA, rRNA). • Demonstration of DNA denaturation and renaturation. • Observation of replication forks using models/photographs. • Identification of enzymes involved in DNA replication through diagrammatic study. • Comparison of prokaryotic and eukaryotic replication using flowcharts/models.

Module 4 (Credit 1) – Practical's	
Learning Outcomes	After learning the module, learners will be able to understand
	1. Explain DNA ligation of fragments.
	2. Describe methods of bacterial transformation.
	3. Identify recombinant clones using screening methods.
	4. Explain recombinant gene integration in Ti-plasmids.
	5. Prepare a flowchart of the gene cloning process.
Content Outline	<p>Practical's</p> <ul style="list-style-type: none"> • Identification of cloning vectors using photographs (pBR322, pUC18, Ti-plasmid). • Study of restriction endonuclease recognition sites using diagrams/models. • Demonstration of restriction digestion of plasmid DNA (conceptual or video). • Study of transformation methods in bacteria (e.g., heat-shock, electroporation). • Screening of recombinant clones using blue-white selection (photographs). • Study of recombinant gene integration in plant Ti-plasmid (diagram/animation). • Preparation of a flowchart showing steps in gene cloning. • Assignment: Design a cloning strategy for a hypothetical gene. • Analysis of genetically modified crops: Bt cotton, Golden Rice – photographs & case study. • Study of ethical issues in recombinant DNA technology – discussion. • Class presentation: Applications of recombinant DNA technology in agriculture and medicine.

Assignments/Activities towards Comprehensive Continuous Evaluation (CCE)

- DNA Extraction Report – Extract DNA from plant material, document procedure, and analyze results.
- Gel Electrophoresis Demonstration – Observe DNA migration; interpret and submit a photo-based report.
- Study of Photomicrographs – Analyze DNA and RNA images; identify structural differences.
- Enzyme Function Assignment – Prepare a chart of DNA replication and cloning enzymes with their functions.
- Replication Fork Diagram – Draw and label DNA replication fork; explain semi-conservative replication.

- Cloning Vectors Identification – Study plasmid (pBR322, pUC18) and Ti-plasmid diagrams; prepare a comparative table.
- Flowchart of Gene Cloning – Design a stepwise diagram for gene cloning and transformation.
- Cloning Strategy Exercise – Plan a hypothetical gene cloning experiment.
- GM Crops Case Study – Research Bt cotton or Golden Rice; report on gene modification and applications.
- Ethics and Biosafety Discussion – Write a short essay on biosafety in recombinant DNA technology.
- Presentation – Present a mini-project on applications of recombinant DNA in agriculture or medicine.
- Problem-Solving Exercises – Predict products of replication or restriction digestion in hypothetical examples.
- Optional Demonstration – Observe PCR or DNA fingerprinting workflow and write a short report.

References:

1. Molecular Biology of the Cell – Bruce Alberts, 6th Edition (2014).
2. Molecular Cell Biology – Harvey Lodish, 8th Edition (2016).
3. Molecular Biology of the Gene – James D. Watson, 7th Edition (2013).
4. Lewin's Genes XI – Jocelyn E. Krebs, Elliott S. Goldstein, Stephen T. Kilpatrick, 11th Edition (2017).
5. Principles of Gene Manipulation and Genomics – Sandy B. Primrose & Richard Twyman, 8th Edition (2019).
6. Molecular Biology – David P. Clark & Nanette J. Pazdernik, 3rd Edition (2013).
7. Essential Cell Biology – Bruce Alberts et al., 4th Edition (2013).
8. Biotechnology: Principles and Techniques – H.C. Kumar, 3rd Edition (2015).

Semester – V

.5.4 Major (Elective)

Course Titles	Plant Pathology (Th+Pr)
Course Credits	4 Credit's (2 Th + 2 Pr)
Course Outcomes	After completing the course, learners will be able to:
	1. Identify major plant diseases and their causal organisms based on symptoms.
	2. Perform basic laboratory techniques such as slide preparation, culturing, and pathogen isolation.
	3. Describe disease development, disease cycle, and factors affecting plant diseases.
	4. Develop scientific observation, reporting, and problem-solving skills related to plant disease diagnosis and management.
Module 1 (Credit 1) – Fundamentals of Plant Pathology	
Learning Outcomes	After learning the module, learners will be able to understand
	1. Identify major causes and symptoms of plant diseases.
	2. Explain the role of environmental factors in disease spread.
	3. Discuss the economic importance of plant diseases in agriculture.
	4. Recognize the contributions of important plant pathologists.
	5. Apply fundamental knowledge for preliminary disease diagnosis.
Content Outline	<ul style="list-style-type: none"> • Introduction to Plant Pathology. • Important terminology: Host, Pathogen, Parasite, Symptoms, Disease, Infection, Inoculum. • History and importance of Plant Pathology. • Contributions of Anton de Bary and B. B. Mundkur. • Disease cycle: inoculation, penetration, infection, and dissemination. • Economic impact of plant diseases. • Plant disease epidemics and factors affecting disease development. • Introduction to disease management principles.
Module 2 (Credit 1) – Plant Diseases and Their Management	
Learning Outcomes	After learning the module, learners will be able to understand
	1. Identify common fungal, bacterial, viral, and oomycete plant diseases.
	2. Explain symptoms, causal organisms, and disease cycles of

	important crop diseases.
	3. Compare different methods of plant disease management.
	4. Describe physical, chemical, and biological control measures.
Content Outline	<ul style="list-style-type: none"> • Fungal diseases. <ul style="list-style-type: none"> ○ White rust of crucifers – Albugo candida. ○ Tikka disease of groundnut – Cercospora. • Bacterial diseases. <ul style="list-style-type: none"> ○ Citrus canker – Xanthomonas axonopodis. • Viral diseases. <ul style="list-style-type: none"> ○ Leaf curl disease of papaya. • Oomycete disease. <ul style="list-style-type: none"> ○ Damping off disease – Pythium. • Disease symptoms and disease cycle. • Physical methods of disease control. • Chemical methods of disease control. • Biological control and Integrated Disease Management (IDM).
Module 3 (Credit 1) – Practical's	
Learning Outcomes	After learning the module, learners will be able to understand
	1. Identify common plant diseases based on symptoms.
	2. Differentiate fungal, bacterial, and viral diseases.
	3. Prepare and observe temporary slides of infected material.
	4. Handle laboratory equipment and microscopes properly.
Content Outline	<p>Practical's</p> <ul style="list-style-type: none"> • Study of common plant disease symptoms (Leaf spot, Rust, Smut, Wilt, Blight, and Mosaic). • Identification of fungal pathogens using temporary slides. • Observation of bacterial disease symptoms. • Study of viral disease symptoms in crop plants. • Preparation of temporary mounts of infected plant material. • Use and handling of microscope in plant pathology. • Collection and preservation of diseased specimens. • Submission of practical record and disease album.
Module 4 (Credit 1) – Practical's	
Learning	After learning the module, learners will be able to understand

Outcomes	1. Perform basic sterilization and laboratory safety procedures.
	2. Prepare culture media and isolate plant pathogens.
	3. Demonstrate fungal culturing and subculturing techniques.
	4. Explain the importance of Koch's postulates in disease identification.
	5. Apply different disease management practices.
Content Outline	<p>Practical's</p> <ul style="list-style-type: none"> • Sterilization techniques used in plant pathology laboratory. • Preparation of culture media (PDA). • Isolation of fungi from infected plant parts. • Pure culture technique and subculturing. • Study of spore germination. • Demonstration of Koch's postulates. • Seed treatment methods. • Preparation and application of fungicides/Bordeaux mixture. • Biological control using bioagents (Trichoderma). • Field visit to observe diseased crops or plant clinic.

Assignments/Activities towards Comprehensive Continuous Evaluation (CCE)

- Seminar/Presentation on crop diseases.
- Quiz/MCQ tests.
- Field survey and report writing.
- Practical record book maintenance.
- Diseased specimen collection and herbarium.
- Slide preparation and pathogen identification.
- Laboratory demonstrations.
- Viva-voce / Mini project.

References:

1. Plant Pathology — George N. Agrios, 5th Edition, Academic Press/Elsevier.
2. Agrios' Plant Pathology — Richard Oliver, 6th Edition, Elsevier.
3. Essential Plant Pathology — 2nd Edition, APS Press.
4. Concise Encyclopedia of Plant Pathology — P. Vidhyasekaran, 1st Edition, CRC Press/Taylor & Francis.
5. Basic Plant Pathology Methods — 2nd Edition, CRC Press.
6. Plant Pathogens and Principles of Plant Pathology — Latest Edition, NIPA Publications.
7. Plant Pathology — 2024 Edition, New India Publishing Agency.

Semester – V

. 5.5. Minor Stream

Course Titles	Biostatistics (Th+Pr)
Course Credits	4 Credit's (2 Th + 2 Pr)
Course Outcomes	After completing the course, learners will be able to:
	1. Collect, organize, and represent biological data.
	2. Apply statistical measures, correlation, regression, and hypothesis testing.
	3. Analyze biological datasets using statistical tools and interpret results.
Module 1 (Credit 1) – Introduction to Biostatistics & Data Representation	
Learning Outcomes	After learning the module, learners will be able to understand
	1. Understand the role and importance of biostatistics in biological research.
	2. Classify and organize different types of data.
	3. Apply appropriate sampling methods.
	4. Construct frequency tables and graphical representations of data.
Content Outline	<ul style="list-style-type: none"> • Definition, scope, and applications of biostatistics in biology. • Types of data: qualitative and quantitative. • Collection of data, sampling methods. • Frequency distribution and data tabulation. • Graphical representation: bar diagram, histogram, pie chart, frequency polygon.
Module 2 (Credit 1) – Measures of Central Tendency and Dispersion	
Learning Outcomes	After learning the module, learners will be able to understand
	1. Calculate and interpret mean, median, and mode for given data sets.
	2. Determine measures of variability and understand their biological significance.
	3. Understand the use of standard error in data analysis.
	4. Apply these concepts to analyze experimental biological data.
Content Outline	<ul style="list-style-type: none"> • Mean, median, mode – calculation and interpretation. • Measures of dispersion: range, variance, standard deviation, coefficient of variation. • Standard error and its significance.

	<ul style="list-style-type: none"> • Practical applications in biological data.
Module 3 (Credit 1) – Practical's	
Learning Outcomes	After learning the module, learners will be able to understand
	1. Understand basic concepts of biostatistics and data types.
	2. Organize and tabulate biological data effectively.
	3. Represent data using appropriate graphs and diagrams.
Content Outline	<p>Practical's</p> <ul style="list-style-type: none"> • Introduction to Biostatistics. • Types of data: qualitative and quantitative data. • Data collection and classification. • Tabulation of biological data. • Graphical representation: <ul style="list-style-type: none"> ○ Bar diagram. ○ Histogram. ○ Pie chart. ○ Frequency polygon. • Measures of central tendency: <ul style="list-style-type: none"> ○ Mean. ○ Median. ○ Mode.
Module 4 (Credit 1) – Statistical Testing and Applications in Biology	
Learning Outcomes	After learning the module, learners will be able to understand
	1. Understand probability and sampling methods in research.
	2. Analyze and interpret experimental biological data.
	3. Develop basic data analysis skills for research work in botany.
Content Outline	<p>Practical's</p> <ul style="list-style-type: none"> • Measures of dispersion: <ul style="list-style-type: none"> ○ Range. ○ Variance. ○ Standard deviation. • Correlation and regression. • Probability concepts in biology. • Statistical tests. • Chi-square test.

	<ul style="list-style-type: none">• Sampling methods in biological studies.• Interpretation of biological experimental data.• Use of statistical software (introductory exposure).
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Assignments/Activities towards Comprehensive Continuous Evaluation (CCE)

- Collect biological data and prepare a dataset.
- Create frequency tables and graphs (bar, histogram, pie chart).
- Calculate mean, median, mode, and measures of dispersion (range, SD, CV).
- Perform correlation and regression analysis on paired data.
- Solve probability problems related to biology.
- Apply chi-square test and t-test on sample data.
- Conduct a mini-project or report analyzing biological data.
- Present findings using graphs and statistical interpretation.

References:

1. Biostatistics: A Foundation for Analysis in the Health Sciences – Wayne W. Daniel & Chad L. Cross, 10th Edition (2018).
2. Fundamentals of Biostatistics – Bernard Rosner, 8th Edition (2015).
3. Introduction to Biostatistics – Robert R. Sokal & F.J. Rohlf, 4th Edition (2012).
4. Practical Biostatistics – Indranil Samanta & Samir K. Ghosh, 2nd Edition (2019).
5. Statistics for Biologists – Campbell & Heyer, 2nd Edition (2006).
6. Biostatistics for the Biological and Health Sciences – Marc M. Triola & Mario F. Triola, 2nd Edition (2018).
7. Essentials of Biostatistics in Public Health – Lisa M. Sullivan, 3rd Edition (2017).

Semester – V

.5.6 Vocational Skill Courses (VSC-4)

Course Titles	Algal Technology
Course Credits	2 Credit's
Course Outcomes	After completing the course, learners will be able to:
	1. Identify and classify different algal groups using microscopic and macroscopic features.
	2. Apply laboratory techniques for culturing, isolating, and maintaining algae.
	3. Utilize algae for biotechnological applications like biomass production and biofertilizers.
	4. Analyze algal products and understand their commercial, ecological, and industrial relevance.
Module 1 (Credit 1)	
Learning Outcomes	After learning the module, learners will be able to understand
	1. Identify and classify algae based on morphological and microscopic features.
	2. Isolate and maintain pure algal cultures in the laboratory.
	3. Understand and observe asexual reproduction in different algal groups.
	4. Monitor and measure algal growth under controlled conditions.
Content Outline	<ul style="list-style-type: none"> • Collection and identification of algae from freshwater, marine, and soil samples. • Study of algal morphology using photomicrographs and preserved slides. • Isolation of algae from environmental samples (pond, soil, wastewater). • Preparation of pure algal cultures in agar and liquid media. • Measurement of algal growth using optical density or cell counting. • Observation of asexual reproduction – binary fission, fragmentation, spore formation.
Module 2 (Credit 1)	
Learning Outcomes	After learning the module, learners will be able to understand
	1. Examine sexual reproduction in algae and differentiate between types.
	2. Quantify algal biomass and assess chlorophyll content.

	3. Identify commercial products derived from algae and understand their applications.
	4. Apply algae in biofertilization and study environmental factors affecting growth.
Content Outline	<ul style="list-style-type: none"> • Study of sexual reproduction – isogamy, anisogamy, oogamy in selected algae. • Preparation and estimation of algal biomass – harvesting and drying techniques. • Estimation of chlorophyll content using extraction methods or spectrophotometry. • Study of commercially important algal products – agar, carrageenan, alginate. • Application in biofertilizers – nitrogen-fixing algae and cyanobacteria in soil enrichment. • Observation of environmental effects on algal growth – light, temperature, and nutrient variations.

Assignments/Activities towards Comprehensive Continuous Evaluation (CCE)

- Collect and record algae from different habitats.
- Identify algae using slides or photomicrographs.
- Prepare algal cultures in liquid and agar media.
- Isolate and maintain pure algal strains.
- Measure algal growth and plot graphs.
- Observe asexual and sexual reproduction.

References:

1. Algae: An Introduction to Phycology – C.J. Alexopoulos & C.W. Mims, 3rd Edition (2007).
2. Phycology – R.R. Rao & S.P. Sarma, 2nd Edition (2010).
3. Textbook of Algae – B.G. Platt, 2nd Edition (2005).
4. Handbook of Phycological Methods – A. Krishnamurthy, 1st Edition (2012).
5. Algal Biotechnology – S.S. Lele, 1st Edition (2015).
6. A Textbook of Algae – S. Parameswaran, 1st Edition (2010).
7. Algal Cultures and Biotechnology – Amos Richmond, 1st Edition (2004).
8. Introduction to Algae and their Biotechnology – A.K. Sharma & R.K. Agarwal, 1st Edition (2016).

Semester – V

.5.7 Field Projects (FP)

Course Titles	Field Projects (Pr)
Course Credits	2 Credit's
Course Outcomes	After going through the course, learners will be able to practically experience vegetation in the field.
	1. Learners will be able to practically study and identify vegetation in the field.
	2. After completing the field project, learners will be able to observe, document, and analyze plant diversity in natural habitats.
	3. Learners will gain hands-on experience in field-based botanical studies and vegetation assessment.
	4. Students will be able to apply botanical concepts for the identification and classification of plants during field visits.
	5. The course will enable learners to develop practical skills in vegetation survey and ecological observation.
Module 1 (Credit 1)	
Learning Outcomes	After learning the module, learners will be able to understand
	1. Identify and classify common plant species in different habitats.
	2. Understand the ecological significance of diverse vegetation types.
	3. Develop practical skills in plant collection, preservation, and herbarium preparation.
	4. Record and document field observations systematically.
	5. Identify and classify common plant species in different habitats.
Content Outline	<ul style="list-style-type: none"> • Field visits to local and outside areas to understand different types of habitats and ecosystems. • Study of flora in botanical gardens, rural areas, forests, wetlands, and urban ecosystems. • Observation and identification of plant diversity using morphological characters. • Field excursions, nature trails, and tree walks for ecological understanding and biodiversity assessment. • Collection, preservation, and documentation of plant specimens. • Preparation of herbarium specimens with proper labeling and scientific identification. • Maintenance of a field record book and preparation of a detailed tour report.

Module 2 (Credit 1)	
Learning Outcomes	After learning the module, learners will be able to understand
	1. Understand the basic principles of Remote Sensing and GIS in plant sciences.
	2. Apply geospatial tools for vegetation and habitat analysis.
	3. Use GPS and digital applications for field-based botanical studies.
	4. Interpret ecological and spatial data for biodiversity assessment.
Content Outline	<ul style="list-style-type: none"> • Introduction to Remote Sensing and Geographic Information System (GIS) in botanical and ecological studies. • Application of GIS in vegetation mapping, biodiversity assessment, and habitat analysis. • Use of digital tools and mobile applications for plant identification and ecological surveys. • Basics of GPS handling, geo-tagging, and field data collection. • Interpretation of satellite imagery for vegetation and land-use studies. • Introduction to ethnobotanical studies and the role of plants in rural livelihoods. • Mini field-based project on habitat mapping or vegetation analysis.

Assignments/Activities towards Comprehensive Continuous Evaluation (CCE)

- Field Record Book.
- Herbarium Preparation (10 specimens).
- Field Visit / Tour Report.
- Plant Identification Assignment.
- GIS & Remote Sensing Activity.
- Seminar / Group Presentation.
- Mini Project on Vegetation Study.
- Nature Trail / Tree Walk Observation Notes.
- Quiz / Viva Voce.

Course Syllabus

Semester – VI

.6.1 Major (Core)

Course Titles	Embryology (Th+Pr)
Course Credits	4 Credit's (2 Th + 2 Pr)
Course Outcomes	After going through the course, learners will be able to
	1. Understand the basic concepts of plant embryology and reproductive biology in angiosperms.
	2. Describe the structure and development of anther, microsporangium, and pollen grain.
	3. Explain microsporogenesis and development of male gametophyte.
	4. Identify different types of ovules and explain megasporogenesis.
	5. Describe embryo sac structure and types of female gametophyte development.
Module 1 (Credit 1) – Gametophyte Development	
Learning Outcomes	After learning the module, learners will be able to understand
	1. Explain reproductive biology in angiosperms.
	2. Describe microsporangium structure and male gametophyte development.
	3. Identify types of ovules.
	4. Explain mega gametogenesis and embryo sac development.
Content Outline	<ul style="list-style-type: none">• Introduction to Reproductive Biology in Angiosperms.• Structure and development of microsporangium.• Structure of mature anther.• Micro gametogenesis and development of male gametophyte (pollen grain).• Structure of typical angiosperm ovule.• Types of ovules.• Mega gametogenesis and development of female gametophyte (embryo sac).• Types of embryo sac development.
Module 2 (Credit 1) – Endosperm and Embryogenesis	
Learning Outcomes	After learning the module, learners will be able to understand
	1. Describe types and importance of endosperm.
	2. Explain zygote structure and embryogenesis.

	3. Differentiate between dicot and monocot embryo development.
	4. Understand the role of embryo and endosperm in seed development.
Content Outline	<ul style="list-style-type: none"> • Endosperm: types, development, and biological importance. • Structure and composition of zygote. • Embryogenesis in angiosperms. • Development of dicot embryo. • Development of monocot embryo. • Comparative study of dicot and monocot embryogenesis. • Significance of embryo and endosperm in seed development.
Module 3 (Credit 1) – Practical's	
Learning Outcomes	After learning the module, learners will be able to understand
	1. Understand the process of microsporogenesis.
	2. Explain the development of male gametophyte.
	3. Perform temporary mounting techniques for pollen study.
Content Outline	<p>Practical's</p> <ol style="list-style-type: none"> 1. Study of permanent slides of microsporogenesis. 2. Study of permanent slides of male gametophyte development. 3. Temporary mounting of pollen grains. 4. Study of different types of pollen grains. 5. In vitro pollen germination experiment. 6. Observation and identification of anther structure and pollen morphology.
Module 4 (Credit 1) – Practical's	
Learning Outcomes	After learning the module, learners will be able to understand
	1. Identify different types of ovules and placentation.
	2. Explain the process of megasporogenesis and embryo sac development.
	3. Perform mounting and microscopic observation of embryos.
Content Outline	<p>Practical's</p> <ul style="list-style-type: none"> • Study of permanent slides of different types of ovules. • Study of megasporogenesis using permanent slides. • Study of embryo sac development through permanent slides. • Study of different types of placentation. • Temporary mounting and observation of embryo.

	<ul style="list-style-type: none">• Identification and comparative study of monocot and dicot embryos.
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Assignments/Activities towards Comprehensive Continuous Evaluation (CCE)

- Practical Record Book Submission.
- Slide Identification Test.
- Pollen Germination Experiment Report.
- Diagram Drawing and Labeling.
- Viva Voce on Reproductive Structures.
- Herbarium / Specimen Observation Report.
- Seminar / Presentation on Plant Embryology.
- Quiz on Gametophyte and Embryogenesis.

References:

1. An Introduction to Embryology of Angiosperms — P. Maheshwari, 5th Edition.
2. Plant Embryology — S. S. Bhojwani & S. P. Bhatnagar, Revised Edition.
3. Embryology of Angiosperms — S. S. Bhojwani & S. P. Bhatnagar, Latest Edition.
4. Plant Anatomy — B. P. Pandey, Revised Edition.
5. A Textbook of Botany — B. P. Pandey, Latest Edition.
6. Plant Systematics — Gurcharan Singh, 4th Edition.
7. Botany for Degree Students: Embryology, Genetics and Plant Breeding — P. S. Verma & V. K. Agarwal, Latest Edition.
8. Plant Morphology — R. N. Pandey & A. Malhotra, Latest Edition.

Semester – VI**.6.2 Major (Core)**

Course Titles	Genetics (Th+Pr)
Course Credits	4 Credit's (2 Th + 2 Pr)
Course Outcomes	After going through the course, learners will be able to
	1. Understand the fundamental principles of Mendelian inheritance.
	2. Explain the chromosomal theory of inheritance and gene location on chromosomes.
	3. Distinguish between autosomes and sex chromosomes and their role in inheritance.
	4. Analyze different patterns of inheritance such as dominance, co-dominance, incomplete dominance, epistasis, and pleiotropy.
	5. Explain multiple alleles, lethal genes, and extrachromosomal inheritance.
	6. Understand linkage, crossing over, and construct basic chromosome maps.
Module 1 (Credit 1) – Mendelian Genetics and Chromosomal Basis	
Learning Outcomes	After learning the module, learners will be able to understand
	1. Explain Mendelian principles of inheritance.
	2. Describe chromosomal theory and sex determination.
	3. Interpret patterns like dominance, epistasis, and pleiotropy.
	4. Explain multiple alleles and extrachromosomal inheritance.
Content Outline	<ul style="list-style-type: none"> • Mendelian genetics: principles of inheritance. • Mendel's laws of inheritance. • Chromosome theory of inheritance. • Autosomes and sex chromosomes. • Dominant and recessive traits. • Incomplete dominance and co-dominance. • Multiple alleles, lethal alleles, epistasis, pleiotropy. • Extrachromosomal (cytoplasmic) inheritance.
Module 2 (Credit 1) – Linkage and Population Genetics	
Learning Outcomes	After learning the module, learners will be able to understand
	1. Explain linkage, crossing over, and gene mapping.
	2. Describe sex-linked inheritance.
	3. Apply Hardy-Weinberg law in population studies.

	4. Understand genetic drift, variation, and speciation.
Content Outline	<ul style="list-style-type: none"> • Linkage and crossing over. • Chromosome mapping. • Sex linkage and sex-linked inheritance. • Population genetics and evolutionary genetics. • Hardy-Weinberg equilibrium law. • Genetic drift. • Genetic variation and mechanisms of speciation.
Module 3 (Credit 1) – Practical's	
Learning Outcomes	After learning the module, learners will be able to understand
	1. Interpret Mendelian laws using seed ratios.
	2. Analyze monohybrid and dihybrid crosses.
	3. Understand incomplete dominance using practical examples.
Content Outline	<p>Practical's</p> <ul style="list-style-type: none"> • Study of Mendel's laws using monohybrid seed ratios. • Study of dihybrid ratios using seed characters. • Analysis of segregation ratio (3:1) using seed traits. • Analysis of independent assortment (9:3:3:1) using seed ratios. • Study of incomplete dominance through seed/flower color ratios. • Gene interaction (epistasis) problems using seed ratio interpretation. • Numerical problems based on Mendelian inheritance and ratio analysis.
Module 4 (Credit 1) – Practical's	
Learning Outcomes	After learning the module, learners will be able to understand
	1. Construct and interpret pedigree charts.
	2. Differentiate between autosomal and sex-linked traits.
	3. Identify dominant and recessive inheritance patterns in humans.
Content Outline	<p>Practical's</p> <ul style="list-style-type: none"> • Construction and interpretation of simple pedigree charts. • Analysis of autosomal dominant inheritance patterns. • Analysis of autosomal recessive inheritance patterns. • Study of sex-linked (X-linked) dominant traits. • Study of sex-linked (X-linked) recessive traits. • Identification of inheritance patterns from given case studies.

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| | <ul style="list-style-type: none">• Solving pedigree-based genetic problems and interpretation. |
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Assignments/Activities towards Comprehensive Continuous Evaluation (CCE)

- Problem solving on Mendelian ratios and seed genetics.
- Worksheet on incomplete dominance and gene interaction.
- Pedigree chart construction and interpretation.
- Case study analysis of autosomal and sex-linked traits.
- Numerical assignments on genetic crosses.
- Class test / quiz on Mendelian laws and inheritance patterns.
- Diagrammatic representation of pedigree charts.
- Viva voce on practical experiments.
- Short seminar / presentation on human genetic traits.
- Practical record book submission.

References:

1. Principles of Genetics — D. Peter Snustad & Michael J. Simmons.
2. Genetics: Analysis and Principles — Robert J. Brooker.
3. Principles of Genetics — Eldon J. Gardner, Michael J. Simmons & D. Peter Snustad.
4. An Introduction to Genetic Analysis — Anthony J. F. Griffiths, Susan R. Wessler, Sean B. Carroll & John Doebley.
5. Genetics — P. K. Gupta.
6. Principles of Genetics — D. P. Singh.
7. Textbook of Genetics — V. K. Agarwal & S. R. Singh.

Semester – VI

.6.3. A. Major (Elective)

Course Titles	Plant Breeding (Th+Pr)
Course Credits	4 Credit's (2 Th + 2 Pr)
Course Outcomes	After going through the course, learners will be able to
	1. Understand the basic concepts and principles of plant breeding and crop improvement.
	2. Explain different breeding systems and methods used in crop improvement.
	3. Apply selection methods in self-pollinated and cross-pollinated crops.
	4. Describe hybridization techniques and their role in developing improved crop varieties.
	5. Understand vegetative propagation and its significance in agriculture.
6. Explain quantitative inheritance and the genetic basis of complex traits.	
Module 1 (Credit 1) – Breeding Systems and Selection	
Learning Outcomes	After learning the module, learners will be able to understand
	1. Explain plant breeding systems.
	2. Describe methods of crop improvement.
	3. Differentiate selection methods in plants.
4. Understand vegetative propagation.	
Content Outline	<ul style="list-style-type: none">• Breeding systems in plants.• Methods of crop improvement.• Selection methods in self-pollinated and cross-pollinated plants.• Types of vegetative propagation in plants.
Module 2 (Credit 1) – Hybridization Techniques	
Learning Outcomes	After learning the module, learners will be able to understand
	1. Explain hybridization in plants.
	2. Differentiate self and cross hybridization.
	3. Describe artificial hybridization methods.
4. Understand its role in crop improvement.	
Content Outline	<ul style="list-style-type: none">• Hybridization: self, cross and vegetative hybridization.• Techniques of artificial hybridization.• Role of hybridization in crop improvement.

	<ul style="list-style-type: none"> Controlled pollination methods.
Module 3 (Credit 1) – Practical's	
Learning Outcomes	After learning the module, learners will be able to understand
	1. Understand basic principles of plant breeding and crop improvement.
	2. Identify floral structures suitable for hybridization.
	3. Perform emasculation, bagging, and controlled pollination techniques.
Content Outline	<p>Practical's</p> <ul style="list-style-type: none"> Introduction to Plant Breeding. Study of crop plant variability and selection methods. Emasculation techniques in self-pollinated crops. Bagging and tagging of flowers. Controlled pollination techniques. Study of floral biology of crop plants. Methods of artificial hybridization. Maintenance of breeding records.
Module 4 (Credit 1) – Practical's	
Learning Outcomes	After learning the module, learners will be able to understand
	1. Understand hybrid seed production and heterosis concepts.
	2. Evaluate improved crop varieties based on desirable traits.
	3. Gain exposure to mutation breeding and germplasm conservation.
Content Outline	<ul style="list-style-type: none"> Study of selection methods (mass, pure line, clonal selection). Hybrid seed production techniques. Study of heterosis and inbreeding depression (demonstration). Evaluation of improved crop varieties. Study of mutation breeding techniques (theoretical + demonstration). Germplasm collection and conservation methods.

Assignments/Activities towards Comprehensive Continuous Evaluation (CCE)

- Problem-based assignment on selection methods in crops.
- Chart/diagram of plant breeding systems.
- Worksheet on hybridization techniques.
- Case study on heterosis in crop improvement.
- Short notes on quantitative inheritance examples.

- Viva voce on vegetative propagation methods.
- Quiz on mutation breeding concepts.
- Seminar / presentation on crop improvement strategies.

References:

1. Principles of Plant Breeding — Robert W. Allard, 2nd Edition.
2. Plant Breeding: Principles and Methods — B. D. Singh, Latest Edition.
3. Plant Breeding — D. N. Bhojwani & S. S. Bhatnagar, Revised Edition.
4. Principles of Plant Genetics and Breeding — George Acquaah, 2nd Edition.
5. Plant Breeding — M. D. Hayward, N. O. Bosemark & I. Romagosa.
6. Plant Breeding — S. K. Gupta, Latest Edition.

Semester – VI

.6.3 B. Major (Elective)

Course Titles	Ecology (Th+Pr)
Course Credits	4 Credit's (2 Th + 2 Pr)
Course Outcomes	After going through the course, learners will be able to
	1. Analyze interactions between organisms and their environment, including biotic and abiotic factors.
	2. Develop awareness of conservation strategies and sustainable development practices for environmental protection.
	3. Apply field techniques such as quadrat and transect methods for ecological data collection and analysis.
Module 1 (Credit 1) – Fundamentals of Ecology	
Learning Outcomes	After learning the module, learners will be able to understand
	1. Explain basic ecological concepts and terminology.
	2. Describe the effects of abiotic and biotic factors on organisms.
	3. Differentiate levels of ecological organization.
	4. Interpret population characteristics and ecological adaptations.
Content Outline	<ul style="list-style-type: none"> • Introduction and scope of Ecology. • Levels of organization: organism, population, community, ecosystem. • Abiotic factors: light, temperature, water and soil. • Biotic interactions: mutualism, parasitism, predation and competition. • Population ecology: population growth and ecological adaptations. • Ecological succession – hydrosere and xerosere.
Module 2 (Credit 1) – Ecosystem and Environmental Conservation	
Learning Outcomes	After learning the module, learners will be able to understand
	1. Describe ecosystem structure and ecological relationships.
	2. Explain energy flow and ecological pyramids.
	3. Discuss major biogeochemical cycles.
	4. Understand the importance of biodiversity conservation.
Content Outline	<ul style="list-style-type: none"> • Ecosystem: structure and functions. • Food chain, food web and ecological pyramids. • Energy flow in ecosystem. • Biogeochemical cycles: carbon and nitrogen cycles.

	<ul style="list-style-type: none"> • Biodiversity and its importance. • Environmental pollution: air, water and soil pollution. • Conservation of natural resources and sustainable development.
Module 3 (Credit 1) – Practical's	
Learning Outcomes	After learning the module, learners will be able to understand
	1. Use basic ecological instruments properly.
	2. Analyze soil and environmental parameters.
	3. Study vegetation using quadrat methods.
Content Outline	<p>Practical's</p> <ul style="list-style-type: none"> • Study of ecological instruments: thermometer, hygrometer, rain gauge, lux meter. • Determination of soil pH and soil moisture. • Study of aquatic and terrestrial habitats. • Quadrat method for vegetation analysis. • Frequency, density and abundance calculations. • Field visit and ecological observations.
Module 4 (Credit 1) – practical's	
Learning Outcomes	After learning the module, learners will be able to understand
	1. Perform basic water quality analysis.
	2. Identify biodiversity and pollution indicators.
	3. Interpret ecological data and environmental observations.
Content Outline	<p>Practical's</p> <ul style="list-style-type: none"> • Estimation of dissolved oxygen in water samples. • Determination of water pH and water quality. • Study of biodiversity in local habitats. • Preparation of ecological charts and diagrams. • Study of pollution indicators. • Study of food chains and food webs. • Mini project/field report on environmental issues.

Assignments/Activities towards Comprehensive Continuous Evaluation (CCE)

- Problem-solving assignment based on structure and functioning of ecosystems.
- Preparation of charts/diagrams illustrating ecological pyramids and food chains/food webs.
- Completion of worksheets on population growth models and carrying capacity concepts.

- Case study analysis on biodiversity decline in a local ecosystem.
- Writing short notes on ecological succession with examples of hydrosere and xerosere.
- Viva voce based on ecological instruments and field methods such as quadrat and transect techniques.
- Quiz assessment on biogeochemical cycles and environmental pollution topics.
- Seminar/presentation on climate change impacts and biodiversity conservation strategies.

References:

1. Principles of Plant Breeding — Robert W. Allard, 2nd Edition
2. Plant Breeding: Principles and Methods — B. D. Singh, Latest Edition
3. Plant Breeding — D. N. Bhojwani & S. S. Bhatnagar, Revised Edition
4. Principles of Plant Genetics and Breeding — George Acquaah, 2nd Edition
5. Plant Breeding — M. D. Hayward, N. O. Bosemark & I. Romagosa
6. Plant Breeding — S. K. Gupta, Latest Edition

Semester – VI

.6.4 Minor Stream

Course Titles	Bioinformatics
Course Credits	2 Credit's
Course Outcomes	After going through the course, learners will be able to
	1. Understand the fundamental concepts and scope of bioinformatics in biological sciences.
	2. Explain biological data organization and major biological databases.
	3. Describe NCBI data models and their applications in data storage and retrieval.
	4. Use biological databases for retrieving nucleotide and protein information.
5. Perform sequence similarity searches using BLAST.	
Module 1 (Credit 1) – Introduction to Bioinformatics and Biological Databases	
Learning Outcomes	After learning the module, learners will be able to understand
	1. Understand the basic concepts and scope of bioinformatics.
	2. Explain the organization of biological data.
	3. Describe NCBI data models and biological databases.
4. Identify different types of biological databases and their applications.	
Content Outline	<ul style="list-style-type: none">• Introduction to Bioinformatics and its scope in life sciences.• Organization of biological data.• NCBI data models.• Major biological databases (GenBank, protein databases, genome databases).• Data retrieval systems and database structure.
Module 2 (Credit 1) – Bioinformatics Tools and Applications	
Learning Outcomes	After learning the module, learners will be able to understand
	1. Use Entrez for biological data retrieval.
	2. Perform basic sequence alignment using BLAST.
	3. Visualize biomolecular structures using RASMOL.
4. Understand applications of bioinformatics tools in research.	
Content Outline	<ul style="list-style-type: none">• Data retrieval tools: Entrez system.• Sequence analysis tool: BLAST (Basic Local Alignment Search Tool).

	<ul style="list-style-type: none">• Molecular visualization tools: RASMOL.• Applications of bioinformatics in genomics and proteomics.• Introduction to computational tools used in biological research.
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Assignments/Activities towards Comprehensive Continuous Evaluation (CCE)

- Database search assignments using NCBI/Entrez.
- BLAST analysis exercise and result interpretation.
- Protein or DNA sequence retrieval activity.
- Molecular visualization practice using RASMOL.
- Worksheet on biological databases and data organization.
- Quiz on bioinformatics tools and applications.
- Short report on genome/protein database exploration.
- Practical record book submission.
- Viva voce on tools like BLAST and Entrez.
- Mini project on sequence analysis or database study.

References:

1. Odum, E. P. & Barrett, G. W. — Fundamentals of Ecology, 5th Edition, Cengage Learning.
2. Chapman, J. L. & Reiss, M. J. — Ecology: Principles and Applications, Cambridge University Press.
3. Sharma, P. D. — Ecology and Environment, 13th Edition, Rastogi Publications.
4. Krebs, C. J. — Ecology: The Experimental Analysis of Distribution and Abundance, Pearson.
5. Smith, R. L. & Smith, T. M. — Elements of Ecology, 9th Edition, Pearson.
6. Kumar, H. D. — Modern Concepts of Ecology, 10th Edition, Vikas Publishing House.
7. Singh, J. S., Singh, S. P. & Gupta, S. R. — Ecology, Environmental Science and Conservation, S. Chand Publishing.

Semester – VI**.6.5 Minor Stream**

Course Titles	Plant Biotechnology (Th+Pr)
Course Credits	4 Credit's (2 Th + 2 Pr)
Course Outcomes	After going through the course, learners will be able to
	1. Understand the basic concepts and scope of plant biotechnology.
	2. Explain the principles of plant tissue culture and totipotency.
	3. Describe culture media composition, preparation, and sterilization techniques.
	4. Perform basic plant tissue culture techniques such as callus induction and explant culture.
5. Understand somatic embryogenesis, organogenesis, and Soma clonal variation.	
Module 1 (Credit 1)	
Learning Outcomes	After learning the module, learners will be able to understand
	1. Explain totipotency and basics of tissue culture.
	2. Describe culture media and sterilization techniques.
	3. Differentiate callus and suspension cultures.
4. Explain meristem culture and plant regeneration methods.	
Content Outline	<ul style="list-style-type: none"> • Totipotency of plant cells. • Plant tissue culture: principles and scope. • Culture media: composition, types, preparation and sterilization. • Callus culture and suspension culture. • Meristem culture and its applications. • Somaclonal variation: concept and significance. • Somatic embryogenesis and organogenesis.
Module 2 (Credit 1) – Advanced Tissue Culture Techniques	
Learning Outcomes	After learning the module, learners will be able to understand
	1. Explain synthetic seeds and haploid production.
	2. Describe anther culture and protoplast culture.
	3. Understand somatic hybridization and cybrids.
4. Discuss applications of tissue culture in plant improvement.	
Content Outline	<ul style="list-style-type: none"> • Synthetic seeds production. • Anther culture and production of haploids.

	<ul style="list-style-type: none"> • Protoplast culture. • Somatic hybridization and cybrid formation. • Applications of plant tissue culture in crop improvement. • Genetic manipulation and plant breeding applications.
Module 3 (Credit 1) – Practical's	
Learning Outcomes	After learning the module, learners will be able to understand
	1. Understand the organization of a plant tissue culture laboratory.
	2. Identify and use basic laboratory equipment.
	3. Apply different sterilization techniques effectively.
Content Outline	<p>Practical's</p> <ul style="list-style-type: none"> • Layout and organization of plant tissue culture laboratory. • Study and handling of basic laboratory instruments and glassware. • Demonstration of sterilization techniques (dry heat and moist heat). • Chemical sterilization methods for laboratory materials. • Preparation of stock solutions for MS medium. • Calculation and preparation of MS medium components. • Preparation of complete MS medium for plant tissue culture.
Module 4 (Credit 1) – Practical's	
Learning Outcomes	After learning the module, learners will be able to understand
	1. Perform aseptic techniques in plant tissue culture.
	2. Sterilize seeds using appropriate methods.
	3. Inoculate seeds and explants successfully in sterile conditions.
	4. Select suitable explants for tissue culture studies.
Content Outline	<p>Practical's</p> <ul style="list-style-type: none"> • Demonstration of aseptic techniques in laminar airflow cabinet. • Surface sterilization of seeds using chemical agents. • Seed inoculation under sterile conditions. • Explant selection and preparation. • Inoculation of explants onto MS medium. • Maintenance of in vitro cultures under controlled conditions. • Observation and recording of culture growth responses.

Assignments/Activities towards Comprehensive Continuous Evaluation (CCE)

- Practical record book submission.
- MS medium preparation worksheet.
- Sterilization techniques demonstration report.
- Seed sterilization and inoculation practical assessment.
- Viva voce on tissue culture techniques.
- Quiz on plant biotechnology concepts.
- Diagram/flowchart of tissue culture process.
- Short assignment on somatic embryogenesis or organogenesis.
- Seminar / presentation on applications of plant biotechnology.
- Mini project report on in vitro culture techniques.

References:

1. Plant Biotechnology — S. S. Purohit, Latest Edition.
2. Plant Tissue Culture: Theory and Practice — S. S. Bhojwani & M. K. Razdan, Revised Edition.
3. Plant Biotechnology — H. S. Chawla, 3rd Edition.
4. Plant Tissue Culture and Biotechnology — K. K. De, Latest Edition.
5. Principles of Plant Biotechnology — S. N. Jain, Latest Edition.
6. Plant Biotechnology — B. D. Singh, Latest Edition.
7. Biotechnology: Fundamentals and Applications — S. S. Purohit & others (reference text).

Semester – VI

.6.6 On Job Training

Course Titles	On Job Training (Pr)
Course Credits	4 Credit's
Course Outcomes	After going through the course, learners will be able to
	Apply classroom knowledge in real workplace environments related to plant sciences.
	1. Understand the functioning of plant-based industries such as tissue culture labs, nurseries, horticultural units, and Ayurvedic institutes.
	2. Develop practical skills in plant propagation, cultivation, and maintenance techniques.
	3. Demonstrate workplace discipline, ethics, and safety practices.
	4. Improve communication, teamwork, and interpersonal skills in professional settings.
	5. Enhance problem-solving and critical thinking abilities in real-time situations.
Module1 (Credit 1)	
Learning Outcomes	After learning the module, learners will be able to understand
	1. Understand the purpose and scope of OJT in plant sciences.
	2. Relate academic knowledge to real-world workplace settings.
	3. Identify different plant-based industrial training sectors.
	4. Demonstrate basic workplace ethics and safety awareness.
Content Outline	<ul style="list-style-type: none"> • Concept and objectives of On-the-Job Training (OJT). • Alignment of classroom learning with workplace requirements. • Overview of plant-based industries (tissue culture labs, nurseries, horticulture institutes, Ayurvedic institutes). • Workplace ethics, discipline, and safety practices.
Module 2 (Credit 1)	
Learning Outcomes	After learning the module, learners will be able to understand
	1. Gain hands-on experience in plant-based work environments.
	2. Apply basic techniques of plant propagation and maintenance.
	3. Understand nursery and horticultural operations.
	4. Observe industrial applications of plant sciences.
Content Outline	<ul style="list-style-type: none"> • Practical exposure to plant tissue culture laboratories. • Nursery management and horticultural practices.

	<ul style="list-style-type: none"> • Basic techniques in propagation and plant maintenance. • Observation of Ayurvedic and medicinal plant processing units.
Module 3 (Credit 1)	
Learning Outcomes	After learning the module, learners will be able to understand
	1. Develop effective communication skills in professional environments.
	2. Work collaboratively in teams during field/lab activities.
	3. Apply problem-solving skills to practical tasks.
Content Outline	<ul style="list-style-type: none"> • Communication skills in workplace settings. • Teamwork and collaboration in field/lab environments. • Problem-solving and critical thinking in practical situations. • Documentation and reporting of work activities.
Module 4 (Credit 1)	
Learning Outcomes	After learning the module, learners will be able to understand
	1. Perform assigned tasks in real workplace environments.
	2. Integrate theoretical knowledge with practical applications.
Content Outline	<ul style="list-style-type: none"> • Structured OJT in selected discipline (tissue culture, nursery, horticulture, Ayurveda, etc.). • Real-time workplace assignments and tasks. • Interaction with industry professionals. • Final training report preparation and presentation.

Assignments/Activities towards Comprehensive Continuous Evaluation (CCE)

- Daily/weekly training logbook maintenance.
- Supervisor/mentor feedback report.
- Workplace task completion record.
- Observation report of assigned industry/lab/nursery activities.
- Problem-solving case study from training site.
- Communication skill assessment (oral presentation/interview).
- Final OJT report submission.
- Seminar / presentation on training experience.
- Viva voce based on field experience.
- Attendance and discipline evaluation by training institute