



BHARATHIDASAN UNIVERSITY, TIRUCHIRAPPALLI - 620 024.

M.Sc. BOTANY

**CHOICE BASED CREDIT SYSTEM -
LEARNING OUTCOMES BASED CURRICULUM FRAMEWORK (CBCS - LOCF)**

(Applicable to the candidates admitted from the academic year 2026 - 2027 onwards)

Sem.	Course	Course Title	Ins. Hrs.	Credit	Exam Hrs.	Marks		Total
						Int.	Ext.	
I	Core Course - 1 (CC - 1)	Plant Diversity – I Algae, Fungi, Lichens and Bryophytes	6	4	3	30	70	100
	Core Course - 2 (CC - 2)	Plant Diversity – II Pteridophytes, Gymnosperms and Paleobotany	6	4	3	30	70	100
	Core Practical - 1 (CP - 1)	Plant Diversity I and Plant Diversity II	6	4	3	40	60	100
	Discipline Centric Elective Course - 1 (DCEC - 1)	Any one from the list	5	4	3	30	70	100
	Generic Elective Course - 1 (GEC - 1)	Any one from the list	5	3	3	30	70	100
	Skill Enhancement Course - 1 (SEC - 1)	Biodiversity Conservation	2	2	3	30	70	100
	Value Added Course - 1 (VAC - 1) *	Food Technology	-	2*		30	70	100*
Total			30	21	-	-	-	600
II	Core Course - 3 (CC - 3)	Advanced Plant Anatomy, Embryology and Morphogenesis	6	4	3	30	70	100
	Core Course - 4 (CC - 4)	Microbiology and Plant Pathology	6	4	3	30	70	100
	Core Practical - 2 (CP - 2)	Advanced Plant Anatomy, Embryology and Morphogenesis, Microbiology and Plant Pathology	6	4	3	40	60	100
	Discipline Centric Elective Course - 2 (DCEC - 2)	Any one from the list	4	4	3	30	70	100
	Generic Elective Course - 2 (GEC - 2)	Any one from the list	4	3	3	30	70	100
	Skill Enhancement Course - 2 (SEC - 2)	Plant Tissue Culture	2	2		30	70	100
	Non-Major Elective Course - 1 (NMEC - 1)	One Course from Outside Department	2	2	3	30	70	100
Total			30	23	-	-	-	700
Summer Internship / Industrial Activity during the Summer Vacation after 1st Year								

III	Core Course - 5 (CC - 5)	Taxonomy of Angiosperms	6	4	3	30	70	100
	Core Course - 6 (CC - 6)	Genetics and Evolution	6	4	3	30	70	100
	Core Practical - 3 (CP - 3)	Taxonomy of Angiosperms, Genetics and Evolution	6	4	2	40	60	100
	Discipline Centric Elective Course - 3 (DCEC - 3)	Any one from the list	5	4	2	30	70	100
	Generic Elective Course - 3 (GEC - 3)	Any one from the list	5	3	3	30	70	100
	Non-Major Elective Course - 2 (NMEC - 2)	One Course from Outside Department	2	2	3	30	70	100
	Internship / Industrial Activity @			2		20	80	100
	Total		30	23	-	-	-	700
IV	Core Course - 7 (CC - 7)	Plant Physiology	6	4	3	30	70	100
	Core Course - 8 (CC - 8)	Biochemistry and Biophysics	6	4	3	30	70	100
	Core Practical - 4 (CP - 4)	Plant Physiology, Biochemistry and Biophysics	6	4	3	40	60	100
	Discipline Centric Elective Course - 4 (DCEC - 4)	Any one from the list	4	4	2	30	70	100
	Entrepreneurship / Industry Based Course @	Bio Entrepreneurship	3	3	3	30	70	100
	Project Work @		5	5	-	20	80	100
	Value Added Course - 2 (VAC - 2) *	Floriculture	-	2*		30	70	100*
	Total		30	24	-	-	-	600
Grand Total				91				2600

LIST OF DISCIPLINE CENTRIC ELECTIVE COURSE

Discipline Centric Elective Course - 1 (DCEC - 1)	
1.	Ecology, Phytogeography and Climate Change
2.	Forestry and Wood Science
Discipline Centric Elective Course - 2 (DCEC - 2)	
1.	Horticulture and Plant Breeding
2.	Green House Technology
Discipline Centric Elective Course - 3 (DCEC - 3)	
1.	Biological Techniques and Bioinformatics
2.	Bio nanotechnology
Discipline Centric Elective Course - 4 (DCEC - 4)	
1.	Research Methodology and IPR
2.	Economic Botany and Sustainable Development

LIST OF NON-MAJOR ELECTIVE COURSE (for other Department Students only)

NON-MAJOR ELECTIVE COURSE - 1 (NME-1)	
1	Biofertilizers and Biopesticides
NON-MAJOR ELECTIVE COURSE - 2 (NME-2)	
2	Pharmacognosy

LIST OF GENERIC ELECTIVE COURSE (GEC)

GENERIC ELECTIVE COURSE - 1 (GEC - 1)	
1.	Medicinal Botany
2.	Clinical Microbiology
3.	Mushroom Technology
GENERIC ELECTIVE COURSE - 2 (GEC - 2)	
1.	Cell and Molecular Biology
2.	Seed Technology
3.	Organic Farming
GENERIC ELECTIVE COURSE - 3 (GEC - 3)	
1.	Biotechnology
2.	Industrial Biotechnology
3.	Downstream Processing

SUMMARY OF CURRICULUM STRUCTURE OF PG PROGRAMMES

Sl. No.	Types of the Course	No. of Courses	Credits for each Course	Total Credits	Marks
1.	Core Course	8	4	32	800
2.	Core Practical	4	4	16	400
3.	Discipline Centric Elective Course	4	4	16	400
4.	Generic Elective Course	3	3	9	300
5.	Skill Enhancement Course	2	2	4	200
6.	Non-Major Elective Courses	2	2	4	200
7.	Internship / Industrial Activity @	1	2	2	100
8.	Entrepreneurship / Industry Based Course @	1	3	3	100
9.	Project @	1	5	5	100
Total		26	-	91	2600
Value Added Courses *		2*	2	4*	200*

*	The value added courses credit will not be included in the total CGPA. These courses are extra-credit courses. Instruction hours for these courses is 30 hours								
@	Summer Internship will be carried out during the summer vacation after the First year. Viva Voce will be conducted by the college and Marks shall be sent to the University and the same will be included in the 3rd semester Mark Statement. Summer Internship / Industrial Activity & Project Scheme of Evaluation: <table><tr><th>Description</th><th>Marks</th></tr><tr><td>Report</td><td>80</td></tr><tr><td>Viva</td><td>20</td></tr><tr><td>Total</td><td>100</td></tr></table>	Description	Marks	Report	80	Viva	20	Total	100
Description	Marks								
Report	80								
Viva	20								
Total	100								



BHARATHIDASAN UNIVERSITY, TIRUCHIRAPPALLI - 620 024.

**MASTER GRADUATE – SCIENCE CURRICULUM STRUCTURE
M.Sc. BOTANY**

CANDIDATES ELIGIBLE FOR M.Sc. BOTANY

Candidates eligible for Botany M.Sc. Botany admission generally include:

- Students with a **B.Sc. Degree in Botany**
- Students with **B.Sc. Plant Biology / Plant Science**
- Candidates with a **B.Sc. in Life Sciences / Biological Sciences**

Common Eligibility Requirements

- Minimum **50%–55% marks** in the qualifying degree (relaxation for reserved categories in many universities).
- Botany should usually be studied as a Major/Core subject.

PROGRAMME OBJECTIVES:

- To provide advanced and in-depth knowledge in various branches of plant sciences.
- To develop analytical, experimental, and research skills in botany and allied disciplines.
- To enhance understanding of plant biodiversity, molecular biology, biotechnology, ecology, and environmental science.
- To train students in modern laboratory techniques, instrumentation, and scientific methodologies.
- To promote independent research, scientific writing, and innovative thinking.
- To create awareness about conservation of biodiversity and sustainable utilization of plant resources.
- To prepare students for careers in research, teaching, industry, entrepreneurship, and higher studies.
- To develop leadership, communication, and professional ethics among students.

PROGRAMME OUTCOMES:

After successful completion of the programme, the graduates will be able to:

PO1	Disciplinary Knowledge: Acquire advanced and specialized knowledge in various branches of Botany including Plant Taxonomy, Ecology, Plant Physiology, Genetics, Molecular Biology, Plant Biotechnology, Microbiology, Plant Pathology, and Environmental Biology. Demonstrate the ability to critically integrate and apply scientific concepts, principles, and methodologies to solve theoretical and practical problems in plant sciences.
PO2	Critical Thinking: Develop the ability to critically analyse scientific problems through field studies, laboratory investigations, literature surveys, and research-based learning. Ability to evaluate scientific evidence, formulate hypotheses, interpret biological data, and draw logical conclusions using independent and reflective thinking.
PO3	Analytical Reasoning: Strengthen analytical reasoning skills through

	scientific discussions, experimental studies, data interpretation, and critical evaluation of research literature. Ability to identify gaps in existing knowledge, formulate research questions, and synthesize innovative scientific ideas in plant sciences.
PO4	Scientific Reasoning: Develop a strong foundation in scientific methods, experimental design, advanced laboratory techniques, instrumentation, and statistical analysis. Ability to conduct scientifically valid experiments, apply appropriate methodologies, and accurately interpret experimental results in botanical research.
PO5	Self-Directed Learning: Demonstrate independent learning abilities through assignments, seminars, project work, dissertation preparation, and literature-based studies. Ability to organize, analyse, and present scientific findings effectively in professional and academic formats relevant to higher education and industry.
PO6	Reflective Thinking: Develop the ability to reflect on scientific observations, research experiences, and laboratory practices to improve understanding of botanical concepts and research methodologies. Ability to evaluate the broader applications of plant sciences in agriculture, biotechnology, environmental management, and conservation biology.
PO7	Problem-Solving Skills: Apply scientific principles, quantitative reasoning, and analytical methods to solve complex biological and environmental problems. Ability to analyse experimental data, interpret scientific findings, and propose sustainable solutions related to biodiversity conservation, agriculture, climate change, and ecosystem management.
PO8	Research-Related Skills: Acquire research competence through internships, dissertation work, field studies, and independent research projects. Gain hands-on experience in research methodology, scientific writing, experimental techniques, data analysis, documentation, and ethical research practices, preparing students for advanced research and professional careers.
PO9	Lifelong Learning: Cultivate a mindset of continuous learning and adaptability to emerging scientific developments, technologies, and interdisciplinary approaches in plant sciences. Ability to engage in self-directed learning for academic advancement, professional growth, and research excellence throughout life.
PO10	Leadership Readiness: Develop leadership qualities, teamwork, communication, and organizational skills through seminars, collaborative projects, fieldwork, internships, and research activities. Ability to manage scientific responsibilities effectively, contribute to academic and industrial environments, and provide responsible leadership in scientific and societal contexts.

PROGRAMME EMPLOYMENT OPPORTUNITIES – M.Sc. BOTANY GRADUATES

Postgraduates have wider career opportunities in:

- Universities and colleges as Assistant Professors (after qualifying required eligibility tests)
- Research institutes and laboratories
- Biotechnology and pharmaceutical industries
- Environmental consultancy firms
- Agricultural research organizations
- Forest and wildlife departments

- Tissue culture and plant biotechnology laboratories
- Seed technology and breeding industries
- Biodiversity conservation organizations
- Government departments and public sector organizations

JOB ROLES

- Research Scientist
- Assistant Professor / Lecturer
- Botanist
- Plant Biotechnologist
- Ecologist
- Environmental Consultant
- Tissue Culture Specialist
- Quality Control Officer
- Scientific Officer
- Bioinformatics Analyst

HIGHER STUDIES OPPORTUNITIES

- Ph.D. in Botany and allied disciplines
- Competitive examinations (CSIR-UGC NET, SET, UPSC, TNPSC, etc.)
- Research fellowships and international research programmes
- Entrepreneurship in herbal products, floriculture, mushroom cultivation, and plant nurseries.

PLANT DIVERSITY - I
ALGAE, FUNGI, LICHENS AND
BRYOPHYTES
(Theory)

COURSE OBJECTIVES

- To understand the classification, range of thallus structure, reproduction methods and life cycle patterns of lower plants.
- To gain knowledge about the ecological and economic importance of algae, fungi, lichens and bryophytes.
- To learn various culture techniques for growing freshwater and marine algae in laboratory condition.
- To know the classification range of structural variations in gametophytes, sporophytes, evolution, ecology and economic importance of Bryophytes.
- To understand the classification, range of thallus structure, reproduction methods and life cycle patterns of lower plants.

UNIT – I ALGAE:

General account of algology, Contributions of Indian Phycologist (T.V.Desikachary, V.Krishnamurthy and V.S. Sundaralingam), Classification of algae by F.E. Fritsch (1935-45). Salient features of major classes: Cyanophyceae, Chlorophyceae, Xanthophyceae, Chrysophyceae, Cryptophyceae, Dinophyceae, Chloromonadineae, Euglenophyceae, Charophyceae, Bacillariophyceae, Phaeophyceae and Rhodophyceae. Range of thallus organization, algae of diverse habitats, reproduction (vegetative, asexual and sexual) and life cycles. Structure, reproduction and life histories of the following genera: *Oscillatoria*, *Scytonema*, *Ulva*, *Codium*, *Diatoms*, *Dictyota* and *Gelidium*.

UNIT – II FUNGI:

General Characteristics, occurrence and distribution. Mode of nutrition in fungi. Contributions of Indian Mycologists (C.V.Subramanian), Classification of Fungi by Alexopoulos and Mims (1979) & Recent trends in the classification of fungi - Phylogeny and inter-relationships of major groups of fungi. General characters of major classes: Mastigomycotina, Zygomycotina, Ascomycotina, Basidiomycotina and Deuteromycotina. Heterothallism in fungi, sexuality in fungi, Para sexuality, sex hormones in fungi. Structure, reproduction and life histories of the following genera: *Plasmodiophora*, *Phytophthora*, *Rhizopus*, *Taphrina*, *Polyporus* & *Colletotrichum*.

UNIT – III LICHENS:

Introduction and Classification (Hale, 1969). Occurrence and inter-relationship of phycobionts and mycobionts, structure and reproduction in Ascolichens, Basidiolichens and Deuterolichens.

UNIT – IV BRYOPHYTES:

General characters and Classification of Bryophytes by Watson (1971). Distribution, Structural variations and evolution of gametophytes and sporophytes in Bryopsida, Anthoceropsida and Mosses. General characters of major groups - Marchantiales, Jungermaniales, Anthocerotales, Sphagnales, Funariales and Polytrichales. Reproduction - Vegetative and sexual, spore

dispersal mechanisms in bryophytes, spore germination patterns in bryophytes. Structure, reproduction and life histories of the following genera: *Targionia*, *Marchantia*, *Porella* and *Polytrichum*.

UNIT – V ECONOMIC IMPORTANCE:

Algae - Economic importance in Food and feed - Single cell protein, Industrial products (Agar-Agar, Carrageenan, Alginic acid, Iodine, biofertilizers, Vitamins and biofuel), Medicinal value and Diatomaceous earth. Fungi – Economic importance in food, industries and medicine. Culturing and cultivation of mushrooms - *Pleurotus*. Lichen – economic importance and as indicator pollution. Bryophytes – Ecological and economic importance – industry, horticulture and medicine.

UNIT – VI CURRENT CONTOURS (For Continuous Internal assessment only)

Current developments related to the plant diversity-1: algae, fungi, lichens and bryophytes during the Semester concerned to be kept abreast of continuously and cumulatively through collection, discussion and evaluation from news and events over the world collected through multiple reliable informative sources - Research articles, Review materials, Print, Internet, Interaction, Social Media, Webinars and so on.

Recommended Textbooks:

1. Kumar, H.D. and Singh, H.N., (1971). A text book of Algae. East West Press Pvt. Ltd., New Delhi.
2. Vasisthta, B.R., (1977). Botany for Degree students- Part –I. Algae. S. Chand and company Ltd. Ram Nagar, New Delhi
3. Gangulee and Kar, College Botany, Vol. II, New Central Book Agency, Calcutta.
4. Parihar, N.S., (1957). An Introduction to Bryophyta. Central Book Depot, Allahabad.
5. Vijayakumar, S., (2020). Introduction to Applied Phycology. Mayas Publication. Tamil Nadu.
6. Sharma, O.P. 2014. Bryophyta, Mcgraw Hill, ISBN: 9781259062872, 1259062872
7. Singh, Pandey and Jain. 2020. A text book of Botany, 5th Edition, Rastogi Publication, Meerut.

Reference Books:

1. Bold, H.C. and Wynne, M.J., (1978). Introduction of Algae-structure and reproduction, Prentice Hall, New Jersey.
2. Alexopoulos, C.J., (1973). Introductory Mycology. Wiley Eastern Private Ltd., New York.

Web resources:

1. <https://youtu.be/1P1yggEZm9w>
2. <https://youtu.be/MbXH-qJ3hT8>
3. <https://youtu.be/hBHAVnupcak>
4. <https://youtu.be/GkFFuj4V9ws>
5. https://youtu.be/czBdDUL_xSg

COURSE OUTCOMES:

Course Outcomes	On completion of this course the student will be able to	Cognitive Level
CO1	Analyze the classification, structural organization, and diversity of algae, fungi, lichens, and bryophytes using morphological, anatomical, and taxonomic characteristics.	K1
CO2	Evaluate the life cycle patterns, reproductive biology, and evolutionary relationships among major groups of algae, fungi, lichens, and bryophytes.	K2
CO3	Apply theoretical knowledge and practical skills to identify, classify, and document lower plant forms through laboratory techniques and field investigations.	K3
CO4	Assess the ecological significance, economic importance, and adaptive strategies of algae, fungi, lichens, and bryophytes in natural ecosystems.	K4
CO5	Critically examine the conservation needs, sustainable utilization, and research potential of lower plant resources and propose appropriate management strategies for biodiversity conservation.	K5 & K6

Cognitive Level: **K1** - Remember; **K2** - Understanding; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Mapping with POs:

Relationship Matrix											
Semester	Course Code	Title of the Course								Hours	Credits
I		PLANT DIVERSITY - I Algae, Fungi, Lichens and Bryophytes (Theory)								6	4
Course Outcomes	Programme Outcomes (POs)										Mean Score
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	
CO1	3	2	2	2	1	1	1	2	2	2	1.8
CO2	3	3	2	2	1	1	2	2	2	2	2.0
CO3	3	2	2	3	2	2	3	3	1	3	2.4
CO4	2	2	3	2	1	2	3	3	3	3	2.4
CO5	2	3	2	2	2	3	3	2	3	3	2.5
Mean Overall Score											2.22 (High)

**PLANT DIVERSITY – II
PTERIDOPHYTES, GYMNOSPERMS
AND PALEOBOTANY
(Theory)**

COURSE OBJECTIVES

- To know the classification and salient features of Pteridophytes and Gymnosperms
- To study of the morphology, sporophyte and gametophyte of Pteridophytes and Gymnosperms
- To understand the economic importance of Pteridophytes and Gymnosperms
- To analyse the phylogeny and Paleontology of Pteridophytes and Gymnosperms
- To study the concept of fossils and fossilization.

UNIT - I PTERIDOPHYTES:

General characteristics and classification (K.R. Sporne, 1975). Range of structure, reproduction and evolution of the gametophytes, Gametophyte types – sex organs. Apogamy and Apospory. Life cycles. Stellar evolution. Heterospory and seed habit, Telome theory, morphogenesis, Economic importance of Pteridophytes.

UNIT - II PTERIDOPHYTES:

Structure, reproduction and life cycle of the following genera: *Angiopteris*, *Osmunda*, *Pteris*, *Azolla*, *Salvinia*, *Adiantum*, *Gleichenia* and *Hymenophyllum*.

UNIT - III GYMNOSPERMS:

General characters - distribution - Phylogeny and classification (K.R. Sporne, 1965). Morphology, anatomy, reproduction of *Lyginopteridaceae*, *Medullosaceae*, *Williamsoniaceae* and *Pentoxylaceae*. Economic importance of Gymnosperms.

UNIT - IV GYMNOSPERMS:

Structure (Exomorphic and endomorphic), anatomy, reproduction and life cycle of the following genera: *Taxus*, *Cupressus*, *Araucaria*, *Podocarpus*, *Gnetum* and *Ephedra*. *Pinus* and *Ginkgo*

UNIT - V PALEOBOTANY:

Geological Scale; Radiocarbon dating; Contribution of Birbal Sahni to Paleobotany. Gondwana flora of India. Study of fossils in understanding evolution. Fossilization and fossil types. Economic importance of fossils – fossil fuels and industrial raw materials and uses. Study of fossils genera: *Rhynia*, *Lepidocarpon*, *Calamites*, *Cordaite* and *Lyginopteris*.

UNIT - VI CURRENT CONTOURS (For Continuous Internal assessment only)

Current developments related to the Pteridophytes, Gymnosperms and Paleobotany during the Semester concerned to be kept abreast of continuously and cumulatively through collection, discussion and evaluation from news and events over the world collected through multiple reliable informative sources -

Research articles, Review materials, Print, Internet, Interaction, social media, Webinars and so on.

Recommended Textbooks:

1. Vashishta, P.C. Sinha, A.K and Anil Kumar. 2016. Botany for Degree students. Gymnosperms. S. Chand and Company Ltd., New Delhi.
2. Singh, V., Pande, P.C and Jain, D.K. 2021. A Textbook of Botany. Rastogi Publications, Meerut.
3. Bhatnagar, S.P and Alok Moitra. 2020. Gymnosperms, New Age International (P) Ltd., Publishers, Bengaluru.
4. Sharma, O.P. 2017. Pteridophyta, McGraw Hill Education, New York.
5. Vashishta. P.C., A.K. Sinha and Anil Kumar. 2018. Botany for Degree students -Gymnosperms. S. Chand and Company Ltd., New Delhi.
6. Johri, R.M, Lata, S, Tyagi, K. 2005. A textbook of Gymnosperms, Dominate pub and Distributer, New Delhi.

Reference books:

1. Parihar, N.S. 2019. An Introduction to Embryophyta Pteridophytes. 5th Edition, Surjeet Publication, Delhi.
2. Pandey, S.N and Trivedi, P.S. 2015. A Textbook of Botany Vol. II- 12 th edition (Paperback), Vikas Publishing.
3. Rashid, A. 2013. An introduction to Pteridophyta – Diversity, Development and differentiation (2nd edition), Vikas Publications.
4. Arnold A.C. 2005. An Introduction to Paleobotany. Agrobios (India). Jodhpur.
5. Sporne, K.R. 2017. The morphology of Pteridophytes (The structure of Ferns and Allied Plants) (Paperback), Andesite Press.
6. Sporne, K.R. 1967. The Morphology of Gymnosperms. Hutchinson & Co., London.
7. Taylor, E, Taylor, T, Krings, M. 2008. Paleobotany: The Biology and Evolution of Fossil Plants, 2nd Edition, Academic Press.

Web resources:

1. <https://www.toppr.com/guides/biology/plant-kingdom/pteridophytes/>
2. http://www.bsienviis.nic.in/Database/Pteridophytes-in-India_23432.aspx
3. <https://books.google.co.in/books/about/Gymnosperms.html?id=4dvyNckni8wC>
4. <https://arboretum.harvard.edu/wp-content/uploads/2013-70-4-beyond-pine-cones-an-introduction-to-gymnosperms.pdf>
5. <https://www.palaeontologyonline.com/>

COURSE OUTCOMES:

Course outcomes	On completion of this course the student will be able to	Cognitive Level
CO1	Critically explain the classification, phylogenetic relationships, evolutionary trends and diagnostic characteristics of Pteridophytes and Gymnosperms using contemporary taxonomic approaches.	K1
CO2	Evaluate the morphological, anatomical, reproductive and developmental features of major groups of Pteridophytes and Gymnosperms and interpret their adaptive significance in plant evolution.	K2
CO3	Assess the ecological roles, economic importance, and	K3

	applied potential of Pteridophytes, Gymnosperms and fossil plant resources in forestry, horticulture, medicine and environmental management.	
CO4	Compare, interpret and synthesize evidence from extant and fossil taxa to elucidate evolutionary relationships and diversification patterns among vascular plants.	K4
CO5	Critically examine fossil types, fossilization processes, paleobotanical records, and research findings to reconstruct the evolutionary history of Pteridophytes and Gymnosperms and address contemporary questions in plant evolution and biodiversity conservation	K5 & K6

Cognitive Level: **K1** - Remember; **K2** - Understanding; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Mapping with COs and POs :

Relationship Matrix												
Semester	Course Code		Title of the Course								Hours	Credits
I			PLANT DIVERSITY - II Pteridophytes, Gymnosperms and Paleobotany (Theory)								6	4
Course Outcomes	Programme Outcomes (POs)										Mean Score	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10		
CO1	3	3	3	2	2	2	1	2	1	1	2.1	
CO2	3	3	2	3	1	2	2	1	2	1	2.1	
CO3	2	2	2	2	2	2	3	1	2	2	2.1	
CO4	3	3	3	3	1	2	2	2	1	1	2.1	
CO5	2	3	3	3	2	2	2	3	2	1	2.3	
Mean Overall Score											2.14 (High)	

COURSE OBJECTIVES

- To learn how to employ the use of instruments, technologies and methodologies related to thallophytes and non-flowering plant groups
- To enhance information on the identification of each taxonomical group by developing the skill-based detection of the morphology and microstructure of algae, and fungi.
- To comprehend the fundamental concepts and methods used to identify bryophytes, pteridophytes and gymnosperms through morphological changes and evolution, anatomy and reproduction
- To develop the technical abilities in staining, sectioning, sterilizing, and characterizing, thallophytes, and other varieties of non-flowering plants.
- To compare the structural diversity of fossil and extant plant species.

ALGAE:

External morphology and internal anatomy of the vegetative and reproductive structures of the following living forms: *Oscillatoria*, *Scytonema*, *Ulva*, *Codium*, *Diatoms*, *Dictyota* and *Gelidium* (depending on availability of the specimen).

Preparation of culture media and culture of green algae and blue green algae in the laboratory (Demonstration).

FUNGI

Study of morphological and reproductive structures of the following living forms: *Plasmodiophora*, *Phytophthora*, *Rhizopus*, *Taphrina*, *Polyporus* and *Colletotrichum*.

Isolation and identification of fungi from soil, air, and Baiting method. Preparation of culture media. Cultivation of mushroom in the laboratory (Demonstration).

LICHENS

Study of morphological and reproductive structures of the genera *Parmelia*.

BRYOPHYTES

External morphology and internal anatomy of the vegetative and reproductive organs of the following living forms: *Targionia*, *Marchantia*, *Porella* and *Polytrichum* (depending on availability of the specimen).

PTERIDOPHYTES

External morphology and internal anatomy of the vegetative and reproductive organs of the following living forms: *Angiopteris*, *Osmunda*, *Pteris*, *Azolla*, *Salvinia*, *Adiantum*, *Gleichenia* and *Hymenophyllum*.

Fossil slides observation: *Rhynia*, *Lepidocarpon*, *Calamites*.

GYMNOSPERMS

External morphology and internal anatomy of the vegetative and reproductive organs of the following living forms: *Taxus Cupressus*, *Araucaria*, *Podocarpus*, *Gnetum*, *Ephedra*. *Pinus* and *Ginkgo*.

PALEOBOTANY

Fossil slides observation: *Cordaitea*, *Lyginopteris*, *Medullosa*, *Williamsonia*, *Pentoxylon*

Recommended Textbooks:

1. Kumar, H.D. 1999. Introductory Phycology. Affiliated East-West Press, Delhi.
2. Das, S and Saha, R. 2020. Microbiology Practical Manual. CBS Publishers and Distributors (P) Ltd., New Delhi, India.
3. Sharma, O.P. 2012. Pteridophyta, Tata McGraw-Hills Ltd, New Delhi.
4. Sharma O.P and S, Dixit. 2002. Gymnosperms. Pragati Prakashan.
5. Johri, R.M, Lata, S, Tyagi, K. 2005. A textbook of Gymnosperms, Dominate pub and Distributer, New Delhi.

Reference Books:

1. Chmielewski, J.G and Kravesky, D. 2013. General Botany laboratory Manual. Author House, Bloomington, USA.
2. Ashok, M. Bendre and Kumar. 2010. A textbook of Practical Botany, Algae, Fungi, Lichen, Bryophyta, Pteridophyta, Gymnosperms and Palaeobotany. Revised edition. Published by Rakesh Kumar Rastogi publication.
3. Gangulee, H.C and A.K. Kar. 2013. College Botany. Vth Edition. S. Chand.

Web resources:

1. <https://www.frontiersin.org/articles/10.3389/fmicb.2017.00923/full>
2. <https://microbiologyonline.org/file/7926d7789d8a2f7b2075109f68c3175e.pdf>
3. http://www.cuteri.eu/microbiologia/manuale_microbiologia_pratica.pdf

COURSE OUTCOMES:

Course outcomes	On completion of this course the student will be able to	Cognitive Level
CO1	Apply taxonomic principles, diagnostic keys, and structural characteristics to identify, classify and differentiate economically and ecologically important species of algae and fungi.	K1
CO2	Demonstrate proficiency in laboratory and field techniques for the collection, observation, identification and documentation of Thallophytes, Bryophytes, Pteridophytes, and Gymnosperms	K2
CO3	Analyze and interpret the structural organization, diversity, and adaptive features of algae, fungi, lichens, bryophytes, pteridophytes and gymnosperms in relation to their ecological and evolutionary significance.	K3
CO4	Critically evaluate the role of structural diversity and evolutionary innovations in the origin, adaptation and diversification of major plant groups	K4
CO5	Apply and assess standard techniques for the isolation, cultivation, and maintenance of algae and fungi and investigate the diversity and biological significance of	K5 & K6

	lower and higher plant forms through experimental studies.	
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Mapping with POS:

Relationship Matrix											
Semester	Course Code		Title of the Course							Hours	Credits
I			Plant Diversity I and Plant Diversity II (Practical)							6	4
Course Outcomes	Programme Outcomes (POs)										Mean Score
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	
CO1	3	2	2	2	2	2	2	2	2	1	2.0
CO2	2	3	2	2	3	2	2	3	1	1	2.1
CO3	3	3	3	2	1	2	2	1	2	1	2.0
CO4	3	3	3	3	2	2	2	2	2	1	2.3
CO5	2	2	2	3	2	2	3	3	2	1	2.2
M3ean Overall Score											2.12 (High)

COURSE OBJECTIVES

- To analyse and comprehend the fundamental ideas of plant ecology as a scientific study of environment
- To study the plant communities and plant succession stages
- To be aware of the causes, impacts and control measures of pollution.
- To study biodiversity management and conservation
- To enhance the knowledge of the students and equip them in evaluate and protecting invaluable components of nature and interactions with the environment

UNIT - I: NATURAL RESOURCES:

Definition – Importance – Classification – Human physiological socio-economic and cultural development –Human Population Explosion – Natural Resource Degradation – Concept of conservation – Value system – Equitable resource use for sustainable life system.

UNIT - II: FOREST RESOURCES:

Forest cover in India and the World – Importance – Desertification – Forest Wealth – Afforestation –Vanasamrakshna Samithi– Agroforestry – Social Forestry – Joint Forest Management Strategy for Forest Conservation. Wildlife: Resources – Importance – Benefits – Wildlife Extinction – Causes for Extinction – List of Endanger species in India and in the World – Ecological approach in wild life management – Eco Tourism – Wildlife projects in India – Sanctuaries and National Parks In India – Man and Biosphere Programme.

UNIT - III: LAND AND SOIL RESOURCES:

Soil, Complexity of soil nature, regional deposits, Land use and capability classification systems, Land use Planning models and their limitations. Impacts of natural and man- made activities on land characteristics and land use planning– Soil Erosion – Loss of Soil Nutrients – Restoration of Soil Fertility – Soil Conservation Methods and Strategies in India. Wet Land Conservation and Management – Ecological Importance of wetlands in India – Conservation Strategy and ecological Importance. Water Resources: Rivers and Lakes in India – Water Conservation and ground water level increase - Watershed Programme.

UNIT - IV: MINERAL RESOURCES:

Use and exploitation – Environmental effects of extracting and using mineral resources – Restoration of mining lands – Expansion of supplies by substitution and conservation. Food Resources: World Food Problems – Changes caused by agriculture – overgrazing effects of modern agriculture – Fertilizer-Pesticide problems – Water Logging – Salinity – Sustainable agriculture, life stock breeding and farming.

UNIT - V: BIODIVERSITY & CONSERVATION

Definition, types of biodiversity – values of biodiversity. Threats to biodiversity: habitat loss,

Invasive and exotic species. IUCN red list categories. Biodiversity conservation in situ conservation – Hot spots–KMTR, endemic plant species of India, biosphere reserves – Agasthiaymalai Biosphere Reserve, protected areas / sanctuaries (Valanadu wildlife sanctuary) and national parks (Indhira Ghandhi National Park) IUCN Green List of Protected and Conserved Areas. Ex situ conservation – botanical gardens, field gene bank, in vitro conservation. Indicators of biodiversity conservation, management approaches – reserve selection and reserve size. Indian case studies on conservation and management strategies - Project Tiger, Project Elephant, and Project Bustard.

UNIT - VI CURRENT CONTOURS (For Continuous Internal Assessment Only):

Current developments related to biodiversity conservation during the semester concerned to be kept abreast of continuously and cumulatively through collection, discussion and evaluation from news and events over the world collected through multiple reliable informative sources–Research articles, review materials, print, Internet, Interaction, social media, Webinars and so on.

Recommended Textbooks:

1. Trivedi R.K.1994. Environment and Natural Resources Conservation.
2. Murthy J.V.S.1994. Watershed Management in India.
3. Raymond, F Dasmann. 1984. Environmental Conservation, John Wiley.
4. Nalini, K.S. 1993. Environmental Resources and Management, Anmol Publishers, New Delhi.
5. Shyam Divan and Armin Rosencranz. 2001. Environmental Law and Policy in India, Oxford Uni. Press.

Reference Books:

1. Haue, R and Freed V.H. 1975. Environmental Dynamics of Pesticides, Menum Press, London
2. Singh, B. 1992. Social Forestry for Rural Development, Anmol Publishers, New Delhi.
3. Shafi. R. 1992. Forest Ecosystem of the World.
4. Stacy Keach. 2016. Natural Resources Management. Syrawood Publishing House.
5. Rathor B.S. 2013. Management of Natural Resource for Sustainable Development. Daya Publishing House, New Delhi.

Web resources:

1. https://books.google.co.in/books/about/Natural_Resource_Conservation_and_Enviro.html?id=T2SRuhxpUW8C&redir_esc=y
2. <https://www.kobo.com/ww/en/ebook/natural-resources-conservation-law>
3. <https://www.scribd.com/book/552185119/Natural-Resources-Conservation-and-Advances-for-Sustainability>
4. <https://www.scribd.com/document/354699536/Conservation-of-Natural-Resources>

COURSE OUTCOMES:

Course outcomes	On completion of this course the student will be able to	Cognitive Level
CO1	Explain the patterns, distribution, and significance of biodiversity at genetic, species and ecosystem levels and evaluate their role in maintaining ecological stability and sustainability.	K1
CO2	Critically assess the causes and consequences of biodiversity loss, habitat degradation, climate change and anthropogenic disturbances on ecosystem functioning and species survival.	K2
CO3	Apply ecological principles, conservation tools, and biodiversity assessment techniques to identify, monitor and manage biological resources in natural and managed ecosystems.	K3
CO4	Evaluate national and international conservation policies, protected area networks, environmental legislation and sustainable management strategies for biodiversity conservation.	K4
CO5	Design and propose scientifically sound conservation, restoration and sustainable utilization strategies based on field observations, research evidence, and contemporary approaches to biodiversity management.	K5 & K6

Cognitive Level: K1 - Remember; **K2** - Understanding; **K3** - Apply; **K4** - Analyze; **K5** – Evaluate; **K6** – Create

Mapping with POs :

Relationship Matrix												
Semester	Course Code		Title of the Course								Hours	Credits
I			Biodiversity Conservation (Theory)								2	2
Course Outcomes	Programme Outcomes (POs)										Mean Score	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10		
CO1	3	2	2	2	2	2	2	2	2	1	2.0	
CO2	2	3	3	3	2	1	2	3	2	1	2.2	
CO3	3	2	2	2	3	1	3	2	1	1	2.0	
CO4	2	3	2	2	1	3	2	1	2	2	2.0	
CO5	2	3	3	3	2	2	3	3	2	3	2.6	
Mean Overall Score											2.16 (High)	

COURSE OBJECTIVES:

- To understand the basic characteristics of food materials.
- To learn about the types of food materials derived from plant origin.
- To gain knowledge regarding food preparation methods
- To know about the various kinds of food spoilage and their impact on human being.
- To apply knowledge related to the food industry.

UNIT-I FOOD SCIENCE

Introduction to food science - Types, Constituents and functions of food - Nutritive aspects of food constituents. Quality factors in food. Microorganisms associated with food - Aims of food science and technology.

UNIT-II FOOD MATERIALS OF PLANT ORIGIN

Food materials of plant origin - Cereals and cereal products, Pulses, Nuts and Oil Seeds. Vegetables and fruits - Sugar and related products - Fats, Oil and Spices.

UNIT-III FOOD PRESERVATION

Food Preservation - Impact of science and technology in food preservation - Principles of food preservation - Physical methods - Low temperature - Freezing - Drying - Irradiation - Canning - High temperature and modification of atmosphere.

UNIT-IV FOOD PRESERVATION

Chemical preservatives – Traditional antimicrobials - Organic acids and esters - Acetic acid and acetates - Benzoic acid and benzoates, lactic acid and lactates - propionic acid and propionates - sorbic acid and sorbates - Nitrites - Parabens - NaCl - Sulphites - Dimethyl Dicarbonate - Phenolic antioxidants and phosphates.

UNIT-V FOOD SPOILAGE

Microbial and biochemical aspects of food spoilage - Causes of food spoilage - Spoilage of cereals, vegetables and fruits. Food adulteration - Types of adulterants - Quality factors in foods - Food poisoning - Food borne intoxications and food borne infections - Food borne Bacteria, Fungi and Viruses.

UNIT-VI CURRENT CONTOURS (For Continuous Internal Assessment Only):

Current developments related to the Food technology during the semester concerned to be kept abreast of continuously and cumulatively through collection, discussion and evaluation from news and events over the world collected through multiple reliable informative sources—Research articles, review materials, print, Internet, Interaction, social media, Webinars and so on.

Recommended Textbooks:

1. Subbulakshmi, G., Subhadra & Mandalika (2014) - Functional Foods and Nutrition, ASTRAL International (P) Ltd, New Delhi.

2. Khetarpaul, Neelam (2013) - Food Microbiology. ASTRAL International (P) Ltd, New Delhi 3. Adams M.R, Moss Mo.2007. Food Microbiology New ase international (p) Limited, New Delhi.

Reference Books:

1. Khatkar, Bhupendra Singh (2013 - Food Science and Technology. ASTRAL International (P) Ltd, New Delhi.
2. Khetarpaul, Neelam (2013) - Food Processing and Preservation. ASTRAL International (P) Ltd, New Delhi.

Web Resources:

1. <https://discoverfoodtech.com/food-technology-ebooks/>
2. <https://ncert.nic.in/textbook/pdf/lehe105.pdf>
3. <http://ekatmik.balbharati.in/pdfs/1203010496.pdf>

COURSE OUTCOMES:

Course outcomes	On completion of this course the student will be able to	Cognitive Level
CO1	Explain the composition, nutritional value, quality attributes and functional properties of food materials and evaluate their significance in human health and food industries.	K1
CO2	Apply principles of food processing, preservation, packaging and storage technologies to enhance food quality, safety and shelf life.	K2
CO3	Evaluate the role of microorganisms, enzymes, additives and biotechnological interventions in food production, quality assurance and value-added product development.	K3
CO4	Critically assess food safety standards, quality control measures, regulatory frameworks, and hazard management systems to ensure consumer health and product quality.	K4
CO5	Design and propose innovative, sustainable, and economically viable food products and processing strategies based on scientific principles, research findings and industry requirements.	K5 & K6

Cognitive Level: **K1** - Remember; **K2** - Understanding; **K3** - Apply; **K4** - Analyze; **K5** – Evaluate; **K6** – Create

Mapping with POs:

Relationship Matrix											
Semester	Course Code		Title of the Course							Hours	Credits
I			Food Technology (Theory)							-	2*
Course Outcomes	Programme Outcomes (POs)										Mean Score
	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	
CO1	3	2	2	2	2	2	2	2	2	1	2.0
CO2	3	2	2	3	3	2	1	3	2	1	2.2
CO3	2	3	3	3	1	2	2	3	2	1	2.2
CO4	2	3	2	3	1	2	3	2	2	2	2.2
CO5	2	3	3	3	2	2	3	3	2	3	2.6
Mean Overall Score											2.24 (High)

COURSE OBJECTIVES:

- To learn the importance of plant anatomy
- To classify meristems and identify their structures, functions and their role in monocot and dicot plant growth and secondary growth of woody plants.
- To understand the mechanism underlying the shift from vegetative to reproductive phase.
- To trace the development of male and female gametophyte.
- Understand the process of plant morphogenesis and the role of hormones

UNIT – I ADVANCED PLANT ANATOMY:

Cell wall: Morphological and physico-chemical changes; Plasmodesmata- types of pits – growth of cell wall – formation of intercellular spaces; Meristems: Classifications: Theories of shoot and root apices. Vascular Cambium: Composition and organization – multiplicative and additive divisions. Xylem: Primary and secondary xylem – tracheary elements and vessels – vessel less dicots – xylem rays and axial parenchyma; Phloem: Ultra structure and ontogeny of sieve tube elements and companion cell. Evolution of tracheary elements.

UNIT – II ADVANCED PLANT ANATOMY:

Periderm: Structure, organization and activity of phellogen. Phelloderm and Rhytidem, Normal secondary thickening in Dicots; Anomalous secondary growth in Dicots (*Amaranthus*, *Aristolochia*, *Bignonia*, *Nyctanthus*) and arborescent Monocots (*Draeceana*). Structure and types of Stomata; Leaf abscission, wound healing, Major nodal types.

UNIT – III EMBRYOLOGY:

Structure and development of Anther: Male gametophyte; Palynology: Morphology and ultrastructure of pollen wall, pollen kitts substances, pollen analysis, pollen storage, pollen sterility and pollen physiology. Structure and development of Megasporangium; Types of ovules, Endothelium, obturator and nucellus. Megasporogenesis: Female gametophyte: Structure, types, haustorial behavior and Nutrition of embryo sacs.

UNIT – IV EMBRYOLOGY:

Fertilization: Double fertilization and triple fusion; Sexual incompatibility. Endosperm: Development of endosperm, types, physiological efficiency of endosperm haustoria and functions; Ruminant endosperm. Embryogeny: Development of monocot (*Luzula*) and dicot (*Capsella*) embryos. Causes of Polyembryony, classification, induction and practical application. Apomixis and its significance. Seed and Fruit development and role of growth substances. Parthenocarpy and its importance.

UNIT – V MORPHOGENESIS:

Morphogenesis and its relation to morphology - Morphogenetic factors - growth regulators - genetic and environment - polarity and symmetry - Nuclear

transplantation experiment (*Acetabularia*)– Molecular basis of morphogenesis - Cytosol, microtubules and microfilaments - Cellular level morphogenesis - Morphogenesis at tissue level – Differentiation, dedifferentiation and redifferentiation of vascular tissue *in vivo* and in wounds. Plant galls and their importance in morphogenesis.

Unit – VI CURRENT CONTOURS (For Continuous Internal assessment only)

Current developments related to the anatomy, embryology and morphogenesis during the semester concerned to be kept abreast of continuously and cumulatively through collection, discussion and evaluation from news and events over the world through multiple reliable informative sources – Research articles, review materials, print, Internet, Interaction, social media, Webinars and so on.

Recommended Textbooks:

1. Bhojwani, S.S. Bhatnagar, S.P and Dantu, P.K. 2015. The Embryology of Angiosperms (6th revised and enlarged edition). Vikas Publishing House, New Delhi.
2. Maheshwari, P. 1963. Recent Advances in Embryology of Angiosperms. Intl. Soc. Plant Morphologists, New Delhi.
3. Sharma, P.C. 2017. Textbook of Plant Anatomy. Arjun Publishing House, New Delhi.
4. Pandey.S. N and Ajanta Chandha. 2006. Plant Anatomy and Embryology. Vikas Publishing House Pvt. Ltd, New Delhi.
5. Narayanaswamy, S. 1994. Plant Cell and Tissue Culture. Tata McGraw Hill Ltd. New Delhi.

Reference Books:

1. Swamy, B.G.L and Krishnamurthy. K.V 1990. From flower to fruits, Tata – McGraw Hill publishing Co Ltd, New Delhi.
2. Pullaiah, T., Lakshminarayana, K and Hanumantha Rao, B. 2006. Textbook of Embryology of Angiosperms. Regency Publications, New Delhi.
3. Bierhorst, D.W. 1971. Morphology of Vascular Plants. Macmillan publishers, New York.
4. Crang, R., Lyons-Sobaski, S and Wise, R. 2018. Plant Anatomy: A Concept-Based Approach to the Structure of Seed Plants. Springer International Publishing.
5. Cutler, D. F., Botha, T and Stevenson, D.W. 2008. Plant Anatomy: An Applied Approach. Blackwell Publishing, Malden, USA.
6. Eames, A.J and Mac Daniels, L.H. 2013. Introduction to Plant Anatomy, 3rd Edition. McGraw-Hill Inc., US.

Web Resources:

1. <https://www.ipni.org/>
2. <http://www.theplantlist.org/>
3. https://faculty.etsu.edu/liuc/plant_anatomy_sites.htm
4. http://aryacollegeludhiana.in/E_BOOK/Botany/plant_anatomy.pdf
5. <https://www.uou.ac.in/sites/default/files/slm/BSCBO-202.pdf>
6. http://greenlab.cirad.fr/GLUVED/html/P1_Prelim/Bota/Bota_typo_014.html

COURSE OUTCOME:

Course Outcomes	On successful completion of this course, students will be able to	Cognitive Levels
CO1	Explain the structure, organization and functional significance of apical and lateral meristems in monocotyledonous and dicotyledonous plants and evaluate their roles in primary and secondary growth.	K1
CO2	Critically examine the anatomical organization, secondary growth patterns and functional adaptations of woody stems in monocot and dicot plants and interpret their ecological and evolutionary significance.	K2
CO3	Apply advanced laboratory techniques, including sectioning, staining, dissection and microscopic analysis to investigate and document various stages of plant growth and development.	K3
CO4	Evaluate the cellular, molecular and physiological mechanisms underlying plant development, reproduction and differentiation and relate them to plant form and function.	K4
CO5	Analyze the role of plant growth regulators in morphogenesis, organogenesis and developmental processes and assess their applications in plant improvement, propagation and biotechnology.	K5 & K6

Cognitive Level: K1 - Remember; **K2** - Understanding; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Mapping with POs:

Relationship Matrix											
Semester	Course Code		Title of the Course							Hours	Credits
II			Advanced Plant Anatomy, Embryology and Morphogenesis (Theory)							-	4
Course Outcomes	Programme Outcomes (POs)										Mean Score
	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	
CO1	3	2	2	3	2	2	2	2	2	1	2.1
CO2	3	3	3	2	2	2	2	2	2	1	2.2
CO3	3	2	2	3	2	2	2	3	3	1	2.3
CO4	3	3	3	3	2	2	3	2	2	1	2.4
CO5	2	3	3	3	2	2	3	3	2	2	2.5
Mean Overall Score											2.3 (High)

COURSE OBJECTIVES:

- To provide students with basic understanding of microbiology, immunology, plant pathology and the etiology of specific plant diseases
- To provide comprehensive knowledge about microbes and its effect on man and environment.
- To provide comparative analysis of major groups of microbes.
- To study the principles of immune system, immunizing agents like antibodies and vaccines and gene therapy methods
- To enhance the knowledge and skills needed for self-employment using the microbial derived products

UNIT-I MICROBIOLOGY

Types of microorganisms. General characteristic of bacteria – Outline classification of Bergey's manual of 9th edition. Classification of bacteria based on Morphological, cultural, physiological and molecular characteristics. Bacterial growth – batch culture and continuous culture. Growth Curve. Factors affecting growth. Determination of bacterial growth – Direct method: Haemocytometer, Viable plate count; Indirect method: Turbidity. Nutritional types. Reproduction - Fission and sporulation. Genetic recombination- Transformation, Transduction and Conjugation. Isolation and cultivation of bacteria. Maintenance of bacterial culture.

UNIT-II MICROBIOLOGY

General characters, Classification, Structure, Multiplication. Overview of Phycoviruses and Mycoviruses. Viruses of Eukaryotes – Animal & Plant viruses. Cultivation of viruses – in embryonated egg and in plants. Control of viral infections. Bacteriophages- classification, replication of DNA and RNA phages - Lytic and Lysogenic cycle. Viroids and prions. Mycoplasma: Structure and classification. Viral metagenomics for discovery and characterization of novel viruses, CRISPR-based antiviral strategies and host defence mechanisms.

UNIT-III MICROBIOLOGY

Beneficial role of microbes – yoghurt, Olives, Cheese, Bread, Wine, Tempeh, Miso & Fermented green tea. Spoilage of fruits, vegetables, meats, poultry, eggs, bakery products, dairy products and canned foods. Importance of Microbial flora of soil and factors affecting the microbial community in soil. Interaction among soil microbes (positive and negative interactions) & with higher plants (rhizosphere & phyllosphere). Microbial degradation of chemical pesticides and hydrocarbon.

UNIT-IV PLANT PATHOLOGY

History and significance of plant pathology. Classification of plant diseases, Symptomology (important symptoms of plant pathogens). Principles of plant infection –Inoculum, inoculum potential, Pathogenicity. Disease triangle. Host parasite interrelationship and interaction. Causal agents of plant diseases - biotic causes (fungi, bacteria virus, mycoplasma, nematodes, parasitic algae,

angiospermic parasites - Abiotic causes (Physiological, deficiency of nutrients & minerals and pollution).

UNIT-V PLANT PATHOLOGY

Mechanism of penetration- Disease development of pathogen (colonization) and dissemination of pathogens. Role of enzymes and toxins in disease development. Defence mechanism of host – structural and biochemical defences. Important diseases of crop plants in India - Sheath blight of rice, Late blight of potato, Little leaf of Brinjal and Red rust of tea. Principles of disease management – Cultural practices, physical, chemical and biological methods, disease controlled by immunization. Biocontrol - merits and demerits; Plant quarantine and legislation. Integrated Pest Management system. Diagnostic technique to detect pest/pathogen infection - Immunofluorescence (IF).

UNIT-VI CURRENT CONTOURS (For Continuous Internal assessment only)

Self-directed learning activities: Growing edible mushrooms like oyster or button mushrooms. Growing pesticide-free vegetables or nutrient-rich microgreens. Cultivating and processing medicinal plants like Tulsi, Aloe vera. Converting organic waste into nutrient-rich compost. Rearing honeybees for honey and pollination. visit any one of Agri based markets. Precision agriculture tools and IoT-based monitoring for optimizing growth conditions, development of integrated farming systems for sustainable resource utilization

Recommended Textbooks:

1. Singh, R.S. 2018. Introduction to Principles of Plant Pathology, 4th Edition.
2. Bilgrami, K.S and H.C. Dube. 2010 A textbook of Modern Plant Pathology – Vikas Publishing House (P) Ltd., New Delhi
3. Mehrotra, R.S. and Aggarwal, A. 2017. Plant Pathology. McGraw Hill Publisher.
4. Dube, H.C. 2010. A textbook of Fungi, Bacteria and Viruses, 3rd Edition, Agrobios India, ISBN: 8188826383.

Reference Books:

1. Agrios, A.G. 2007. Plant Pathology, Elsevier. ISBN: 9780120445653.
2. Jeffery, C., Pommerville. 2014. Alcamos Fundamentals of Microbiology. 10th Edition. Johns and Bartlett Learning.
3. Pelczar, M. J. 2007. Microbiology. 35th Edition, Tata-McGraw Hill Publications, New York, ISBN: 0074623260.
4. Ravi Chandra, N.G. 2013. Fundamentals of Plant Pathology, Phi Learning, ISBN:812034703X.
5. Willie, J. and Sherwood, L. 2016. Prescott's Microbiology McGraw-Hill Education; 10th Edition, ISBN: 978-1259281594
6. Chaube, H.S. and Singh, R. 2015. Introductory Plant Pathology CBS Publishers, ISBN: 978-8123926704.
7. Rangasamy, G. 2006. Disease of crop plants in India (4th edition). Tata Mc Graw Hill New Delhi.
8. Mishra, A., A. Bohra and A. Mishra. 2011. Plant Pathology-Disease and Management. Agro Bios, Jodhpur.

Web Resources:

1. <https://www.wileyindia.com/a-textbook-of-plant-pathology.html>
2. <https://www.britannica.com/science/plant-disease>.
3. <https://www.planetatural.com/pest-problem-solver/plant-disease/>

4. <https://www.elsevier.com/books/plant-pathology/agrios/978-0-08-047378-9>
5. <https://www.elsevier.com/life-sciences/immunology-and-microbiology/books>
6. <https://www.amazon.in/INTRODUCTION-IMMUNOLOGY-RAFIA-IMRAN-ebook/dp/B09B66SD3J>

COURSE OUTCOMES:

Course Outcomes	On successful completion of this course, the students will be able to	Cognitive Levels
CO1	Explain the diversity, structural organization, physiology, and functional characteristics of microorganisms, plant defense systems, and components of innate and adaptive immunity.	K1
CO2	Evaluate the mechanisms of disease development, host-pathogen interactions, and defense responses in plants and humans, and interpret their significance in disease resistance and health management	K2
CO3	Critically examine microbial interactions with plants and humans, and assess their ecological, agricultural, industrial, and medical implications.	K3
CO4	Assess the roles of beneficial and harmful microorganisms in ecosystem functioning, agriculture, human health, and disease management, and evaluate the effectiveness of immune responses against microbial infections.	K4
CO5	Apply advanced diagnostic and analytical techniques to detect, identify, and interpret pathogen diversity, virulence mechanisms, and adaptive strategies, and propose appropriate approaches for disease monitoring and control.	K5 & K6

Mapping with POs:

Relationship Matrix											
Semester	Course Code		Title of the Course							Hours	Credits
II			Microbiology and Plant Pathology (Theory)							6	4
Course Outcomes	Programme Outcomes (POs)										Mean Score
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	
CO1	3	2	3	2	2	2	2	2	2	1	2.1
CO2	3	3	3	2	2	2	3	2	2	1	2.3
CO3	2	3	3	2	2	2	2	2	2	1	2.1
CO4	3	3	2	3	1	2	3	2	2	1	2.2
CO5	2	3	3	3	2	2	3	3	2	1	2.4
Mean Overall Score											2.22 (High)

Year: I	CORE PRACTICAL 2	Semester: II
Code:	ADVANCED PLANT ANATOMY, EMBRYOLOGY AND MORPHOGENESIS, MICROBIOLOGY AND PLANT PATHOLOGY (Practical)	Credits: 4

COURSE OBJECTIVES:

- To understand the cell, molecular structure and its function.
- To acquire knowledge on anatomy of Normal stem, root and leaf.
- To study about the anomalous secondary growth of stem and root; structure of anther, endosperm and embryo
- To understand the Microbiological techniques
- To gain awareness about the defence mechanisms in host parasite interactions.

ADVANCED PLANT ANATOMY:

1. Study of shoot tip and Root tip
2. Observation of cambial types.
3. Study of Primary structure of Stem, Root and Leaf.
4. Sectioning and observation of nodal types.
5. Study of anomalous secondary growth of *Amaranthus*, *Aristolochia*, *Bignonia*, *Nyctanthus* and *Draceana*
6. Observation of stomatal types by epidermal peeling.
7. Maceration of wood and observation of the components of xylem.

EMBRYOLOGY:

1. Observation of T.S. of anther.
2. Observation of ovule types.
3. Observation of mature embryo sacs.
4. Dissection and observation of embryos (globular and cordate embryos).
5. Study of pollen morphology
6. Study of in vitro pollen germination.
7. Observation of endosperm types.

MICROBIOLOGY:

1. Observation of Microbes in Air, Water and Soil.
2. Equipments used in Microbiology.
3. Media Preparation techniques.

PLANT PATHOLOGY:

1. Study of the disease cycle given in the syllabus
2. Slide preparation of causative organisms.
3. Study of various plant protection methods.

COURSE OUTCOMES:

Course Outcomes	On successful completion of this course, the students will be able to	Cognitive Levels
CO1	Explain the structural organization, developmental patterns and functional significance of plant tissues, organs, embryological processes and morphogenetic mechanisms in relation to plant growth and differentiation.	K1
CO2	Evaluate the cellular, molecular and physiological factors regulating embryogenesis, morphogenesis, organogenesis and plant developmental pathways under diverse environmental conditions.	K2
CO3	Critically examine the diversity, physiology, ecological roles and interactions of microorganisms with plants and assess their beneficial and detrimental impacts on plant health and productivity.	K3
CO4	Analyze and interpret host-pathogen interactions, disease development processes, defense mechanisms and pathogen adaptation strategies using contemporary concepts in plant pathology and microbiology.	K4
CO5	Apply advanced laboratory, diagnostic and research methodologies to investigate plant anatomical features, developmental processes, microbial diversity and plant diseases and propose scientifically sound solutions for plant health management and sustainable crop improvement.	K5 &K6

Cognitive Level: K1 - Remember; **K2** - Understanding; **K3** - Apply; **K4** - Analyze; **K5** – Evaluate; **K6** – Create

Mapping with POs:

Relationship Matrix											
Semester	Course Code	Title of the Course								Hours	Credits
II		Advanced Plant Anatomy, Embryology and Morphogenesis, Microbiology and Plant Pathology (Practical)								6	4
Course Outcomes	Programme Outcomes (POs)										Mean Score
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	
CO1	3	3	2	2	2	2	2	2	2	2	2.2
CO2	3	3	3	3	2	2	2	2	2	1	2.3
CO3	3	3	2	2	2	1	2	2	2	1	2.0
CO4	3	3	3	3	1	2	3	2	2	1	2.3
CO5	3	3	3	3	2	2	3	3	2	2	2.6
Mean Overall Score											2.28 (High)

COURSE OBJECTIVES:

- To give basic knowledge about plant tissue culture, transgenics and genetic modifications in agriculture.
- To understand the concept of tissue culture
- To know the importance of Totipotency
- To understand the process and application of somatic hybridization
- To know the importance of in vitro haploid production

UNIT – I PLANT TISSUE CULTURE:

History of Plant Tissue Culture, Basic concept, principles and scope of plant cell and tissue culture, concepts of cellular differentiation; Totipotency; basic techniques of plant tissue culture; callus formation, organogenesis and embryogenesis. Protoplast isolation, fusion and culture, somatic hybridization, hybrid selection and regeneration. Cybrids and their application.

UNIT – II HAPLOID PRODUCTION:

In vitro haploid production and its significance, Anther/Pollen culture and ovary culture; Embryo and ovule culture Production of triploids through endosperm culture. Micropropagation: meristem culture and virus-free plants; Cryopreservation of plant cell and tissue cultures and establishment of gene banks Somaclonal variations and isolation of useful mutants; mechanisms and applications in genotype improvement.

UNIT – III SECONDARY METABOLITES:

Sources and production of secondary metabolites; criteria for cell selection, factors affecting the culture of cells; different bioreactors and their use in secondary metabolite production; biochemical pathways for the production of different secondary metabolites; biotransformation.

UNIT – IV SOMATIC EMBRYOGENESIS:

Somatic embryogenesis, production of synthetic seeds, importance, limitation and their utilization. Application of tissue culture in forestry and agriculture; status of tissue and cell culture technology in India edible vaccines, and their prospects.

UNIT – V MICROPROPAGATION:

Selection and preparation of explants for adventitious shoot bud induction and axillary bud proliferation. Steps of micropropagation-management of donor plants, culture establishment, shoot multiplication, rooting and hardening and acclimatization. Protoplast isolation, culture and differentiation. Somatic hybridization.

UNIT – VI CURRENT CONTOURS (For Continuous Internal Assessment Only):

Current developments related to the Plant tissue culture during the semester concerned to be kept abreast of continuously and cumulatively through collection, discussion and evaluation from news and events over the world collected through multiple reliable informative sources – Research articles, review materials, print, Internet, Interaction, social media, Webinars and so on.

Recommended Textbooks:

1. Bhojwani, S.S. and Razdan, M.K., 1996, Plant Tissue Culture: Theory and Practice (Revised Edition), Elsevier Science Pub., New York, USA.
2. Chawla, H.S., 2020, Introduction to Plant Biotechnology (3rd Edition), Oxford and IBH Pub. Co., New Delhi.
3. Collins, H.A. and Edwards, S. 1998, Plant Cell Culture, Bios Scientific Pub., Oxford, U.K.
4. Glick, B.R., and Pasternak, J.J., 1998, Molecular Biotechnology: Principles and Applications, ASM Press, Washington.

Reference Books:

1. DC. Razdan, M.K., 1993, An introduction to Plant Culture, Oxford & IBH Pub., Co., New Delhi, India.
2. Robert Smith. Plant tissue culture: Techniques and Experiments. South Asia Edition.
3. Gamborg and Phillip. Plant Cell, Tissue and Organ Culture.
4. Narosa Dixon and Gonzales. Plant Cell Culture. Panima.

Web Resources:

1. <https://axonb.com/wp-content/uploads/2020/05/PLANT-TISSUE-CULTURE-Bhojwani-Razdan.pdf>
2. <https://biot202.wordpress.com/wp-content/uploads/2015/09/plant-tissue-culture-third-edition-techniques-and-experiments-by-roberta-h-smith.pdf>
3. https://books.google.co.in/books?id=oe_liiY_tVsC&printsec=frontcover#v=onepage&q&f=false

COURSE OUTCOMES:

Course Outcome	On successful completion of this course, the students will be able to	Cognitive Levels
CO1	Explain the principles, methodologies, and applications of non-conventional plant propagation techniques and evaluate their significance in crop improvement, forestry, and conservation biology.	K1
CO2	Apply in vitro culture techniques for the regeneration of complete plants from cells, tissues, and organs, and assess their effectiveness in large-scale plant production and genetic resource management.	K2
CO3	Evaluate the role of plant tissue culture, micropropagation, and related biotechnological approaches in agriculture, horticulture, forestry, and sustainable plant production systems.	K3
CO4	Demonstrate and assess advanced techniques for artificial seed production, germplasm storage, and ex situ conservation, and interpret their applications in biodiversity conservation and plant genetic resource preservation.	K4
CO5	Design and optimize micropropagation protocols, donor plant management strategies, and culture conditions for efficient plant regeneration, conservation, and commercial propagation of economically important species.	K5

Mapping with POs:

Relationship Matrix											
Semester	Course Code	Title of the Course								Hours	Credits
II		Plant Tissue Culture (Theory)								2	2
Course Outcomes	Programme Outcomes (POs)										Mean Score
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	
C01	3	2	2	2	2	1	2	2	2	2	2.0
C02	3	2	2	3	2	1	2	3	2	1	2.1
C03	3	3	2	2	1	2	3	2	2	2	2.2
C04	2	3	3	3	2	2	3	3	2	2	2.5
C05	2	3	3	3	2	2	3	3	2	2	2.5
											2.26 (High)

COURSE OBJECTIVES:

- To understand the importance of biofertilizers and their cultivation methods.
- To learn about bacterial biofertilizers.
- To study about the types of mycorrhizae and its advantages.
- To study biopesticides production and commercialization.
- To impart the knowledge about the types of biopesticides and its advantages.

UNIT-I BIOFERTILIZERS

Biofertilizers – Introduction, scope and advantages. A general account of Cyanobacterial biofertilizers – organisms – medium (*BG II*) isolation, mass cultivation – field application of cyanobacterial inoculants. Mass cultivation of Azolla – Symbiotic association of cyanobacteria.

UNIT- II BIOFERTILIZERS

Bacterial biofertilizers – A general account of bacterial bioinoculants. Isolation – Azotobacter – Ashby's mannitol agar – Azospirillum – Semi solid medium (*Bullow and Dobereiner, 1975*). Rhizobium – Yeast Extract Mannitol Agar medium. Culture characteristics. Mass production of Rhizobium, Azotobacter, Azospirillum and Phosphobacteria Phosphate solubilization and mobilization. Mechanism of nitrogen fixation (free-living and symbiotic).

UNIT-III BIOFERTILIZERS:

Mycorrhiza: Scope and advantages of mycorrhiza as biofertilizers. General account of Ecto, Endo and Arbuscular mycorrhizae (AM). Methods of collection wet sieving and decanting method and inoculum production. Culture of mycorrhizae in Modified Melin – Norkrans (MMN) agar medium. National and Regional Biofertilizers Production and Development centres.

UNIT-IV BIOPESTICIDES:

Biopesticides - Definition, types and importance. Plants used as biopesticides – compounds – natural biopesticides – organic farming. Advantages of biopesticides and commercialization.

UNIT-V BIOPESTICIDES:

Mechanism of action and application of biopesticides – bacterial origin (*Bacillus thuringiensis*) – fungal origin (*Trichoderma*) – viral origin (NPV). Genetic improvement and strain engineering for enhanced efficacy and specificity of biopesticidal agents.

UNIT-VI CURRENT CONTOURS (For Continuous Internal Assessment Only):

Current developments related to the Biofertilizer and Biopesticides during the semester concerned to be kept abreast of continuously and

cumulatively through collection, discussion and evaluation from news and events over the world collected through multiple reliable informative sources – Research articles, review materials, print, Internet, Interaction, social media, Webinars and so on. Data-driven agriculture using artificial intelligence and big data analytics for optimizing bio input application, and regulatory frameworks and biosafety assessment for commercialization and large-scale adoption of biofertilizers and biopesticides are included.

Recommended Textbooks:

1. Dubey, R.C. (2008). A Textbook of Biotechnology. S. Chand & Co., New Delhi.
2. Subba Rao, N.S. (1982). Advances in Agricultural Microbiology. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
3. Subba Rao, N.S. (2002). Soil Microbiology. 4th ed. Soil Micro organisms and Plant Growth. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.

Reference Books:

1. Varma, A. and Hock, B. (1995). Mycorrhiza Springer – Varlag, Berlin.
2. Yaaco Vokan (1994). *Azospirillum* / Plant Associations. CRC Press, Boca Raton, FL.
3. Joshi, S.R. (2018). Biopesticides: A Biotechnological Approach. New Age International (P) Ltd., Publishers.
4. Koul, O. and Dhaliwal, G.S. 2012. Biopesticides and Pest Management. Cumpus Books International.

Web Resources:

1. <http://kamarajcollege.ac.in/Department/Microbiology/II%20Year/005%20Allied%20III%20%20Plant%20Pathology,%20Biofertilizers%20and%20Biopesticides%20%20III%20Sem.pdf>
2. <https://courseware.cutm.ac.in/wp-content/uploads/2020/06/Lec-11- Biofertilizer-and-biopesticide.pdf>
3. <https://www.agrifs.ir/sites/default/files/Handbook%20of%20Biofertilizers%20and%20Biopesticides%20%7BR.M.%20Khobragade%7D%20%5B9788189473150%5D%20%28ABD%20Publishers%20-%202007%29.pdf>
4. <http://eagri.org/eagri50/SSAC222/lec17.pdf>
5. <https://eternaluniversity.edu.in/docs/ProductionTechnologyforBioagentsandBiofertilizers.pdf>

COURSE OUTCOMES:

CO No.	On successful completion of this course, the students will be able to	Cognitive Levels
CO1	Explain the diversity, characteristics, mechanisms of action, and applications of biofertilizers and biopesticides in sustainable agriculture and environmental management.	K1
CO2	Evaluate the roles of beneficial microorganisms in nutrient cycling, soil fertility enhancement, plant growth promotion, and biological control of plant pests and pathogens.	K2
CO3	Apply laboratory and field techniques for the isolation,	K3

	identification, mass multiplication, formulation, and quality assessment of biofertilizers and biopesticides.	
C04	Critically assess the effectiveness, environmental impact, economic feasibility, and limitations of biofertilizers and biopesticides in comparison with conventional agrochemicals.	K4
C05	Design and propose integrated nutrient and pest management strategies utilizing biofertilizers and biopesticides to improve crop productivity, environmental sustainability, and agricultural resilience.	K5

Mapping with POs:

Relationship Matrix											
Semester	Course Code		Title of the Course							Hours	Credits
II			Biofertilizers and Biopesticides (Theory)							2	2
Course Outcomes	Programme Outcomes (POs)										Mean Score
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	
C01	3	2	2	2	2	2	2	2	3	1	2.1
C02	3	3	2	3	2	2	2	2	2	1	2.2
C03	3	2	2	3	2	2	2	3	2	1	2.2
C04	2	3	3	2	2	2	3	3	2	1	2.3
C05	2	3	3	3	2	2	3	3	2	3	2.6
Mean Overall Score											2.28 (High)

COURSE OBJECTIVES:

- To acquire the fundamental values of plant systematics.
- To list out basic concepts and principles of plant Taxonomy.
- To employ a suitable method for correct identification and adequate characterization and know the economic importance of plants.
- To formulate taxonomic relationship in plant systematic studies and different classification systems.
- To acquire knowledge on economic plant producers.

UNIT – I SCOPE OF PLANT TAXONOMY

History of plant taxonomy, Definition, Aims, importance and scope of plant taxonomy Development and phases of classification, systems of classification Artificial-Linnean system, Natural Bentham & Hooker, phylogenetic-Armen Takhtajan and APG IV system of classification. Phenetics, Cladistics, concepts of taxonomic hierarchy, Systematic evidence - Morphology, Anatomy, embryology. Numerical taxonomy, Chemotaxonomy, sero taxonomy and molecular taxonomy.

UNIT – II PLANT NOMENCLATURE:

Plant Nomenclature, Principles of ICN and new Regulations. Binomial nomenclature, Typification-Principles of priority, Author citation, Retention, Rejection and Changing of names, Effective and valid publication-Monographs, Periodicals, Flora and manuals -Plant identification. Herbarium techniques, Botanical Garden, Botanical survey of India.

UNIT – III SYSTEMATIC STUDY:

Study of important taxonomical characters with suitable examples of following families- Ranunculaceae, Caryophyllaceae, Rutaceae, Rhamnaceae, Sapindaceae, Lythraceae, Aizoaceae, Rutaceae, Asteraceae and Sapotaceae.

UNIT – IV SYSTEMATIC ANALYSIS:

Study of taxonomical and reproductive characters with suitable examples of following families-Nyctaginaceae, Aristolochiaceae, Piperaceae, Loranthaceae, Euphorbiaceae, Orchidaceae, Amaryllidaceae, Commelinaceae, Palmae and Cyperaceae.

UNIT – V ECONOMIC BOTANY:

Scope of Economic Botany, study of economically important plants and their products (a) Cereals and pulses (b) Fruit and Vegetables (c) Spices and Condiments (d) wood timber and Lumber (e) Resins, gum, tannins, cork- (f) Rubber and other latex products (g) Textile products, Fibres- soft and Hard fibres (h) Fumitories and masticatories.

UNIT - VI CURRENT CONTOURS (For continuous internal assessment only):

Current developments related to the Taxonomy and Economic Botany during the semester concerned to be kept abreast of continuously and cumulatively through collection, discussion and evaluation from news and events over the world collected through multiple reliable informative sources – Research articles, review materials, print, Internet, Interaction, social media, Webinars and so on.

Recommended Textbooks:

1. A.J. 1969, Numerical Taxonomy Academic Press, London Bhattacharya, B and Johri. Flowering plant taxonomy and phylogeny Narosa Publishing house, New Delhi
2. Vasishta, P.C., 1994 Taxonomy of Angiosperms. S.Chand & company
3. Sharma, O.P. 1993, Plant taxonomy Data Mc Grow Hill Edition, New Delhi
4. Lawrence, G.H>M., 1969. Taxonomy of Vascular plants Oxford & IBH publishing co, New Delhi
5. Subramanian, N.S.2009. Modern plant taxonomy, Vikas publishing House, Pvt, Ltd New Delhi
6. Sambamurthy, A 2010 Textbook of plant taxonomy, Wiley Eastern Pvt Ltd.

Reference Books:

1. Saxena, N.B. and Sabena 7th edition pragmatic Pragati Meerut.
2. Stace, C, 1985. Plant Taxonomy and biosystematics, Edward Arnold, London
3. Takhtajan, A.L. 1997 Diversity and classification of flowering plants Columbia University press,
4. Sokal R.R. and sneath, P.H.A 1963, Principles of Numerical Taxonomy Fremen & co San Francisco
5. Walter,S. Judd Christopher.S. Campbell Elizabeth A, kelog, peter,F Stevens Michael J.Donoghue,2015 plant systematics A phylogenetic Approach, Sinauer, USA.

Web Resources:

- 1.<https://www.uou.ac.in/sites/default/files/slm/BSCBO-302.pdf> 13.
- 2.<https://byjus.com/neet/important-notes-of-biology-for-neet-plant-taxonomy/>

COURSE OUTCOMES:

Course Outcomes	On completion of this course, the students will be able to:	Cognitive Level
CO1	Explain the morphological diversity and diagnostic features of vegetative and reproductive plant organs, including leaves, flowers, and fruits for accurate identification and classification of plants.	K1
CO2	Apply the principles of plant taxonomy, taxonomic hierarchy, nomenclature and modern systematic approaches to classify and name plant taxa according to international standards.	K2
CO3	Construct and interpret floral formulae, floral diagrams and taxonomic descriptions to evaluate systematic relationships among flowering plant groups.	K3
CO4	Critically evaluate the characteristic features, phylogenetic relationships and economic importance of major plant families and assess their significance in biodiversity, agriculture, horticulture and industry.	K4
CO5	Investigate and document plant diversity through field studies, herbarium techniques and botanical garden surveys and interpret the role of ex situ and in situ conservation in preserving plant genetic resources.	K5 & K6

Cognitive Level: K1 - Remember; **K2** - Understanding; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Mapping with POs:

Relationship Matrix											
Semester	Course Code	Title of the Course								Hours	Credits
III		Taxonomy of Angiosperms (Theory)								6	4
Course Outcomes	Programme Outcomes (POs)										Mean Score
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	
C01	3	2	2	2	2	2	2	2	2	1	2.0
C02	3	3	2	2	2	2	2	2	2	1	2.1
C03	3	2	3	2	2	2	2	2	2	1	2.1
C04	3	3	3	2	1	2	2	2	2	1	2.1
C05	2	3	2	3	2	2	2	3	2	2	2.3
Mean Overall Score											2.12 (High)

COURSE OBJECTIVES:

- To have conceptual understanding of laws of inheritance, genetic basis of loci and alleles and their linkage.
- To develop critical understanding of biochemical basis of genes and their interactions at population and evolutionary levels.
- To understand the process of replication.
- To analyse about the transposons and their role.
- To know about the process of evolution and its significance

UNIT I GENETICS:

Genetics of Eukaryotes: Basic concepts – gene as a concept. Linkage, Crossing over - homologous recombination - model and mechanism - three-point cross, and chromosome mapping. Organisation of chromosomes, specialized chromosomes, quantitative inheritance, population genetics - Hardy Weinberg equilibrium.

UNIT II GENETICS:

Identification of DNA as genetic material. Gene as the unit of mutation and recombination. Mutations: Molecular nature; Mutagens. Origin of spontaneous mutations and control. Reversion and Suppression - suppression of nonsense, missense and frameshift mutations. Chromosomal aberrations. Para sexual process in bacteria: transformation, transduction and conjugal gene transfer: phenomena & mechanisms. Hfr mapping - time of entry technique.

UNIT III GENETICS:

Gene as the unit of expression. Colinearity of gene and polypeptide. DNA damage and repair: DNA damage by UV, alkylating agent, cross linkers. Mechanism of repair - photo reactivation, excision repair, recombinational repair, SOS.

UNIT IV GENETICS:

Transposable genetic elements - Identification of transposition - IS elements, composite transposons, Tn3 and Tn5. Mechanism of transposition. Transposable elements in eukaryotes: Maize - Ac & Ds, Spm & Dspm, Drosophila - P elements. Retrotransposons.

UNIT V EVOLUTION:

Inorganic chemical and molecular evolution and Origin of life, Origin of Species. Evidence in favour of evolution (Morphology and Anatomy, Embryology, Palaeontology). Theories of Lamarck and Charles Darwin with Merits and Demerits - Contributions of Weismann, Hugo de Vries and Sewall Wright and Modern Synthetic Theories.

UNIT VI CURRENT CONTOURS (For continuous internal assessment only):

Current developments related to the Genetics and Evolution during the semester concerned to be kept abreast of continuously and cumulatively through collection, discussion and evaluation from news and events over the world

collected through multiple reliable informative sources – Research articles, review materials, print, Internet, Interaction, social media, Webinars and so on.

Recommended Texts:

1. Benjamin, A. Pierce. 2012. Genetics- A conceptual Approach. W.H. Freeman and Company, New York, England.
2. Stansfield, W.D. 1969. Theory and problems of Genetics. McGraw-Hill
3. Sinnott, E.W. Dunn, L.E and Dobzhansky, T. 1973. Principles of Genetics. McGraw-Hill. New York.
4. Brown, T.A. 1992. Genetics a Molecular Approach, 2nd Ed. Chapman and Hall.
5. Gupta, P.K. 2009. Genetics. Rastogi publications, Meerut, New Delhi

Reference Books:

1. Watson, J.D. *et al.* 2003. Molecular Biology of the Gene. Fourth Edition. The Benjamin Cummings Pub. Co.
2. Lewin, B. 2003. Genes VIII. Oxford University Press.
3. Friefielder, D. 2005. Molecular Biology. Second Edition. Narosa Pub. House.
4. Sobtir, C. and Gobe. 1991. Eukaryotic chromosomes. Narosa Publishing house.
5. Strickberger, M.W. 2005. Genetics (III Ed). Prentice Hall, New Delhi, India.

Web Resources:

1. <https://www.cdc.gov/genomics/about/basics.htm>
2. <https://ocw.mit.edu/courses/biology/7-03-genetics-fall-2004/lecture-notes/>
3. <https://www.britannica.com/science/evolution-scientific-theory>
4. <https://www.britannica.com/science/cell-biology>
5. <https://medlineplus.gov/genetics/understanding/basics/cell/>

COURSE OUTCOMES:

Course Outcome	On completion of this course, the students will be able to:	Cognitive Level
CO1	Explain the principles of Mendelian inheritance, gene interactions and patterns of genetic transmission and interpret their significance in the inheritance of biological traits.	K1
CO2	Evaluate the genetic and molecular mechanisms governing heredity, variation and transmission of traits across generations and assess their roles in biological diversity.	K2
CO3	Apply linkage analysis, gene mapping techniques and genetic principles to construct and interpret linkage maps and predict inheritance patterns.	K3
CO4	Critically examine the causes, types and consequences of mutations and evaluate the roles of physical, chemical and biological mutagens in generating genetic variability and evolutionary change.	K4
CO5	Analyze and interpret evolutionary processes, mechanisms of speciation and major evolutionary theories using genetic, ecological and molecular evidence to explain the origin and diversification of life.	K5 & K6

Cognitive Level: K1 - Remember; **K2** - Understanding; **K3** - Apply; **K4** - Analyze; **K5** – Evaluate; **K6** – Create

Mapping with POs:

Mapping with POs:											
Relationship Matrix											
Semester	Course Code	Title of the Course								Hours	Credits
III		Genetics and Evolution (Theory)								6	4
Course Outcomes	Programme Outcomes (POs)										Mean Score
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	
C01	3	2	2	2	2	3	2	2	2	1	2.1
C02	3	3	2	2	2	2	2	1	2	1	2.0
C03	3	2	3	3	2	1	2	3	2	1	2.2
C04	3	3	3	3	3	1	2	2	2	1	2.3
C05	3	3	3	3	3	1	2	2	2	1	2.3
Mean Overall Score											2.18 (High)

COURSE OBJECTIVES:

- To study the morphological characters of stem, stipule, leaf and fruit.
- To acquire knowledge on taxonomy of angiosperms.
- To understand the key preparation.
- To work out the problems in genetics.
- To understand the principles of evolution.

TAXONOMY OF ANGIOSPERMS:

1. Preparation of artificial keys.
2. Description of a species, based on virtual herbarium and live specimens of the families mentioned in the theory.
3. Study the products of plants mentioned in the syllabus of economic botany with special reference to the morphology, botanical name and family.
4. A detailed study of the diagnostic features, flower characters and economic importance of families included in theory.
5. Submission of fifteen herbarium specimen with binomial family and field note book along with tour report.
6. Tour and field study of botanical gardens research institution and natural vegetation under the guidance of staff for three to five days within the state.

GENETICS AND EVOLUTION:

1. Problem solving on dihybrid phenotypic, genotypic and test cross ratios.
2. Incomplete dominance in plants.
3. Interactions of factors and modified dihybrid ratios.
4. Multiple alleles in plants, blood group inheritance in human.
5. Sex linked inheritance in Drosophila and plants.

REFERENCES:

1. Heywood, V.H. Plant Taxonomy. English Language Book Society, London, 1967.
2. Sambamurthy, A.V.S.S. Taxonomy of Angiosperms. I.K. International Pvt. Ltd., New Delhi, 2005.
3. Davis, P.H. and Heywood, V.H. 1963. Principles of Angiosperm Taxonomy. Oliver & Boyd, London
4. <https://www.uou.ac.in/sites/default/files/slm/BSCBO-202.pdf>

COURSE OUTCOMES:

Course Outcome	On completion of this course, the students will be able to:	Cognitive Level
CO1	Explain the contemporary concepts and recent advances in plant morphology, floral biology and systematic botany to interpret their significance in plant classification and evolutionary relationships.	K1

CO2	Apply morphological and floral characteristics, artificial keys and taxonomic tools to identify, classify and conserve plant species using modern systematic approaches.	K2
CO3	Evaluate the diagnostic features, phylogenetic significance and economic importance of major plant families and assess their contributions to agriculture, horticulture, medicine and industry.	K3
CO4	Apply and interpret genetic principles, inheritance patterns and analytical approaches to solve problems related to heredity, variation and plant improvement.	K4
CO5	Critically analyze evolutionary concepts, mechanisms and theories using genetic, fossil and molecular evidence to explain the origin, diversification and adaptation of life forms.	K5 & K6

Cognitive Level: **K1** - Remember; **K2** - Understanding; **K3** - Apply; **K4** - Analyze; **K5** – Evaluate; **K6** – Create

Mapping with POs:

Relationship Matrix											
Semester	Course Code		Title of the Course							Hours	Credits
III			Taxonomy of Angiosperms, Genetics and Evolution (Practical)							6	4
Course Outcomes	Programme Outcomes (POs)										Mean Score
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	
C01	3	3	2	2	2	2	2	2	2	1	2.1
C02	3	2	3	2	2	1	2	2	2	1	2.0
C03	3	3	2	2	2	1	2	2	2	1	2.0
C04	3	3	3	3	3	1	3	2	2	1	2.4
C05	3	3	3	3	3	1	2	2	2	1	2.3
Mean Overall Score											2.16 (High)

COURSE OBJECTIVES:

- To learn the traditional knowledge on plant derived drugs and their conventional classification.
- To elucidate the biosynthetic pathway of major classes of secondary metabolites.
- To study the general pharmacological mode of action of crude drugs of few medicinal plants.
- To elucidate the isolation and characterization of plant derived drugs using modern biotechniques.
- To acquire knowledge on pharmacological action of drugs.

UNIT – I INTRODUCTION:

History and scope of Pharmacognosy including indigenous system of medicine. Various systems of classification of drugs. pharmacological action of plant drugs. Significance of Pharmacopeial standards.

UNIT – II BIOSYNTHETIC PATHWAYS:

Acetate pathway (fatty acids and polyketides), mevalonate and deoxy xylulose phosphate pathway (terpenoids and steroids), shikimate pathway (phenols, amino acids etc.

UNIT – III CHARACTERIZATION OF THERAPEUTIC DRUGS:

Extraction, separation, isolation (Chromatographic techniques) and characterization of secondary metabolites (Spectroscopic techniques). Quality control of plant drugs: Classical and modern approaches

UNIT – IV PLANT DRUGS:

Anti-cancer, Bitter tonic, Carminatives and G.I. regulators, Cardiotonics, CNS-Stimulant, Expectorant, Laxatives, Purgatives. Outline of pharmacogenomics functions.

UNIT – V TOXIC PLANTS

Hallucinogenic, allergenic and other toxic plants, poisonous plants - biopesticides - biocides – bio fungicides.

UNIT – VI CURRENT CONTOURS (For Continuous Internal Assessment Only):

Current developments related to the Pharmacognosy during the semester concerned to be kept abreast of continuously and cumulatively through collection, discussion and evaluation from news and events over the world collected through multiple reliable informative sources – Research articles, review materials, print, Internet, Interaction, social media, Webinars and so on.

Recommended Textbooks:

1. Bruneton J., 1999. Pharmacognosy, Phytochemistry, Medicinal Plants, Intercept Ltd., Paris.
2. Evans W.C., 2002, Trease and Evan's Pharmacognosy, W.B. Saunders.
3. Harborne, J.B. 1998. Phytochemical Methods, Chapman and Hall.

Reference Books:

1. Vickery M.L. and B. Vickery, 1981. Secondary Plant Metabolism, The MacMillan Press Ltd.
2. Wagner H., S. Bladt and E.M. Zgainski (Translated by A. Scott) 1984, Plant Drug Analysis, Springer-Verlag.

Web Resources:

1. <https://nootanpharmacy.in/public/upload/Uhrq97UKMps61EcUZvdAdnbNH ydCoBcCoQXEMMCA.pdf>
2. https://books.google.co.in/books?id=yhfEEAAAQBAJ&printsec=frontcover&redir_esc=y#v=onepage&q&f=false
3. <https://pharmabookbank.files.wordpress.com/2019/03/14.2.pharmacognosy-by-birensahavinash-seth-1.pdf>

COURSE OUTCOMES:

Course Outcomes	On successful completion of this course, the students will be able to	Cognitive Levels
CO1	Explain the traditional knowledge systems, classification, sources and therapeutic significance of plant-derived drugs and evaluate their contributions to healthcare and natural product research.	K1
CO2	Evaluate the biosynthetic pathways, regulation and biological significance of major classes of plant secondary metabolites and interpret their roles in plant defence mechanism and pharmaceutical applications.	K2
CO3	Apply advanced analytical and instrumental techniques for the extraction, isolation, characterization and quality assessment of plant metabolites and herbal products.	K3
CO4	Critically assess the pharmacological activities, mechanisms of action, efficacy and safety of herbal drugs using scientific evidence and contemporary research approaches.	K4
CO5	Analyze and propose the medical, agricultural, industrial and commercial applications of plant-derived bioactive compounds and evaluate their potential for sustainable development and innovation.	K5

Mapping with POs:

Relationship Matrix											
Semester	Course Code		Title of the Course							Hours	Credits
III			Pharmacognosy (Theory)							2	2
Course Outcomes	Programme Outcomes (POs)										Mean Score
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	
CO1	3	2	2	2	2	2	2	2	2	1	2.0
CO2	3	3	3	2	2	2	2	2	2	1	2.2
CO3	3	2	3	3	2	2	3	3	2	1	2.4
CO4	2	3	3	3	1	2	3	2	2	1	2.2
CO5	2	3	3	3	2	2	3	2	2	3	2.5
	Mean Overall Score										2.26 (High)

COURSE OBJECTIVES:

- To develop an advanced understanding of plant physiological processes, including photosynthesis, respiration, and nutrient regulation at multiple levels.
- To gain research expertise in plant physiology, encompassing experimental design, data analysis, and modern research tools.
- To apply plant physiology knowledge to address practical challenges in agriculture, environment, and biotechnology through critical thinking.
- To recall the physiological pathway involved in plant nutrition.
- To describe the metabolic phenomenon involved in plant growth regulators.

UNIT-I WATER RELATIONS:

Water and plant cells: Water and its role in plants, diffusion and osmosis, water potential. Water balance of plants: absorption by roots, transport through the xylem, aquaporins. Transpiration-structure of stomata, role of hormones and ions in stomatal movement. Mineral nutrition: essential nutrients, deficiencies, plant disorders. Solute transport: passive and active transport, molecular basis of inter and intracellular uptake and transport. Pathway and mechanism of translocation in the phloem.

UNIT-II PHOTOSYNTHESIS:

Photosynthesis: The light reactions-nature of light, properties and various roles of pigments, organisation of photosynthetic apparatus and light absorbing antenna systems, molecular basis of electron transport and its coupling to ATP synthesis. The carbon reactions- The Calvin-Benson cycle, photorespiration, inorganic carbon concentrating mechanisms (The C₄ carbon cycle, Crassulacean Acid Metabolism), and carbon allocation (starch and sucrose).

UNIT-III RESPIRATION:

Respiration: Glycolysis, gluconeogenesis and their regulation. Oxidation of pyruvate and the Citric Acid cycle. Pasteur effect, anaplerotic reactions, amphibolic nature of the Citric Acid cycle. Oxidative pentose phosphate pathway and its roles. Respiratory chain complexes and oxidative phosphorylation, internal and external NAD(P) dehydrogenase, alternative oxidase. Non phosphorylating mechanisms and their roles. Bottom-upregulation of plant respiration. The Glyoxylate cycle and its role in germinating seeds.

UNIT-IV PHOTOPERIODISM:

Nitrogen cycle, physiology of biological and non-biological nitrogen fixation, assimilation of nitrate and ammonium-GS-GOGAT; Plant responses to light signals: the phytochromes and the blue-light responses (cryptochromes, phototropins and zeaxanthin). Biosynthesis, metabolism, transport, physiological and developmental effects of auxin, gibberellin, cytokinin, ethylene and abscisic acid.

UNIT-V FRUIT DEVELOPMENT

Flowering and fruit development: Floral evocation, Circadian rhythm, photoperiodism, vernalisation. Physiology of fruit development and ripening. Physiology of seed development, maturation, dormancy, germination and tropisms. Ageing and senescence-types and physiological/ biochemical changes. Abiotic stress (drought, heat and salinity): Plant responses and mechanisms of tolerance.

UNIT-VI CURRENT CONTOURS (For Continuous Internal Assessment Only):

Current developments related to the Plant physiology during the semester concerned to be kept abreast of continuously and cumulatively through collection, discussion and evaluation from news and events over the world collected through multiple reliable informative sources – Research articles, review materials, print, Internet, Interaction, social media, Webinars and so on.

Recommended Textbooks:

1. Plant Physiology, Biochemistry and biotechnology - S.K.Verma - 1995, S.Chand & Co - New Delhi.
2. Fundamental physiology - V.K.Jain - 2000 - S. Chand & Co - New Delhi.
3. Jain, J.L.Sanjay Jain and Nitin Jain, 2007 - Fundamentals of Biochemistry S.Chand & Co - New Delhi.

Reference Books:

1. Lincoln Taiz and Eduardo Zeiger, 2005. Plant Physiology Sinauer Associates Inc. Sublishers, Sunderland, Massachusetts.
2. Salisbury, F.B. and Cleon Ross 2007. Plant Physiology, Wadsworth publishing company Belimont.
3. William G.Hopkins, 1999 - Introduction to Plant Physiology, John Wiley and sons, INC - New York.

Web Resources:

1. http://www.esalq.usp.br/lepse/imgs/conteudo_thumb/Handbook-of-Plant---Crop-Physiology-Revised---Expanded-by-Mohammad-Pessarakli-2001-.pdf
2. <https://www.jstor.org/stable/i40135622>
3. https://ses.library.usyd.edu.au/bitstream/handle/2123/3578/Agriculture_2008.pdf?sequence=1&isAllowed=y

COURSE OUTCOMES:

Course Outcomes	On successful completion of this course, the students will be able to	Cognitive Levels
CO1	Explain the structure, function, kinetics and regulatory mechanisms of enzymes and evaluate their roles in plant physiological and metabolic processes.	K1
CO2	Evaluate the biochemical pathways and energy-yielding mechanisms involved in respiration, including glycolysis, the TCA cycle and associated metabolic networks.	K2
CO3	Analyze and interpret the mechanisms of electron transport, oxidative phosphorylation and energy conservation in cellular systems and assess their significance in plant	K3

	metabolism.	
C04	Critically examine the biochemical, physiological, and environmental factors influencing photosynthesis and evaluate their roles in plant productivity and carbon assimilation.	K4
C05	Assess the physiological functions, mechanisms of action and applications of plant growth regulators in plant growth, development, stress responses and crop improvement.	K5

Mapping with POs:

Relationship Matrix											
Semester	Course Code		Title of the Course							Hours	Credits
IV			Plant Physiology (Theory)							6	4
Course Outcomes	Programme Outcomes (POs)										Mean Score
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	
C01	3	2	2	3	2	2	2	2	2	1	2.1
C02	3	3	2	3	2	2	2	2	2	1	2.2
C03	3	3	3	3	2	1	2	2	2	1	2.3
C04	3	3	3	3	3	1	2	2	2	1	2.3
C05	2	3	3	3	2	2	3	2	2	1	2.3
	Mean Overall Score										2.22 (High)

COURSE OBJECTIVES:

- To understand the structural and functional role of biomolecules.
- To explore metabolic pathways emphasizing enzymatic regulations in health and disease.
- To analyze Protein Structure and Function along with their biomedical implications.
- To understand enzyme kinetics with their industrial and pharmaceutical applications.
- To integrate biomolecular concepts with modern applications.

UNIT-I BIOCHEMISTRY:

Carbohydrates: Classification and general properties of monosaccharide, polysaccharides. Proteins: Structural organization of protein (primary, secondary, tertiary and quaternary) - amino acid biosynthesis – properties of amino acids.

UNIT-II BIOCHEMISTRY:

Lipids – Classification and general properties - Structure of fatty acids - alpha and beta oxidation – Secondary metabolites – Phenols – Terpenoids –Porphyrins - Alkaloids and Flavonoids.

UNIT-III BIOCHEMISTRY:

Enzymes: classification, nomenclature, chemical nature, structure and properties. Mechanism of enzyme action – Michaelis-Menton's constant – enzyme inhibitors – competitive, non-competitive and allosteric control of enzyme behaviour – Factors affecting enzyme action.

UNIT-IV BIOPHYSICS:

Bioenergetics, Energy and work. Laws of Thermodynamics. Energy transductions in biological systems. Redox potential, Redox couples, ATP bioenergetics. Photobiology: Dual nature of light, characteristics of solar radiation, solar energy - Efficiency of atoms Absorption spectra in molecules, energy states, Deexcitation.

UNIT-V BIOPHYSICS:

Principle and applications of Colorimetry, Centrifuge and centrifugation -Basic principles, Types of centrifuges, Chromatography -Principles, procedures and applications of Paper (PC), Thin layer (TLC), High performance thin layer chromatography (HPTLC), Ion exchange, Affinity, Gas chromatography (GC), Gas liquid chromatography (GLC), High performance liquid chromatography (HPLC). Electrophoresis -Basic principles -Isolation and staining of DNA and Protein from plant sample -AGE, PAGE, PFGE -Extraction and estimation of DNA by AGE - Extraction and estimation Protein by PAGE.

UNIT-VI CURRENT CONTOURS (For Continuous Internal Assessment Only):

Current developments related to the Biochemistry and Biophysics during the semester concerned to be kept abreast of continuously and cumulatively through collection, discussion and evaluation from news and events over the world

collected through multiple reliable informative sources – Research articles, review materials, print, Internet, Interaction, social media, Webinars and so on.

Recommended Textbooks:

1. Casey, E.J. (1962). Biophysics: Concepts and Mechanics. Van Nostrand Reinhold Co. and East West Press, New Delhi.
2. Rajeshwari, M.R. (2012)- Biophysics, Rastogi Publications, Meerut.
3. Salil Bose, S. (1982). Elementary Biophysics. Vijaya Printers, Madurai.

Reference Books:

1. Aggarwal S.K, 2009 Foundation Course in Biology Students Edition P 7993.
2. Eldon D.Enger, Frederick C.Ross and David Bailey (2008) -11th Edition, Concepts in Biology. Tata McGraw Hill, New Delhi.
3. Wilson & Walkar 2008 Principles and Techniques of Biochemistry and Molecular Biology Cambridge University Press.
4. Ghatak K.L. 2011.Techniques and Methods in Biology. PHI Learning Pvt. Ltd. New Delhi.
5. Gupta A. 2009. Instrumentation and Bio Analytical Techniques. Pragati Prakashan, Meerut.
6. Steven Ruzin, (2005). Plant Micro technique and Microscopy. Oxford university press, London.
7. Jayaraman - Laboratory manual in Biochemistry, Madurai.
8. Sadasivan, S. and Manickam - Biochemical methods, Coimbatore.
9. David T. Plummer - Introduction to Practical Biochemistry, New Delhi.

Web Resources:

1. [http://priede.bf.lu.lv/grozs/AuguFiziologijas/Augu_biokimija/Plant%20Biochemistry 204.pdf](http://priede.bf.lu.lv/grozs/AuguFiziologijas/Augu_biokimija/Plant%20Biochemistry%204.pdf)
2. http://www.brainkart.com/subject/Plant-Biochemistry_257/
3. https://swayam.gov.in/nd2_cec20_bt12/preview
4. <https://www.biorxiv.org/content/10.1101/660639v2>

COURSE OUTCOMES:

Course Outcomes:	On successful completion of this course, the students will be able to	Cognitive Levels
CO1	Explain the structure, properties, and biological functions of major biomolecules including carbohydrates, proteins, lipids and nucleic acids and evaluate their roles in cellular organization and metabolism.	K1
CO2	Evaluate the biochemical pathways involved in the biosynthesis and metabolism of carbohydrates, proteins and lipids and interpret their significance in cellular growth, development and energy balance.	K2
CO3	Analyze and apply the principles of enzyme kinetics, catalytic mechanisms, and regulatory processes to interpret enzyme behaviour under physiological and experimental conditions.	K3
CO4	Critically examine the concepts of bioenergetics, energy transformation and metabolic regulation and assess their significance in sustaining biological processes.	K4
CO5	Apply and evaluate modern biochemical separation,	K5

	purification and analytical techniques for the characterization and investigation of biomolecules in research and industrial applications.	
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Mapping with POs:

Relationship Matrix											
Semester	Course Code	Title of the Course								Hours	Credits
IV		Biochemistry and Biophysics (Theory)								6	4
Course Outcomes	Programme Outcomes (POs)										Mean Score
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	
C01	3	2	2	2	2	2	2	2	2	1	2.0
C02	3	3	2	3	2	2	2	2	2	1	2.2
C03	3	3	2	3	2	3	2	2	2	1	2.3
C04	3	3	3	3	2	2	2	2	2	1	2.3
C05	3	3	3	3	3	2	3	3	2	1	2.6
	Mean Overall Score										2.28 (High)

COURSE OBJECTIVES:

- To understand the knowledge about estimation and separation of photosynthetic pigments.
- To examine the factors affecting Photosynthesis.
- To analyze the process of respiration.
- To know the various techniques for phytochemicals analysis and separation.
- To know the knowledge about instrument operation and utilization.

PLANT PHYSIOLOGY (INDIVIDUAL EXPERIMENTS)

1. Determination of water potential in plant tissues.
2. Determination of stomatal frequency and stomatal index in leaf.
3. Estimation of photosynthetic pigments (chlorophyll and carotenoid).
4. Estimation Respiratory Quotient in flower buds or germinating seeds.
5. Separation of photosynthetic pigments by Paper Chromatography.
6. Determination of pH in the soil and water sample using p^H meter.

BIOCHEMISTRY (INDIVIDUAL EXPERIMENTS)

1. Extraction and estimation of starch.
2. Extraction and estimation of total sugar
3. Extraction and estimation of total protein
4. Extraction and estimation of total amino acid.
5. Extraction and estimation of lipid
6. Estimation of total acidity.
7. Extraction and estimation of total phenol.

DEMONSTRATION ONLY: (SPOTTERS)

Physiology- Osmosis, Anaerobic respiration,

Growth regulators and their role (IAA, IBA, NAA, 2,4-D, GA3, KIN)

Biochemistry Enzymes and their actions - peroxidase, catalase, amylase, nitrate reductase.

BIO – INSTRUMENTATION**Principle and working mechanism of**

1. pH Meter
2. Centrifuge
3. Spectrophotometer
4. Electrophoretic apparatus

Recommended Textbooks:

1. Plant Physiology, Biochemistry and biotechnology - S.K.Verma - 1995, S.Chand & Co - New Delhi.
2. Fundamental physiology - V.K.Jain - 2000 - S. Chand & Co - New Delhi.
3. Jain, J.L.Sanjay Jain and Nitin Jain, 2007 - Fundamentals of Biochemistry S.Chand & Co - New Delhi.
4. Casey, E.J. (1962). Biophysics: Concepts and Mechanics. Van No strand

Reinhold Co. and East West Press, New Delhi.

5. Rajeshwari, M.R. (2012)- Biophysics, Rastogi Publications, Meerut.

6. Salil Bose, S. (1982). Elementary Biophysics. Vijaya Printers, Madurai.

Reference Books:

1. Lincoln Taiz and Eduardo Zeiger, 2005. Plant Physiology Sinauer Associates Inc. Sublishers, Sunderland, Massachusetts.
2. Salisbury, F.B. and Cleon Ross 2007. Plant Physiology, Wadsworth publishing company Belimont.
3. William G.Hopkins, 1999 - Introduction to Plant Physiology, John Wiley and sons, INC - New York.
4. Wilson & Walkar 2008 Principles and Techniques of Biochemistry and Molecular Biology Cambridge University Press.
5. Ghatak K.L. 2011.Techniques and Methods in Biology. PHI Learning Pvt. Ltd. New Delhi.
6. Gupta A. 2009. Instrumentation and Bio Analytical Techniques. Pragati Prakashan, Meerut

Web Resources:

1. file:///C:/Users/User/Downloads/2021%20Botany%20Syllabus%20after%20BoS%20formatted1%20(1).pdf
2. <https://kau.in/document/laboratory-manual-biochemistry>
3. <https://www.amazon.in/Practical-Manual-on-Plant-Biochemistry/dp/6200539790>
4. <https://www.amazon.in/Laboratory-Manual-Physiology-Mukesh-Amaregouda/dp/6133993502>
5. <https://www.kopykitab.com/A-Laboratory-Manual-of-Plant-Physiology-Biochemistry-and-Ecology-by-Akhtar-Inam>

COURSE OUTCOMES:

Course Outcomes:	On successful completion of this course, the students will be able to	Cognitive Levels
CO1	Analyze the biochemical and physiological mechanisms underlying photosynthesis and evaluate their significance in plant growth, productivity and carbon assimilation.	K1
CO2	Evaluate the pathways and regulatory mechanisms of plant respiration and interpret their roles in energy production, metabolism and physiological adaptation.	K2
CO3	Apply quantitative and analytical techniques to estimate, analyze and interpret the levels of major plant biomolecules including carbohydrates, proteins, lipids, pigments and nucleic acids.	K3
CO4	Compare and assess the biosynthesis, transport, physiological functions and interactions of plant growth regulators in regulating plant growth, development and stress responses.	K4
CO5	Demonstrate and evaluate biochemical assays and modern analytical methods for the quantification of plant metabolites and interpret experimental data for scientific and research applications.	K5 & K6

Mapping with POs:

Relationship Matrix											
Semester	Course Code		Title of the Course							Hours	Credits
IV			Plant Physiology, Biochemistry and Biophysics (Practical)							6	4
Course Outcomes	Programme Outcomes (POs)										Mean Score
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	
CO1	3	2	2	3	2	2	2	2	2	1	2.1
CO2	3	3	2	3	2	2	2	2	2	1	2.2
CO3	2	2	3	3	2	2	3	2	2	1	2.2
CO4	3	3	3	2	2	2	2	2	2	1	2.2
CO5	2	3	3	3	2	2	3	3	2	1	2.4
	Mean Overall Score										2.22 (High)

COURSE OBJECTIVES:

- To understand the fundamental principles of entrepreneurship as applied to the life sciences industry, including the unique challenges and opportunities in commercializing biological discoveries.
- To identify and evaluate market opportunities arising from biomedical innovations, agricultural biotechnology and industrial biotechnology sectors through structured opportunity assessment frameworks.
- To develop comprehensive business plans tailored to biotech ventures, incorporating regulatory pathways, intellectual property strategy, and funding mechanisms specific to the life sciences domain.
- To evaluate financial models, valuation methods, and funding strategies such as venture capital, angel investment, grants, and licensing used to support bioscience startups from seed to commercialization.
- To apply ethical frameworks and social responsibility principles to entrepreneurial decision-making in biotechnology, addressing biosafety, bioethics, biodiversity, and equitable access to innovations

UNIT I: FOUNDATIONS OF BIOENTREPRENEURSHIP:

Introduction to entrepreneurship - definitions, types, and traits of entrepreneurs; Overview of biotechnology industry sectors: pharmaceuticals, diagnostics, agricultural biotech, industrial biotech, and bioinformatics; Role of academic institutions, government agencies, and private sector in fostering biotech innovation.

UNIT II: MARKET ANALYSIS AND OPPORTUNITY IDENTIFICATION:

Market research methodologies for bioscience products; Identifying unmet medical, agricultural, and environmental needs; Customer segmentation and target market definition; Porter's Five Forces; Total Addressable Market (TAM), Serviceable Addressable Market (SAM), and Serviceable Obtainable Market (SOM);

UNIT III: BUSINESS PLANNING AND INTELLECTUAL PROPERTY:

Components of a biotech business plan: executive summary, mission/vision, product description, market analysis, operations plan, management team, and financial plan; Intellectual Property (IP) in biotechnology - patents, trade secrets, copyrights, and trademarks; Patent filing strategies: provisional vs. non-provisional patents.

UNIT IV: REGULATORY AFFAIRS, FUNDING, AND FINANCIAL MANAGEMENT:

Regulatory pathways for biotech products: FDA (USA), EMA (Europe), CDSCO (India), and other national agencies; Drug and biologics approval processes: IND, NDA, BLA, 510(k), and PMA; Regulatory strategy and compliance planning for startups; Funding landscape for biotech ventures - government grants (DST, DBT, BIRAC in India; NIH, NSF in USA).

UNIT V: ETHICS, SUSTAINABILITY, AND FUTURE TRENDS:

Ethical, Legal, and Social Implications (ELSI) of biotech entrepreneurship; Biosafety and biosecurity considerations in commercial biotech; Bioethics in human genomics, cloning, and gene therapy products.

UNIT VI: CURRENT CONTOURS (For Continuous Internal Assessment Only):

Identify Problems Around You and prepare report eg. Pollution, Waste management, Health issues and Food quality. Create a Mini Bio-Business Idea - Organic fertilizer production, Herbal skincare products and Mushroom cultivation business. **Bio Idea Journal:** Maintain a notebook: Write a idea, Sketch solutions and Note business potential.

Recommended Textbooks:

1. Craig Shimasaki. Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies, (2014), Academic Press / Elsevier.
2. Evan Loh and Steven Holtzman. The Biotech Entrepreneur's Handbook, (2019), Wiley-Blackwell.
3. Shreefal S. Mehta. Commercializing Successful Biomedical Technologies: Basic Principles for the Development of Drugs, Diagnostics and Devices, (2020), Cambridge University Press.

Reference Books:

1. Eric Ries The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses, (2011), Crown Business.
2. Douglas Friedman (Ed.) Biotechnology Entrepreneurship: From Science to Solution, (2018), NGLP / Entrepreneur Press .
3. Mark Gear, Pharmaceutical and Biotech Project Management in a New Era,(2021),CRC Press.

Web Resources:

1. BIRAC (Biotechnology Industry Research Assistance Council) www.birac.nic.in — Govt. of India funding, schemes, and bio incubation programs for biotech startups.
2. SBIR / STTR — NIH & NSF www.sbir.gov — US federal small business innovation research grants for biotech ventures.
3. MIT Open Course Ware — Entrepreneurship ocw.mit.edu — Free lecture materials on entrepreneurship, technology commercialization, and venture finance.
4. NASSCOM Bio IT & Startup India www.startupindia.gov.in — Indian biotech startup ecosystem, funding, and incubation resources.

COURSE OUTCOMES:

Course Outcomes:	On successful completion of this course, students will be able to	Cognitive Levels
CO1	Explain the principles, processes and technological advancements in fermentation and evaluate their applications in the development of fermented food products and industrial bioprocesses.	K1
CO2	Apply microbial growth kinetics, fermentation strategies and microorganism selection criteria to optimize the	K2

	production of fermented products for food, pharmaceutical and industrial applications.	
CO3	Evaluate the production processes, quality parameters and commercial significance of biologically derived products, including biopharmaceuticals, enzymes, organic acids and biofuels.	K3
CO4	Critically assess ethical, regulatory, biosafety, and sustainability issues associated with fermentation technology and their impact on industrial production and societal well-being.	K4
CO5	Design and optimize fermentation processes by selecting suitable microorganisms and substrates and propose innovative approaches for improving product yield, process efficiency and industrial scalability.	K5 & K6

Mapping with POs and PSOs:

Relationship Matrix											
Semester	Course Code		Title of the Course							Hours	Credits
			Bio Entrepreneurship (Theory)							3	3
Course Outcomes	Programme Outcomes (POs)										Mean Score
	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	
CO1	3	2	2	2	2	2	2	2	2	1	2.0
CO2	3	3	3	3	3	1	2	2	2	1	2.3
CO3	3	2	3	3	1	2	2	2	2	1	2.1
CO4	2	3	2	2	1	3	2	1	2	2	2.0
CO5	2	3	3	3	2	2	3	3	2	3	2.6
Mean Overall Score											2.2 (High)

COURSE OBJECTIVES:

- To recognize the concept of research and its various forms in the context of botany.
- To improve abilities relating to scientific experiments.
- To become proficient in data collection and the documentation of scientific findings.
- To prepare students for entry-level positions or professional training programmes in any field of Botany.
- To compare the various reporting and writing styles used in science

ASSESSMENT /EVALUATION /VIVA-VOCE:**1. PROJECT REPORT EVALUATION (Both Internal & External):**

I. Plan of the Project	- 20 marks
II. Execution of the Plan/collection of Data / Organization of Materials / Hypothesis, Testing etc. and presentation of the report.	- 45 marks
III. Individual initiative	- 15 marks

2. VIVA-VOCE / INTERNAL& EXTERNAL - 20 marks**TOTAL** - 100 marks**PASSING MINIMUM:**

Project	Vivo-Voce 20 Marks 40% out of 20 Marks (i.e. 8 Marks)	Dissertation 80 Marks 40% out of 80 marks (i.e. 32 marks)
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A candidate shall be declared to have passed in the Project work if he/she gets not less than 40% in each of the Project Report and Viva-voce but not less than 50% in the aggregate of both the marks for Project Report and Viva-voce.

A candidate who gets less than 40% in the Project must resubmit the Project Report. Such candidates need to defend the resubmitted Project at the Viva-voce within a month. A maximum of 2 chances will be given to the candidate.

COURSE OUTCOMES:

Course Outcomes	On completion of this course, the students will be able to	Cognitive Level
C01	Apply disciplinary knowledge, technical competencies, and professional ethics to perform effectively in industrial, research, and academic environments related to plant sciences and allied sectors.	K1
C02	Design and execute experimental protocols, data collection strategies, and analytical procedures using appropriate scientific and industrial methodologies.	K2
C03	Analyze, interpret, and communicate scientific and industrial data using quantitative and qualitative approaches to draw evidence-based conclusions and recommendations.	K3 &K5
C04	Evaluate industrial processes, emerging technologies, quality standards, and professional practices to enhance technical expertise and workplace readiness.	K4
C05	Demonstrate leadership, teamwork, communication, innovation, and entrepreneurial skills by developing creative solutions to scientific and industrial challenges.	K5 &K6

Mapping with POs:

Relationship Matrix											
Semester	Course Code		Title of the Course							Hours	Credits
IV			Project Work							5	5
Course Outcomes	Programme Outcomes (POs)										Mean Score of COs
	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	
C01	3	2	2	2	2	2	1	1	2	3	2.0
C02	2	2	3	3	2	1	2	3	2	2	2.2
C03	2	3	3	3	1	2	3	3	1	2	2.3
C04	2	2	3	2	2	2	2	2	3	3	2.3
C05	2	3	2	2	2	2	3	2	3	3	2.4
Mean Overall Score											2.24 (High)

COURSE OBJECTIVES:

- To impart basic knowledge about the importance and production technology of cut flowers grown in India.
- To state the fundamentals of floriculture.
- To learn the techniques of propagation methods in horticulture.
- To understand the role of Plant growth regulators in horticulture.
- To get familiarized with common ornamental and flowering plants.

UNIT I SCOPE OF FLORICULTURE:

Scope of cut flowers in global trade, Global Scenario of cut flower production, Varietal wealth and diversity, area under cut flowers and production problems in India- Patent rights, nursery management, media for nursery, special nursery practices.

UNIT II GROWING FLOWERS:

Growing environment, open cultivation, protected cultivation, soil requirements, artificial growing media, soil decontamination techniques, planting methods, influence of environmental parameters, light, temperature, moisture, humidity and CO₂ on growth and flowering.

UNIT III FLOWER PRODUCTION:

Flower production – water and nutrient management, fertigation, weed management, rationing, training and pruning, disbudding, special horticultural practices, use of growth regulators, physiological disorders and remedies, IPM and IDM, production for exhibition purposes.

UNIT IV FLOWER FORCING:

Flower forcing and year-round flowering through physiological interventions, chemical regulation, environmental manipulation.

UNIT V: CUT FLOWER STANDARDS AND GRADES:

Cut flower standards and grades, harvest indices, harvesting techniques, post-harvest handling, Methods of delaying flower opening, Pre-cooling, pulsing, packing, Storage & transportation, marketing, export potential, institutional support, Agri Export Zones. Crops: Cut rose, cut chrysanthemum, carnation, gerbera, gladioli, tuberose, orchids, anthurium, aster, lilies, bird of paradise, heliconia, alstroemeria, Alpinia, ornamental ginger, bromeliads, dahlia, gypsophilla, Limonium, statice, stock, cut foliage and fillers.

UNIT - VI CURRENT CONTOURS (For continuous internal assessment only):

Current developments related to the Floriculture during the semester concerned to be kept abreast of continuously and cumulatively through collection, discussion and evaluation from news and events over the world collected through multiple reliable informative sources – Research articles, review materials, print, Internet, Interaction, social media, Webinars and so on.

Recommended Textbooks:

1. Arora JS. 2006. Introductory Ornamental horticulture.
2. Pointer Publ. Bose TK & Yadav LP. 1989. Commercial Flowers.
3. Naya Prokash. Bose TK, Maiti RG, Dhua RS & Das P. 1999. Floriculture and Landscaping.
4. Lauria A & Ries VH. 2001. Floriculture – Fundamentals and Practices. Agrobios.

Reference Books:

1. Prasad S & Kumar U. 2003. Commercial Floriculture. Agrobios.
2. Randhawa GS & Mukhopadhyay A. 1986. Floriculture in India. Allied Publ.
3. Reddy S, Janakiram B, Balaji T, Kulkarni S & Misra RL. 2007. Hightech Floriculture. Indian Society of Ornamental Horticulture, New Delhi.

Web Resources:

1. <https://www.psscive.ac.in/storage/uploads/textbooks/pdf/english/floriculturist-open-cultivation>
2. <https://mkjc.in/download/downloads/2703251028342852.pdf>
3. <https://www.sciencedirect.com/book/edited-volume/9780124376519/introduction-to-floriculture>

COURSE OUTCOMES:

Course Outcomes:	On successful completion of this course, the students will be able to	Cognitive Levels
CO1	Explain the global and national trends in cut flower production, marketing, trade and commercialization and evaluate their economic significance in the floriculture industry.	K1
CO2	Apply scientific principles and propagation techniques for the efficient multiplication, cultivation and management of ornamental and flowering plants.	K2
CO3	Evaluate the concepts, practices, and technological advancements in floriculture for sustainable production and improvement of ornamental crops.	K3
CO4	Design and assess indoor gardening systems by selecting suitable ornamental plants and management practices to enhance aesthetic, environmental, and functional values.	K4
CO5	Analyze and develop landscape garden plans by integrating various garden types, design principles and structural components to meet horticultural, ecological and recreational objectives.	K5

Mapping with POs:

Relationship Matrix											
Semester	Course Code	Title of the Course								Hours	Credits
IV		Floriculture (Theory)								-	2
Course Outcomes	Programme Outcomes (POs)										Mean Score
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	
CO1	3	2	2	2	2	2	2	2	2	1	2.0
CO2	3	2	2	3	2	1	2	2	2	1	2.0
CO3	3	3	2	2	2	2	2	1	2	1	2.0
CO4	2	3	3	2	3	2	3	1	2	2	2.3
CO5	2	3	3	2	2	2	3	2	2	3	2.4
	Mean Overall Score										2.14 (High)

Year: I

**DISCIPLINE CENTRIC ELECTIVE
COURSE 1**

Semester: I

Code:

**1. ECOLOGY, PHYTOGEOGRAPHY
AND CLIMATE CHANGE
(Theory)**

Credits: 4

COURSE OBJECTIVES:

- To apply knowledge qualitative and quantitative knowledge on ecosystem.
- To discuss the ecological chain among population.
- To measure the global environmental changes and conservation strategies.
- To value the principle and concepts of Phytogeography.
- To operate bioremediation, biomonitoring and to get awareness on environmental education.

UNIT – I ECOLOGY:

Ecosystem Structure and function of ecosystem: energy flow. Characteristics of communities Analytical Quantitative – Frequency, density, Abundance, Cover and Basal area. Qualitative – Physiognomy, Phenology, Stratification, sociability, vitality and Life form. Method of study of communities- Raunkiaer's Life form, Physiological methods- Sampling units, Quadrat method, Transect method, Point method.

UNIT – II ECOLOGY:

Population Ecology: Characteristics of a population (Population size and Density, Dispersion, Age structure Natality (Birth Rate), Mortality (Death rate), Biotic potential, Life Tables, Population growth curves. Ecological Succession - Causes, trends of succession, Types of succession- Primary, secondary and allogenic, Process of succession- Nudation, Invasion, competition and coactions-reaction, stabilization. Concept of climax- Monoclimax and Polyclimax theories.

UNIT – III ECOLOGY:

Global environmental change -Atmosphere composition and structure, Global warming- Greenhouse gases and Ozone depletion. Remote sensing and Geographic Information System (GIS). Conservation strategies: IUCN categorization- In-situ conservation (National parks, Biosphere reserves, Wildlife sanctuaries) Ex-situ conservation – (Seed bank, Botanical gardens). Sacred groves.

UNIT – IV PHYTOGEOGRAPHY:

Principles and importance of plant geography- Phytogeographic regions of India. Agro- climatic regions of India, Patterns of distribution – Disjunction and Variance. Theories of present-day distribution of plants- Continental drift hypothesis- Gondwana land factors involved in distribution. Factors involved in distribution – Endemism, Age and Area hypothesis; Dispersal and Migration and their aims and methods.

UNIT – V CLIMATE CHANGE:

Environmental pollution types and threats; Greenhouse effect and global warming, ozone depletion and acid rain. Eco-restoration/remediation ecological footprints – carbon footprint – eco labeling - environmental auditing. Functional role of IPCC.

UNIT – VI CURRENT CONTOURS (For Continuous Internal Assessment Only):

Current developments related to the Ecology, phytogeography and environmental biotechnology during the semester concerned to be kept abreast of continuously and cumulatively through collection, discussion and evaluation from news and events over the world collected through multiple reliable informative sources – Research articles, review materials, print, Internet, Interaction, social media, Webinars and so on.

Recommended Textbooks:

1. Singh, J.S., Singh, S.P. and Gupta, S. 2006, Ecology, Environment and Resource Conservation, Anamaya Publications, New Delhi.
2. Sharma, P.D. 2013, Ecology and Environment, XI edition, Rastogi Publications, Meerut.
3. Ambasht R.S., 1978 The Book of Plant Ecology, Students friends Co.

Reference Books:

1. Odum, E.P. Gary W. Barrelet, 2004, Fundamentals of Ecology (15th edition), Thomson Asia Pvt.Ltd.
2. Krebs, 1985, Ecology, C.J.Haper and Row, New York.
3. Sinha, R.K. and Dalbirshigh, 1997, Global biodiversity, INA shree publishers, Jodhpur.
4. Dash, M.C. 2004, Fundamentals of Ecology, Tata McGraw Hill, New Delhi.
5. Russell K. Monson, 2014, Ecology and the Environment, Springer Dordrecht, Heidelberg, New York.
6. Cain, S.A. 1944. Foundations of Plant Geography Harper & Brothers, N.Y.
7. Mani, M.S 1974. Ecology & Biogeography of India Dr. W. Junk Publishers, he Haque
8. Good, R. 1997: The Geography of flowering Plants (2ndEdn.) Longmans, Green & Co., Inc., London & Allied Science Publishers, New Delhi- 495ppE- Materials
9. Willings W.D. 1964 Plants and Ecosystem, Wasworti Publishing Co.
10. Daubenmire R.F, 1973 Plant and Environment. John Willey.
11. Chatterji, A.K. (2011). Introduction to Environmental Biotechnology. Prentice Hall India Pvt., Ltd., New Delhi.

Web Resources:

1. <https://www.ohio.edu/plantbio/staff/mccarthy/dendro/ecology.htm> 2.
2. <https://www.lcps.org/cms/lib4/VA01000195/Centricity/Domain/14721/Ecol%20Notes.pdf> 32.
3. <https://www.coursehero.com/file/8469123/PHYTOGEOGRAPHY-Lecture-34/>
4. https://swayam.gov.in/nd1_noc19_ge23/preview
<https://www.classcentral.com/course/swayam-ecology-and-environment-14021>
5. <https://www.agrimoon.com/principles-of-plant-biotechnology-icar-ecourse-pdf/>

COURSE OUTCOMES:

Course Outcomes	On successful completion of this course, the students will be able to	Cognitive Levels
CO1	Explain the principles of population ecology, community ecology and ecosystem ecology and evaluate their roles in maintaining ecological balance and ecosystem sustainability.	K1
CO2	Apply ecological and environmental concepts to assess contemporary environmental issues and evaluate the role of environmental botany in sustainable resource management and conservation	K2
CO3	Investigate and evaluate sources, types and impacts of environmental pollution, and propose scientifically sound strategies for pollution prevention, mitigation and ecosystem restoration.	K3
CO4	Assess the structure and distribution of plant communities, classify major biomes, identify threatened and endangered plant species and develop biodiversity conservation and environmental awareness initiatives.	K4
CO5	Analyze vegetation patterns, species interactions, ecological relationships, and environmental factors influencing ecosystem dynamics and interpret their significance in biodiversity conservation and environmental management.	K5

Cognitive Level: K1 - Remember; **K2** - Understanding; **K3** - Apply; **K4** - Analyze; **K5** – Evaluate; **K6** – Create

Mapping with POs:

Relationship Matrix											
Semester	Course Code		Title of the Course							Hours	Credits
I			1.Ecology, Phytogeography and Climate Change (Theory)							5	4
Course Outcomes	Programme Outcomes (POs)										Mean Score
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	
CO1	3	2	2	2	2	2	2	2	2	1	2.0
CO2	3	3	2	2	2	2	2	2	2	1	2.1
CO3	2	3	3	3	1	2	3	2	2	1	2.2
CO4	3	3	2	2	2	3	2	3	2	2	2.4
CO5	3	3	3	3	1	2	2	2	2	1	2.2
	Mean Overall Score										2.18 (High)

COURSE OBJECTIVES:

- To study various aspects of Forest Botany.
- To understand the importance and different forests and plants species.
- To know the ecological significance of forests.
- To enable the students to information on forests laws.
- To raise student awareness of the need to create a sustainable way of living and the current Global issues with forestry caused by human interference

UNIT - I FORESTRY:

World and Indian forest scenario; Forest types of India; Forest influences and protection; Rare and endangered species; Conservation strategies; Exotics and its significance; Silvicultural principles and practices; Genetic Engineering and its application in forestry; Remote sensing and GIS in forestry.

Silviculture: concept and scope of study, forest in general form, composition, classification of world forests and Indian forests. Classification based on its quality density, tolerance, crown; water cycles of forest. Photosynthetic processes in forest: nitrogen and mineral nutrition in forests.

UNIT - II FORESTRY:

Forest Resources and utilization; Forest products; Forest laws and policies, people and Forest; Social and community forestry; Forest industries; Role of social forestry in cottage industry; Role of forestry in Indian economy. Biomass conversion strategies - energy plantations.

UNIT - III FORESTRY:

Measurement: definition, direct measurements, direct and indirect estimate, and prediction. Measurement of diameter – rules and methods, measurement of height – different rules, methods, instruments, total height and merchantable length. Forestry for social and national development. Progress to be achieved in social forestry, industrial forestry and multiple forestry. Forest Laws- Indian Forest Act, 1927; Forest conservation Act. Wild Life Protection Act, 1972.

UNIT - IV WOOD TECHNOLOGY:

Nature and properties of wood: physical, chemical, mechanical and anatomy of wood. Durability of wood. Monocot and dicot wood; pycnoxylic and manoxylic wood; dendrochronology; Wood seasoning and preservation. Defects and abnormalities of wood; types of commercial wood species of India. Wood deterioration- fungi, insects and other agents; Wood protection- Practical methods for preserving and protection, Chemical processing of wood.

UNIT - V WOOD TECHNOLOGY:

Composite wood: adhesives-manufacture, properties, uses, manufacture and uses of plywood, fiber boards and particle boards. Present status of composite wood, paper and rayon industries. wood substitution.

UNIT - VI CURRENT CONTOURS (For Continuous Internal Assessment Only):

Current developments related to Forestry and Wood Technology during the semester concerned to be kept abreast of continuously and cumulatively through collection, discussion and evaluation from news and events over the world collected through multiple reliable informative sources– Research articles, review materials, print, Internet, Interaction, social media, Webinars and so on.

Recommended Textbooks:

1. Jha, L.K. (1996). Forestry for Rural Development. APH Publishing Corporation, New Delhi.
2. Negi, S.S. (1994). India's Forests, Forestry and Wildlife. Indus Publishing Co., New Delhi.
3. Manikandan, K and S. Prabhu. 2013. Indian forestry, a breakthrough approach to forest service. Jain Bros.
4. Singhi, G.B. 1987. Forest Ecology of India, Publisher: Rawat.
5. Ramprakash. 1986. Forest management. IBD Publishers, Debra Dun.
6. Tiwari, K.M. 1983. Social forestry in India. Nataraj Publishers, Dehra Dun

Reference Books:

1. Bowyer, J.L., Shmulsky, R. and Haygreen, J.G. (2007). Forest Products and Wood Science: An Introduction. Wiley-Blackwell, Oxford.
2. De Vere Burton L. (2000). Introduction to Forestry Science. Delmar Publishers, New York.
3. Franz F.P. Kollmann and Wilfred A. Jr. Cote. (2012). Principles of Wood Science and Technology: Solid Wood. Springer-verlag, Berlin.
4. Roger Sands. 2013. Forestry in a global context, CAB international.
5. Balakathiresan. S.1986. Essentials of Forest Management. Natraj Publishers, Dehradun.
6. Agarwala, V.P. 1990. Forests in India, Environmental and Protection Frontiers. Oxford & IBH Publishing Co. New Delhi.
7. Chundawat, B.S. and Gautham, S.K. 1996. Text book of Agro forestry. Oxford and IBH publisher, New Delhi..

Web Resources:

1. http://www.wds.worldbank.org/external/default/WDServer/WDSP/IB/2006/10/19/000112742_20061019150049/Rendered/PDF/367890Loggerheads0Report.pdf.
2. <https://www.britannica.com/science/forestry>
3. <https://en.wikipedia.org/wiki/Forestry>.
4. <https://www.biologydiscussion.com/forest/essay-forest-importance.major-products-and-its-conservation/25119>
5. <https://academic.oop.com>
6. <https://www.sciencedirect.com/topics/agriculture-and-biological-science-forest-product>.

COURSE OUTCOMES:

Course Outcomes	On successful completion of this course, the students will be able to	Cognitive Levels
CO1	Explain the principles, concepts and scope of forest botany, including forest structure, composition, diversity and ecological functions.	K1
CO2	Evaluate the classification, distribution, ecological significance and economic importance of different forest types and their contributions to biodiversity conservation and sustainable development.	K2
CO3	Assess the ecological, environmental and commercial significance of forest wood resources and interpret their roles in ecosystem functioning and resource management.	K3
CO4	Analyze forest ecosystem dynamics, including succession, productivity, nutrient cycling, regeneration and biotic interactions and evaluate their influence on forest sustainability.	K4
CO5	Critically examine Indian forest policies, laws and conservation acts and assess their roles in forest protection, biodiversity conservation and sustainable resource utilization.	K5

Mapping with POs:

Relationship Matrix												
Semester	Course Code		Title of the Course								Hours	Credits
I			2.Forestry and Wood Science (Theory)								5	4
Course Outcomes	Programme Outcomes (POs)										Mean Score	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10		
CO1	3	2	2	2	2	2	2	2	2	1	2.0	
CO2	3	3	2	2	1	2	2	2	2	1	2.0	
CO3	2	3	3	2	2	2	2	2	2	1	2.1	
CO4	3	3	3	3	3	2	2	2	2	1	2.4	
CO5	2	3	2	2	2	2	2	1	2	3	2.1	
	Mean Overall Score										2.12 (High)	

COURSE OBJECTIVES:

- To know about the brief history, divisions, classification and structure of horticultural plants.
- To acquire knowledge on plant growth processes and stages of plant growth.
- To understand the plant growth environment in relation to soil, nutrients, fertilizers, and bio inoculants.
- Study the sexual and vegetative propagation methods including propagation through specialized vegetative structures.
- Compare and contrast the genetic basis of breeding self- and cross-pollinated crops.

UNIT I HORTICULTURE:

Introduction, Scope and Importance of Horticulture. Divisions of Horticulture, Classification of horticultural plants – Fruits and Vegetables. Important Horticultural Research Centres in India. Garden Implements. Types (Formal, Informal and Kitchen) and Components of Garden.

UNIT II HORTICULTURE:

Indoor and outdoor plants - Flower arrangements – Fruits and Vegetable carving – Establishment and maintenance of Topiary, Bonsai, Rockery, Orchard and Lawn - Training and Pruning Techniques. Role of Plant Growth Regulators in Horticulture.

UNIT III HORTICULTURE:

Plant propagation methods by Seeds – Propagation through specialized underground structures – Corm, Tuber, Sucker, Bulb, Bulbil and Rhizome; Vegetative Propagation – Cutting, Layering, Grafting and Budding.

UNIT IV PLANT BREEDING:

Plant breeding - Objectives. Methods of breeding - Selection methods - Pureline, Mass and Clonal - Hybridization techniques - types and steps involved. Heterosis and Hybrid vigour.

UNIT V PLANT BREEDING:

Breeding for disease resistance – Mutation – Polyploid and its application in Plant Breeding – Breeding for Crop Quality– Rice, cotton and Tomato, Breeding for nutritional quality. Sources for quality traits.

UNIT VI CURRENT CONTOURS (For Continuous Internal Assessment Only):

Current developments related to Horticulture and Plant Breeding during the semester concerned to be kept abreast of continuously and cumulatively through collection, discussion and evaluation from news and events over the world collected through multiple reliable informative

sources–Research articles, review materials, print, Internet, Interaction, social media, Webinars and so on.

Recommended Textbooks:

1. Acquaah, G. 2011. Horticulture: Principles and Practices. (4th ed), Pearson Education, London, UK.
2. Janik, J. 1972. Horticultural Science. W.H. Freeman & Company, San Francisco.
3. Kumar, N. 1994. Introduction to Horticulture, Rajalakshmi Publication, India.
4. Manibhushan Rao, K. 2005. Text Book of Horticulture. (2nd ed), Macmillan India Ltd., New Delhi.
5. Schilletter, J. C. and Richey, H. W. 2005. Text Book of general Horticulture. 2nd ed. Biotech Books, Delhi.
6. Sharma, R.R. 2016. Propagation of horticultural crops. Kalyani Publishers, New Delhi.
7. Subba Rao, N.S. 1997. Biofertilizers in Agriculture and Forestry. India Book House Limited, Oxford and IBH publishing Co. Pvt. Ltd, New Delhi.
8. Chaudhari, H.K. 1984. Elementary Principles of Plant Breeding. Oxford & IBH Publishing Company.
9. Brown, T.A. 1992. Genetics a Molecular Approach, 2nd Ed. Chapman and Hall.
10. Chahal, G.S and Gosal, S.S. 2018. Principles and Procedures of Plant Breeding Biotechnological and Conventional Approaches, Narosa Publishing House, New Delhi.
11. Singh, B.D. 2013. Plant Breeding: Principles and Methods, Kalyani Publishers, New Delhi
12. Singh, P. 2017. Fundamentals of Plant Breeding, Kalyani Publishers.
13. Chaudhary, R.C. 2017. Introductory principles of plant breeding, Oxford IBH Publishers, New Delhi.

Reference Books:

1. Acquaah, G. 2002. Horticulture Principles and Practices. 2nd ed. Pearson Education (Singapore) Pvt. Ltd.
2. Ashman, M.A. and Puri, G. 2002. Essential soil science-A clear and concise introduction to soil science. Blackwell scientific publishers, London.
3. Denisen, E.L. 1979. Principles of Horticulture. MacMillan Publishing co, Inc. New York.
4. Dirr, M. and Heuser, C.W. 2009. The Reference Manual of Woody Plant Propagation: From Seed to Tissue Culture. Timber Press, Oregon, USA.
5. Thomson, L.M. and Troen, F.R. 1975. Soils and soil fertility Tata, McGraw Hill Publication Co. Ltd. New Delhi.
6. Tolanus, S. 2006. Soil fertility, Fertilizer and Integrated Nutrient management. CBS Publication, Delhi, India.
7. Allard, R.W. 2010. Principles of Plant Breeding. 2 nd ed. John Wiley and Sons, Inc. New Jersey, US.

Web Resources:

1. <https://www.kobo.com/in/en/ebooks/horticulture>
2. <https://www.gale.com/gardening-and-horticulture>
3. <https://www.iaritoppers.com/p/horticulture-icar-ecourse-pdf-books.html>

4. <https://www.amazon.in/Introduction-Horticulture-N-Kumar-ebook/dp/B08M4289M6>
5. https://www.researchgate.net/publication/316438576_Polyembryony_in_Horticulture_and_its_significance

COURSE OUTCOMES:

Course Outcomes	On Completion of the course students will be able to	Cognitive Level
C01	Explain the diversity, classification, growth requirements, and environmental factors influencing the productivity and quality of horticultural crops.	K1
C02	Apply advanced propagation, cultivation, and management techniques for the efficient production, maintenance, and improvement of horticultural plants under diverse growing conditions.	K2
C03	Evaluate the principles, objectives, and methodologies of plant breeding and assess their applications in crop improvement, yield enhancement, and stress tolerance.	K3
C04	Compare and critically assess the genetic principles, breeding strategies, and selection methods employed in self-pollinated and cross-pollinated crops for developing improved cultivars.	K4
C05	Demonstrate and integrate horticultural and plant breeding knowledge to design sustainable production systems and explore professional, entrepreneurial, and industrial opportunities in the horticulture sector.	K5 & K6

Cognitive Level: **K1** - Remember; **K2** - Understanding; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Mapping with POs:

Relationship Matrix												
Semester	Course Code		Title of the Course								Hours	Credits
II			1.Horticulture and Plant Breeding (Theory)								4	4
Course Outcomes	Programme Outcomes (POs)										Mean Score	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10		
CO1	3	2	2	2	2	2	2	2	2	1	2.0	
CO2	3	2	2	3	3	2	2	2	2	1	2.2	
CO3	3	3	3	3	2	2	3	2	2	1	2.4	
CO4	3	3	3	3	1	2	2	2	2	1	2.2	
CO5	2	3	3	2	2	2	2	2	3	3	2.4	
	Mean Overall Score										2.24 (High)	

COURSE OBJECTIVES:

- To acquire knowledge on construction, design and maintenance of a greenhouse.
- To appreciate the nature of soil required, methods of irrigation and plant propagation.
- To evaluate plant nutritional requirement and irrigation methods.
- To learn the techniques pest and disease management.
- To collect knowledge on greenhouse maintenance and safety practices.

UNIT-I INTRODUCTION:

Fundamentals of Greenhouse Technology: Introduction; scope – classification of greenhouses - construction of greenhouse- heating unit - cooling unit - environmental control (light and temperature). Net- poly houses- low-cost green houses.

UNIT-II FERTILIZER APPLICATION:

Fertilizer Application: Root media for greenhouses - fertilizers – organic and inorganic – liquid fertilizers – application of fertilizers - nutrient deficiencies and toxicities.

UNIT-III IRRIGATION SYSTEM:

Water in the Greenhouse: Irrigation system in green houses – misting, drip irrigation – micro irrigation - water quality, water sanitation.

UNIT-IV PEST AND DISEASE MANAGEMENT:

Plant Protection in Greenhouses: Diseases of greenhouse plants (bacterial, fungal, nematodes and viral diseases) – management of pest and diseases – integrated pest management.

UNIT-V APPLICATION:

Applications of Greenhouse Technology: Importance of greenhouse technology. Micropropagation and greenhouse planting of tissue culture transplants- advantages and disadvantages of greenhouse technology. Seed production, cut flower gardening

UNIT-VI CURRENT CONTOURS (For Continuous Internal Assessment Only):

Current developments related to the Greenhouse Technology during the semester concerned to be kept abreast of continuously and cumulatively through collection, discussion and evaluation from news and events over the world collected through multiple reliable informative sources– Research articles, review materials, print, Internet, Interaction, social media, Webinars and so on.

Recommended Textbooks:

1. Sheela V.L. 2011. Horticulture. MJP Publishers. Chennai,
2. Prasad S., Kumar U. 2012. Green House Management for Horticultural Crops. Agrobios India.
3. Pant V. and Nelson. 1991. Green House Operation and Management. Bali Publication. New Delhi.

Reference Books:

1. Randhava, G.S, 1973 – Ornamental horticultural in India Today and Tomorrow Printers and Publishers, New Delhi.
2. Yawalkar, K.S. 1961 – Vegetables crops of India – Agri, Horticultural Publishing House, Nagpur.
3. Chauhan, V.S. Vegetable Production in India, Ramprasad Publications – Agra
4. Nayak, K.C. South Indian fruits and their culture P.L. Varadaraj & Co., & Lingichetti Street, Madras.
5. Kunte, Y.N. Introduction to principles of fruit growing – Agri – Horticultural Publishing house Dharmapath, Nagpur.

Web Resources:

1. <http://www.agrimoon.com/wpcontent/uploads/Introduction-to-soil-science.pdf>
2. <http://scialert.net/fulltext/?doi=ijar.2006.364.372&org=10>

COURSE OUTCOMES:

Course Outcomes:	On Completion of the course students will be able to	Cognitive Level
CO1	Explain the principles, design, construction, and maintenance requirements of greenhouse structures and evaluate their role in protected cultivation systems.	K1
CO2	Assess the characteristics and suitability of various rooting media and growing substrates for enhancing plant growth, productivity, and resource-use efficiency under greenhouse conditions.	K2
CO3	Apply appropriate irrigation and fertigation techniques to optimize water and nutrient management for sustainable greenhouse crop production.	K3
CO4	Analyze and propose effective strategies for the diagnosis and management of nutritional disorders, pests, and diseases affecting greenhouse-grown crops.	K4
CO5	Evaluate and design greenhouse production systems by integrating modern technologies to improve crop yield, quality, resource efficiency, and economic sustainability.	K5 & K6

Cognitive Level: K1 - Remember; **K2** - Understanding; **K3** - Apply; **K4** - Analyze; **K5** – Evaluate; **K6** – Create

Mapping with POs:

Relationship Matrix												
Semester	Course Code		Title of the Course								Hours	Credits
II			2.Green House Technology (Theory)								4	4
Course Outcomes	Programme Outcomes (POs)										Mean Score of COs	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10		
CO1	3	2	2	2	2	2	2	2	2	1	2.0	
CO2	3	2	2	2	2	2	2	2	2	1	2.0	
CO3	3	2	3	3	3	2	1	2	2	1	2.2	
CO4	2	3	3	3	3	1	2	3	2	1	2.3	
CO5	2	3	3	3	2	2	3	3	2	3	2.6	
	Mean Overall Score										2.22 (High)	

COURSE OBJECTIVES:

- To understand the principle, operation and maintenance of various tools/equipment in the laboratory.
- To perform experiments using the laboratory instruments, formulate experiments for project work and evaluate critically the acquisition of data.
- To equip students to collect, analyze and evaluate data generated by their own inquiries in a scientific manner.
- To give an exposure to various forms of field research and data analysis techniques.
- To provide an overview on modern equipments which motivate students to commence research careers and/or start entrepreneurial ventures.

UNIT – I MICROSCOPY:

Introduction, principles and properties of light and laser light; polarization of light, resolution power-numerical aperture; polarized and lambda filters. Principles and working of: Phase contrast microscopy; Fluorescent microscopy; Confocal Raman microscopy, Atomic Force Microscopy and Electron microscopy (TEM & SEM).

UNIT – II SEPARATIONTECHNIQUE

Centrifugation–Principles, types, and theory of centrifugation; Chromatography – introduction, principle, types of chromatography – paper chromatography, thin layer chromatography, HPTLC, column chromatography- HPLC, Gas Chromatography.

UNIT – III SEPARATION TECHNIQUES:

Electrophoresis–Introduction, principle, buffers, detection and assay, recording and storage, safety and applications, factors affecting electrophoresis; types of electrophoresis –moving boundary electrophoresis, paper electrophoresis, gel electrophoresis - polyacrylamide gel electrophoresis (PAGE), agarose electrophoresis; isoelectric focusing gel electrophoresis, immune electrophoresis, denaturing gradient electrophoresis, temperature gradient electrophoresis, capillary electrophoresis.

UNIT – IV SPECTROSCOPICAND RADIOCHEMICALTECHNIQUES:

Introduction, Principle of Spectroscopy – visible and UV; Atomic absorption spectroscopy. Introduction to Radioactivity, Units of radioactivity, Stable and radioactive isotopes, half-life of radioisotopes, Specific activity, Isotopic dilution techniques, theory and construction of GM Counter, Liquid and Scintillation counter, auto radiography and applications of tracer techniques. Gene isolation and characterization through PCR, Microarrays, DNA based molecular markers - RAPD, AFLP, RFLP.

UNIT – V INTRODUCTION TO BIOINFORMATICS:

Introduction to bioinformatics: Biological Database – Protein and DNA sequence data base, Structure database, literature database, (PubMed, NCBI, Medline). Sequence Alignment, Database similarity searching; FASTA; BLAST, Proteomics – protein structure prediction (primary, secondary & tertiary), Human Genome Project.

UNIT – VI CURRENT CONTOURS (For Continuous Internal Assessment Only):

Current developments related to the Biological techniques and Bioinformatics during the semester concerned to be kept abreast of continuously and cumulatively through collection, discussion and evaluation from news and events over the world collected through multiple reliable informative sources–Research articles, review materials, print, Internet, Interaction, social media, Webinars and so on.

Recommended Textbooks:

1. Kothari, C.R. 2000. Research Methodology - Methods & Techniques. Vishwa Prakashan.
2. Misra, R.P, 2000 Research Methodology - a handbook, Concept Publishing Company, New Delhi.
3. Nageswara Rao, G. 1983. Statistics for Agricultural Science Oxford & IBH, New Delhi.

Reference Books:

1. Hawkins, C and Sorgi, M. 2000 Research, Narosa Publishing House, New Delhi.
2. Daniel, W.W., 1983, Biostatistics; A Foundation for Analysis in the Health Science, John Wiley and Sons Inc., New York.

Web Resources:

1. <https://www.schandpublishing.com/books/higher-education/sciences/bioinformatics-genomics-proteomics/9789325978553/#.W0L0qdIzbIU>
2. <https://www.schandpublishing.com/books/higher-education/biology/introduction-biostatistics-a-textbook-biometry/9788121923293/#.W0L06NIzbIU>

COURSE OUTCOMES:

Course outcomes:		Programme Outcomes
	On completion of this course, the students will be able to: CO	
CO1	Explain the principles, applications, and significance of modern biological techniques and instrumentation used in plant sciences, biotechnology and interdisciplinary research.	K1
CO2	Evaluate the working principles, capabilities, and applications of light, compound, fluorescence and electron microscopy for the observation and analysis of biological specimens.	K2
CO3	Apply appropriate experimental designs, data collection methods, statistical tools, and scientific	K3& K6

	communication strategies for effective interpretation and dissemination of research findings.	
CO4	Compare and assess the principles, methodologies and applications of various chromatographic techniques for the separation, identification and characterization of biological molecules.	K4
CO5	Develop and optimize protocols for the extraction, purification, analysis and characterization of biochemical compounds using advanced analytical and laboratory techniques	K5

Mapping with Pos:

Relationship Matrix											
Semester	Course Code		Title of the Course							Hours	Credits
III			1.Biological Techniques and Bioinformatics (Theory)							5	4
Course Outcomes	Programme Outcomes (POs)										Mean Score
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	
CO1	3	2	2	2	2	2	2	2	2	1	2.0
CO2	3	3	2	3	1	2	2	2	2	1	2.1
CO3	2	3	3	3	3	1	2	3	2	1	2.3
CO4	3	3	3	3	3	1	2	2	2	1	2.3
CO5	2	3	3	3	2	2	3	3	2	1	2.4
	Mean Overall Score										2.22 (High)

COURSE OBJECTIVES:

- To introduce the learners to the basic concepts in the emerging frontiers of nanotechnology.
- To give perspective to researchers and students who are interested in nanoscale physical and biological systems and their applications in medicine.
- To introduce the concepts in nanomaterials and their use with biocomponents to synthesize and interact with larger systems.
- To impart knowledge on the most recent molecular diagnostic and therapeutic tools used to treat various diseases.
- To incorporate sustainability into account while developing nanotechnology.

UNIT-I BASIC CONCEPTS IN NANOBIOLOGY

History of Nanotechnology, Difference between Nanoscience and Nanotechnology, Green nanotechnology, Bottom up and top-down approaches.

UNIT-II DIVERSITY IN NANOSYSTEMS

Carbon based nanostructures - fullerenes, nanotubes, Nano shells, buckyballs – biomolecules and nanoparticles, Nano sensors, nanomaterials - Classification based on dimensionality quantum dots, wells and wires – metal based nano materials (gold, silver and oxides) - Nanocomposites- Nano polymers – Nano glasses–Nano ceramics.

UNIT-III METHODS OF NANOBIO TECHNOLOGY

Optical tools – Nano force and imaging – Surface methods – Mass spectrometry – Electrical Characterization and Dynamics of Transport – Microfluidics: Concepts and applications to the Life Sciences.

UNIT-IV BIONANOTECHNOLOGY

Nanodevices and nanomachines based on biological nanostructures - Protein and DNA nanoarrays, tissue engineering, and luminescent quantum dots for biological labelling.

UNIT-V APPLICATIONS OF NANOBIO TECHNOLOGY

Real Time PCR – Biosensors : From the glucose electrode to the Biochip – DNA Microarrays – Protein Microarrays – Cell Biochips – Lab on a chip – Polyelectrolyte multilayers – Bio integrating materials – Pharmaceutical applications of nanoparticles carriers.

UNIT-VI CURRENT CONTOURS (For Continuous Internal Assessment Only):

Current developments related to Bio nanotechnology during the semester concerned to be kept abreast of continuously and cumulatively through collection, discussion and evaluation from news and events over the world collected through multiple reliable informative sources–Research articles,

review materials, print, Internet, Interaction, social media, Webinars and so on.

Recommended Textbooks:

1. Dupas, C, Houdy, P., Lahmani, M. 2007. Nanoscience: –Nanotechnologies and Nanophysics, Springer-Verlag Berlin Heidelberg.
2. Sharon, M and Sharon, M. 2012. Bio-Nanotechnology- Concepts and Applications, CRC Press.
3. Atkinson, W.I. 2011. Nanotechnology. Jaico Book House, New Delhi.
4. Nalwa, H.S. 2005. Handbook of Nanostructured Biomaterials and Their Applications in Nanobiotechnology. American Scientific Publ.

Reference Books:

1. Lindsay, S.M. 2011. Introduction to Nanoscience, Oxford universal Press, First Edition.
2. Jain K.K. 2006. Nanobiotechnology molecular diagnostics: Current techniques and application (Horizon Bioscience).Taylor & Francis 1st edition.
3. Pradeep, T. 2012. Textbook of Nanoscience and Nanotechnology, McGraw Hill Education(India) Private Limited.
4. XiuMei Wang, Murugan Ramalingam, Xiangdong Kong and Lingyun Zhao. 2017. Nanobiomaterials: Classification, Fabrication and Biomedical Applications, Wiley-VCH Verlag GmbH & Co. KGaA.

Web Resources:

1. <https://onlinelibrary.wiley.com/doi/book/10.1002/3527602453>
2. <https://www.elsevier.com/books/nanobiotechnology/ghosh/978-0-12-822878-4>
3. <https://www.routledge.com/Nanobiotechnology-Concepts-and-Applications-in-Health-Agriculture-and/Tomar-Jyoti-Kaushik/p/book/9781774635179>
4. https://www.nanowerk.com/nanotechnology/periodicals/ebook_a.php

COURSE OUTCOMES:

Course Outcomes	On completion of this course, the students will be able to:	Cognitive Level
CO1	Explain the fundamental principles of biology and nanotechnology and evaluate their integration in the development of bio nanotechnology and its interdisciplinary applications.	K1
CO2	Evaluate the methods of synthesis, characterization, and functionalization of nanomaterials and assess their applications in agriculture, medicine, biotechnology and environmental management.	K2
CO3	Apply scientific principles and experimental approaches to develop and optimize nanomaterials for specific biological and technological applications.	K3
CO4	Critically assess the advantages, limitations, risks, and societal implications of nanoparticles in healthcare, agriculture, industry and environmental sustainability.	K4
CO5	Design, construct, and evaluate nanomaterials and nanotechnology-based products for diverse	K5& K6

	applications, and assess their environmental impact, safety and long-term sustainability.	
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Mapping with POs:

Relationship Matrix											
Semester	Course Code	Title of the Course								Hours	Credits
III		2.Bio Nanotechnology (Theory)								5	4
Course Outcomes	Programme Outcomes (POs)										Mean Score
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	
C01	3	3	2	2	2	2	2	2	2	1	2.1
C02	3	3	3	3	1	2	2	2	2	1	2.2
C03	2	2	3	3	2	1	3	3	2	1	2.2
C04	2	3	3	2	1	3	2	2	2	1	2.1
C05	2	3	3	3	2	2	3	3	2	3	2.6
	Mean Overall Score										2.24 (High)

Code:

**1. RESEARCH METHODOLOGY
AND IPR
(Theory)**

Credits: 4

COURSE OBJECTIVES:

- To obtain knowledge on basic concepts in Research and in Biostatistics.
- To acquire knowledge on sampling techniques, evaluate literature, collection of data and thesis writing.
- To analyze the significance of data bases and Citation Index.
- To introduce the fundamentals of Intellectual Property Rights and their importance in biological sciences.
- To enable students to apply IPR concepts in research, innovation, and commercialization.

UNIT-I RESEARCH METHODOLOGY:

Research-types, objectives and approaches. Hypothesis: definition, characteristics, types, significance. Methods of collecting data: primary and Secondary- merits and demerits, Code of research ethics. Literature collection: Books, Research articles and e-resources.

UNIT-II RESEARCH METHODOLOGY:

Structure of thesis & research article. Journals in Life Sciences, Impact factor of Journals, Ethical issues related to publishing, Plagiarism and Software. Manuscript for publication and proof correction. Structure and components of research proposal, National and International funding sources.

UNIT-III RESEARCH METHODOLOGY:

Bibliometrics: definition and relevance; Bibliometrics databases, h-index, SNIP, Page Rank, Impact Factor and evaluation. The use of biblio metrics in research: Citation Research, Science Citation Index. The Institute for Scientific Information (ISI), Thomson Reuter's Web metric and ORCID. Tailored Research and Retraction. Indian Patent Act.

UNIT-IV IPR:

Introduction to Intellectual Property Rights: Concept and importance. Types of IPR: Patents, Copyrights, Trademarks, Geographical Indications, Trade Secrets. Patent system in India: Indian Patents Act, 1970, Patentable and non-patentable inventions, Process of patent filing and grant. International agreements: TRIPS Agreement and World Intellectual Property Organization.

UNIT-V IPR

IPR in Botany and Biotechnology: IPR in plant sciences and biotechnology, Plant Variety Protection: Protection of Plant Varieties and Farmers' Rights Act, 2001. Biodiversity and IPR: Convention on Biological Diversity, Traditional knowledge and biopiracy, Access and Benefit Sharing (ABS), Case studies (e.g., Neem, Turmeric patents), Ethical issues in biological research and conservation

UNIT-VI CURRENT CONTOURS (For Continuous Internal Assessment Only):

Research Article Critique: Students select a published research paper. Identify research question, methodology, results, critically evaluate strengths & limitations. Topic Selection & Problem Formulation: Students choose a research topic of interest. Frame a research problem, Write objectives and hypotheses. Basics of Data Analysis: Provide a small dataset. Calculate mean, median, SD and Interpret results. Patent & Copyright Search: Students explore: World Intellectual Property Organization database -Search for a patent in their field and summarize its innovation.

Recommended Textbooks:

1. Kothari, C. R. (2014). *Research Methodology-Methods & Techniques*. Wishwa Prakashan.
2. Misra, R. P. (2000). *Research Methodology-A Handbook*. Concept Pub. Company.
3. Venkataraman M. (2015). *An Introduction to Intellectual Property Rights*. Create space Independent Pub. North Charleston.

Reference Books:

1. Gopalakrishnan N. S., & Agitha, T.G. (2009). *Principles of Intellectual Property*. Eastern Book Company.
2. Ramakrishna, B., & Kumar, A.H.S. (2017). *Fundamentals of Intellectual Property Rights: For Students, Industrialist and Patent Lawyers*. Notion Press.
3. Boyle, J., & Jenkins, J. (2018). *Intellectual Property: Law & the Information Society- Cases and Materials*. Create space Independent Pub. North Charleston.
4. Reddy, D. S. V. (2019). *Intellectual Property Rights - Law and Practice*. Asia Law House.

Web Resources:

1. <https://ipindia.gov.in/>
2. <https://www.annauniv.edu/ipr/files/downloadable/Overview%20of%20IPR.pdf>
3. <https://www.fao.org/faolex/results/details/en/c/LEX-FAOC110356/>

COURSE OUTCOMES:

Course Outcomes	On successful completion of this course, students will be able to	Cognitive Levels (K-Level)
CO1	Apply fundamental principles of research methodology to formulate research problems, develop hypotheses, and conduct scientific investigations in plant sciences.	K1
CO2	Evaluate and select appropriate research methods, experimental designs, and analytical tools to achieve specific research objectives and generate reliable scientific outcomes.	K2
CO3	Demonstrate critical thinking, scientific writing, and communication skills to analyze research findings and present scientific information effectively in academic and	K3

	professional formats.	
CO4	Design and implement suitable research plans by integrating experimental approaches, data collection strategies, statistical analysis, and ethical research practices.	K4
CO5	Analyze and assess various forms of Intellectual Property Rights (IPR) and evaluate their applications in plant breeding, biotechnology, biodiversity conservation, and innovation management.	K5& K6

Mapping with POs:

Relationship Matrix											
Semester	Course Code		Title of the Course							Hours	Credits
IV			1.Research Methodology and IPR (Theory)							4	4
Course Outcomes	Programme Outcomes (POs)										Mean Score
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	
CO1	3	2	2	3	2	3	2	2	2	1	2.2
CO2	2	3	3	3	3	2	2	2	3	1	2.4
CO3	2	3	2	2	2	1	3	2	2	2	2.1
CO4	2	3	3	3	2	2	3	3	2	2	2.5
CO5	2	3	2	2	2	1	3	2	2	2	2.1
Mean Overall Score											2.26 (High)

COURSE OBJECTIVES:

- To understand the scope, history, and interdisciplinary nature of economic botany.
- To examine plants of economic importance across major use categories.
- To analyse plant secondary metabolites and their industrial and pharmaceutical applications.
- To evaluate traditional ecological knowledge (TEK) and ethnobotanical practices.
- To apply sustainability principles to plant resource management and conservation and integrate emerging technologies and green innovations in plant-based industries.

UNIT-I FOUNDATION OF ECONOMIC BOTANY AND FOOD PLANTS:

Definition, scope, and historical development of economic botany; relationship with ethnobotany and agronomy. Plant domestication — centres of origin (Vavilov centres); co-evolution of plants and human civilisations. Cereal crops — rice, wheat, millets: nutritional significance, and global trade. Pulse crops — chickpea, soybean. Root and tuber crops — potato, sweet potato, yam; tropical significance. Oil-yielding plants — groundnut, sesame, Beverage plants — tea, coffee, Food security, crop biodiversity, and the Green Revolution: achievements and ecological critiques.

UNIT-II INDUSTRIAL AND TIMBER PLANTS:

Fibre plants — cotton, jute, Timber and wood — classification of timber, teak, Bamboo as a sustainable material — growth biology, industrial uses, carbon sequestration potential. Rubber — *Hevea brasiliensis*: tapping, latex chemistry, tapping and trade Dye and tannin plants — indigo, henna, turmeric, mangrove tannins; natural dyes vs. synthetic — ecological case. cosmetic and industrial applications. Paper and pulp — wood pulp sources, bamboo paper, environmental impact of paper industry.

UNIT-III MEDICINAL PLANTS, PHYTOCHEMISTRY AND NUTRACEUTICALS:

Classification and significance of medicinal plants; global herbal medicine market. Major plant secondary metabolites — alkaloids (morphine, quinine, caffeine, berberine), terpenoids (menthol, artemisinin, taxol), flavonoids, tannins, saponins, glycosides: biosynthesis, functions, examples. Important Indian medicinal plants — *Withania somnifera*, Neem, *Aloe vera*, *Phyllanthus niruri*. Ayurvedic, Siddha, and Unani systems — botanical basis and scientific validation of traditional formulations. Nutraceuticals and functional foods — definition, plant sources, regulatory frameworks (FSSAI, WHO).

UNIT-IV ETHNOBOTANY AND CONSERVATION:

Ethnobotany - definition, methods, and scope; Traditional ecological knowledge (TEK) - documentation methods, community knowledge registers, People's Biodiversity Registers (PBR) in India. Tribal and folk uses of plants in India - case studies from Western Ghats, Eastern Himalayas, Thar Desert, and Andaman

Islands. Sacred groves (*Devavans*) as in situ biodiversity conservation - ecological significance and community governance. Biodiversity hotspots of India.

UNIT-V SUSTAINABILITY AND PLANT BASED BIO ECONOMY:

Sustainable development - concepts, pillars, Agroforestry systems - types, ecological benefits, carbon sequestration. Biofuels - first, second, and third generation; *Jatropha*, sugarcane ethanol, algal biodiesel; energy policy in India. Phytoremediation. Green chemistry and plant-derived solvents, surfactants, and catalysts - principles of green chemistry applied to botanical resources. Circular bioeconomy - zero-waste utilisation of crop residues; valorisation of agricultural by-products.

UNIT-VI CURRENT CONTOURS (For Continuous Internal Assessment Only):

Local Plant Resource Survey: Students survey their local area/market/village- Identify economically important plants (food, medicinal, fibre, timber), Record local names, uses, and availability. Choose crops like millets, pulses, or medicinal plants: Analyse its Economic importance. Market Survey & Price Analysis: Visit a local market. Record the prices of plant products (grains, fruits, spices) and Seasonal variations.

Recommended Textbooks:

1. Beryl B. Simpson & Molly Conner Ogorzaly, *Economic Botany* (2001). Plants in Our World McGraw-Hill · 3rd edition.
2. Jha, P.N, *Economic Botany*. (2009) S. Chand & Company, India
3. Jain, S.K and DeFilipps R.A *Medicinal Plants of India* (1991) Vol. I & II, Reference Publications

Reference Books:

1. Paul E. Minnis (Ed.), *Ethnobotany — A Reader*, (2000). University of Oklahoma Press
2. C. K. Kokate, C.K. Purohit, A.P and Gokhale S.B, *Pharmacognosy and Phytochemistry* (2017). Nirali Prakashan · 52nd edition.
3. Okechukwu Ukaga, Chris Maser & Michael Reichenbach, *Sustainable Development Principles, Frameworks and Case Studies*, (2011), CRC Press.
4. Michael Balick and Paul Alan Cox, *Plants, People and Culture — Science of Ethnobotany* (1996), Scientific American Library.
5. Steven McCutcheon and Jerald Schnoor (Eds.), *Phytoremediation — Transformation and Control of Contaminants*, (2003), Wiley-Interscience

Web Resources:

1. PLANTS Database - USDA NRCS, plants.usda.gov · Comprehensive plant classification, images, distribution, and economic use data; freely accessible.
2. Kew Gardens - Plants of the World Online (POWO), owo.science.kew.org · Authoritative taxonomic and distribution data for all economic plants.
3. India Biodiversity Portal, indiabiodiversity.org · Species occurrence data, citizen science records, threatened species profiles across Indian flora, NMPB - National Medicinal Plants Board.
4. FAO - Food and Agriculture Organization digital library, fao.org/publications · Crop production, food security, agroforestry, and plant genetic resources — free access reports.

COURSE OUTCOMES:

Course Outcomes:	On successful completion of this course, students will be able to	Cognitive Levels
CO1	Explain and classify economically important plant species based on their botanical characteristics, utilization patterns, commercial value, and contribution to sustainable development.	K1
CO2	Evaluate the biosynthesis, functions, and industrial applications of plant secondary metabolites and assess their significance in pharmaceuticals, agriculture, food and biotechnology sectors.	K2
CO3	Document, analyze, and critically assess traditional ecological knowledge and ethnobotanical practices for their scientific relevance, conservation value and socio-economic importance.	K3
CO4	Design and develop sustainable plant resource management strategies by integrating ecological principles, conservation approaches and environmental policy frameworks.	K4
CO5	Assess and communicate the applications of green technologies, plant-based innovations, and bioresource utilization through scientific reports, research outputs and entrepreneurial initiatives for sustainable industrial development.	K5 & K6

Mapping with POs:

Relationship Matrix											
Semester	Course Code		Title of the Course							Hours	Credits
IV			2.Economic Botany and Sustainable development (Theory)							4	4
Course Outcomes	Programme Outcomes (POs)										Mean Score
	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	
CO1	3	2	2	2	2	2	2	2	2	1	2.0
CO2	3	3	3	3	2	1	2	2	2	1	2.1
CO3	2	3	2	2	3	2	2	2	2	1	2.2
CO4	2	3	3	3	2	2	3	2	2	2	2.4
CO5	2	3	3	2	2	2	3	3	3	3	2.6
Mean Overall Score											2.26 (High)

COURSE OBJECTIVES:

- To understand, apply and analyze the importance of Indian system of medicine.
- To analyse the phytoconstituents of therapeutic values & evaluate the drug adulteration.
- To understand the authentication of plant drugs, collection and processing.
- To remember the indigenous traditional drugs.
- To Understand and apply the pharmaceutical preparation for commerce.

UNIT – I INTRODUCTION:

History, Definition and scope of plant medicine; Indian system of Medicines – Ayurveda, Siddha and Unani. Sources of plant drugs. Classification of Crude drugs – Taxonomical, Morphological, Pharmacological and chemical classifications. Importance of plant medicines, Plant Vs. conventional drugs.

UNIT – II DRUG CONSTITUENTS & ADULTERATION:

Carbohydrates, glycosides, lipids – fixed oils, volatile oils, resins, gums, alkaloids, tannins and polyphenols. Definition and types of drug adulteration and its detection. Methods of drug evaluation– physical, morphological and microscopical.

UNIT – III PROCESSING & EXTRACTION OF DRUGS:

Identification and authentication of plants, Different methods of processing of herbs like collection, harvesting, garbling, packing and storage. Methods of drying – Natural and artificial drying methods with their merits and demerits. General methods of plant extraction-Cold and Hot method, isolation and purification of phytoconstituents.

UNIT – IV INDIGENOUS TRADITIONAL DRUGS OF INDIA:

Distribution, biological source, characters, chemical constituents and medicinal uses of the following: Amla (*Emblica officinalis*), Brahmi (*Hydrocotyl asiatica*), Tulasi (*Ocimum sanctum*), Garlic (*Allium sativum*), Vasaka (*Adhatoda vasica*), Ginger (*Zingiber officinale*), Clove (*Syzygium aromaticum*), Pepper (*Piper nigrum*), Cinchona (*Cinchona officinalis*) and Lemon grass oil (*Cymbopogon citratus*).

UNIT – V PREPARATION OF CRUDE DRUGS FOR COMMERCE:

Preparation of herbal infusions- Hot and cold infusion, decoctions for cold and fever, lotions- sunscreen lotion, tinctures for burns and wounds, syrups for dry cough and digestion, poultices for inflammation and insect bites, ointments for wounds and swelling, oils- hair growth and insect repellent. Surgical fibre-cotton, sutures and dressings materials from plants.

UNIT – VI Current Contours (For Continuous Internal Assessment Only):

Current developments related to the Medicinal Botany during the semester concerned to be kept abreast of continuously and cumulatively through collection, discussion and evaluation from news and events over the world

collected through multiple reliable informative sources – Research articles, review materials, print, Internet, Interaction, Social media, Webinars and so on.

Recommended Textbooks:

1. Somasundaram S. 1997, Medicinal Botany (Maruthuvath Thavaraviyal) – (Tamil Medium Book)
2. Wallis, T. E. Text book of Pharmacognosy. CBS Publishers & Distributors. Jain Bhawan, New Delhi.
3. Hill, A. F., 1996. Economic Botany – Tata Mc Graw – Hill publishing company Limited, New Delhi.
4. Mohammed Ali. Text book of Pharmacognosy. CBS Publishers & Distributors, New Delhi.

Reference Books:

1. Edwin Jerald, E and Sheeja Edwin Jerald, 2007. Text book of Pharmacognosy and Phytochemistry. CBS Publishers and Distributors Pvt. Ltd.
2. Biren N. Shah and Seth, A. K. 2010. Text book of Pharmacognosy and Phytochemistry. Elsevier Publishers.
3. Michael Heinrich, Joanne Barnes, Jose M. Prieto Garcia, Simon Gibbons and Elizabeth M. Williamson. 2018. Fundamentals of Pharmacognosy and Phytotherapy. Elsevier Publishers.
4. Chengki Z, Junfu Z, 1984. Chinese sea weeds in herbal medicine. Junk Publishers, Dordrecht.

Web Resources:

1. <https://www.scribd.com/document/285304375/botany>
2. https://www.benthamscience.com/ebook_volume/3607
3. <https://doi.org/10.1007/978-3-032-01356-9>

COURSE OUTCOMES:

Course Outcome	On successful completion of this course, the students will be able to	Cognitive Levels (K-Level)
CO1	Explain the principles, scope, and significance of Indian systems of medicine and classify crude drugs based on their source, morphology and therapeutic applications.	K1
CO2	Evaluate indigenous traditional medicinal plants and drugs with respect to their ethnobotanical significance, medicinal properties and applications in healthcare systems.	K2
CO3	Analyze and assess the phytochemical constituents, therapeutic potential, quality standards, and adulteration of plant-derived drugs using scientific and pharmacognostic approaches.	K3
CO4	Apply standard methods for the collection, authentication, processing, preservation and quality evaluation of medicinal plant materials to ensure efficacy and safety.	K4
CO5	Evaluate the industrial and commercial applications of medicinal plants as technical products and assess their potential in pharmaceutical, cosmetic, nutraceutical and allied industries.	K5

Relationship Matrix											
Semester	Course Code		Title of the Course							Hours	Credits
I			1. Medicinal Botany (Theory)							5	3
Course Outcomes	Programme Outcomes (POs)										Mean Score
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	
CO1	3	2	2	2	2	2	2	2	2	1	2.0
CO2	3	3	2	2	1	2	2	2	2	1	2.0
CO3	3	3	3	3	1	2	2	2	3	1	2.3
CO4	2	2	3	3	2	1	2	3	2	1	2.1
CO5	2	3	3	2	2	2	3	2	2	2	2.3
Mean Overall Score											2.14 (High)

COURSE OBJECTIVES:

- To understand the diversity and pathogenicity of clinically significant microorganisms.
- To apply principles of diagnostic microbiology and laboratory techniques.
- To evaluate host-pathogen interactions and immune responses.
- To analyse antimicrobial agents, resistance mechanisms, and stewardship.
- Examine hospital-acquired infections and infection control strategies

UNIT-I INTRODUCTION TO CLINICAL MICROBIOLOGY AND MICROBIAL DIVERSITY:

Scope and significance of clinical microbiology; historical milestones: Classification of microorganisms of clinical importance - bacteria, fungi, viruses, protozoa, helminths. Bacterial morphology, staining (Gram, acid-fast, special stains), and culture characteristics. Medically important fungi - yeasts, moulds, dimorphic fungi; comparison with plant pathogenic fungi. Viruses: structure, classification, replication cycles. Microbial genetics - plasmids, transposons, horizontal gene transfer, pathogenicity islands. Normal microbiota and its role in health.

UNIT-II PATHOGENESIS, VIRULENCE AND HOST PATHOGEN INTERACTIONS:

Concepts of infection, disease, and epidemiology; Koch's postulates revisited. Virulence factors — adhesins, toxins (exo/endotoxins), invasins, immune evasion strategies. Intracellular pathogens: *Mycobacterium*, *Listeria*, *Leishmania*. Innate immunity: barriers, phagocytosis, complement, pattern recognition receptors (TLRs, NLRs). Adaptive immunity: T-cell and B-cell responses, antigen presentation, memory. Comparison with plant immunity: PAMP-triggered immunity (PTI) and effector-triggered immunity (ETI). Sepsis, systemic inflammatory response, and immunopathology.

UNIT-III CLINICAL BACTERIOLOGY AND DIAGNOSTIC METHODS:

Clinically important bacteria - *Staphylococcus*, *Streptococcus*, *Mycobacterium tuberculosis*, *Salmonella*, *E. coli*, *Pseudomonas*, *Clostridium*, *Helicobacter*. Specimen collection, transport, and processing protocols. Conventional diagnostics: culture, biochemical identification (IMViC, API systems). Serological tests: ELISA, Widal, Western blot, agglutination assays. Molecular diagnostics: PCR, RT-PCR, multiplex PCR, CRISPR-based diagnostics. Next-generation sequencing (NGS) in clinical microbiology and metagenomics. MALDI-TOF MS for rapid microbial identification. Point-of-care (POC) testing and rapid antigen/antibody tests.

UNIT-IV ANTIMICROBIALS AND MEDICAL MICROBIOLOGY: Classification of antibiotics - beta-lactams, aminoglycosides, fluoroquinolones, macrolides, glycopeptides. Antifungal agents - polyenes, azoles, echinocandins; mechanisms of action. Antimicrobial susceptibility testing - disc diffusion (Kirby-Bauer), MIC, E-test, VITEK. Mechanisms of drug resistance - enzymatic inactivation, target modification, efflux pumps, biofilms. Multidrug-resistant (MDR), extensively drug-resistant (XDR) pathogens; ESKAPE pathogens. Plant-derived antimicrobials - alkaloids, terpenes, flavonoids, essential oils; ethnopharmacological relevance.

UNIT-V HOSPITAL INFECTIONS, BIOSAFETY AND ONE HEALTH PERSPECTIVE:

Nosocomial (healthcare-associated) infections - epidemiology, common causative agents, surveillance Sterilization and disinfection - autoclave, dry heat, UV, chemical disinfectants; validation methods. Biofilm formation, persistence, and clinical implications. Biosafety levels (BSL 1–4) and containment in clinical and botanical research labs Infection control programmes - hand hygiene, PPE, isolation protocols. One Health framework - zoonoses, food-borne outbreaks, environmental reservoirs. Emerging and re-emerging infectious diseases; pandemic preparedness. Microbiome research, Phyto microbiome, and therapeutic applications.

UNIT-VI CURRENT CONTOURS (For Continuous Internal Assessment Only):

Assign students a specific organism (e.g., *Staphylococcus aureus*, *E. coli*). Study morphology, culture media, biochemical tests, Create a flowchart for identification. Antibiotic Sensitivity Interpretation: Provide a Kirby-Bauer disc diffusion result (zone sizes). Interpret sensitivity/resistance, Suggest appropriate antibiotics. **Literature Review:** Emerging antibiotic resistance in India, Role of microbiome in health. **Problem-Based Learning (PBL):** Present a **real-world problem**, e.g.: Hospital-acquired infection outbreak, Investigate source and Suggest control measures.

Recommended Textbooks:

1. Subhash Chandra Parija, Textbook of Microbiology & Immunology (2016). Elsevier India · 3rd edition.
2. Anantha Narayan and Paniker's Textbook of Microbiology, (2017). Universities Press · 10th edition.

Reference Books:

1. Forbes, Sahm and Weisfeld, Bailey & Scott's Diagnostic Microbiology (2016).Elsevier · 14th edition ·
2. Carroll, Pfaller et al. Jawetz, Melnick and Adelberg's Medical Microbiology (2019). McGraw-Hill · 28th edition
3. Rai and Bridge (Eds.), Clinical Mycology: Current Trends and Future Prospects (2015). CRC Press.
4. Bennett, Dolin and Blaser. Mandell, Douglas & Bennett's Principles of Infectious Diseases (2019). Elsevier · 9th edition.

Web Resources:

1. pubmed.ncbi.nlm.nih.gov · Peer-reviewed research, systematic reviews on clinical microbiology.
2. WHO AMR Global Action Plan & GLASS.who.int/antimicrobial-resistance · Surveillance data, policy documents, AMR reports.
3. Coursera — Epidemiology & Clinical Microbiology (Johns Hopkins, Duke),coursera.org · Auditable MOOCs; infection biology, public health microbiology.
4. CDC — Clinical Laboratory Reference & Infection Control.cdc.gov/laboratory · Protocols, guidelines, MMWR case reports, biosafety manuals.
5. DOAJ — Directory of Open Access Journals (Microbiology section),doaj.org · Free access to peer-reviewed microbiology journals.
6. ASM Microbe Library & mBio (American Society for Microbiology),asm.org/microbiology · Teaching resources, open-access journals, case studies.

COURSE OUTCOMES:

Course Outcomes:	On successful completion of this course, students will be able to	Cognitive Levels (K-Level)
CO1	Explain and classify clinically significant microorganisms based on their taxonomic, morphological, physiological and pathogenic characteristics for accurate identification and diagnosis.	K1
CO2	Apply and interpret standard clinical microbiological techniques, diagnostic procedures, and laboratory methods for the detection, identification and characterization of microbial pathogens.	K2
CO3	Evaluate and compare innate and adaptive immune mechanisms involved in host defense against microbial infections and assess their significance in disease prevention and management.	K3
CO4	Critically assess the causes, mechanisms, and impacts of antimicrobial resistance and propose evidence-based strategies for its prevention, surveillance and control.	K4
CO5	Design and implement infection control measures, biosafety practices, and laboratory quality assurance protocols to ensure safe and effective clinical and research environments.	K5 & K6

Mapping with POs:

Relationship Matrix											
Semester	Course Code		Title of the Course							Hours	Credits
			2. Clinical Microbiology (Theory)							5	3
Course Outcomes	Programme Outcomes (POs)										Mean Score
	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	
CO1	3	2	2	2	2	2	2	2	2	2	2.1
CO2	3	2	3	3	2	1	2	3	2	1	2.2
CO3	3	3	2	2	1	2	2	2	2	1	2.0
CO4	2	3	3	3	1	2	3	2	2	1	2.2
CO5	2	3	3	3	2	2	3	2	2	3	2.5
Mean Overall Score											2.2 (High)

COURSE OBJECTIVES:

- To teach the identification of mushrooms.
- To differentiate the edible mushrooms with toxic and hallucinating fungi.
- To study the cultivation technique of mushrooms.
- To learn the economic importance of mushroom in various fields.
- To study how to establish mushroom cultivation as business enterprise

UNIT-I INTRODUCTION:

Introduction to mushrooms - history, scope and importance mushroom cultivation; Edible Mushroom cultivation, commercial production, medicinal value of mushrooms, nutraceuticals and dietary supplements using mushrooms; Nutritive Value – proteins – amino acids, mineral elements, carbohydrates, Crude fiber content and vitamins of edible mushrooms.

UNIT-II MORPHOLOGICAL AND MICROSCOPICAL IDENTIFICATION OF MUSHROOMS:

Keys for identification of edible mushrooms: *Agaricus bisporus*, *Pleurotus sajorcaju*, *Volvariella volvcea* and *Calocybe indica*. Key for identifying hallucinogenic mushroom (*Psilocybe* sp.) Medicinal Mushroom – *Cordyceps*, *Ganoderma lucidum* and *Lentinus edodes*.

UNIT-III CULTIVATION:

Substrate sterilization, bed preparation, cropping room and maintenance, raising of pure culture and spawn preparation, factors effecting button mushroom production (Temp, pH, air and water management, competitor moulds and other disease). Mushroom bed preparation – Paddy straw, sugarcane thrash, maize straw, banana leaves. Factors affecting the mushroom bed preparation - low-cost technology, composting technology in Mushroom production.

UNIT-IV POST-HARVEST MANAGEMENT:

Harvest, storage: Short-term storages (Refrigeration – up to 24 hrs); Long term storage (canning, pickles, papads), drying, storage in salt solutions, quality assurance of mushrooms. Pest management

UNIT-V MARKETING OF MUSHROOMS:

World production edible mushroom, Legal and regulatory issues of introducing the medicinal mushrooms in different countries. Developing small scale industry and Government schemes. Mushroom Research Centres – International and National levels.

UNIT-VI CURRENT CONTOURS (For Continuous Internal Assessment Only):

Spawn production: learn the process of inoculating sterilized grains like sorghum or wheat with mycelium to create your own seed or spawn. Substrate experimentation: compare the growth rates of specific species like Oyster mushroom on different agricultural waste such as paddy straw, sugarcane trash, banana leaves and maize straw.

Recommended Textbooks:

1. Marimuthu, T., Krishnamoorthy, A.S., Sivaprakasam, K. and Jayarajan, R., (1991). Oyster Mushrooms, Department of plant pathology, Tamil Nadu Agricultural University, Coimbatore.
2. Swaminathan, M., (1990). Food and Nutrition, Bappco, The Bangalore Printing and Publishing Co. Ltd., No. 88, Mysore Road, Bangalore 560 018.
3. Tewari, PankajKapoor, S.C., (1988). Mushroom Cultivation, Mittal Publications Delhi.
4. Suman, B.C., Sharma V.P., (2007). Mushroom Cultivation in India. Daya Publication House.
5. Chang S.T. and Mies.P.G (2004). Mushroom Cultivation, Nutritional value, Medicinal effect and Environmental Impact (2nd Edition) CRC Press.

Reference Books:

1. Adegbeye, M.J. Ravi Kanth Reddy P, Obaisi A.I, Elghandour M.M.M.Y, Oyebamiji, K.J. Salem, A.Z.M. Morakinyo-Fasipe, O.T. Cipriano-Salazar, M. and Camacho-Díaz, L.M. 2020. Sustainable agriculture options for production, greenhouse gasses and pollution alleviation, and nutrient recycling in emerging and transitional nations - An overview, *Journal of Cleaner Production*, <https://doi.org/10.1016/j.jclepro.2019.118319>.
2. Gayathri, G., Gomathi, S., Ambikapathy, V., Panneerselvam, A., and Babu, S. (2023). Production, Cost Benefit Analysis and Marketing of Oyster Mushroom. In: Amaresan, N., Dharumadurai, D., Babalola, O.O. (eds) *Food Microbiology Based Entrepreneurship*. Springer, Singapore. https://doi.org/10.1007/978-981-19-5041-4_3.
3. Murray C. Tseng, John H. Luong, (1984). Chapter 3 - Mushroom Cultivation - Technology for Commercial Production, Editor(s): GEORGE T. TSAO, Annual Reports on Fermentation Processes, Elsevier, <https://doi.org/10.1016/B978-0-12-040307-3.50008-1>
4. Abirami, G., Gomathi, S., Ambikapathy, V., Gayathri, G., Shijila Rani, A.S., Panneerselvam, A. (2023). Small/Large Scale Production, Cost Benefits Analysis, and Marketing of Milky Mushroom. In: Amaresan, N., Dharumadurai, D., Babalola, O.O. (eds) *Food Microbiology Based Entrepreneurship*. Springer, Singapore. https://doi.org/10.1007/978-981-19-5041-4_5.

Web Resources:

1. https://agricoop.nic.in/sites/default/files/ICAR_8.pdf
2. <https://www.mycoiq.com/mushroom-technology>
3. https://www.academia.edu/11324578/Mushroom_Production_and_Processing_Teaching_Note
4. https://books.google.co.in/books/about/Mushroom_Cultivation_Technology.html?id=OfKJDwAAQBAJ&redir_esc=y
5. <https://www.biologydiscussion.com/fungi/mushrooms-meaning-values-and-cultivation-procedure/46635>

COURSE OUTCOMES:

Course Outcomes:	On the successful completion of the course, students will be able to	Cognitive Level
CO1	Classify edible and toxic mushrooms belonging to Ascomycota and Basidiomycota based on their morphological, taxonomic and diagnostic characteristics.	K1
CO2	Evaluate the nutritional, nutraceutical, medicinal, and therapeutic properties of edible mushrooms and assess their significance in human health and food security.	K2
CO3	Apply scientific principles and cultivation technologies for the production of edible and medicinal mushrooms under controlled and commercial conditions.	K3
CO4	Assess and implement appropriate harvesting, post-harvest handling, processing, preservation, and quality management techniques to enhance mushroom yield and shelf life.	K4
CO5	Develop and evaluate sustainable production, value-addition, entrepreneurship, and marketing strategies for mushroom-based industries and commercial enterprises.	K5

Cognitive Level: K1 - Remember; **K2** - Understanding; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Mapping with POs:

Relationship Matrix											
Semester	Course Code		Title of the Course							Hours	Credits
I			3. Mushroom Technology (Theory)							5	3
Course Outcomes	Programme Outcomes (POs)										Mean Score
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	
CO1	3	2	2	2	2	2	2	2	2	1	2.0
CO2	3	3	2	2	1	2	2	2	2	1	2.0
CO3	3	2	3	3	2	1	2	2	2	1	2.1
CO4	2	2	3	3	2	1	2	2	2	1	2.0
CO5	2	3	3	2	2	2	3	2	3	3	2.5
Mean Overall Score											2.12 (High)

COURSE OBJECTIVES:

- To learn various cell structures and functions of prokaryotes and eukaryotes and understand the salient features and functions of cellular organelles.
- To understand the cell division and its molecular mechanism so as to appreciate and manipulate normal and abnormal cell and tissue growth
- To enlighten people of past molecular biology developments.
- To comprehend the molecular processes.
- To analyse the DNA structure, replication process, transcription process and translation processes

UNIT - I CELL BIOLOGY:

Concept of prokaryote and Eukaryote. Structural organization of plant cell. Cell wall- Structure and functions, Plasma membrane; structure, models and functions, site for ATPase, ion carriers channels and pumps, receptors. Plasmodesmata and its role in movement of molecule. Membrane transport kinetics and signal transduction pathways regulating ion fluxes and cellular communication, cytoskeleton dynamics in maintaining cell shape, intracellular transport and cell division

UNIT - II CELL BIOLOGY:

Chloroplast-structure and function, genome organization, gene expression, RNA editing, Mitochondria; structure, genome organization, biogenesis. Plant Vacuole - Tonoplast membrane, ATPases transporters as a storage organelle. Structure and function of other cell organelles- Golgi apparatus, lysosomes, endoplasmic reticulum and microbodies. Organelle crosstalk and retrograde signaling between chloroplasts, mitochondria and nucleus in regulating cellular metabolism, proteomics and metabolomics approaches for functional characterization of organelles.

UNIT - III MOLECULAR BIOLOGY:

Nucleus: Structure and function, nuclear pore, Nucleosome organization, euchromatin and heterochromatin. Ribosome- Structure and functional significance. RNA and DNA Structure. A, B and Z Forms. Replication, transcription, translation in prokaryotes and eukaryotes. DNA damage and repair (Thymine dimer, photoreactivation, excision repair). Cell cycle and Apoptosis Control mechanisms, role of cyclin dependent kinases. Retinoblastoma and E2F proteins, cytokinesis and cell plate formation, mechanisms of programmed cell death. Epigenetic regulation including DNA methylation and histone modifications in gene expression, CRISPR-Cas mediated genome editing.

UNIT - IV MOLECULAR BIOLOGY:

DNA replication (prokaryotes and eukaryotes), enzymes involved in replication, DNA repair. DNA sequencing. Transcription, enzymes involved in transcription, post transcription changes, reverse transcription, Translation. overlapping genes.

Next-generation sequencing technologies for high-throughput genome analysis, regulation of gene expression through RNA interference and non-coding RNAs.

UNIT - V MOLECULAR BIOLOGY:

DNA/gene manipulating enzymes: endonuclease, ligase, polymerase, phosphatase, transcriptase, transferase, topoisomerase. Gene cloning: cloning vectors, molecular cloning and DNA libraries. Molecular genetic elements, insertion elements, transposons. Recombinant DNA. Direct and indirect gene transfer. Detection of recombinant molecule, production of gene products from cloned genes. Genome library, cDNA library. CRISPR-Cas genome editing for precise genetic manipulation, synthetic biology approaches for designing novel genetic circuits and engineered organisms.

UNIT - VI CURRENT CONTOURS (For Continuous Internal Assessment Only):

Current developments related to the Cell & Molecular biology during the semester concerned to be kept abreast of continuously and cumulatively through collection, discussion and evaluation from news and events over the world collected through multiple reliable informative sources – Research articles, review materials, print, Internet, Interaction, social media, Webinars and so on. Application of artificial intelligence and machine learning in genomics and precision plant breeding, genome-wide association studies and genomic selection for crop improvement.

Recommended Textbooks:

1. Karp, G. 2010. Cell and Molecular Biology: Concepts and Experiments. 6th edition. John Wiley & Sons.
2. Aminul, I. 2011. Text Book of Cell Biology. Books and Allied (P) Ltd, Kolkata, India.
3. Geoffrey M. Cooper. 2019. The Cell: A Molecular Approach, Oxford University Press.
4. Turner, P.C., Mclennan, A.G., Bates, A.D. and White, M.R.H. 2001. Instant notes on molecular biology.
5. Watson, J.D, Baker T.A., Bell S.P., Gann A., Levine M., Losick R. 2014. Molecular Biology of the Gene (7th edition), Pearson Press.
6. Snustad Peter, D. Michael J. Simmons. 2015. Principles of Genetics, John Wiley Sons.
7. Clark, D. 2010. Molecular Biology. Academic Press Publication.

Reference Books:

1. Alberts B., Bray, D., Lewis, J., Raff, M., Roberts, K. and Watson, J. D. 1989. Molecular biology of the Cell (2nd edition). Garland Pub. Inc., New York.
2. Karp, G. 1999. Cells and Molecular Biology: Concepts & Experiments. John Wiley and Sons, Inc., USA.
3. Lodish S, Baltimore B , Berk, C and Lawrence K, 1995 , Molecular Cell Biology , 3rd edn, Scientific American Books, N.Y
4. De Robertis and De Robertis, 1988, Cell and Molecular Biology, 8th edn, Info-Med, Hongkong.
5. Lewin, B. 2011. GENE X. Oxford University Press, New York, USA
6. Cooper G M and Hausman R E, 2007, The Cell: Molecular Approach 4th Edn, Sinauer Associates, USA.

7. Molecular Biology of the Cell – Alberts, B, Bray, D, Raff, M, Roberts, K and Watson JD, Garland Publishers, 1999

Web Resources:

1. <https://www.pdfdrive.com/cell-biology-books.html>
2. <http://www.bio-nica.info/Biblioteca/Bolsover2004CellBiology.pdf>
3. <https://www.e-booksdirectory.com/listing.php?category=549>
4. <https://www.elsevier.com/books/molecular-biology/clark/978-0-12-813288-3>
5. <https://www.kobo.com/in/en/ebooks/molecular-biology>

COURSE OUTCOMES:

Course Outcomes:	On successful completion of this course, the students will be able to	Cognitive Levels
CO1	Explain the structural organization and functional significance of plant cells and evaluate their roles in cellular processes and biological systems.	K1
CO2	Examine and interpret the structure, organization, and functions of cellular organelles and assess their contributions to cellular metabolism, growth and development.	K2
CO3	Evaluate the structure, properties, and biological significance of nucleic acids and analyze their roles in the storage, transmission and expression of genetic information.	K3
CO4	Compare and critically assess the mechanisms of DNA replication, repair, and associated enzymatic processes in prokaryotic and eukaryotic systems and interpret their significance in genome stability.	K4
CO5	Apply and develop molecular biology techniques for DNA isolation, gene manipulation, recombinant DNA technology and genetic analysis in research and biotechnological applications.	K5

Mapping with POs:

Relationship Matrix											
Semester	Course Code		Title of the Course							Hours	Credits
II			1.Cell and Molecular Biology (Theory)							4	3
Course Outcomes	Programme Outcomes (POs)										Mean Score
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	
CO1	3	2	2	2	2	2	2	2	2	2	2.1
CO2	3	2	2	3	2	2	2	2	2	1	2.1
CO3	3	3	2	2	1	2	2	2	2	1	2.0
CO4	3	3	3	3	1	2	2	2	2	1	2.2
CO5	2	3	3	3	2	1	3	3	2	1	2.3
Mean Overall Score											2.14 (High)

COURSE OBJECTIVES:

- To study seed structure development and dispersal.
- To learn the techniques of seed production and processing.
- To know about seed vigour and factors affecting germination.
- To understand seed testing and seed certification.
- To acquire knowledge on hybrid seed production techniques.

UNIT – I SEED DEVELOPMENT & MORPHOLOGY:

Seed development (sporogenesis, fertilization, embryogenesis & seed formation) in a typical dicot and monocot crop. Endosperm types and functions, cotyledons - Seed coat structure, permeability, seed dormancy and factors causing dormancy of seeds Seed dispersal strategies, types of seeds; economic importance of seeds.

UNIT – II SEED PRODUCTION AND PROCESSING:

Seed as basic input in agriculture; importance of genetic purity in seed production; seed production in self- and cross-pollinated crops; methods of hybrid seed development; custom seed production in India- Seed processing: Introduction and importance; Equipment's used for seed cleaning, drying, grading, destoning & gravity separating. Seed treatments (physical and chemical), benefits and precautions. Seed storage – introduction, steps, factors affecting storage; insect, rodent and bird control of storage houses.

UNIT – III SEED GERMINATION AND VIGOUR:

Seed germination – introduction & types; germination requirements in agriculture and horticulture crop seeds. Factors affecting seed germination, role of promoters and inhibitors. Seed vigour – concept, factors affecting seed vigour, physiological and genetic basis of seed vigour. Methods of measuring seed vigour; seed & seedling vigour in relation to crop establishment and yield.

UNIT – IV SEED TESTING AND SEED CERTIFICATION:

National seed testing rules and organizations; seed sampling, heterogeneity test, sample receipt and registration. - Moisture test, tetrazolium test – principles, procedure and evaluation; methods to break seed dormancy. - Seed certification – concept, purpose and phases of seed certification, certification agency, certified seed level, certification tag and validity period of certification. Seeds Act, rules & law enforcement; seed control order & seed policy; role of “Quality Control” for import and export of seeds.

UNIT – V HYBRID SEED PRODUCTION:

Techniques of hybrid seed production - emasculation and crossing: use of self-incompatibility, modification of sex; types of male sterility and exploitation in hybrid development and its use in hybrid seed production; development and maintenance of A, B and R lines. Fertility restoration; use of chemical hybridizing agents, problems of non-synchrony in flowering of parental lines and methods to overcome; planting ratios and population density in relation to hybrid seed yield; salient features of hybrid seed production of various crops viz., rice, sorghum, bajra, maize, sunflower, cotton and other major vegetables.

UNIT – VI CURRENT CONTOURS (For continuous internal assessment only):

Current developments related to the Seed technology during the semester concerned to be kept abreast of continuously and cumulatively through collection, discussion and evaluation from news and events over the world collected through multiple reliable informative sources – Research articles, review materials, print, Internet, Interaction, social media, Webinars and so on.

Recommended Textbooks:

1. Bhojwani SS & Bhatnagar SP. 1999. The embryology of Angiosperm. Vikas publications.
2. Copeland LO & McDonald MB. 2001. Principles of seed science and Technology. 4th Ed. Chapman & Hall.
3. Agarwal RL. 1997. Seed Technology. 2nd Ed. Oxford & IBH. 3. Kelly AF. 1998. Seed Production of Agricultural Crops. Longman.

Reference Books:

1. McDonald MB Jr & Copeland Lo. 1997. Seed Production: Principles and Practices. Chapman & Hall.
2. Barton LV. 1985. Seed Preservation & Longevity. International Books and Periodicals Supply Service. New Delhi.
3. Justice OL & Bass LN. 1978. Principles and Practices of seed storage. Castle House Publ. Ltd.
4. Nema NP. 1986. Principles of Seed Certification and Testing. Allied Publications.
5. Tunwar NS & Singh SN. 1988. Indian Minimum Seed Certification Standards. CSCB, Ministry of Agriculture, New Delhi.

Web Resources:

1. https://www.coabnau.in/uploads/1614660953_GPB-4.4.TheoryNote.pdf
2. <https://www.agrimoon.com/wp-content/uploads/PRINCIPLES-OF-SEED-TECHNOLOGY.pdf>
3. <https://drive.google.com/file/d/1DMIwt6NJ72hN4rTnWXW9DpyaZBDFRujr/view>
4. <https://drive.google.com/file/d/1KJg8Upc8B2U0pBw5zj537iNDpFrQsoKx/view>

COURSE OUTCOMES:

Course Outcomes:	On successful completion of this course, the students will be able to	Cognitive Levels
CO1	Explain the principles, concepts, and applications of seed technology and evaluate their significance in crop improvement, seed quality enhancement and agricultural productivity.	K1
CO2	Apply scientific methods and techniques involved in seed production, processing, storage and certification to ensure the production of high-quality seeds.	K2
CO3	Assess the physiological, genetic, and environmental factors influencing seed vigour and evaluate their impact on seed performance, germination and crop establishment.	K3
CO4	Evaluate seed testing procedures, quality control standards, and certification protocols to determine seed quality, purity, viability and marketability.	K4
CO5	Develop and implement strategies for hybrid seed	K5

	production, maintenance breeding, and seed multiplication programs to support sustainable crop improvement and commercial seed production.	
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Mapping with POs:

Relationship Matrix											
Semester	Course Code	Title of the Course								Hours	Credits
II		2.Seed Technology (Theory)								4	3
Course Outcomes	Programme Outcomes (POs)										Mean Score
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	
C01	3	2	2	2	2	2	2	2	2	1	2.0
C02	3	2	3	3	2	2	2	2	2	2	2.3
C03	3	3	3	2	1	2	2	2	2	1	2.1
C04	2	3	3	3	1	2	2	2	2	2	2.2
C05	2	3	3	3	3	3	2	2	2	2	2.5
Mean Overall Score											2.22 (High)

COURSE OBJECTIVES:

- To encourage and enhance biological cycles within farming system involving microorganisms, soil flora and fauna, plants and animals.
- To learn plant nutritional requirements and the role of chemical fertilizers.
- To study the nutritional source of organic farming.
- To study important biofertilizers.
- To employ knowledge on vermicompost production and its application.

UNIT - I ORGANIC FARMING:

Definition, objective and scope. Types and importance of organic farming – Integrated Farming system, Mixed farming – Soil reclamation – Weed management. Precision organic farming using digital tools for site-specific nutrient and weed management, carbon sequestration.

UNIT - II PLANT NUTRIENTS:

Plant nutrients – functions of nutrients in plant growth and development of crops – Nutrient uptake and utilization by plants. Chemical fertilizers – Advantage and Disadvantage of their use – Microorganisms in organic farming – Sustainable agriculture, pesticide and fungicide residues. Efficiency and precision nutrient management using sensor-based and decision support systems, role of plant-microbe interactions.

UNIT - III SOURCES OF NUTRIENTS:

Sources of nutrients for Organic agriculture – (a) Organic Manure (FYM / Rural compost, urban compost, oil cakes, Animal waste, vermicompost). (b) Green Manure (Green manure with Leguminous crops in crop rotation). (c) non leguminous Nitrogen contributing plants. (d) Liquid manure. Role of cyanobacteria in organic farming. Development of fortified and enriched composts using microbial consortia for enhanced nutrient availability, liquid biofertilizer formulations for efficient nutrient delivery.

UNIT - IV BIOFERTILIZERS:

Importance of Biofertilizers in soil productivity – (a) nitrogen fixing (symbiotic and asymbiotic) (b) Phosphate and Potassium solubilizing bacteria and fungi (Mycorrhiza), Preparation, dosage and method of applications of biofertilizers. Multi-strain microbial consortia for synergistic nutrient mobilization and improved soil health, formulation of carrier-based and liquid biofertilizers.

UNIT - V VERMICOMPOST:

(a) Pit construction (b) Raw materials (c) Availability of species of earthworm (d) Method of preparation (e) Quality of improvement of finished vermicompost – Field application. Vermiculite and vermiwash, Biopesticides – Advantages and applications. Optimization of vermicomposting through microbial enrichment and controlled environmental parameters for enhanced

nutrient quality.

UNIT - VI CURRENT CONTOURS (For continuous internal assessment only):

Current developments related to the Organic farming during the semester concerned to be kept abreast of continuously and cumulatively through collection, discussion and evaluation from news and events over the world collected through multiple reliable informative sources – Research articles, review materials, print, Internet, Interaction, social media, Webinars and so on. Sensor-based decision support systems, climate-resilient organic practices and carbon footprint assessment for sustainable agriculture.

Recommended Textbooks:

1. Annadurai, K. and Palaniappan, S.P. (2018). Organic Farming. Scientific Publishers (India).
2. Dubey, R.C. (2005). A Textbook of Biotechnology. S. Chand & Co. Ltd., New Delhi.
3. Juneja, A.C. (2015). Biofertilizers and Organic Farming. Satyam Publishers and Distributors.
4. Mamta Bansal (2018). Basics of Organic Farming. Publishers and Distributors Pvt. Ltd.
5. Natarajan, T. (2010). Organic Farming for Business. Swastik Publication.
6. Reddy, S.R. (2017). Principles of Organic Farming. Kalyani Publishers

Reference Books:

1. Satha , T.V. (2004). Vermiculture & Organic farming. Daya Publishers.
2. Subba Rao, N.S. (2000). Soil Microbiology. Oxford & IBH Publishers, New Delhi.
3. Vayas, S.C., Vayas, S. and Modi, H.A. (1998). Biofertilizers and Organic Farming. Akta Prakashan, Nadiad.
4. Walia, S.S. and Nanwal, R.K. (2018). Principles of Organic Farming. New Delhi Publishing Agency – Nipa.

Web Resources:

1. https://www.fao.org/fileadmin/templates/nr/sustainability_pathways/docs/Compilation_techniques_organic_agriculture_rev.pdf
2. <https://www.jaivikkheti.in/DMS/Production%20Technology%20of%20Organic%20Inputs.pdf>
3. <https://www.nabard.org/demo/auth/writereaddata/File/OC%2038.pdf>

COURSE OUTCOMES:

Course Outcomes:	On successful completion of this course, the students will be able to	Cognitive Levels
CO1	Compare and evaluate the principles, advantages, and limitations of organic and chemical fertilizers and assess their impacts on soil health, crop productivity and environmental sustainability.	K1
CO2	Analyze the role of biological cycles and ecological processes in farming systems and evaluate their contributions to sustainable agricultural production.	K2
CO3	Assess and utilize organic nutrient resources, including composts, green manures, biofertilizers, and organic amendments, for improving soil fertility and crop performance.	K3
CO4	Evaluate the significance of microbial diversity in agricultural ecosystems and propose strategies for its conservation and sustainable utilization in organic farming practices.	K4
CO5	Develop and promote environmentally sustainable agricultural practices and awareness programs for ecosystem conservation, resource management and environmental protection.	K5

Mapping with POs and PSOs

Relationship Matrix											
Semester	Course Code		Title of the Course							Hours	Credits
II			3. Organic farming (Theory)							4	3
Course Outcomes	Programme Outcomes (POs)										Mean Score
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	
C01	3	3	2	2	2	2	2	2	2	1	2.1
C02	3	3	3	3	1	2	2	2	2	1	2.2
C03	3	2	3	2	1	2	2	2	1	2	2.0
C04	2	3	2	2	1	3	2	2	2	1	2.0
C05	2	3	2	2	2	3	3	2	3	3	2.5
Mean Overall Score											2.16 (High)

COURSE OBJECTIVES:

- To give a clear knowledge of genetic engineering, cloning vectors, enzymes involved in cloning.
- To understand the procedure involved in recombinant DNA technology and restriction mapping.
- To focus on the application of gene cloning in plants and animals.
- To enable the students to information on Gene Therapy.
- To raise student to create transgenic plants for hybrid seed production and molecular farming.

UNIT - I PLANT TISSUE CULTURE:

Biotechnology as Interdisciplinary and Multidisciplinary approach - Plant Tissue Culture – Introduction - Objectives and Goals – Laboratory organisation – Nutrient medium – Sterilization Techniques – Types of Cultures (seed, embryo, Root, callus, organ, cell, protoplast and axillary bud cultures) – Cell suspension culture and Secondary metabolites - Plant Micropropagation – Somatic embryogenesis – embryogenesis - Organogenesis – Protoplast Isolation and Fusion.

UNIT - II APPLICATION OF PLANT TISSUE CULTURE:

Application of tissue culture in agriculture – crop improvement – horticulture and forestry. Application of Biotechnology in Conservation of plant genetic resources – Gene banks – Cryopreservation – Germplasm Conservation – Application in Genetically Modified Organisms (Fruits, Vegetables, Crops and Cereals)

UNIT - III TRANSGENIC PLANTS

Transgenic plants - Transgenic plants with herbicide resistance, insect resistance, virus resistance and resistance against bacterial and fungal pathogens. Transgenic plants for hybrid seed production and molecular farming.

UNIT - IV GENETIC ENGINEERING

Tools of Genetic engineering – Restriction types of Enzymes (Exo and Endo nucleases) – Different types of enzymes used in Genetic engineering (Methylase, SI nuclease, Ligase, Alkaline Phosphatase, Reverse transcriptase, T4 kinase, Terminal transferase, adapters and Linkers) – Vectors and their types – Plasmid (pBR 322, pUC Vectors), Agrobacterium based Plasmids, Bacteriophage vectors, Cosmids, Phagemids, YAC, CaMV, Gemini Virus, Shuttle and Expression vectors.

UNIT - V GENETIC ENGINEERING

Restriction mapping –. Random amplified polymorphic DNA using PCR. DNA finger printing; Gene Tagging. Physical methods of gene delivery. Gene transfer techniques. Genetic counselling – Eugenics, Euthenics. Cloning Strategies – Basic Methods – rDNA technology – Genomic and cDNA library – Hybridization techniques – Labelling methods – Gene transfer mechanisms and Nucleotide sequencing methods – Application of genetic engineering in various fields.

UNIT - VI CURRENT CONTOURS (For continuous internal assessment only):

Current developments related to Biotechnology during the semester concerned to be kept abreast of continuously and cumulatively through collection, discussion and evaluation from news and events over the world collected through multiple reliable informative sources – Research articles, review materials, print, Internet, Interaction, social media, Webinars and so on.

Recommended Textbooks:

1. Das, H.K. 2010. Textbook of Biotechnology (4th edition). Wiley India Pvt. Ltd. New Delhi
2. Gamborg, O.L and G.C. Phillips (eds). 1995. Plants, genes and agriculture. Jones and Bartlett Publishers.
3. Verma, P.S and Agarwal V.K. 2009. Genetic Engineering. S.Chand & Co. Ltd. New Delhi
4. Kreuzer, H and A. Massey. 1996. Recombinant DNA and biotechnology. A guide for teachers. ASM Press.
5. Ramavat, K.G. 2006. Plant Biotechnology. S. Chand and Co. Ltd., New Delhi.
6. Chawla, H.S. 2009. Introduction to Biotechnology. 2nd edn. Oxford IBH, ISBN: 978-81-204- 1732-8.
7. Halford, N. 2015. Plant Biotechnology: Current and Future Applications of Genetically Modified crops, John Wiley and Sons.
8. Kumar, Pradeep. 2018. Advances in Microbial Biotechnology: Current Trends and Future Prospects. 10.1201/9781351248914.
9. Thieman. 2014. Introduction to Biotechnology 3rd Edition. Pearson Education India.
10. Khan. I.A. and A. Khanum .2004. Fundamentals of Biotechnology – Forensic Science Genetic Engineering. Ukaaz publication, Hyderabad.
11. Gupta. P.K. 1998. Elements of Biotechnology. Rastogi publications, Meerut.

Reference Books:

1. Smith. J.K. 1996. Biotechnology – 3rd Ed. Cambridge Univ. Press, Cambridge.
2. Slater, A. Scott, N and Fowler, M. 2008. Plant Biotechnology: The Genetic Manipulation of Plants. Oxford University Press Inc.
3. Reynolds, P.H.S. 1999. Inducible Gene Expression in Plants. CABI Publishing, U.K.
4. Chawla, H.S. 2009. Introduction to Biotechnology, 2nd edn. Oxford IBH, ISBN:978-81-204-1732-8.
5. Halford, N. 2015. Plant Biotechnology: Current and Future Applications of Genetically Modified Crops, John Wiley and Sons.
6. Glick B.R and J. J. Pasternak. 2009. Molecular Biotechnology, Panima Publication Co.
7. Primrose S., Twyman R. and Old B. 2001. Principles of Gene Manipulation (6th ed.). Blackwell Science. Oxford.
8. Ignacimuthu, S.1998. Applied Plant Biotechnology. Tata Mc Graw Hill, publishing company Ltd., New Delhi.

Web Resources:

1. <https://www.amazon.in/Gene-Cloning-Manipulation-Christopher-Howe-ebook/dp/B000SK4YLI>
2. <https://www.amazon.in/Gene-Cloning-Steve-Minchin-ebook/dp/B000SHTUT2>
3. <https://www.futuremedicine.com/doi/book/10.2217/9781780842134>
4. https://www.researchgate.net/publication/51144570_Introduction_to_Gene_Therapy_A_Clinical_Aftermath
5. <https://link.springer.com/book/10.1007/978-88-470-1643-9>

COURSE OUTCOMES:

Course Outcomes:	On successful completion of this course, the students will be able to	Cognitive Levels
CO1	Explain the principles, methodologies, and applications of gene cloning and evaluate their significance in genetic engineering and biotechnology.	K1
CO2	Apply molecular techniques for clone identification, selection, screening, and characterization in recombinant DNA technology and genetic improvement programs	K2
CO3	Evaluate the concepts, strategies, and applications of gene therapy and assess its potential in disease management, crop improvement and modern biotechnology.	K3
CO4	Compare and critically assess various gene therapy approaches, delivery systems, ethical considerations, and regulatory aspects associated with therapeutic and agricultural applications.	K4
CO5	Develop and integrate molecular biology techniques for hybrid seed production, molecular farming, and transgenic technology to enhance agricultural productivity and biotechnological innovation.	K5

Mapping with POs:

Relationship Matrix												
Semester	Course Code		Title of the Course								Hours	Credits
III			1.Biotechnology (Theory)								5	3
Course Outcomes	Programme Outcomes (POs)										Mean Score	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10		
CO1	3	2	3	3	2	2	2	2	2	1	2.2	
CO2	3	2	3	3	3	2	1	2	3	2	2.4	
CO3	3	3	2	2	1	2	2	2	2	1	2.0	
CO4	2	3	3	2	1	3	2	2	2	1	2.1	
CO5	2	3	3	3	2	2	3	3	2	2	2.5	
Mean Overall Score											2.24 (High)	

COURSE OBJECTIVES:

- To outline the basis of Bioprocess Engineering.
- To relate reactors in fermentation.
- To differentiate fermentation processes.
- To understand the stoichiometric steps during the process.
- To assess scale up and scale down.

UNIT - I FERMENTATION TECHNOLOGY:

Introduction to Fermentation Technology (18 Hours) Interaction between chemical engineering, Microbiology and Biochemistry. History of fermentation. Introduction to fermentation processes, Media formulation and optimization. Basic concepts- batch, Continuous and fed batch culture, selection methods for industrially important microorganisms. Strain improvement, preservation, and properties of industrial strains. Immobilization: different matrices, whole cell and enzyme immobilization.

UNIT - II FERMENTERS:

Fermenters (18 Hours) Design & Types: Gaden's Fermentation classification, Design and operation of Fermenters, Basic concepts for selection of a bioreactor, Impellers, baffles and sparger, sterilization. Types of reactors- tube reactor, continuous flow stir type reactor - airlift reactor- jet loop reactor, packed bed reactor, Fluidized bed reactor.

UNIT - III: BIOPROCESS CONTROL

Bioprocess Control and Monitoring Variables - O₂ requirement and uptake, Foam and antifoams, their effect on oxygen transfer, factors affecting K_{La}. Flow measurement and control, control system - manual and automatic. Application and the role of computers in bioprocess. Fermentation economics.

UNIT - IV: DOWNSTREAM PROCESSING

Down-Stream Processing - Introduction, recovery of microbial cells, precipitation, filtration-theory of filtration, batch and continuous filters. Centrifugation. Cell disruption - physical and chemical methods. Extraction liquid-liquid extraction and aqueous-two phase extraction. Chromatography, membrane processes, drying and crystallization.

UNIT - V INDUSTRIAL PRODUCTION STRATEGIES:

Industrial Production Strategies - Production strategies for industrial products: (Lactic acid and Ethanol), therapeutics (Insulin and Interferon), antibiotics (Cephalosporin), Microbial enzymes (Chitinase, Glucose Oxidase, Lipase), Exopolysaccharides (Pullulan). Use of fungi in industry including food industry, Agriculture and environmental applications: fuel cells, Biofertilizers, Bioremediation and Biological control. Animal cell culture technology to produce recombinant vaccines.

UNIT - VI: CURRENT CONTOURS (For continuous internal assessment only):

Fermentation at Home: Preparing fermented foods (idli/dosa batter), **Research Paper Summaries**, Pick beginner-friendly research articles and summarize them in your own words. **Suggested topics:** Recombinant DNA technology, CRISPR applications in industry, Bioplastics production. Educational Video Analysis: Watch documentaries or lectures and write reflections. **Suggested topics:** Biopharmaceutical production, Wastewater treatment using microbes, Industrial enzyme use

Recommended Textbooks:

1. Stanbury, P. F. (1999). Principles of Fermentation Technology. Butterworth-Heinemann.
2. El-Mansi, E. M. T. (2007). Fermentation Microbiology & Biotechnology. CRC / Taylor & Francis.

Reference Books:

1. Bailey, J., and D. F. Ollis. (2017). Biochemical Engineering Fundamentals. (2nd Ed.). McGraw- Hill.
2. Cinar, A. (2003). Batch Fermentation - Modelling, Monitoring and Control. Marcel Dekker.

Web Resources:

1. <https://microbenotes.com/design-of-a-fermenter/>
2. [https://www.deshbandhucollege.ac.in/pdf/resources/1587179880_BT\(H\)-VI_Industrial_and_Environmetal_Microbiology-I.pdf](https://www.deshbandhucollege.ac.in/pdf/resources/1587179880_BT(H)-VI_Industrial_and_Environmetal_Microbiology-I.pdf)
3. <https://www.mdpi.com/2075-1729/11/6/557>

COURSE OUTCOMES:

Course Outcomes:	On successful completion of this course, students will be able to	Cognitive Levels
CO1	Explain the fundamental principles of fermentation technology and evaluate the role of microbial processes in the development of fermented food products and industrial bioprocesses.	K1
CO2	Assess microbial growth kinetics, fermentation systems, and microorganism selection strategies for the efficient production of fermented foods and industrially important products.	K2
CO3	Apply fermentation technologies for the production of biologically derived products, including biopharmaceuticals, industrial enzymes, biofuels and value-added biomolecules.	K3
CO4	Evaluate ethical, biosafety, quality assurance, and regulatory considerations associated with fermentation technology and commercial bioproduct manufacturing.	K4
CO5	Design and optimize fermentation processes by selecting suitable microorganisms and substrates, and develop innovative strategies to improve product yield, efficiency and industrial sustainability.	K5

Mapping with POs:

Relationship Matrix											
Semester	Course Code		Title of the Course							Hours	Credits
III			2. Industrial Biotechnology (Theory)							5	3
Course Outcomes	Programme Outcomes (POs)										Mean Score
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	
CO1	3	2	2	3	2	2	2	2	2	1	2.1
CO2	3	3	3	3	1	2	2	2	2	1	2.2
CO3	3	2	3	3	2	1	2	3	2	1	2.2
CO4	2	3	2	2	1	3	2	2	2	1	2.0
CO5	2	3	3	3	2	2	3	3	3	2	2.6
Mean Overall Score											2.22 (High)

COURSE OBJECTIVES:

- To understand the principles and importance of downstream processing in bioproduct recovery.
- To learn various techniques for separation, purification, and polishing of biomolecules.
- To analyze different cell disruption and solid-liquid separation methods.
- To study extraction, precipitation, and membrane-based separation processes.
- To understand chromatographic techniques used in purification.
- To evaluate the design and economic aspects of downstream processing.

UNIT - I INTRODUCTION TO DOWNSTREAM PROCESSING:

Role and importance in bioprocessing, Characteristics of biological products, Overview of recovery and purification stages, Process economics and product quality.

UNIT - II CELL DISRUPTION AND SOLID-LIQUID SEPARATION:

Cell disruption methods (mechanical, chemical, enzymatic), Filtration (depth, membrane), Centrifugation principles and equipment, Sedimentation and flocculation.

UNIT - III ISOLATION AND CONCENTRATION:

Precipitation (salt, solvent, pH), Extraction (liquid-liquid extraction), Adsorption techniques, Aqueous two-phase systems, Evaporation and drying methods

UNIT - IV PURIFICATION TECHNIQUES:

Chromatography principles, Ion exchange chromatography, Gel filtration chromatography, Affinity chromatography, Electrophoresis basics, Dialysis and ultrafiltration

UNIT - V POLISHING AND FINAL PROCESSING:

Crystallization, Drying techniques (spray drying, freeze drying), Formulation and stabilization, Sterilization and packaging, Case studies e.g. antibiotics, enzymes and vaccines.

UNIT - VI CURRENT CONTOURS (For continuous internal assessment only):

Current developments related to Downstream Processing during the semester concerned to be kept abreast of continuously and cumulatively through collection, discussion and evaluation from news and events over the world collected through multiple reliable informative sources – Research articles, review materials, print, Internet, Interaction, social media, Webinars and so on.

Recommended Textbooks:

1. Belter, P. A., Cussler, E. L., and Hu, W. S. *Bioseparations: Downstream Processing for Biotechnology* (1988). Prentice Hall, Englewood Cliffs, New Jersey, USA.

2. Pau Loke Show, Chien Wei Ooi & Tau Chuan Ling, (2019) . Bioprocess Engineering- Downstream processing. CRC Press, 2019.

Reference Books:

1. Harrison, R. G., Todd, P., Rudge, S. R., & Petrides, D. P. Bioseparations Science and Engineering (2003), Oxford University Press.
2. Scopes, R. K.. *Protein Purification: Principles and Practice* (2nd ed.). (1994) Springer-Verlag, New York, USA.
3. Wheelwright, S. M. *Protein Purification: Design and Scale-up of Downstream Processing*. (1991). Wiley-Liss, Inc., New York, USA.

Web Resources:

1. <https://nptel.ac.in>
2. <https://www.coursera.org/>
3. <https://www.edx.org>
4. <https://www.khanacademy.org>
5. <https://www.sciencedirect.com/topics/engineering/downstreamprocessing>

COURSE OUTCOMES:

Course Outcomes:	On successful completion of this course, students will be able to	Cognitive Levels
CO1	Explain the principles, stages, and significance of downstream processing and evaluate its role in the recovery, purification and commercialization of bioproducts.	K1
CO2	Apply appropriate cell disruption, extraction, clarification, and separation techniques for the efficient recovery of biomolecules from diverse biological materials.	K2
CO3	Evaluate and select suitable purification strategies for proteins, enzymes, pharmaceuticals, and other biomolecules based on product characteristics and process requirements.	K3
CO4	Analyze and compare chromatographic, membrane-based, and advanced separation technologies for the purification and quality enhancement of industrial bioproducts.	K4
CO5	Design and optimize downstream processing workflows by integrating recovery, purification, scale-up, economic, and quality considerations to improve process efficiency and industrial feasibility.	K5 & K6

Mapping with POs:

Relationship Matrix											
Semester	Course Code		Title of the Course							Hours	Credits
III			3.Downstream processing (Theory)							5	3
Course Outcomes	Programme Outcomes (POs)										Mean Score
	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	
C01	3	2	2	3	2	2	2	2	2	1	2.1
C02	3	2	3	3	2	2	2	2	2	1	2.2
C03	3	3	3	3	1	2	2	2	2	1	2.2
C04	2	3	3	3	3	2	2	3	2	2	2.5
C05	2	3	3	3	3	2	3	3	2	2	2.6
Mean Overall Score											2.32 (High)