BHARATHIDASAN UNIVERSITY, TIRUCHIRAPPALLI - 620 024
B.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	Part	Courses	Title	Ins. Hrs.	Credits	Exam. Hours	Maximum Marks		
							Int.	Ext.	Total
I	I	Ability Enhancement Course – I (AEC - I)	(Tamil $ / Other Languages +, #)	6	3	3	30	70	100
	II	Ability Enhancement Course – II (AEC - II)	English Course - I	6	3	3	30	70	100
	III	Core Course - 1 (CC - 1)	Plant Diversity – I Algae, Fungi, Lichens and Bryophytes	4	4	3	30	70	100
		Core Practical - 1 (CP - 1)	Plant Diversity – I Algae, Fungi, Lichens and Bryophytes	4	4	3	40	60	100
		Allied Course – 1 (AC - 1)	Any one from the list	4	4	3	30	70	100
		Allied Course Practical – 1 (ACP-1)	Any one from the list	2	**	**	**	**	**
	IV	Value Education		2	2	3	30	70	100
		Interdisciplinary Course – 1 (IDC - 1) #	One Course from Outside Department	2	2	3	30	70	100
	Total			**30**	**22**	--	--	--	**700**
II	I	Ability Enhancement Course – III (AEC - III)	(Tamil $ / Other Languages +, #)	6	3	3	30	70	100
	II	Ability Enhancement Course – IV (AEC - IV)	English Course - II	6	3	3	30	70	100
	III	Core Course - 2 (CC - 2)	Plant Diversity – II Pteridophytes, Gymnosperms and Paleobotany	4	4	3	30	70	100
		Core Practical - 2 (CP - 2)	Plant Diversity – II Pteridophytes, Gymnosperms and Paleobotany	4	4	3	40	60	100
		Allied Course – 2 (AC - 2)	Any one from the list	4	4	3	30	70	100
		Allied Course Practical - 1 (ACP- 1)	Any one from the list	2	4	3	40	60	100
	IV	Skill Enhancement Course - 1 (SEC - 1) ##	Naan Mudhalvan Course	2	2	3	30	70	100
		Interdisciplinary Course – 2 (IDC - 2) #	One Course from Outside Department	2	2	3	30	70	100
	Total			**30**	**26**	--	--	--	**800**

III	I	Ability Enhancement Course – V(AEC - V)	(Tamil $ / Other Languages +, #)	6	3	3	30	70	100
	II	Ability Enhancement Course – VI (AEC - VI)	English Course - III	6	3	3	30	70	100
	III	Core Course - 3 (CC - 3)	Plant Anatomy and Embryology	4	4	3	30	70	100
		Core Practical - 3 (CP - 3)	Plant Anatomy and Embryology	4	4	3	40	60	100
		Allied Course – 3 (AC - 3)	Any one from the list	4	4	3	30	70	100
		Allied Course Practical – 2 (ACP-2)	Any one from the list	2	**	**	**	**	**
	IV	Skill Enhancement Course - 2 (SEC - 2) ##	Naan Mudhalvan Course	2	2	3	30	70	100
		Interdisciplinary Course – 3 (IDC - 3) $$	One Course from Outside Department	2	2	3	30	70	100
		Health & Wellness @		--	1	--			100
	Total			**30**	**23**	**--**	--	--	**800**
	I	Ability Enhancement Course – VII (AEC - VII)	(Tamil $ / Other Languages +, #)	6	3	3	30	70	100
IV	II	Ability Enhancement Course – VIII (AEC - VIII)	English Course - IV	6	3	3	30	70	100
	III	Core Course - 4 (CC - 4)	Microbiology, Plant Pathology and Plant Protection	4	4	3	30	70	100
		Core Practical - 4 (CP - 4)	Microbiology, Plant Pathology and Plant Protection	4	4	3	40	60	100
		Allied Course – 4 (AC - 4)	Any one from the list	4	4	3	30	70	100
		Allied Course Practical - 2 (ACP-2)	Any one from the list	2	4	3	40	60	100
	IV	Skill Enhancement Course - 3 (SEC - 3) ##	Naan Mudhalvan Course	2	2	3	30	70	100
		Interdisciplinary Course – 4 (IDC - 4) $$	One Course from Outside Department	2	2	3	30	70	100
	Total			**30**	**26**	**--**	--	--	**800**
	Summer Internship / Industrial Activity during the Summer Vacation after II Year								

V	III	Core Course - 5 (CC - 5)	Morphology and Economic Botany	4	4	3	30	70	100
		Core Course - 6 (CC - 6)	Genetics, Biostatistics and Evolution	5	4	3	30	70	100
		Core Course - 7 (CC - 7)	Cell and Molecular Biology	5	4	3	30	70	100
		Core Course - 8 (CC - 8)	Taxonomy of Angiosperms	5	4	3	30	70	100
		Core Practical - 5 (CP - 5)	Morphology & Economic Botany, Genetics, Biostatistics and Evolution, Cell and Molecular Biology, Taxonomy of Angiosperms	5	4	3	40	60	100
	IV	Skill Enhancement Course - 4 (SEC - 4)	Any one from the list	2	2	3	30	70	100
		Skill Enhancement Course - 5 (SEC - 5) ##	Naan Mudhalvan Course	2	2	3	30	70	100
		Introduction to Disaster Management		2	2	3	30	70	100
		Summer Internship / Industrial Activity @@	(with Viva-Voce)	--	2	--	20	80	100
	Total			**30**	**28**	--	--	--	**900**
VI	III	Core Course - 9 (CC - 9)	Plant Physiology and Biochemistry	5	4	3	30	70	100
		Core Course - 10 (CC - 10)	Plant Biotechnology	5	4	3	30	70	100
		Core Practical- 6 (CP - 6)	Plant Physiology & Biochemistry, Plant Biotechnology	4	4	3	40	60	100
		Core Project Work (CPW) @@	Project Work (with Viva-Voce)	6	4	3	20	80	100
	IV	Value Added Course	General Studies for Competitive Examinations	2	1	--	30	70	100
		Skill Enhancement Course - 6 (SEC - 6)	Any one from the list	2	2	3	30	70	100
		Skill Enhancement Course - 7 (SEC - 7) ##	Naan Mudhalvan Course	2	2	3	30	70	100
		Environmental Studies		2	2	3	30	70	100
		Gender Studies		2	1	3	30	70	100
		Extension Activities *		--	1	--	--	--	--
	Total			**30**	**25**	--	--	--	**900**
	Grand Total			**180**	**150**	--	--	--	**4900**

ALLIED COURSE

First Year	Second Year
1. Allied Zoology	2. Allied Chemistry

SKILL ENHANCEMENT COURSE (SEC)			
Sl. No.	**Title of paper**	**Sl. No.**	**MANDATORY Naan Mudhalvan Scheme ##**
1.	Biodiversity and Climate Change	1.	**2nd Semester:**
2.	Industrial Biotechnology		
3.	Seed Technology	2.	**3rd Semester:**
4.	Herbal Botany		
5.	Clinical Microbiology	3.	**4th Semester:**
6.	Biological Techniques		
7.	Agri based Bio-Entrepreneurship	4.	**5th Semester:**
--		5.	**6th Semester:**

INTERDISCIPLINARY COURSE (IDC) FOR WHO HAVE OPT TAMIL AS PART – I (for other Department Students only)	
1st Semester	Mushroom Cultivation
2nd Semester	Horticulture and Landscape Gardening
3rd Semester	Solid Waste Management
4th Semester	Biofertilizers and Biopesticides

INTERDISCIPLINARY COURSE (IDC) # FOR WHO HAVE NOT OPT TAMIL AS PART - I		
Those who have studied Tamil upto 10th +2 but opt for other languages in degree	1st Semester	Special Tamil - I
	2nd Semester	Special Tamil - II
Those who have not studied Tamil in school level	1st Semester	Basic Tamil - I
	2nd Semester	Basic Tamil – II
Those students who opt for either special Tamil (or) Basic Tamil as IDCs, have to choose 2 more IDCs courses in their 3rd and 4th Semester from Outside his/her department.		

INTERDISCIPLINARY COURSE (IDC) $$ FOR NCC CADETS ONLY	
NCC Course is a Compulsory Course for the NCC Cadets in the 3rd Semester:	**NCC Course is a Compulsory Course for the NCC Cadets in the 4th Semester:**
Introduction to NCC	1. Special Subject Army **(or)** 2. Special Subject Navy **(or)** 3. Special Subject Air force
Those students who opt for NCC Courses as IDCs, have to choose 2 more IDCs courses in their 1 st and 2 nd Semester from Outside his/her department.	

SUMMARY OF CURRICULUM STRUCTURE OF UG PROGRAMMES – SCIENCE

Sl. No.	Part	Types of the Courses	No. of Courses	Credits for each Course	Total Credits	Marks
1.	I	Ability Enhancement Course	4	3	12	400
2.	II	Ability Enhancement Course	4	3	12	400
3.	III	Core Course	11	4	44	1100
4.		Core Practical	5	4	20	500
5.		Allied Course (MC)	4	4	16	400
6.		Allied Course Practical (ACP)	2	4	8	200
7.		Core Project Work (CPW)	1	4	4	100
8.	IV	Skill Enhancement Course (SEC)	7	2	14	700
9.		Interdisciplinary Course (IDC)	4	2	8	400
10.		Value Education	1	2	2	100
11.		Health and Wellness	1	1	1	100
12.		Introduction to Disaster Management	1	2	2	100
13.		Summer Internship / Industrial Activity	1	2	2	100
14.		Value Added Course	1	1	1	100
15.		Environmental Studies	1	2	2	100
16.		Gender Studies	1	1	1	100
17.		**EXTENSION ACTIVITIES** (NCC / NSS / SPORTS / ANTI DRUG CELL / YRC & Any Other Activities	--	1	1	--
Total			**49**	**-**	**150**	**4900**

$ For those who have studied Tamil upto 10th +2 (Regular Stream)

\+ Syllabus for other Languages should be on par with Tamil at degree level

\# Those who have studied Tamil upto 10th +2 but opt for other languages in degree level under Part - I should study special Tamil and those who have not studied Tamil in the school level should study Basic Tamil in Part – IV under the Interdisciplinary Course.

** Examination at the end of the next semester

Naan Mudhalvan Scheme: As per the Naan Mudhalvan Scheme instructions, 5 courses from 2nd to 6th semester should be studied under Skill Enhancement Course.

$$ NCC Course is one of the Choices in the Interdisciplinary Course. Only the NCC Cadets are eligible to choose this course. However, NCC Course is a Compulsory Course for the NCC Cadets.

@ **Health and Wellness: Assessments:**

- Use self-reflective worksheets to assess their understanding
- submit the worksheets to internal audit / external audit
- Every student's activity report should be documented and the same have to be assessed by the Physical Director with Mentor. The evaluation should be for 100 marks. No examination is required.

Scheme of Evaluation:

Part	Description	Marks
A	Report	40
B	Attendance	20
C	Activities (Observation During Practice)	40
Total		**100**

@@ **Summer Internship / Industrial Activity**

Internship will be carried out during the summer vacation after the second 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 5th semester Mark Statement.

Summer Internship / Industrial Activity & Project Work

Scheme of Evaluation:

Description	Marks
Report	80
Viva-Voce	20
Total	**100**

* Extension Activities shall be outside instruction hours.

PROGRAMME OBJECTIVES:

- To provide fundamental and advanced knowledge in plant sciences.
- To develop understanding of plant diversity, structure, physiology, genetics, ecology, and biotechnology.
- To enhance practical laboratory and field skills related to botany.
- To promote scientific thinking, research aptitude, and problem-solving abilities.
- To create awareness about environmental conservation and sustainable utilization of plant resources.
- To prepare students for higher studies, research, entrepreneurship, and employment opportunities in plant sciences and allied fields.
- To develop communication, analytical, and teamwork skills among students.

- To demonstrate the range of plant diversity in term of structure function and environmental relationship.
- To understand the responsibilities relevant to the biodiversity conservation practices with the help of applying basic knowledge to assess plant diversity and its importance to the society, health, safety and environmental issues.
- To analyse the plant form by applying fundamental process of plant and knowledge of basic sciences.

PROGRAMME OUTCOME:

PO1	**Communication Skills:** Students will develop effective oral and written communication skills through seminars, presentations, assignments, and scientific report writing, enabling professional and academic interaction.
PO2	**Disciplinary Knowledge:** Students will acquire comprehensive knowledge in various branches of Botany including plant diversity, taxonomy, anatomy, physiology, genetics, ecology, biotechnology, and economic botany.
PO3	**Critical Thinking:** Students will develop the ability to analyse biological problems, interpret scientific data, evaluate evidence, and apply logical reasoning in plant science studies.
PO4	**Analytical Reasoning:** Students will gain analytical skills through laboratory experiments, field studies, and scientific investigations to understand plant structure, function, and interactions with the environment.
PO5	**Scientific Reasoning:** Students will understand scientific principles, laboratory techniques, instrumentation, and experimental methodologies used in modern botanical sciences.
PO6	**Self-directed Learning:** Students will develop independent learning abilities through project work, field reports, assignments, herbarium preparation, and use of digital learning resources.
PO7	**Reflective Thinking:** Students will relate theoretical concepts with practical applications in agriculture, horticulture, conservation, environmental management, and biotechnology.
PO8	**Problem Solving:** Students will apply scientific knowledge and quantitative skills to identify and solve problems related to plant

	sciences, biodiversity conservation, and sustainable utilization of biological resources.
PO9	**Research-related Skills:** Students will acquire basic research skills including plant collection, identification, documentation, experimentation, data analysis, and scientific reporting through laboratory and field-based studies.
PO10	**Lifelong Learning:** Students will develop the ability to adapt to advances in plant sciences and engage in continuous learning for higher education, research, entrepreneurship, and career development.

PROGRAMME EMPLOYMENT OPPORTUNITIES

After B.Sc. Botany

Graduates can find employment opportunities in:

- Schools and educational institutions
- Herbal and pharmaceutical industries
- Agriculture and horticulture sectors
- Forest and environmental departments
- Seed and fertilizer companies
- Plant nurseries and botanical gardens
- Food processing industries
- Quality control laboratories
- NGOs related to environment and biodiversity
- Research laboratories and field assistant positions

JOB ROLES

- Lab Technician
- Field Assistant
- Herbarium Assistant
- Plant Nursery Manager
- Agricultural Assistant
- Quality Analyst
- Environmental Assistant
- Medical Coding and allied biological science jobs

Year: First **CORE COURSE 1** **Semester: I**
Code: **PLANT DIVERSITY - I** **Credits: 4**
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:
Classification - (Fritsch-1935-1945), General characters of algae – Chlorophyceae, Phaeophyceae, Rhodophyceae and Cyanophyceae. Algal distribution - Thallus structure - Thallus organization (unicellular-*Chlorella,* Diatoms, colonial-*Volvox*, filamentous-*Anabaena*, *Oedogonium*, siphonous - *Caulerpa*, parenchymatous - *Sargassum, Gracilaria*). Reproduction-Vegetative, asexual, sexual reproduction and life histories (haplontic-*, Oedogonium* and *Chara*, diplontic-Diatoms and *Sargassum*, diplohaplontic – *Ulva* and diplobiontic- *Gracilaria*)

UNIT II FUNGI:
Classification of fungi - (Alexopoulos and Mims, 1979), criteria for classification, Characteristic features, thallus organization, mode of nutrition, structure, reproduction and life-history of classes, each with one suitable example: Zygomycotina (*Rhizopus*), Ascomycotina (*Saccharomyces*), Basidiomycotina (*Pleurotus,*) and Deuteromycotina (*Cercospora*). Importance of mycorrhizal association.

UNIT III LICHENS:
Classification (Hale, 1969). Habitat, nature of association, Structure, Nature of Mycobionts and Phycobionts, Study of growth forms of lichens (crustose, foliose and fruticose), types, distribution, thallus organization, reproduction and ecological significance of lichens with special reference to *Usnea*.

UNIT IV BRYOPHYTES:
General characters of Bryophytes, classification (Watson, 1971) (up to family). Economic importance of Bryophytes – Ecological importance (Pollution indicators and monitoring), Medicinal uses, horticulture, industrial uses and absorbent and ages - Structure, reproduction and life cycle of the following classes each with a suitable example: Hepaticopsida (*Riccia*); Anthocerotopsida (*Anthoceros*) and Bryopsida (*Funaria*). Evolution of Bryophytes.

UNIT-V ECONOMIC IMPORTANCE:
Algae - Algae as food and feed: Agar - agar, Alginic acid and Carrageenan; Diatomite.

Role of algae in CO_2 sequestration, Algae as indicator of water pollution, algal bio inoculants, Bio luminescence. Fungi - Fungi in agriculture application (biofertilizers): Biopesticides, Production of industrially important products from fungi- alcohol (ethanol), organic acids (citric acid), enzymes (protease). Lichens: food, fodder and nutrition, flavour, tanning and dyeing, cosmetics and perfumes, air pollution and biomonitoring, poison from lichens. Bryophytes – Ecological and economic importance – industry, horticulture and medicine.

Unit –VI CURRENT CONTOURS (For Continuous Internal Assessment Only):
Self-directed learning activities: Algae – Create a pigment profile chart for green, brown and red algae. Fungi – Herbarium for major fungal disease – Lichens – Draw the internal stratification of foliose and fruticose lichens – Bryophytes – draw a comparison timeline of the sporophyte evolution from Riccia to Funaria.

Recommended Textbooks:

1. Singh, V., Pande, P.C and Jain, D.K. 2021. A Textbook of Botany. Rastogi Publications, Meerut.
2. Vashista, B.R., (1977). Botany for Degree students- Part –I. Algae. S. Chand and company Ltd. Ram Nagar, New Delhi
3. Lee, R.E. 2008. Phycology, IV Edition, Cambridge University Press, New Delhi.
4. Pandey.S.N. 1997. College Botany. Vol. I Fungi & Pathology.
5. Mehrotra, R. Sand Aneja, K.R. 2003. An introduction to mycology. New age International (P) Ltd, Publishers, New Delhi.
6. Mahendra Rai. 2009. Advances in Fungal Biotechnology. I.K. International Publishing House, New Delhi.
7. Parihar, N.S., (1957). An Introduction to Bryophyta. Central Book Depot, Allahabad.
8. Sharma, O.P. 2014. Bryophyta, Mc Graw Hill, ISBN: 9781259062872, 1259062872
9. 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
3. Pandey B.P. 1986, Textbook of Botany (College Botany) Vol I &II, S. Chand and Co. New Delhi.
4. Webster, J and Weber, R. 2007. Introduction to Fungi. 3rd edition. Cambridge University Press, Cambridge.
5. Sharma, O.P. 2011. Fungi and allied microbes The Mc Graw –Hill companies, New Delhi.
6. Burnett, J.H. 1971. The fundamentals of Mycology. ELBS Publication, London.
7. Bessey, E.A. 1979. Morphology and Taxonomy of fungi, Vikas publishing House Pvt. Ltd, New Delhi.
8. Pandey, P.B. 2014. College Botany 1: Including Algae, Fungi, Lichens, Bacteria, Viruses, Plant Pathology, Industrial Microbiology and Bryophyta. Chand Publishing, New Delhi.
9. Mishra, A. and Agarwal, R.P. 1978. Lichens – A Preliminary Text. Oxford and IBH.

10. Pandey, B.P. 2005. College Botany I: Including Algae, Fungi, Lichens, Bacteria, Viruses, Plant Pathology, Industrial Microbiology and Bryophyta.
S. Chand & Company
11. Sharma, O.P. 2017. Bryophyta, Mac Millan India Ltd. Delhi.
12. Alam, A.2020. Contemporary Research on Bryophytes Book Series: Recent Advances in Botanical Science. 10.2174/9789811433788120010 1.
13. Chopra, R.N.2005.Biology of bryophytes. New Age International (P)Ltd. New Delhi, India.

Web Resources:

1. https://www.crcpress.com/Therapeutic-and-Nutritional-Uses-of-Algae/ Pereira/p/book/9781498755382
2. https://www.crcpress.com/Algae-Anatomy-Biochemistry-and-Biotechnology-Second-Edition/Barsanti-Gualtieri/p/book/9781439867327
3. https://www.crcpress.com/Marine-Algae-Biodiversity-Taxonomy-Environmental-Assessment-and-Biotechnology/Pereira-Neto/p/book/9781466581678
4. https://www.kopykitab.com/Botany-For-Degree-Students-ALGAE-by-B-R-Vashishta-Dr-A-K-Sinha-Dr-V-P-Singh
5. https://www.wileyindia.com/a-textbook-of-algae.html
6. https://www.kobo.com/us/en/ebook/the-algae-world
7. http://www.freebookcentre.net/biology-books-download/A-text-book-of-mycology-and-plant-pathology.html
8. http://www.freebookcentre.net/Biology/Mycology-Books.html
9. https://www.kobo.com/us/en/ebook/introduction-to-fungi
10. http://www.freebookcentre.net/biology-books-download/Introductory-Mycology.html
11. http://www.bryoecol.mtu.edu/
12. https://www.amazon.in/Introduction-Bryophytes-Alain-Vanderpoorten-ebook/dp/B007NWFWQK
13. http://scitec.uwichill.edu.bb/bcs/bl14apl/bryo1.htm

COURSE OUTCOMES:

Course Outcomes	On completion of this course the student will be able to	Cognitive Level
CO1	Explain the structural organization, classification, diversity, and significance of algae, fungi, lichens, and bryophytes using scientific terminology and effective communication skills.	**K1**
CO2	Apply theoretical, practical, and analytical knowledge to investigate the morphology, anatomy, ecology, and economic importance of lower plant forms through laboratory and field studies.	**K2**
CO3	Analyse and interpret the life cycle patterns, phylogenetic relationships, and developmental characteristics of algae, fungi, lichens, and bryophytes using critical and scientific reasoning.	**K3**
CO4	Evaluate the reproductive mechanisms, adaptive strategies, and ecological interactions of lower plant groups for scientific problem-solving and sustainable environmental	**K4**

	applications	
CO5	Develop research aptitude, self-directed learning, technical skills, and scientific approaches for conservation, documentation, sustainable utilization, and technological advancement of lower plant 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**
I		**PLANT DIVERSITY I Algae, Fungi, Lichens and Bryophytes Theory**								**4**	**4**
Course Outcomes	**Programme Outcomes (POs)**										**Mean Score**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	
CO1	3	3	2	2	3	2	2	2	1	2	**2.2**
CO2	2	3	3	3	3	2	2	2	2	2	**2.4**
CO3	2	3	3	3	3	2	2	2	2	2	**2.4**
CO4	2	3	3	3	3	2	3	3	2	2	**2.6**
CO5	2	3	2	2	3	3	3	3	3	3	**2.7**
Mean Overall Score											**2.46 (High)**

Year: First **CORE PRACTICAL 1** **Semester: I**
Code: **PLANT DIVERSITY - I** **Credits: 4**

ALGAE, FUNGI, LICHENS AND BRYOPHYTES
(Practical)

COURSE OBJECTIVES:

- To develop skills to identify algae, Fungi and Lichens based on habitat, thallus structure and the internal organization.
- To identify microalgae in a mixture.
- To prepare microslides of fungi.
- To enable students gain expertise in hand sectioning technique.
- To study diversity and anatomical structure of Bryophytes

ALGAE

1. Micro-preparation of the unicellular-*Chlorella,* Diatoms, colonial-*Volvox*, filamentous - *Anabaena*, *Oedogonium*, siphonous-*Caulerpa*, parenchymatous-*Sargassum, Gracilaria*).
2. Identifying the micro slides relevant to Cholorophyceae, Phaeophyceae, Rhodophyceae and Cyanophyceae.
3. Identification of the algal types in algal mixture.
4. Field visit to study fresh water/marine water algal habitats.
5. Visit to nearby industry actively engaged in algal technology

FUNGI

1. Microscopic observation of vegetative and reproductive structures through temporary preparations and permanent slides.
2. Identifying the micro slides
3.
4. Inoculation techniques for fungal culture (Demonstration only).
5. Protocol for mushroom cultivation.
6. Mycorrhiza: ecto-mycorrhiza and endo-mycorrhiza (Photographs)
7. Visit to fungal biotechnology laboratories.

LICHENS

1. Micro-preparation of *Usnea* to study vegetative and reproductive structures.
2. Identifying the micro slides
3. Study of thallus and reproductive structures (apothecium) through permanentslides.

BRYOPHYTES

1. Study of morphology, anatomy and structure of the vegetative and reproductive organs of Bryophytes genera included in the theory syllabus.
   Hepaticopsida (*Riccia*); Anthocerotopsida (*Anthoceros*) and Bryopsida (*Funaria*)
   (need not study developmental aspects).

Recommended Textbooks:

1. Kumar, H.D. 1999. Introductory Phycology. Affiliated East-West Press, Delhi.
2. Bendre, M. Ashok and Ashok Kumar, A. 2020. Text Book of Practical Botany-1 (10th ed). Rastogi Publications, Meerut.
3. Round, FE. 1984.The Ecology of Algae. Cambridge University Press.
4. Aziz, F and Rasheed, R. 2019. A Course Book of Algae. Publisher: University of

Sulaimani.ISBN: 978-9922-20-391-1.
5. Singh, Pandey and Jain. 2020. A text book of Botany, 5th Edition, Rastogi Publication, Meerut.
6. Chmielewski, J.G and Krayesky, D. 2013. General Botany laboratory Manual. Author House, Bloomington, USA.
7. Das, S and Saha, R. 2020. Microbiology Practical Manual. CBS Publishers and Distributors (P) Ltd., New Delhi, India.
8. Webster, J and Weber, R. 2007. Introduction to Fungi, 3rd Ed. Cambridge University Press, Cambridge.
9. Ashok, M. Bendre and Kumar. 2010. A text book of Practical Botany, Algae, Fungi, Lichen,Bryophyta, Pteridophyta, Gymnosperms and Palaeobotany. Revised edition. Published by Rakesh Kumar Rastogi publication.

Reference Books:

1. Nancy Serediak and M. Huynh. 2011. Algae identification lab Guide. Accompanying
2. Manual to algae identification field guide, Ottawa Agriculture and Agri food Canada publisher.
3. Chapman, V.J and Chapaman, D.J. 1960.The Algae, ELBS & MacMillan, London.
4. Lee, R.D. 2008.Phycology 4th Edition, Cambridge University Press, New York.
5. Dehradun. Edwardlee, R. 2018. Phycology, 5th Ed., Cambridge University Press, London.
6. Ashok, M. Bendre and Kumar. 2010. A text book of Practical Botany, Algae, Fungi, Lichen, Bryophyta, Pteridophyta, Gymnosperms and Palaeobotany. Revised edition. Published by Rakesh Kumar Rastogi publication.
7. Alexopoulos, J and Mims, W. 1985. Introductory Mycology, Wiley Eastern Limited NewDelhi.
8. Bendre, M. Ashok and Ashok Kumar, A. 2020. Text Book of Practical Botany 1 (10th ed).Rastogi Publications, Meerut.
9. Mohammed Gufran Khan, Shite Gatew and Bedilu Bekele. 2012. Practical manual forBryophytes and Pteridophytes. Lambert Academic Publishing.

Web Resources:

1. https://www.amazon.in/Practical-Manual-Algae-Sundara-Rajan/dp/8126106492
2. https://books.google.co.in/books/about/Practical_Manual_of_Algae.html?id=8d5DAAAACAAJ&redir_esc=
3. https://freebookcentre.net/biology-books-download/Concepts-of-Botany-Algae-(PDF21P).html.
4. https://www.ebooks.com/en-in/book/210152662/algae/sachin-kumar-mandotra/
5. https://www.amazon.in/Practical-Manual-Fungi-Fungicides/dp/B0025AEFP4
6. https://books.google.co.in/books/about/Practical_Mycology.html?id=5ycJAQAAMAAJ&redir_esc= y
7. https://www.flipkart.com/colour-handbook-practical-plant-pathology/p/itmefsn6dyhfhs9b
8. https://books.google.co.in/books/about/Algae.html?id=s1P855ZWc0kC&redir_esc=y
9. https://www.amazon.in/Manual-Practical-Bryophyta-Suresh-Kumar/dp/B0072GNFX4

COURSE OUTCOMES

Course outcomes:	On completion of this course the student will be able to	Cognitive Level
CO1	Explain the structural organization and classification of algae, Fungi and Lichens through effective scientific communication and disciplinary knowledge.	**K1**
CO2	Apply theoretical, practical, and analytical knowledge to study the morphology, anatomy and significance of lower plant forms through laboratory experiments and field observations.	**K2**
CO3	Analyse and interpret the life cycle patterns, evolutionary relationships, and reproductive mechanisms of algae, fungi, lichens, and bryophytes using critical and scientific reasoning	**K3**
CO4	Evaluate the reproductive adaptations, ecological roles, and environmental interactions of lower plant groups for problem-solving and sustainable biological applications.	**K4**
CO5	Develop research aptitude, self-directed learning, and scientific skills for conservation, documentation, sustainable utilization, and technological advancement of lower plant 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**	
I		**Plant Diversity - I Algae, Fungi, Lichens and Bryophytes (Practical)**							**4**	**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	1	1	2	**2.0**
CO2	2	3	3	3	3	2	2	2	2	2	**2.4**
CO3	2	3	3	3	3	2	2	2	2	2	**2.4**
CO4	2	3	3	3	3	3	3	3	2	2	**2.7**
CO5	2	3	2	2	3	3	3	3	3	3	**2.7**
Mean Overall Score											**2.44 (High)**

Year: First **CORE COURSE 2** **Semester: II**

Code: **PLANT DIVERSITY II** **Credits: 4**

PTERIDOPHYTES, GYMNOSPERMS AND PALEOBOTANY

(Theory)

COURSE OBJECTIVES:

- To know the morphological diversity, economic importance and evolution of Pteridophytes.
- To understand anatomy and reproduction of Pteridophytes**.**
- Enable the students to understand thallus organization, internal and the reproductive structures of Gymnosperms and the importance of evolution.
- Acquaint students with evidence of the past history of plant groups and significance ofthe fossilization.
- To know the scope of Paleobotany, types of fossils and geological time scale.

UNIT-I PTERIDOPHYTES:

General Characters of Pteridophytes - Classification (Reimer, 1954). Apogamy and apospory, homospory and heterospory. Morphology, anatomy and reproduction of the taxa belonging to each of the following classes: Psilotopsida (*Psilotum*), Lycopsida (*Lycopodium*), Sphenopsida (*Equisetum*), Pteropsida (*Marsilea*).

UNIT II PTERIDOPHYTES:

Origin and evolution of Pteridophytes. Stelar Evolution. Economic importance of Pteridophytes.

UNIT III GYMNOSPERMS:

Classification of Gymnosperms (Sporne, 1954) (up to family). General characteristics, Economic importance of Gymnosperms with special reference to oil, resin, timber, etc.

UNIT IV GYMNOSPERMS:

Morphology, anatomy and reproduction of the taxa belonging to each of thefollowing orders: Cycadales (*Cycas*), Coniferales (*Pinus*). Gnetales (*Gnetum*).

UNIT V PALEOBOTANY:

Introduction to fossils and fossilization processes such as compression, casts, molds, petrification, impressions and coal balls. Geological time scale. Radiocarbon dating. Contribution of Birbal Sahni - Study the following fossil members: *Rhynia, Lepidodendron*, *Lepidocarpon, Calamites* and *Williamsonia .*

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

Self-directed learning activities: Comparing primitive structures (*Psilotum*) with advanced heterospory (*Selaginella*) – Comparing the Palm like (*Cycas*), Classic conifer (*Pinus*) and the advanced (*Gnetum*) – Fossil types and the study of extinct lineages.

Recommended Textbooks:

1. Sharma, O.P. 2017. Pteridophyta, McGraw Hill Education, New York.
2. Gupta, M.N. 1972. The Gymnosperms (2nd Edition) Shiva Lal Agarwala & Co., Agra.

3. Vashista, P.C. 1976. Gymnosperms, S. Chand & Co. New Delhi.
4. Bhatnagar, S.P and Moitra, A. 1996. Gymnosperms. New Age International Publishers, New Delhi, India.
5. Anil Kumar. 2006. Gymnosperms. S. Chand & Company Pvt. Ltd. New Delhi.
6. Bhatnagar S.P and Alok Moitra. 2013. Gymnosperms. Publisher: New Age International Pvt Ltd Publishers. New Delhi.

Reference Books:

1. Parihar. N.S. 1967. An introduction of Embryophyta, Vol.III – Pteriodophyta, Central book depot, Allahabad.
2. Smith, G.M. 1955. Cryptogamic Botany, Volume-II– McGraw Hill, Chennai
3. Sporne, K.R. 1976. Morphology of Pteridophytes, 4th edition, B.I. Publication. Chennai.
4. Parihar, N.S. 1996. The Biology and Morphology of Pteridophytes. Central Book Depot, Allahabad
5. Sporne, K.R.1991. The Morphology of Gymnosperms. B.I. Publications, New Delhi.
6. Bhatnagar, S.P and Moitra, A. 1996. Gymnosperms, New Age Int. Pvt. Ltd., New Delhi.
7. Stewart, W.N and Rathwell, G.W. 1993. Paleobotany and the Evolution of Plants. Cambridge University Press.
8. Raup, D.M and Steven, M. Stanley. 2004. Principles of paleontology. San Francisco: W.H. Freeman, 1971.
9. Bhatnagar S.P and Alok Moitra. 2013. Gymnosperms. Publisher: New Age International Pvt Ltd Publishers. New Delhi.
10. Taylor, E, Taylor, T, Krings, M. 2008. Paleobotany: The Biology and Evolution of Fossil Plants, 2nd Edition, Academic Press.

Web Resources:

1. http://www.bsienvis.nic.in/Database/Pteridophytes-in-India_23432.aspx
2. http://www.botany.ubc.ca/bryophyte/mossintro.htmlaeTIUC&redir_esc=y
3. https://books.google.co.in/books?hl=en&lr=&id=Pn7CAAAQBAJ&oi=fnd&pg=PA1&dq=Introduction+to+Gymnosperms&ots=sfYSzCL02&sig=ysX1KRvetV0bAza4Sq6RWau4XU8&redir_esc=y#v=onepage&q=Introduction%20to%20Gymnosperms&f=false
4. https://books.google.co.in/books/about/Botany_for_Degree_Gymnosperm_Multicolor.html?id=HTd FYFNxnWQC&redir_esc=y
5. https://books.google.co.in/books/about/Gymnosperms.html?id=4dvyNckni8wC
6. https://arboretum.harvard.edu/wp-content/uploads/2013-70-4-beyond-pine-cones-an-introduction-to- gymnosperms.pdf
7. https://www.palaeontologyonline.com/

COURSE OUTCOMES:

Course Outcomes:	On completion of this course the student will be able to	Cognitive Level
CO1	Explain the morphology, anatomy, reproduction, classification, and evolutionary significance of Pteridophytes and evaluate their role in plant diversity and evolution.	**K1**
CO2	Investigate and assess the morphological, anatomical, and reproductive adaptations of Gymnosperms in relation to their survival and ecological significance.	**K2**
CO3	Compare, analyze, and evaluate the characteristics, reproductive structures, phylogenetic relationships, and evolutionary trends of Gymnosperms and fossil plant groups.	**K3**
CO4	Apply scientific knowledge to analyze the anatomy, reproduction, ecological importance, economic value, and conservation significance of Gymnosperms in sustainable resource management.	**K4**
CO5	Investigate fossilization processes, interpret paleo botanical evidence, and evaluate fossil records to understand plant evolution, biodiversity patterns, and geological history.	**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		**PLANT DIVERSITY II PTERIDOPHYTES, GYMNOSPERMS AND PALEOBOTANY (Theory)**							**4**	**4**	
Course Outcomes	**Programme Outcomes (POs)**										**Mean Score**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	
CO1	1	3	3	2	2	2	2	2	2	1	**2.0**
CO2	1	3	3	3	3	1	2	2	2	1	**2.1**
CO3	1	3	3	3	3	1	2	2	3	1	**2.2**
CO4	1	3	3	3	3	1	3	3	2	1	**2.3**
CO5	1	3	3	3	3	3	1	2	2	3	**2.4**
Mean Overall Score											**2.2 (High)**

Year: First **CORE PRACTICAL 2** **Semester: II**

Code: **PLANT DIVERSITY II** **Credits: 4**

PTERIDOPHYTES, GYMNOSPERMS AND PALEOBOTANY

(Practical)

COURSE OBJECTIVES:

- To enable students gain expertise in hand sectioning technique.
- To study diversity and anatomical structure of Pteridophytes**.**
- To enable students, observe and record the morphological features and anatomical structure of selected species of Gymnosperms.
- To develop the skill of preparation of microslides of the gymnosperm samples.
- To enable students to gain insights into the basics of Paleobotany, methods of fossilization and the anatomy of the fossil plants through microscopy.

PTERIDOPHYTES

1. Study of morphology, anatomy and structure of the vegetative and reproductive organs of Pteridophytes genera and fossils included in the theory syllabus. Psilotopsida (*Psilotum*) Lycopsida (*Lycopodium*), Sphenopsida (*Equisetum*), Pteropsida (*Marsilea*).
2. Identifying of micro slides.

GYMNOSPERMS AND PALEOBOTANY

1. Study of morphology, anatomy and structure of the vegetative and reproductive organs of *Cycas, Pinus* and *Gnetum.*
2. Identifying the micro slides relevant to the syllabus.
3. Field visit to study the habitat (Hill station).
4. Study the following fossil members: *Rhynia*, *Lepidodendron*, *Lepidocarpon, Calamites* and *Williamsonia sewardiana* through permanent slides.
5. Photograph of evolution scientists.

Recommended Textbooks:

1.Sharma, O.P. 2012. Pteridophyta, Tata McGraw-Hills Ltd, New Delhi.
2.Ashok, M. Bendre and Kumar. 2010. A text book of Practical Botany, Algae, Fungi, Lichen,Bryophyta, Pteridophyta, Gymnosperms and Palaeobotany. Revised edition. Published by Rakesh Kumar Rastogi publication.
3.Sharma O.P and S, Dixit. 2002. Gymnosperms. Pragati Prakashan.
4.Gangulee, H.C and A.K. Kar. 2013. College Botany. Vth Edition. S. Chand.
5.Sharma, O.P. 2012. Textbook of Pteridophyta, TATA MacMillan India Ltd., New Delhi.
6.Chamberlain, C.J. 1934. Gymnosperms: Structure and Evolution. Chicago Reprinted 1950). NewYork.
7.Bhatnagar, S.P and Moitra, A. 1996. Gymnosperms. New Age International Publishers, New Delhi,India.

Reference Books:

1.Sporne, K.R. 1991. The Morphology of Pteridophytes. B.I. Publ. Pvt. Ltd. Chennai.
2.Vashista.P.C. 1971. Botany for Degree students: Pteridophyta. S. Chand & Co. New Delhi.
3.Smith, G.M. 1955. Cryptogamic Botany Vol.II. Tata McGraw Hill. New Delhi.
4.James.W. Byng. 2015. The Gymnosperms practical hand book. A practical guide to extant families and genera of the world. Published by plant Gateway, Tol Bot Street, Herford, SG137BX, United Kingdom.
5.Sharma, O.P. 2012. Textbook of Pteridophyta, TATA MacMillan India Ltd., New Delhi.
6.Chamberlain, C.J. 1934. Gymnosperms: Structure and Evolution. Chicago Reprinted 1950). NewYork.
7.Kirkaldy, J.E. 1963. The study of Fossils. Hutchinson Educational, London

Web Resources:

1.https://www.amazon.in/Practical-Manual-Pteridophyta-Rajan-Sundara/dp/8126106883
2.https://www.toppr.com/guides/biology/plant-kingdom/pteridophytes/
3.https://www.google.co.in/books/edition/Gymnosperms/3YrT5E3Erm8C?hl=en&gbpv
=1&dq=gy mnosperms&printsec=frontcover
4.https://www.amazon.in/Paleobotany-Biology-Evolution-Fossil-Plants/dp/0123739721
5.https://books.google.co.in/books/about/Paleobotany.html?id=HzYUAQAAIAAJ
6.https://trove.nla.gov.au/work/11471742?q&versionId=46695996
7.http://www.freebookcentre.net/Biology/Evolutionary-Biology-Books.html

COURSE OUTCOMES:

Course Outcomes:	On completion of this course students will be able to	Cognitive Level
CO1	Explain and scientifically document the morphological characteristics of selected Pteridophytes and Gymnosperms and evaluate their taxonomic and adaptive significance.	**K1**
CO2	Examine, interpret, and evaluate the structural organization and evolutionary significance of the fossil forms prescribed in the syllabus using paleobotanical evidence.	**K2**
CO3	Identify, analyze, compare, and illustrate the morphological and anatomical features of Pteridophytes and Gymnosperms through microscopic observations and scientific documentation.	**K3**
CO4	Demonstrate proficiency in sectioning, staining, slide preparation, microscopic techniques, and data recording for the investigation of plant structures.	**K4**
CO5	Analyze, interpret, and evaluate the reproductive structures of Gymnosperms and assess their significance in plant evolution, adaptation, and reproductive success.	**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 - II Pteridophytes, Gymnosperms and Paleobotany (Practical)**							**4**		**4**
Course Outcomes	**Programme Outcomes (POs)**										**Mean Score**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	
CO1	2	3	3	3	2	1	2	2	3	1	**2.2**
CO2	2	3	3	3	3	1	2	2	3	1	**2.3**
CO3	2	3	3	3	3	1	2	2	3	1	**2.3**
CO4	2	3	2	3	3	2	1	2	3	1	**2.2**
CO5	2	3	3	3	3	1	1	2	3	3	**2.4**
Mean Overall Score											**2.28 (High)**

Year: Second **CORE COURSE 3** **Semester: III**

Code: **PLANT ANATOMY AND EMBRYOLOGY (Theory)** **Credits: 4**

COURSE OBJECTIVES:

- To assess classification, Identification, Structure, Function and role of apical to Lateral meristem in plant growth.
- To employ the function and organization of woody stem.
- To categorize anatomy of stem, root and leaf to their secondary growth.
- To assess the process of seed setting.
- To illustrate the structure of Micro, Megasporangium and Gametophyte.

UNIT I PLANT ANATOMY:

Meristem: definition, structure, function and classification. Apical organization and theories: Apical cell theory, Histogen theory and Tunica-Corpus theory. Root apex: Histogen theory and Korper-Kappe theory. Tissues - Definition, types - Simple tissue system - parenchyma, collenchyma and sclerenchyma (fibers and sclereids). Complex tissue system - xylem and phloem.

UNIT II PLANT ANATOMY:

Epidermal tissue system: epidermis, cuticle, trichome, bulliform cells, periderm and silica cells. Ground tissue systems: cortex, endodermis, pericycle, pith and pith rays. Vascular tissue systems: different types of vascular bundles and their arrangement in root and stem. Primary structure of root and stem (Dicot and monocot) Nodal anatomy: leaf trace, leaf gap, branch trace and branch gap-types

UNIT III PLANT ANATOMY:

Secondary thickening in monocots and dicots Root and Stem. Anomalous secondary growth of stem- *Boerhaavia, Nyctanthes* and *Dracaena*. Leaf - anatomy of dicot and monocot leaf. Stomatal structure and types.

UNIT IV EMBRYOLOGY:

Structure and development of anther - development of male gametophyte. Ovule: Structure of mature ovule**,** types of ovules; female gametophyte– megasporogenesis (monosporic, bisporic and tetrasporic) and mega gametogenesis (*Polygonum* type); Organization and ultra structure of mature embryo sac.

UNIT V EMBRYOLOGY:

Double fertilization and triple fusion. Endosperm and its types - free nuclear, cellular, helobial, endosperm haustoria. Polyembryony - types, apomixis, parthenogenesis and parthenocarpy. Seed structure and its importance.

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

Current developments related to the Plant Anatomy and Embryology during the semester concerned 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 Bhatnagar, S.P. 1994. Embryology of Angiosperms, Vikas.
2. Bhojwani, S.S and Bhatnagar, S.P. 2000. The Embryology of Angiosperms (4th revised and enlarged edition). Vikas Publishing House, New Delhi.
3. Burgess, J. 1985. An Introduction to Plant Cell Development. Cambridge University Press, Cambridge.
4. Raghavan, V. 1999. Developmental Biology of Flowering Plants. Springer-Verlag, New York.
5. Vimla Singh and Alok Abhishek. 2019. Plant Embryology and Experimental Biology. Educational Publishers and Distributors. New Delhi.
6. Pandey, B.P.2015. Plant Anatomy S. Chand Publ. New Delhi.
7. Bhatnagar,S.P., Dantu, P.K, Bhojwani, S.S. 2014. The Embryology of Angiosperms 6th edition Vikas Publishing House. Delhi.
8. Waisel, Y., Eshel, A and Kafkaki, U. 1996. Plant Roots: The Hidden Hall (2nd edition). Marcel Dekker, New York.

Reference Books:

1. Esau, K. 1985. Anatomy of Seed Plants –John Willey.
2. Cutter, E.G. 1989. Plant Anatomy – Part I – Addison – Wesley Publishing Co..
3. Maheswari, P.1991. An Introduction to Embryology of Angiosperms, Tata McGraw Hill Publishing Co. Ltd.,
4. Swamy, B.G.L and Krishnamoorthy. K.V.1990. From Flower to Fruits, Tata McGraw Hill Publishing Co. Ltd.
5. Dickison, W.C. 2000. Integrative Plant Anatomy. Harcourt Academic Press, USA.
6. Fahn, A. 1974. Plant Anatomy. Pergmon Press, USA.
7. Mauseth, J.D. 1988. Plant Anatomy. The Benjammin/Cummings Publisher, USA.
8. Evert, R.F. 2006. Esau's Plant Anatomy: Meristems, Cells, and Tissues of the Plant Body: Their Structure, Function and Development. John Wiley and Sons, Inc. Any local/state/regional flora published by BSI or any other agency.
9. Swamy, B.G.L and Krishnamurthy, K.V.1980. From flower to fruit. Tata McGraw Hill Co.Pvt. Ltd, New Delhi

Web Resources:

1. https://www.amazon.in/PLANT-ANATOMY-EMBRYOLOGY-BIOTECHNOLOGY-ebook/dp/B07H5JYFBJ/ref=asc_df_B07H5JYFBJ/?tag=googleshopdes-2
2. https://www.kobo.com/us/en/ebook/a-textbook-of-plant-anatomy
3. https://archive.org/EXPERIMENTS/plantanatomy031773mbp
4. https://www.amazon.in/Embryology-Angiosperms-6th-S-P-Bhatnagar-ebook/dp/B00UN5KPQG

COURSE OUTCOMES:

Course Outcomes :	On the successful completion of the course, students will be able to	Cognitive Level
CO1	Explain and evaluate the structure, organization, functions, and significance of various plant tissues and correlate their roles in plant growth and development.	**K1**
CO2	Investigate and assess the tissues involved in primary and secondary growth of dicot and monocot plants and evaluate their contribution to plant adaptation and productivity.	**K2**
CO3	Compare, analyze, and interpret different types of plant growth and examine the structural and physiological mechanisms responsible for luxuriant plant growth.	**K3**
CO4	Analyze the mechanisms of compatibility and incompatibility in plant reproduction and evaluate their significance in successful fertilization and crop improvement.	**K4**
CO5	Examine and evaluate the processes of fertilization, endosperm development, embryo formation, polyembryony, parthenocarpy, and apomixis and assess their applications in plant breeding and agricultural biotechnology.	**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				**Plant Anatomy and Embryology (Theory)**					**4**	**4**	
Course Outcomes	**Programme Outcomes (POs)**										**Mean Score**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	
CO1	1	3	3	3	3	1	2	2	2	1	**2.1**
CO2	1	3	3	3	3	1	2	2	2	1	**2.1**
CO3	1	3	3	3	2	1	3	2	2	1	**2.1**
CO4	1	3	3	3	3	1	2	3	2	1	**2.2**
CO5	1	3	3	3	3	1	3	3	3	1	**2.4**
Mean Overall Score											**2.18 (High)**

Year: Second **CORE PRACTICAL 3** **Semester: III**

Code: **PLANT ANATOMY AND EMBRYOLOGY (Practical)** **Credits: 4**

COURSE OBJECTIVES:

- To provide basic knowledge of plant internal architecture and cellular composition and reproduction.
- To be familiar with the history of microscopy and different parts of compound microscopes.
- To learn about different techniques of anatomy like sectioning and staining.
- To know mounting media and mounting techniques.
- To explain the common stains for plant cells

ANATOMY

1. Identifying Stomatal types using leaf peel method
2. Stem – Primary Structure – *Tridax*, *Zea mays*
3. Root – Primary structure Bean, Canna
4. Leaf anatomy – *Nerium*
5. Anomalous Secondary growth – *Boerhaavia*, *Nyctanthes* and *Dracaena*

EMBRYOLOGY

1. T.S. of anther
2. Types of ovule
3. Male gametophyte development
4. Female gametophyte development
5. Mature Embryo Sac Structure
6. Fertilization
7. Type of Endosperms
8. Dicot embryo development
9. Monocot Embryo development
10. Dissection of Embryo – *Tridax*.

Recommended Textbooks:

1. Bhojwani, S.S., Bhatnagar, S.P., Dantu P. K. (2015). Embryology of Angiosperms, 6th edition. New Delhi, Delhi: Vikas Publication House Pvt. Ltd.
2. Fahn, A. (1982). Plant anatomy. Oxford, U.K.: Pergamon Press

Reference Books:

1. Mauseth, J.D. (1988). Plant Anatomy. San Francisco, California: The Benjamin/Cummings Publisher.
2. Coutler E. G., 1969. Plant Anatomy – Part I Cells and Tissues – Edward Arnold, London.
3. Dickison, W.C. (2000). Integrative Plant Anatomy, Harcourt Academic Press, USA.

COURSE OUTCOMES:

Course Outcomes:	On the successful completion of the course, students will be able to	Cognitive Level
CO1	Explain and evaluate the scope, significance, and applications of Plant Anatomy and Embryology in understanding plant growth, development, evolution, and applied plant sciences.	**K1**
CO2	Investigate and assess the mechanisms, patterns, and causes of normal and anomalous secondary growth in plants and evaluate their structural and adaptive significance.	**K2**
CO3	Apply and demonstrate anatomical techniques, including sectioning, staining, microscopic examination, and interpretation of plant tissues for scientific investigation.	**K3**
CO4	Analyze and interpret the processes of fertilization, endosperm development, and embryogeny and evaluate their significance in plant reproduction and development.	**K4**
CO5	Examine, analyze, and evaluate the structure, development, and functional significance of microsporangium and megasporangium in relation to plant reproductive success and evolution	**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				**Plant Anatomy and Embryology (Practical)**						**4**	**4**
Course Outcomes	**Programme Outcomes (POs)**										**Mean Score**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	
CO1	1	3	3	2	2	1	3	2	2	1	**2.0**
CO2	1	3	3	3	3	1	2	2	2	1	**2.1**
CO3	1	3	2	3	3	2	2	2	3	1	**2.2**
CO4	1	3	3	3	3	1	2	3	2	1	**2.2**
CO5	1	3	3	3	3	1	2	3	3	1	**2.3**
Mean Overall Score											**2.16 High**

Year: Second **CORE COURSE 4** **Semester: IV**

Code: **MICROBIOLOGY, PLANT PATHOLOGY AND PLANT PROTECTION** **Credits: 4**

(Theory)

COURSE OBJECTIVES:

- To evaluate the structure, reproduction, culture and economic importance of bacteria.
- To evaluate the structure, reproduction, culture and economic importance of virus
- To know about the factors responsible for the plant diseases
- To collect knowledge on the pathogens causing diseases in plants.
- To relate the plant protection methods.

UNIT I MICROBIOLOGY:

Bacteria – Discovery, general characteristics and cell structure; nutritional types of bacteria –, sexual and asexual Reproduction. Sterilization techniques, bacterial culture and staining (simple and differential). Bacterial genomics and metagenomics in agricultural microbiology. Antimicrobial resistance and advanced microbial diagnostics. Economic importance.

UNIT II MICROBIOLOGY:

Viruses – Discovery, general structure. Symptoms of virus infection in plants; transmission of plant viruses – purification; structure and multiplication of bacteriophages; genome organization. Structure and multiplication of viroids. Economic importance. Molecular virology and viral genome engineering. CRISPR-based antiviral defense mechanisms in plants.

UNIT III PLANT PATHOLOGY:

Plant Pathology: History – importance – organisms and causal factors responsible for plant diseases (Biotic and Abiotic). General symptoms, Pathogenesis, Host – pathogen interaction. Molecular plant–microbe interactions and effector biology. Climate change impacts on plant disease epidemiology.

UNIT IV PLANT PATHOLOGY:

Study of plant diseases – Symptoms, causative organisms, disease cycle and control measures: (a) Cereals: Rice – blast disease; (b) Vegetables: Brinjal – Little leaf; (c) Fruits: Banana – Bacterial leaf blight, Citrus – Bacterial canker; (d) Oil seeds: Ground nut – Tikka disease; (e) Sugar yielding: Sugarcane – red rot. Disease forecasting systems and digital plant disease surveillance. Molecular diagnostics and nanotechnology in plant disease management.

Unit-V PLANT PROTECTION:

Plant Protection – Scope, importance, equipment used - sprayers – dusters – soil injector – seed dressing drum; seed treatment – soil sterilization. Methods of plant protection

(a) Cultural – Tillage, sowing and planting dates, crop rotation and fertilizer.
(b) Mechanical – Field sanitation.
(c) Physical – Heat and soil Sterilization.
(d) Chemical – Bactericides, Fungicides, Insecticides, Herbicides.

(e) Biological – Biological control of pests.

Integrated Pest Management (IPM) and precision crop protection. Biotechnological and nanotechnological innovations in sustainable plant protection.

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

Current developments related to the Microbiology, Plant Pathology and Plant protection 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. Artificial intelligence and remote sensing in plant disease management. Sustainable agriculture, biosecurity, and global phyto pathological innovations.

Recommended Textbooks:

1. Carpenter, P.L. (1967). Microbiology. Saunders Co., Philadelphia, USA.
2. Stanier, R.Y., Adelberg, E.A. and Ingram, J.L. (1978). General Microbiology Mac Millan & Co., New Delhi.
3. Pelizar, M.J., Chan, E.C.S. and Krieg, N.R. (1993). Microbiology. Tata McGraw Hill Publishing Co. Ltd., New Delhi.
4. Dubey, R.C. and Maheshwari, D.K. (2007). A Textbook of Microbiology. S. Chand and Co. Ltd., New Delhi.
5. Microbiology Third Edition - ***Richard A. Harvey and Cynthia Nau Cornelissen*** .
6. Bap Reddy, D. and Joshi, N.C. (1991). Plant Protection in India. Allied Publishers Ltd., New Delhi.
7. Rangaswami, G. and Mahadevan, A. (1998). Diseases of Crop Plants in India. Prentice Hall of India Ltd., New Delhi.

Reference Books:

1. Pandey, B.P. (2001). Plant Pathology. S. Chand & Co. Ltd., New Delhi.
2. Mehrotra, R.S. (2003). Plant Pathology. Tata McGraw Hill Publishing Co. Ltd., New Delhi.
3. Text book of Plant Protection First edition - Dr.E. Marimuthu, Dr.K. Muthuchelian, Royal book publishing international.
4. 1.A Clinician's Dictionary of Pathogenic Microorganisms by James H. Jorgensen; Michael A. Pfaller 2004.
5. Abiotic Disorders of Landscape Plants: A Diagnostic Guide. Publication 3420.
6. Diseases of Trees and Shrubs. Comstock Publishing Associates, a division of Cornell University Press. Greenwood, P., Halstead, A., Chase, A. R., and Gilrein, D. 2000.

Web Resources:

1. http://whttp://www.apsnet.org/Pages/default.aspx
2. ww.npdn.org/
3. https://www.wpdn.org:

4. http://www.ipmcenters.org/
5. https://www.britannica.com/science/microbiology
6. https://conductscience.com/introduction-and-importance-of-microbiology/
7. https://biologydictionary.net/microbiology/
8. https://www.researchgate.net/publication/356529627_Plant_Pathology_Introducti on
9. https://www.rvskvv.net/images/I-Year-II-Sem_Principles_Plant-
10. Pathology_ANGRAU_20.04.2020.pdf
11. http://www.ca.uky.edu/agc/pubs/ppa/ppa41/ppa41.pdf

COURSE OUTCOMES:

Course Outcomes:	On successful completion of this course, the students will be able to	Cognitive Levels
CO1	Explain and evaluate the structure, reproduction, cultivation techniques, and economic importance of bacteria and assess their applications in agriculture, industry, and environmental management.	**K1**
CO2	Examine, analyze, and evaluate the structure, replication, cultivation methods, and economic significance of viruses and their impact on plants and other living organisms.	**K2**
CO3	Investigate and interpret the causes, symptoms, transmission, and management strategies of major plant diseases affecting agricultural and horticultural crops.	**K3**
CO4	Identify, analyze, and classify different plant pathogens based on their characteristics, mode of infection, and host–pathogen interactions.	**K4**
CO5	Evaluate and apply various plant disease management and plant protection strategies for sustainable crop production and disease control.	**K5**

Mapping with POs:

Relationship Matrix											
Semester	**Course Code**	**Title of the Course**							**Hours**	**Credits**	
IV		**MICROBIOLOGY, PLANT PATHOLOGY AND PLANT PROTECTION (Theory)**							**4**	**4**	
Course Outcomes	**Programme Outcomes (POs)**										**Mean Score**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	
CO1	1	3	3	2	3	1	2	2	2	1	**2.0**
CO2	1	3	3	2	3	1	2	2	2	1	**2.0**
CO3	1	3	3	3	3	1	2	3	2	1	**2.2**
CO4	1	3	3	3	3	1	2	3	3	1	**2.3**
CO5	1	3	3	3	3	1	3	3	3	1	**2.4**
Mean Overall Score											**2.18 (High)**

Year: Second **CORE PRACTICAL 4** **Semester: IV**

Code: **MICROBIOLOGY, PLANT PATHOLOGY AND PLANT PROTECTION (Practical)** **Credits: 4**

COURSE OBJECTIVES:

- To identify the microorganisms.
- To d iscuss the distinct group of microbes which differ in form and other characters.
- To introduce the subject of Plant Pathology, its concepts and principles.
- To impart training on various methods/techniques/instruments used in the study of plant diseases/pathogens.
- To analyse the structure, virus-vector relationship, biology and management of plant viruses.

MICROBIOLOGY PLANT PATHOLOGY & PLANT PROTECTION:

1. Tools and equipment used in microbiology: Spirit lamp, Inoculation loop, Hot air oven, Autoclave, Pressure Cooker, Laminar air flow chamber, Incubator.
2. Media preparation, Serial techniques and plating techniques.
3. Types of Bacteria from temporary / permanent slides / photographs; Binary fission, conjugation.
4. Simple and differential staining.
5. Slide preparation of causative organisms in plant disease.
6. Identification of various plant protection appliances mentioned in the syllabus and their working mechanism.

Recommended Textbooks:

1. Alexopoulos CJ, Mims CW & Blackwell M.2000. Introductory Mycology. 5th Ed. John Wiley & Sons, New York.
2. Sarbhoy AK. 2000. Text book of Mycology. ICAR, New Delhi.
3. Agrios GN. 2005. Plant Pathology. 5th Ed. Academic Press, New York.
4. Mehrotra RS & Aggarwal A. 2003. Plant Pathology. 2nd Ed. Oxford & IBH, New Delhi.
5. Hull R. 2002. Mathew s Plant Virology. 4th Ed. Academic Press, New York.
6. Jayaraman J & Verma JP. 2002. Fundamentals of Plant Bacteriology. Kalyani Publ., Ludhiana.

Web Resources:

1. https://uou.ac.in/sites/default/files/slm/BSCBO-101.pdf
2. https://www.ubkv.ac.in/wp-content/uploads/2014/03/PG-Syllabus_PLANT-PATHOLOGY.pdf

COURSE OUTCOMES:

Course Outcomes:	On successful completion of this course, the students will be able to	Cognitive Levels
CO1	Investigate and explain the symptoms, transmission mechanisms, assay techniques, physical properties, and purification methods of plant viruses.	**K1**
CO2	Examine, analyze, and interpret the symptoms, etiology, disease cycle, and management strategies of major diseases affecting economically important crop plants.	**K2**
CO3	Demonstrate proficiency in the collection, identification, documentation, preservation, and scientific interpretation of diseased plant specimens.	**K3**
CO4	Identify, analyze, and evaluate important plant pathogens using microscopic and laboratory techniques and interpret their role in disease development.	**K4**
CO5	Assess and apply the principles of plant disease management through the formulation, selection, and utilization of fungicides and plant protection equipment for sustainable crop health management.	**K5**

Mapping with POs:

Relationship Matrix											
Semester	**Course Code**	**Title of the Course**							**Hours**	**Credits**	
IV		**MICROBIOLOGY, PLANT PATHOLOGY AND PLANT PROTECTION (Practical)**							**4**	**4**	
Course Outcomes	**Programme Outcomes (POs)**										**Mean Score**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	
CO1	2	3	3	3	3	1	2	2	3	1	**2.3**
CO2	2	3	3	3	3	1	2	3	2	1	**2.3**
CO3	2	3	2	3	2	2	1	2	3	1	**2.1**
CO4	2	3	3	3	3	1	2	2	3	1	**2.3**
CO5	2	3	3	3	3	1	3	3	2	1	**2.4**
Mean Overall Score											**2.28 (High)**

Year: Third **CORE COURSE 5** **Semester: V**
Code: **MORPHOLOGY AND ECONOMIC BOTANY** **Credits: 4**
(Theory)

COURSE OBJECTIVES:

- To have extensive knowledge of the morphology (vegetative structures and floral structures) of flowering plants.
- To know about the basic concepts of classification of plants.
- To understand major evolutionary trends in Angiospermic plants.
- To know the characteristic features of the selected families.
- To know the economic importance of plants.

UNIT I MORPHOLOGY
Parts of the Plant - Root types (Tap root, Fibrous root and Adventitious roots) and its Modification. Leaf Morphology – Structure, Types (Monocots and Dicots), Phyllotaxy and its types, Venation and its types and modifications.

UNIT II MORPHOLOGY
Stem – different Types, Aerial and underground Stem and its types and modifications. Nodal structure and its types.

UNIT III MORPHOLOGY
Inflorescence: Racemose types - Cymose types - Special type. Morphology of flower- Flower modified as shoot, floral parts and their arrangement, aestivation and placentation types- Floral Diagram and Floral Formula. Fruits: Classification and Types.

UNIT IV ECONOMIC BOTANY
Economic Importance and its plant parts used for the following Pulses – Green Gram, Red Lentil, Black Gram, Chickpea, Kidney Bean and Pigeon Pea.
Economic Importance and its plant parts used for the following Cereals – Rice, Wheat, Oats, Millet, Corn and Maize.

UNIT V ECONOMIC BOTANY
Economic Importance and its plant parts used for the following Spices – Coriander seed, Cumin seed, Star Anise, Pepper, Cloves and Fenugreek.
Economic Importance and its plant parts used for the following Cash Crops – Cotton, Jute, Sugarcane, Groundnut, Tobacco and Coffee.

UNIT VI CURRENT CONTOURS (For Continuous Internal Assessment Only):
Current developments related to the Morphology 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.Jeffrey, C. 1982. An Introduction to Plant Taxonomy, Cambridge University Press, UK.
2.Pandey, BP. 1999. Taxonomy of Angiosperms, S.Chand & Co. Ltd., New Delhi.

3.Gurcharan Singh, 2004. Plant Systematics: An Integrated Approach, Science Publishers Inc., New Hampshire, USA.
4.Hutchinson, J. 1973. The Families of Flowering plants , Oxford University press, London.
5.Gamble, J.S., Fisher, L.E.F.1967. The Flora of The presidency of Madras (Vol-III) BSI,
Calcutta

Reference Books:

1.Clive AS.1989. Plant Taxonomy and Biosystematics, Chapman and Hall Inc. New York.
2.Harborne, JB & Turner, BL. 1984. Plant Chemosystematics, Acad. Press, London.
3.Lawrence, GH. 1955. Taxonomy of Vascular Plants, MacMillan Co., USA.
4.Samuel, BJ & Arlene, EL. 1987. Plant Systematics, Mc Graw Hill Inc. New York.
5.Lawrence, G.H.M. 1985. An Introduction to Plant Taxonomy, Central Book Depot, Allahabad.
6.Porter, C.L. 1982. Taxonomy of Flowering Plants, Eurasia Publications House, New Delhi
7.Takhtajan, A.L. 1997. Diversity and Classification of Flowering Plants. Columbia University Press,
New York.
8.Woodland, D.W. 1991. Contemporary Plant Systematics. Prentice Hall. New Jersey.
9.Rajni Gupta. 2012. Plant Taxonomy: Past, Present and Future. Vedams (P) Ltd. New Delhi.

Web Resources:

1.https://www.abebooks.co.uk/servlet/BookDetailsPL?bi=20569837712&searchurl=tn%3Dhandbook%2Bof%2Bthe%2Bbritish%2Bflora%26sortby%3D17%26an%3Dbentham%2Bg&cm_sp=snippet-_-srp1-_-title1
2.https://trove.nla.gov.au/work/16054012
3.https://books.google.co.in/books/about/A_Text_Book_Ofbotany_Plant_Anatomy_and_E.html?id=uMOglvnKUpQC&redir_esc=y

COURSE OUTCOMES:

Course Outcomes:	On completion of this course, the students will be able to	Cognitive Level
CO1	Explain and evaluate the fundamental concepts of plant morphology and apply the principles and rules of botanical nomenclature in plant identification and classification.	K1
CO2	Compare, analyze, and evaluate various systems of plant classification and assess the significance of herbarium and virtual herbarium techniques in taxonomic research and biodiversity documentation.	K2
CO3	Examine and evaluate the principles of Economic Botany and assess the utilization and significance of plant resources in agriculture, industry, healthcare, and sustainable development	K3

CO4	Analyze, compare, and interpret the diagnostic characteristics of plant families based on Bentham and Hooker's system of classification and evaluate their taxonomic significance.	K4
CO5	Assess and interpret the principles, methodologies, and applications of phylogenetic systematics in understanding plant evolution, relationships, and classification	K5

Mapping with POs:

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

Year: Third **CORE COURSE 6** **Semester: V**

Code: **GENETICS, BIOSTATISTICS AND EVOLUTION (Theory)** **Credits: 4**

COURSE OBJECTIVES:

- To understand the principle, the hereditary mechanism, the structure and functions of genetic materials.
- To have conceptual understanding of laws of inheritance, genetic basis of loci and alleles and their linkage.
- To gain knowledge in classical genetics**.**
- To provide an overview of biostatistical methods.
- To familiarize about Evolution & Emergence of evolutionary thoughts.

UNIT I GENETICS

Chromosomes – Morphology, Structure of Polytene, Lampbrush and B-Chromosomes. Nucleic acid – Structure and types of DNA and RNA, Nucleosomes. Cell division – Amitosis, mitosis and meiosis.

UNIT II GENETICS

Mendelian genetics – Mendel's laws of inheritance –Monohybrid, Dihybrid Cross. Interaction of genes. Incomplete dominance and Complementary genes, interaction of genes- Epistasis and lethal genes. Multiple alleles. ABO blood group in man.

UNIT III GENETICS

Linkage and crossing over, chromosomes mapping, Cytoplasmic inheritance: Mitochondria- male sterility in maize. Sex determination in plants. Mutations: Chromosome aberrations. Polyploid types- aneuploids, euploids and allopolyploids.

UNIT IV BIOSTATISTICS

Definition and Scope. Population and Sample, Sampling Techniques-Random sampling. Variables, measurements, functions, limitations and uses of statistics. Collection of data and types, merits and demerits. Classification -tabulation and presentation of data -sampling methods.

Analysis of data - Measures of central tendency -mean, median, mode, geometric mean –merits & demerits. Measures of dispersion -range, standard deviation, mean deviation, quartile deviation -merits and demerits.

UNIT V EVOLUTION

Introduction – Germplasm theory – Lamarckism - Neo-Lamarckism – Darwinism - mutation theory of Hugo de Vries - Natural selection - variation – speciation - species concept. Population genetics – gene pool, gene frequency and Hardy–Weinberg law. Factors affecting gene frequencies.

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

Current developments related to Genetics, Biostatistics 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 Textbooks:

1.Verma, P.S. & V.K. Agarwal, 2003, Genetics. S. Chand & Co.Ltd., New Delhi.
2.Sinnott, EW., Dunn, L.L and Dobzhansky, T. 1997. Principles of Genetics, Tata Mc Graw Hill Publishing
Co. New Delhi.
3.Singh, R. J. 2016. Plant Cytogenetics, 3rd Edition. CRC Press, Boca Raton, Florida, USA.
4. Singh, R.J. 2017. Practical Manual on Plant Cytogenetics. CRC Press, Boca Raton, Florida, USA.
5.Nageswara Rao, G. 1983. Statistics for Agricultural Science Oxford & IBH Publishing company
6.Stewart, W.N and Rathwell, G.W. 1993. Paleobotany and the Evolution of Plants. Cambridge
University Press.

Reference Books:

1.Freifelder, D. 1987. Essentials of Molecular Biology, Jones & Bartlett, Boston.
2.Gardner, EJ., Simmons, MJ. & Snustad, D. 1991. Principles of Genetics, John Wiley & Sons Inc., 8th
Edn. New York.
3.Sinnott, EW., Dunn, LL. & Dobzhansky, T. 1997. Principles of Genetics, Tata Ma Graw Hill Publishing
Co., New Delhi.
4.Gupta, S.P. 2008. Elementary Statistical Methods. Sultan Chand & Sons, New Delhi.
5.Ramakrishnan, P (2001) Biostatistics, Saras Publication, Nagercoil
6.Arora PN and Malhan PK (1996) Biostatistics, Himalaya Publishing House, Mumbai
7.Palanichami S and Manoharan M Statistical methods for biologists, Paramount publications.

Web Resources:

1.https://onlinelibrary.wiley.com/doi/book/10.1002/9781118313718
2.https://www.springer.com/in/book/9783642879302
3.https://trove.nla.gov.au/work/16054012?q&sort=holdings+desc&_=1527503199193&versionId=23683670
4.https://www.amazon.com/Chromosome-Atlas Flowering...Darlington/dp/B0014B1YJA

COURSE OUTCOMES:

Course Outcomes:	On completion of this course, the students will be able to	Cognitive Level
CO1	Explain and evaluate Mendelian principles of inheritance, gene interactions, and their significance in explaining patterns of heredity.	K1
CO2	Investigate and interpret the genetic and environmental factors influencing heredity and evaluate their role in the transmission of traits across generations	K2

CO3	Apply and evaluate gene mapping techniques, including linkage analysis and linkage map construction, for studying genetic relationships and inheritance patterns.	K3
CO4	Analyze biological data using appropriate statistical methods and interpret the results for solving genetic and biological problems.	K4
CO5	Assess and evaluate the origin, evolution, and major evolutionary theories and interpret their significance in understanding biological diversity and adaptation.	K5

Mapping with POs:

Relationship Matrix											
Semester	**Course Code**	**Title of the Course**							**Hours**		**Credits**
V		**Genetics, Biostatistics and Evolution (Theory)**							**5**		**4**
Course Outcomes	**Programme Outcomes (POs)**										**Mean Score**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	
CO1	1	3	3	2	3	1	2	2	2	1	**2.0**
CO2	1	3	3	3	3	1	2	2	2	1	**2.1**
CO3	1	3	3	3	3	1	2	3	3	1	**2.3**
CO4	1	3	3	3	3	2	2	3	3	1	**2.4**
CO5	1	3	3	3	3	1	3	2	2	1	**2.2**
Mean Overall Score											**2.2 (High)**

Year: Third **CORE COURSE 7** **Semester: V**

Code: **CELL AND MOLECULAR BIOLOGY (Theory)** **Credits: 4**

COURSE OBJECTIVES:

- To understand the cell structure and functions
- To analyse the genomics of important cell organelles.
- To have an overview of cell events.
- To assess the molecular structure of DNA and RNA.
- To remember the process of transcription and translation.

UNIT I CELL BIOLOGY:
History and introduction of cell, Ultra structure of prokaryotic and eukaryotic cell. Plant cell structure and function, Cell wall- structure, chemistry and functions. Plasma membrane - structure, chemistry and function-Cell theory. Membrane dynamics and lipid raft signalling. Single-cell imaging and advanced microscopy techniques

UNIT II CELL BIOLOGY:
Structure and functions of mitochondria and chloroplast, Structure and functions of ER, Golgi complex, ribosome and cytoskeletons, Structure and functions of nucleus and nucleolus. Organelle communication and intracellular signalling pathways. Mitochondrial genomics and chloroplast biotechnology.

UNIT III CELL BIOLOGY:
Cell cycle- events of cell cycle, Molecular structure and functions of DNA and RNA. Cell divisions - Mitosis and Meiosis. Genetic regulation of cell cycle in Yeast, Cellular check points, DNA replication, DNA polymerases, eukaryotic system, origin, elongation and termination mechanisms, replication models Cairn's model, linear DNA model, rolling circle model, inhibitors of replication. Epigenetic regulation of cell cycle and genome stability. CRISPR-Cas systems and genome editing technologies.

UNIT IV MOLECULAR BIOLOGY:
Expression of genome, Transcription, RNA polymerase. Prokaryotic and eukaryotic transcription, promoters mediated initiation, RNA polymerases I, II and III, elongation and termination, post transcriptional processing, genetic code, Wobble's hypothesis, elongation and termination of translation. RNA interference (RNAi) and non-coding RNA biology. Transcriptomics and next-generation sequencing applications.

UNIT V MOLECULAR BIOLOGY:
Process of transcriptional regulation, Eukaryotic regulation, response elements, DNA binding domains – promoters, repressors, coactivators, corepressors, enhancer elements. DNA repair mechanisms. Post - translational modification of proteins. Protein folding-self-assembly and role of chaperones. Principles of gene regulation: *lac* and *trp* operons of *E. coli*. Gene families and hormonal control in eukaryotes. Systems biology approaches in gene regulatory networks. Proteomics and protein engineering technologies

UNIT VI CURRENT CONTOURS (For Continuous Internal Assessment Only):
Current developments related to the Cell and 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. Artificial intelligence in molecular biology research. Personalized medicine, synthetic biology, and omics technologies.

Recommended Textbooks:

1. Ajoy Paul Text Book of Cell and Molecular Biology, Books and Allied (P)Ltd, 2007.
2. Buchanan BB Gruissem W Jones RL. Biochemistry and Molecular biology of Plants, IK International Publishers, New Delhi. 2000.
3. Freifielder D. Molecular Biology (2nd edition) Narosa Publishers, New Delhi. 1994.
4. Verma PS Agarwal VK. Molecular Biology (First edition), S. Chand and Company Ltd. New Delhi, (2009).
5. Molecular biology of the cell Fifth edition -2008.
6. Cell and molecular biology Rastogi publications, fourth revised edition by P.K. Gupta @2015
7. Molecular Biology of the Cell (7th Ed., 2022) - Alberts, B., Johnson, A., Lewis, J., Morgan, D., Raff, M., Roberts, K., & Walter, P. (Garland Science).
8. *Molecular Cell Biology* (9th Ed., 2021) - Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A., & Martin, K. C. (W.H. Freeman).

Reference Books:

1. Textbook of cell& molecular biology Dr. Ajoy paul – (2007).
2. Alberts B, Bray D, Johnson A et al. (1997) Essential Cell Biology. London: Garland Publishing.
3. Darwin C (1859) On the Origin of Species. London: Murray.
4. Graur D & Li W-H (1999) Fundamentals of Molecular. Evolution, 2nd edn. Sunderland, MA: Sinauer Associates.
5. Madigan MT, Martinko JM & Parker J (2000).
6. Brock's Biology of Microorganisms, 9th edn. Englewood Cliffs, NJ: Prentice Hall.
7. Margulis L & Schwartz KV (1998) Five Kingdoms: An Illustrated Guide to the Phyla of Life on Earth, 3rd edn. New York: Freeman.

Web Resources:

1.https://www.britannica.com/science/plant-cell
2.https://www.frontiersin.org/articles/10.3389/fpls.2016.00984/full
3.https://www.vedantu.com/biology/plant-cell
4.https://www.britannica.com/science/mitochondrion
5.https://www.vedantu.com/biology/nucleus
6.https://le.ac.uk/vgec/topics/cell-cycle/the-cell-cycle-higher-education

7.https://www.khanacademy.org/science/ap-biology/gene-expression-and- regulation/translation/a/intro-to-gene-expression-central-
8.https://www.nature.com/scitable/topicpage/rna-transcription-by-rna- polymerase-prokaryotes-vs-961/

COURSE OUTCOMES:

Course Outcomes	On successful completion of this course, the students will be able to	Cognitive Levels
CO1	Explain and evaluate the ultrastructure, organization, and functions of plant cells and correlate their roles in cellular activities.	**K1**
CO2	Examine and interpret the structural organization and functional significance of cellular organelles in maintaining cellular processes.	**K2**
CO3	Analyze and evaluate the mechanisms, regulation, and significance of the cell cycle and different types of cell division in plants.	**K3**
CO4	Interpret and evaluate the central dogma of molecular biology and analyze the flow of genetic information from DNA to proteins.	**K4**
CO5	Analyze, compare, and evaluate the mechanisms of transcription and translation in prokaryotes and eukaryotes and assess their significance in gene expression and regulation.	**K5**

Mapping with POs:

Relationship Matrix											
Semester	**Course Code**			**Title of the Course**					**Hours**		**Credits**
V				**Cell and Molecular Biology (Theory)**					**5**		**4**
Course Outcomes	**Programme Outcomes (POs)**										**Mean Score**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	
CO1	1	3	3	2	3	1	2	2	2	1	**2.0**
CO2	1	3	3	3	3	1	2	2	2	1	**2.1**
CO3	1	3	3	3	3	1	2	3	2	1	**2.2**
CO4	1	3	3	3	3	1	2	3	2	1	**2.2**
CO5	1	3	3	3	3	1	2	3	3	1	**2.3**
Mean Overall Score											**2.16 (High)**

Year: Third **CORE COURSE 8** **Semester: V**

Code: **TAXONOMY OF ANGIOSPERMS (Theory)** **Credits: 4**

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 of plants.
- To create the floral diagram and floral formula based on the description of plants.
- To formulate taxonomic relationship in plant systematic studies and different classification systems.

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.

UNIT II TAXONOMIC HIERARCHY:
Phenetics, Cladistics, concepts of taxonomic hierarchy, Systematic evidence - Morphology, Anatomy, embryology. Numerical taxonomy, Chemotaxonomy, Sero taxonomy and molecular taxonomy.

UNIT III 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 manual -Plant identification. Herbarium techniques, Botanical Garden, Botanical survey of India.

UNIT IV SYSTEMATIC STUDY:
Study of important taxonomical characters with suitable examples of following families- Ranunculaceae, Caryophyllaceae, Rutaceae, Rhamnaceae, Sapindaceae, Lytheraceae, Aizoaceae, Rutaceae, Asteraceae and Sapotaceae.

UNIT V SYSTEMATIC STUDY:
Study of taxanomical and reproductive characters with suitable examples of following families-Nyctaginaceae, Aristolochiaceae, Piperaceae, Loranthaceae, Euphorbiaceae, Orchidaceae, Amaryllidaceae, Commelinaceae, Palmae and Cyperaceae.

UNIT - VI CURRENT CONTOURS (For continuous internal assessment only): Current developments related to the Taxonomy 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.R.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.Subramaniyan, N.S.2009. Modern plant taxonomy vikas publishing House, Pvt, lLtd New Delhi
6.Sambamurthy, A 2010 Text book, of plant taxonomy Wiley Eastern Pvt Ltd.
7.Saxena, N.B. and Sabena 7th edition pragmatic Pragati Meerut.

Reference Books:

1. Stace, C, 1985. Plant Taxonomy and biosystematics, Edward Arnold, London
2.Takhtajan, A.L. 1997 Diversity and classification of flowering plants Columbia University press,
3. Sokal R.R. and sneath, P.H.A 1963, Principles of Numerical Taxonomy Fremen & co San Francisco
4. Walter,S. Judd Christopher, S. Campbell Elizabath 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
2. https://byjus.com/neet/important-notes-of-biology-for-neet-plant taxonomy/

COURSE OUTCOMES:

Course Outcomes	On successful completion of this course, the students will be able to	**Cognitive Levels**
CO1	Explain and document the morphological characteristics of leaves, flowers, and other vegetative and reproductive plant parts for scientific identification and classification.	**K1**
CO2	Examine, compare, and evaluate the principles of plant taxonomy and taxonomic hierarchy and assess their significance in plant classification and biodiversity studies.	**K2**
CO3	Apply taxonomic principles to construct, interpret, and evaluate floral formulae and floral diagrams and analyze different systems of plant classification	**K3**
CO4	Identify, analyze, compare, and interpret the diagnostic characteristics of plant families and evaluate their taxonomic significance.	**K4**
CO5	Investigate and document plant diversity through field visits to botanical gardens and evaluate the role of botanical collections, herbaria, and field observations in plant conservation and taxonomic research.	**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**
V				**Taxonomy of Angiosperms (Theory)**						**5**	**4**
Course Outcomes	**Programme Outcomes (POs)**										**Mean Score**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	
CO1	2	3	2	3	2	1	2	2	2	1	**2.0**
CO2	2	3	3	3	3	1	2	2	2	1	**2.2**
CO3	2	3	3	3	3	1	2	3	2	1	**2.3**
CO4	2	3	3	3	3	1	2	2	3	1	**2.3**
CO5	2	3	3	3	2	2	3	2	3	1	**2.4**
Mean Overall Score											**2.24 (High)**

Year: Third **CORE PRACTICAL 5** **Semester: V**

Code: **MORPHOLOGY AND ECONOMIC BOTANY, GENETICS, BIOSTATISTICS AND EVOLUTION, CELL AND MOLECULAR BIOLOGY, TAXONOMY OF ANGIOSPERMS (Practical)** **Credits: 4**

COURSE OBJECTIVES:

- To familiarize students with the basic concepts.
- To apply the modern techniques used in Cell and Molecular Biology and Genetics, Biostatistics and evolution.
- To understand the principle and working of statistical estimation.
- To study morphological characters of leaf, stipule, stem and root.
- Recognizing the taxonomic traits of the various plant groups.

MORPHOLOGY:
Study of Morphological Characters Leaf, Stipule, Stem and Root, Inflorescence, flower and Fruits.

TAXONOMY:
A detailed study of following Families Annonaceae, Capparidaceae, Rubiaceae, Anacardiaceae, Rutaceae, Leguminocae (Fabaceae, Ceasalpinceae and Mimosaceae). Asteraceae, Rubiaceae, Asclepiadaceae, Solanaceae and Lamiaceae, Amaranthaceae, Nyctaginaceae, Aristolochiaceae, Euphorbiaceae, Lilliaceae, Commelinaceae and Poaceae.

GENETICS:
1) Monohybrid Cross
2) Dihybrid Cross
3) Incomplete Dominance
4) Complimentary Genes
5) Gene Interaction
6) Multiple alleles

BIOSTATISTICS:
1.Tabulation of data
2. Diagrammatic representation of data
3.Graphical representation of data
4. Standard deviation
5.Standard error,
6.Chi – Square
7.One-way Anova.

CELL AND MOLECULAR BIOLOGY:
1. Observation of cells in onion peeling.
2. Observation of cell division in onion root tip and Rheo flower buds.
3. Differential staining methods for characterization of cells.
4. Isolation of total DNA from onion bulbs by using salt and detergent method.

Recommended Textbooks:

1. Karp, G (1995) Cell and Molecular Biology, John Wiley and Sons, New York
2. Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics, John Wiley & Sons Inc., India.
3. Bessey, E.A (1979). Morphology and Taxonomy of fungi, Vikas publishing House Pvt. Ltd, New Delhi.

Reference Books:

1. Lawrence, GHM. (1995). The Taxonomy of vascular Plants (Vol I-IV), Central Book, Dept., Allahabad.
2. Hill AW. 1951 Economic Botany - Mc Graw Hill, New Delhi. 6. Pandey, B.P., Economic Botany, S. Chand & Co., New Delhi.

Web Resources:

1.https://www.southalabama.edu/geology/haywick/GY112/112lect41.pdf 8.
2. 2.https://www.studocu.com/en-gb/document/university-college london/biochemistry-and-molecular-biology/cell-molecular-biology notes/10045497
3. https://uou.ac.in/sites/default/files/slm/BSCZO-103.pdf

COURSE OUTCOMES:

Course Outcomes	On successful completion of this course, the students will be able to	Cognitive Levels
CO1	Identify and interpret the structure and functions of cellular components including plasma membrane, cytoplasm, nucleus, nucleolus, cell wall, and plastids through microscopic observation and scientific documentation.	**K1**
CO2	Examine, compare, and evaluate the diversity of plant cells based on their size, shape, structure, and functional specialization.	**K2**
CO3	Analyze and interpret patterns of inheritance and mechanisms of gene action and evaluate their significance in genetics and plant improvement.	**K3**
CO4	Apply biometric and statistical tools, including computer-based applications, to analyze, interpret, and solve biological problems using scientific data.	**K4**
CO5	Assess and evaluate the importance of conservation strategies for economically important plants and analyze their role in sustainable utilization and 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**
V		**Morphology and Economic Botany, Genetics, Biostatistics and Evolution, Cell and Molecular Biology, Taxonomy of Angiosperms (Practical)**							**5**		**4**
Course Outcomes	**Programme Outcomes (POs)**										**Mean Score**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	
CO1	2	3	3	3	3	1	1	2	3	1	**2.2**
CO2	2	3	3	3	2	1	1	2	2	1	**2.0**
CO3	2	3	3	3	3	1	2	3	2	1	**2.3**
CO4	2	3	3	3	3	2	2	3	3	1	**2.5**
CO5	2	3	2	2	3	1	3	3	2	1	**2.2**
Mean Overall Score											**2.24 (High)**

Year: Third **CORE COURSE 9** **Semester: VI**

Code: **PLANT PHYSIOLOGY AND BIOCHEMISTRY (Theory)** **Credits: 4**

COURSE OBJECTIVES:

- To understand the physico -chemical organization and functional aspects of plants.
- To differentiate the C3 and C4 pathway to know about the nutrition requirements.
- To analyse the respiration, nitrogen metabolism and growth regulator.
- To understand the structure and properties of biomolecules.
- To compare the structure and classification of carbohydrate and protein.

UNIT I PLANT PHYSIOLOGY:

Molecular structure and properties of water. Diffusion and osmosis-osmotic pressure, turgor pressure and significance of osmosis. Plasmolysis and its importance. Mechanism of absorption of water passive and active absorption. Ascent of sap-theories on absorption. Absorption, mechanism and transport of mineral salts. Transpiration-types, mechanism, significance, factors affecting transpiration and guttation.

UNIT II PLANT PHYSIOLOGY:

Photosynthesis: photosynthetic apparatus and pigment system, Emerson Enhancement Effect and two pigment systems, antenna complexes and reaction centres, Photosynthetic electron transport system and its mechanism, photo phosphorylation and types- cyclic, non-cyclic, and significance. Path way of carbon, Co_2 fixation-C_3, C_4 and CAM plants.

UNIT-III PLANT PHYSIOLOGY:

Respiration: Glycolysis, Krebs cycle and electron transport chain- Cyanide resistant respiration pathway- Gluconeogenesis. Photoperiodism- classification of plants and mechanism of flowering- phytochrome and its action on flowering- Vernalization mechanism and their practical application. Plant senescence and fruit ripening and their biochemical mechanism.

UNIT-IV 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 V 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. Lipids –classification and general properties- structure of fatty acids- alpha and beta oxidation-secondary metabolites- Phenols-Terpenoids-Porphyrins-Alkaloids and Flavonoids.

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

Current developments related to the Plant physiology and Biochemistry 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. Panda, S. K, 2005. Advances in Stress Physiology of plants, scientific publishers India, Jodhpur.
2. Rajeshwari, M. R. (2012) - Biophysics, Rastogi Publications, Meerut.

Reference Books:

1. Lincoln Taiz and Eduardo Zeiger, 2005. Plant Physiology Sinauer Associates Inc. Publishers,
   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. Jain, J. L., Sunjay Jain and Nitin Jain, 2007. Fundamentals of Biochemistry, S. Chand & Co
   New Delhi.
5. Hans - Walter. Headt, 1997. Plant Biochemistry and Molecular Biology. Oxford University press, 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 and evaluate plant–water relations and interpret their influence on major physiological processes including absorption, transport, transpiration, and water balance in plants.	**K1**
CO2	Examine and evaluate the mechanisms, regulation, and significance of photosynthesis and respiration in plant growth, productivity, and energy metabolism.	**K2**
CO3	Investigate and assess the role of essential plant nutrients and evaluate the physiological and biochemical consequences of nutrient deficiencies in plants.	**K3**
CO4	Analyze and evaluate the biological functions of plant growth regulators, carbohydrates, proteins, lipids, nucleic acids, and enzymes and assess their significance in plant growth, development, and metabolism.	**K4**

CO5	Interpret and evaluate the mechanisms of seed dormancy and germination and assess their ecological, agricultural, and physiological significance in plant establishment and crop production.	**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**
VI				**Plant Physiology and Biochemistry (Theory)**						**5**	**4**
Course Outcomes	**Programme Outcomes (POs)**										**Mean Score**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	
CO1	1	3	3	3	3	1	2	2	2	1	**2.1**
CO2	1	3	3	3	3	1	2	2	2	1	**2.1**
CO3	1	3	3	3	3	1	2	3	2	1	**2.2**
CO4	1	3	3	3	3	1	2	3	3	1	**2.3**
CO5	1	3	3	3	3	1	3	3	2	1	**2.3**
Mean Overall Score											**2.2 (High)**

Year: Third **CORE COURSE 10** **Semester: VI**

Code: **PLANT BIOTECHNOLOGY (Theory)** **Credits: 4**

COURSE OBJECTIVES:

- To employ knowledge on plant tissue culture and its application commercially.
- To expertise the skills on plant tissue culture techniques.
- To state the significance of Recombinant DNA Technology in crop improvement.
- Recognize vectors and gene manipulation techniques in plant biotechnology.
- To devise research in the cutting-edge areas of genetic manipulation and production of transgenic plants.

UNIT I BIOTECHNOLOGY:
Biotechnology - Definition, Scope, Importance and interdisciplinary areas of Biotechnology - Introduction to plant tissue culture - Concept of totipotency and pluripotency - sterilization techniques - solid & liquid medium (MS medium, Whites medium) - callus and cell suspension culture.

UNIT II MICROPROPAGATION:
Micropropagation - stages of micropropagation - applications - meristem culture - somatic embryogenesis - principle and applications of soma clonal variation & cryopreservation.

UNIT III HAPLOID PRODUCTION:
Haploid production - anther culture - pollen culture - embryo culture and rescue - protoplast isolation, fusion and culture - somatic hybridization - cybrids - synthetic seeds.

UNIT-IV GENE TRANSFER:
Plasmids - General account, Plasmid as a vector - pBR 322, Ti and Ri plasmids. Cosmids and phagemids. Gene Transfer in Plants: Agrobacterium mediated transformation, Direct DNA Transformation - Biolistics, Lipofection, Electroporation, Microinjection and Protoplast Transformation. Gene Cloning - PCR technique - Blotting techniques - Southern, Northern and Western blotting.

UNIT V TRANSGENIC PLANTS:
Production of transgenic plants - disease resistant (Bt cotton) - herbicide resistant (round up soya) - golden rice - Flavr savr tomato - Transgenic plants as bioreactors - Edible vaccines - Plant bodies - Intellectual Property Rights (IPR) - Patenting.

UNIT VI CURRENT CONTOURS (For Continuous Internal Assessment Only):
Current developments related to the Plant 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. Chawla H.S., 2000. Introduction to Plant Biotechnology, Oxford & IBH Publishing Co. Pvt. Ltd,
New Delhi.
2. Ramawat, K.G., 2001. Plant Biotechnology, S.Chand & Company Ltd, New Delhi.
3. Satyanarayana, U., 2005. Biotechnology. Books and Allied (P) Ltd., Kolkata.
4. Kumaresan,V. 2001 - Biotechnology, Saras Publications, Nagercoil.
5. Ignacimuthu, S.J. (2003). Plant Biotechnology. Oxford & IBH Publishing, New Delhi.
6. Gupta, P.K. 2005 Elements of Biotechnology. Rastogi Publications Meerut.

Reference Books:

1. Street H. E., 1977. Plant tissue culture, Blackwell Scientific Publications, London.
2. Trigiano R.N. and Gray D.J., 1996. Plant tissue culture - concepts and laboratory exercises.
CRC Press, New York.
3. John Jothi Prakash, E. (2005). Outlines of Plant Biotechnology. Emkay Publishers, New Delhi.
4. Dubey, R.C., (2001). A text book of biotechnology. S. Chand & Co., New Delhi.
5. Trivedi, P.C. 2000. Plant Biotechnology, Panima Publishing Corporation, New Delhi.
6. Lewin, B. 2003. Genes VI, Allied Publishers, Chennai.
7. Singh B.D. 2003 Biotechnology Expanding Horizons. Kalyani publishers Ludhiana.

Web Resources:

1. http://www.freebookcentre.net/Biology/BioTechnology-Books.html
2. https://books.google.co.in/books/about/Introduction_to_Plant_Biotechnology.html?id=RgQLISN8zT8C
3. https://www.kobo.com/us/en/ebook/plant-biotechnology-1

COURSE OUTCOMES:

Course Outcomes	On successful completion of this course, the students will be able to	Cognitive Levels
CO1	Explain and evaluate the fundamental principles, tools, and applications of plant biotechnology and genetic engineering in modern plant sciences.	**K1**
CO2	Examine and interpret the mechanisms of transcription, protein synthesis, and post-translational modifications and assess their significance in gene expression and cellular function.	**K2**
CO3	Investigate and evaluate gene cloning strategies and various gene transfer methods and assess their applications in crop improvement and biotechnology research.	**K3**
CO4	Analyze and evaluate the principles, applications, benefits, and biosafety concerns associated with transgenic technology in agriculture, industry, and environmental management.	**K4**
CO5	Apply and evaluate different plant tissue culture techniques and assess their role in plant propagation, conservation, genetic improvement, and commercial production.	**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**
VI				**Plant Biotechnology (Theory)**						**5**	**4**
Course Outcomes	**Programme Outcomes (POs)**										**Mean Score**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	
CO1	1	3	3	2	3	1	2	2	2	1	**2.0**
CO2	1	3	3	3	3	1	2	2	2	1	**2.1**
CO3	1	3	3	3	3	1	2	3	3	1	**2.3**
CO4	1	3	3	3	3	1	3	3	2	1	**2.3**
CO5	1	3	3	3	3	2	3	3	3	1	**2.5**
Mean Overall Score											**2.24 (High)**

Year: Third **CORE PRACTICAL 6** **Semester: VI**

Code: **PLANT PHYSIOLOGY AND BIOCHEMISTRY, PLANT BIOTECHNOLOGY (Practical)** **Credits: 4**

COURSE OBJECTIVES:

- To determine the chlorophyll, carotenoids and protein.
- To estimate the lipid, reducing sugar and amino acids by ninhydrin method.
- To understand the separation techniques.
- To acquire knowledge on electrophoretic apparatus.
- To understand the steps involved in Genetic Engineering.

PLANT PHYSIOLOGY

1. Determination of osmotic pressure of Onion/Rheo leaf.
2. Effect of light intensity on transportation using Ganong's photometer.
3. Measurement of respiration rate using germinating seeds and flower buds with simple respiroscope.
4. Measurement of oxygen evaluation under direct sunlight using Wilmott's bubbler.
5. Measurement of oxygen evaluation under different colours using Wilmott's bubbler.
6. Separation of plant pigments by paper Chromatography.
7. Determination of photosynthetic rate in water plants under different CO_2 Concentrations.
8. Demonstration- Hill reaction.

BIOCHEMISTRY

1. Colorimetric estimation of sugars.
2. Gravimetric estimation of starch.
3. Extraction and estimation of lipids.
4. Separation of dyes by paper/TLC methods.
5. Estimation of protein by Lowry's method.

PLANT BIOTECHNOLOGY

1. To apply knowledge in tissue culture techniques (media preparation, callus induction, etc.)
2. To employ the tools and techniques in genetic engineering.

DEMONSTRATION:

1. Osmosis.
2. Ganong's Light Screen.
3. Anaerobic Respiration.
4. Fermentation.
5. Lever Auxanometer.
6. Clinostat.

Recommended Textbooks:

1. Taiz L and Zeiger E. Plant physiology (Second edition). The Benjamin/Cummings publishing company, Inc., California, New York, 1998.

2. Jain VK. Fundamentals of Plant Physiology (14th Ed), S. Chand and Company Ltd, New Delhi, 2012.
3. Jain JL. Jain S and Jain N. Fundamentals of Biochemistry. S. Chand and Company Ltd., New Delhi, 2008.
4. Narayanan P. Essentials of Biophysics, New Age International Publishers (P) Ltd., New Delhi, 2000.
5. Stryer,L. Biochemistry, W. H. Freeman and Co., New York, 1989.

Web Resources:

1.https://uou.ac.in/sites/default/files/slm/BSCBO-203.pdf
2.https://uou.ac.in/sites/default/files/slm/BSCBO-303.pdf

COURSE OUTCOMES:

Course Outcomes	On successful completion of this course, the students will be able to	Cognitive Levels
CO1	Perform and interpret the estimation of water content, chlorophyll, carotenoids, and phenolic compounds using standard biochemical techniques.	**K1**
CO2	Apply quantitative biochemical methods to estimate lipids, reducing sugars, and amino acids and evaluate the significance of the results in plant metabolic studies.	**K2**
CO3	Demonstrate and evaluate the principles, applications, and effectiveness of various separation techniques used in biochemical and molecular investigations.	**K3**
CO4	Apply electrophoretic techniques to separate and analyze biomolecules and interpret the resulting data for biological and biotechnological applications.	**K4**
CO5	Analyze and evaluate the experimental procedures, tools, and applications involved in genetic engineering and molecular 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**	
VI				**Plant Physiology and Biochemistry, Plant Biotechnology (Practical)**				**5**		**4**	
Course Outcomes	**Programme Outcomes (POs)**										**Mean Score**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	
CO1	2	3	3	3	3	1	1	2	3	1	**2.2**
CO2	2	3	3	3	3	1	1	2	3	1	**2.2**
CO3	2	3	3	3	3	1	2	2	3	1	**2.3**
CO4	2	3	3	3	3	1	2	3	3	1	**2.4**
CO5	2	3	3	3	3	1	2	3	3	1	**2.4**
Mean Overall Score											**2.3 (High)**

Year: Third **CORE PROJECT WORK** **Semester: VI**

Code: **Credits: 4**

COURSE OBJECTIVES:

The candidate shall be required to take up a Project Work by group or individual and submit it at the end of the final year. The Head of the Department shall assign the Guide who, in turn, will suggest the Project Work to the students in the beginning of the final year. A copy of the Project Report will be submitted to the University through the Head of the Department on or before the date fixed by the University.

The Project will be evaluated by an internal and an external examiner nominated by the University. The candidate concerned will have to defend his/her Project through a Viva-voce.

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 / Organisation 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)

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 successful completion of this course, the students will be able to**	**Cognitive Levels**
CO1	Identify, formulate, and investigate a research problem in Botany through a comprehensive review of relevant scientific literature.	**K1**

CO2	Design and execute appropriate experimental, field-based, or survey methodologies for the collection and analysis of scientific data.	**K2**
CO3	Apply scientific reasoning, analytical techniques, and statistical tools to interpret data and draw valid conclusions from research findings.	**K3**
CO4	Evaluate research outcomes, propose evidence-based solutions to biological problems, and relate findings to contemporary issues in plant sciences.	**K4**
CO5	Prepare and present a scientific project report and communicate research findings effectively through written documentation, presentations, and discussions while demonstrating professional ethics and lifelong learning skills.	**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**
VI				**Core Project Work (Practical)**					**6**		**4**
Course Outcomes	**Programme Outcomes (POs)**										**Mean Score**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	
CO1	2	3	3	2	2	3	1	2	3	2	**2.3**
CO2	2	3	3	3	3	3	1	3	3	2	**2.6**
CO3	2	2	3	3	3	2	1	3	3	2	**2.4**
CO4	2	2	3	3	3	2	3	3	2	2	**2.5**
CO5	3	2	2	2	2	3	2	2	3	3	**2.4**
Mean Overall Score											**2.44 (High)**

SKILL ENHANCEMENT COURSE

Code: 1. BIODIVERSITY AND CLIMATE CHANGE (Theory) Credits: 2

COURSE OBJECTIVES:

- To understand the fundamentals and importance of biodiversity.
- To acquire knowledge about climate change and various treaties significance.
- To understand techniques conservation methods.
- To apply their skill to manage various types of pollution.
- To analyse the various ecological regions and their significance
-

UNIT I BIODIVERSITY:

Types of biodiversity: Genetic, species, and ecosystem diversity. Endemism and biodiversity hotspots: Criteria and hotspots of India.

UNIT II CLIMATE CHANGE AND CARBON MANAGEMENT:

Global warming and anthropogenic climatic consequences: climate crisis, greenhouse effect, ozone depletion and acid rain. Carbon emissions: Causes, consequences and mitigation. Role of carbon credits and carbon sequestration. Blue carbon and alternative energy sources. Climate conferences: CoP, IPCC and UNFCCC.

UNIT III CONSERVATION STRATEGIES:

Natural resource conservation: *In situ* and *Ex situ* approaches. Seed banks and conservation of genetic resources: Importance and applications. Deforestation consequences. Indigenous conservation practices. Sacred groves and their role in biodiversity conservation.

UNIT IV POLLUTION AND ENVIRONMENTAL TOXICOLOGY:

Types of pollution: Air, water, soil, noise, radioactive and thermal pollution. Primary vs. secondary pollutants. Eutrophication. Environmental toxicology: Pesticides, heavy metals and persistent organic pollutants (POPs). Microplastics and emerging pollutants

UNIT V PHYTOGEOGRAPHY:

Vegetation regions of India: Classification and characteristics. Plant indicators and their ecological significance. Island Biogeography and diversification of land plants. Classification of indigenous ecological zones.

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

Students survey a local area (campus, park, roadside) and document plant species. Analyse how temperature rise or rainfall variability affects plant diversity. Create a mini herbarium collection. Conduct a simple experiment on plant growth under different conditions. Study one invasive plant species.

Recommended Textbooks:

1. Kormondy, E.J. (2017). *Concepts of Ecology*. Prentice Hall, U.S.A. 4th edition.
2. Krishnamurthy K.V. (2003) Text book of biodiversity. Science publishers, USA

Reference Books:

1. Sharma, P.D. (2010). *Ecology and Environment*. Rastogi Publications, Meerut, India. (8th edition).
2. Eugene Odum, (2017). *Fundamentals of Ecology* (5th Ed). Cengage, Bengaluru.
3. Sharma P.D. (2019). *Plant ecology and phytogeography*, Rastogi Publications, Meerut.
4. Alexander von Humboldt, AimeBonpl and, Stephen T. Jackson (eds.) (2013). *Essay on the Geography of Plants*, University of Chicago Press.

Web Resources:

1. https://bio.libretexts.org/Bookshelves/Ecology/Environmental_Science_(Ha_and_Schleiger)/02%3A_Ecology/2.04%3A_Ecosystems/2.4.03%3A_Biogeochemical_Cycles
2. https://www.agritech.tnau.ac.in/agriculture/agri_min_nutri_plantsampling.html
3. https://www.ipcc.ch/

COURSE OUTCOMES:

Course Outcomes:	On successful completion of this course, the students will be able to	Cognitive Levels
CO1	Explain and evaluate the concepts, components, values and significance of biodiversity and assess its role in ecosystem stability and sustainable development.	**K1**
CO2	Examine and evaluate the causes, mechanisms, and impacts of climate change on biodiversity, ecosystems, agriculture, and human well-being.	**K2**
CO3	Assess various in-situ and ex-situ conservation strategies and evaluate their effectiveness in biodiversity conservation and sustainable resource management.	**K3**
CO4	Investigate, analyze, and evaluate different types of environmental pollution, their ecological consequences, and appropriate management strategies.	**K4**
CO5	Assess and interpret the characteristics of major vegetation regions and evaluate their ecological significance, biodiversity value, and contribution to environmental sustainability.	**K5**

Mapping with POs:

Relationship Matrix											
Semester	**Course Code**	**Title of the Course**							**Hours**	**Credits**	
II		**1. Biodiversity and Climate Change (Theory)**							**2**	**2**	
Course Outcomes	**Programme Outcomes (POs)**										**Mean Score**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	
CO1	1	3	3	2	3	2	3	2	2	1	2.2
CO2	1	3	3	3	3	1	3	3	2	2	2.4
CO3	2	3	3	3	3	1	3	3	2	1	2.4
CO4	1	3	3	3	3	2	3	3	3	1	2.5
CO5	1	3	3	3	2	1	3	2	2	2	2.2
Mean Overall Score											**2.34 (High)**

SKILL ENHANCEMENT COURSE

Code: **2. INDUSTRIAL BIOTECHNOLOGY (Theory)** **Credits: 2**

COURSE OBJECTIVES:

- To understand the principles and scope of industrial biotechnology.
- To study industrially important microorganisms and fermentation processes.
- To learn upstream and downstream processing techniques used in industries.
- To understand the production of industrial products such as enzymes, antibiotics, organic acids, and biofuels.
- To gain knowledge on bioprocess applications, quality control, and recent trends in industrial biotechnology.

UNIT I INTRODUCTION TO INDUSTRIAL BIOTECHNOLOGY:
History and scope of industrial biotechnology - Isolation, screening and maintenance of industrially important microorganisms - Strain improvement methods -Types of culture media and sterilization techniques - Microbial growth kinetics

UNIT II FERMENTATION TECHNOLOGY:
Principles of fermentation technology - Types of fermenters and bioreactors - Batch, fed-batch and continuous fermentation - Aeration and agitation techniques - Instrumentation and process control in fermentation industries

UNIT III UPSTREAM AND DOWNSTREAM PROCESSING:
Upstream processing: inoculum preparation and media formulation - Scale-up of fermentation processes - Downstream processing methods - Cell disruption, filtration, centrifugation and solvent extraction -Product recovery and purification techniques

UNIT IV INDUSTRIAL PRODUCTION OF BIOPRODUCTS:
Production of industrial enzymes - Antibiotics – penicillin production - Organic acids – citric acid and lactic acid - Alcoholic beverages and ethanol production - Single cell protein and biofertilizers

UNIT V APPLICATIONS AND RECENT TRENDS:
Biotechnology in food and dairy industries - Biopolymers and biodegradable plastics - Biofuels and biogas technology - Environmental biotechnology and waste management - Recent advances in industrial biotechnology and biosafety regulations.

UNIT VI CURRENT CONTOURS (For Continuous Internal Assessment Only):
Current developments related to the Plant 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. Stanbury, P.F., Whitaker, A. and Hall, S.J. *Principles of Fermentation Technology*. Elsevier.
2. Crueger, W. and Crueger, A. *Biotechnology: A Textbook of Industrial Microbiology*. Panima Publications.
3. Casida, L.E. *Industrial Microbiology*. New Age International Publishers.
4. Patel, A.H. *Industrial Microbiology*. Macmillan India Ltd.

Reference Books:

1. Prescott, S.C. and Dunn, C.G. *Industrial Microbiology*. CBS Publishers.
2. Peppler, H.J. and Perlman, D. *Microbial Technology*. Academic Press.
3. Reed, G. *Industrial Microbiology*. CBS Publishers.
4. Shuler, M.L. and Kargi, F. *Bioprocess Engineering: Basic Concepts*. Prentice Hall.
5. Waites, M.J., Morgan, N.L., Rockey, J.S. and Higton, G. *Industrial Microbiology: An Introduction*. Wiley-Blackwell.

Web Resources:

1.https://www.ncbi.nlm.nih.gov/books/
2.https://ocw.mit.edu/

COURSE OUTCOMES:

Course Outcomes:	On successful completion of this course, the students will be able to	Cognitive Levels
CO1	Explain and evaluate the principles, techniques, and applications of industrial biotechnology and assess their role in sustainable industrial development.	**K1**
CO2	Examine and interpret fermentation processes and the design, operation, and optimization of industrial bioreactors for large-scale bioproduction.	**K2**
CO3	Apply and evaluate upstream and downstream processing techniques for the efficient production, recovery, purification, and quality assessment of industrial bioproducts.	**K3**
CO4	Investigate, analyze, and assess the production technologies of industrially important bioproducts and evaluate their economic, environmental, and commercial significance.	**K4**
CO5	Evaluate the recent advances, emerging technologies, ethical considerations, and innovative applications of industrial biotechnology in healthcare, agriculture, environmental management, and bio-based industries.	**K5 & K6**

Mapping with POs:

Relationship Matrix											
Semester	**Course Code**	**Title of the Course**								**Hours**	**Credits**
III		**2.Industrial Biotechnology (Theory)**								**2**	**2**
Course Outcomes	**Programme Outcomes (POs)**										**Mean Score**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	
CO1	2	3	3	2	3	2	2	2	2	2	**2.3**
CO2	2	3	3	3	3	2	2	2	3	2	**2.5**
CO3	2	3	3	3	3	2	2	3	3	2	**2.6**
CO4	2	3	3	3	3	2	3	3	3	2	**2.7**
CO5	2	3	3	3	3	2	3	3	2	3	**2.7**
Mean Overall Score											**2.56 (High)**

SKILL ENHANCEMENT COURSE

Code: **3. SEED TECHNOLOGY** **Credits: 2**
(Theory)

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 AND MORPHOLOGY:
Seed development (sporogenesis, fertilization, embryogenesis and 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.

UNIT III SEED GERMINATION AND VIGOUR:
Seed germination – Introduction and 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.

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.

UNIT V HYBRID SEED PRODUCTION:
Heterosis: definition, expression and estimation of hybrid vigour; utilization of heterosis in agricultural, horticultural and other crop plants for crop improvement. Pre requisites for hybrid seed production; mechanisms and management of 48 pollination in autogamous and allogamous crops; genetic constitution of varieties, hybrids and basic principles in seed production.

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 and Bhatnagar SP. 1999. The embryology of Angiosperm. Vikas publications.

2. Copeland LO and 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 and Longevity. International Books and Periodicals Supply Service. New Delhi.
3. Justice OL and 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 and 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. ttps://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	Examine and evaluate the principles, scope, and significance of seed technology and assess its role in crop improvement, agricultural productivity, and sustainable agriculture.	**K1**
CO2	Apply and evaluate scientific methods involved in seed production, processing, storage, and handling to ensure the availability of high-quality seeds.	**K2**
CO3	Investigate and assess the physiological, genetic, and environmental factors influencing seed vigour and evaluate their impact on seed performance and crop establishment.	**K3**
CO4	Analyze and apply seed testing procedures and quality control measures to evaluate seed purity, viability, germination, and certification standards.	**K4**
CO5	Examine, evaluate, and apply the principles and techniques of hybrid seed production, maintenance, and quality assurance for enhancing crop productivity and genetic purity.	**K5**

Mapping with POs:

Relationship Matrix											
Semester	**Course Code**			**Title of the Course**						**Hours**	**Credits**
IV				**3.Seed Technology (Theory)**						**2**	**2**
Course Outcomes	**Programme Outcomes (POs)**										**Mean Score**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	
CO1	1	3	3	2	3	1	3	2	2	1	**2.1**
CO2	1	3	3	3	3	2	2	3	3	1	**2.4**
CO3	1	3	3	3	3	1	2	3	2	1	**2.2**
CO4	1	3	3	3	3	2	2	3	3	1	**2.4**
CO5	1	3	3	3	3	2	2	3	3	2	**2.5**
Mean Overall Score											**2.32 (High)**

SKILL ENHANCEMENT COURSE

Code: **4. HERBAL BOTANY** **Credits: 2**
(Theory)

COURSE OBJECTIVES:

- To employ the various Indian system of medicine
- To examine the drugs from various parts of plants
- To interpret the application of drugs
- To recognize the significance of plants in ethnobotanical practices
- To construct the interrelationship of humans and plants.

UNIT I HISTORY OF HERBAL MEDICINE:
Classification of medicinal plants and their types – Indian system of medicine – Siddha, Ayurveda and Unani Systems.

UINIT II PHYTOTOXINS:
Phytotoxins - Types – mode of action – list of toxin rich plants –and their toxicity (Nux-vomica, *Opium*, *Abrus*, *Nicotiana*)

UNIT III ACTIVE PRINCIPLES IN PARTS OF HERBAL PLANTS:
Leaves - *Murraya*, *Mentha*, *Solanum nigrum*; Flower- *Hybanthes*, *Eugenia*; Fruits; *Annona*, *Psidium Guajava*: Seeds -*Terminalia chebula*, *Terminalia bellerica*; Plant as a whole. *Centella*, *Andrographis paniculata*; Root - *Withania somnifera*

UNIT IV NATURAL DRUGS:
Phytoconstituents and medicinal importance of *Aloe, Atropa, Acorus Calamus, Alpinia* and *Cinchona*.

UNIT V METHOD OF DRUG ACTION:
Central nervous system - drug used in disorders of Gastro - intestinal tracts- Cardio vascular diseases, Urogenital systems and Psycho– active plants.

UNIT VI CURRENT CONTOURS (For Continuous Internal Assessment Only):
Current developments related to the Herbal 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. Jain, 2001 Medicinal plants. National Book Trust, New Delhi
2. L Gokhale S.M, M.C.K. Kokate and A.P. Purohit Pharmacognosy, Nirali Prakashan
3. Agarwal,1985. Drug plants in India, Kalyani Publishers, Ludhiana
4. Bhattacharya, S.K. 1988 Hand book of medicinal plants. Pointer publishers, Jaipur.

Reference Books:
1. Acharya Vipul Rao - Herbs- that heal Diamond Pocket Books Pvt. Ltd., New Delhi
2. An introduction to Medicinal Botany and Pharmacognosy - N. C. Kumar, Emkay Publications, New Delhi, 2004.

3. Indian Medicinal Plants (Vol. I - V) K. R Kirtikar and B. D. Basu 1975.

Web Resources:

1.https://books.google.co.in/books/about/A_Text_Book_Of_Medicinal_Botany.html?id=vg8MEQAAQBAJ&redir_esc=y

2.https://repo.upertis.ac.id/1889/1/Encyclopedia%20Of%20Herbal%20Medicine.pdf

3.https://www.walnutpublication.com/book/9788119232550/?srsltid=AfmBOooH_m7XWJn2h8NVucPmLmHup8Xx_vsPajjuwDWKHB8ryFBkaJ7j

COURSE OUTCOMES:

Course Outcomes	On successful completion of this course, the students will be able to	Cognitive Levels
CO1	Analyze and evaluate the fundamental principles, scope, and significance of herbal botany and medicinal plant resources in healthcare and sustainable development.	**K1**
CO2	Identify, examine, and assess the characteristics, therapeutic properties, and utilization of commonly used medicinal plants and their economic importance.	**K2**
CO3	Investigate and evaluate the medicinal applications of plant-derived drugs used in the prevention and treatment of various human disorders.	**K3**
CO4	Analyze and assess the importance of natural drugs and evaluate their role in traditional medicine, modern healthcare, and pharmaceutical industries.	**K4**
CO5	Evaluate the mechanisms of drug action, efficacy, and therapeutic significance of plant-based medicines and assess their applications in disease management.	**K5**

Mapping with POs:

Relationship Matrix											
Semester	**Course Code**			**Title of the Course**					**Hours**	**Credits**	
V				**4. Herbal Botany (Theory)**					**2**	**2**	
Course Outcomes	**Programme Outcomes (POs)**										**Mean Score of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	
CO1	1	3	3	2	3	1	3	2	2	1	**2.1**
CO2	1	3	3	3	3	1	2	2	2	1	**2.1**
CO3	1	3	3	3	3	1	2	3	2	1	**2.2**
CO4	1	3	3	3	3	1	3	3	2	1	**2.3**
CO5	1	3	3	3	3	1	2	3	3	1	**2.3**
Mean Overall Score											**2.2 (High)**

SKILL ENHANCEMENT COURSE

Code: **5. CLINICAL MICROBIOLOGY (Theory)** **Credits: 2**

COURSE OBJECTIVES:

- To understand the scope and importance of clinical microbiology.
- To learn about pathogenic microorganisms affecting humans.
- To gain knowledge of disease transmission and prevention.
- To develop basic laboratory diagnostic skills.
- To understand antimicrobial agents and resistance.

UNIT I FUNDAMENTALS OF CLINICAL MICROBIOLOGY:
Definition, scope, and importance. Contributions of Louis Pasteur and Robert Koch, Normal microflora and Infection types and transmission.

UNIT II BACTERIOLOGY:
Morphology and classification, Pathogenic bacteria (*E. coli*, *Salmonella*, *Vibrio*), Sterilization and disinfection, Staining techniques (Gram staining), Culture media.

UNIT III VIROLOGY & MYCOLOGY:
Virus structure and classification, Viral diseases (influenza, hepatitis, HIV), Fungal morphology and classification, Mycoses and antifungal agents.

UNIT IV PARASITOLOGY & IMMUNOLOGY:
Protozoan diseases (malaria, amoebiasis), Helminths, Immune system basics, Antigen–antibody reactions, Vaccines Production.

UNIT V DIAGNOSTICS & ANTIMICROBIAL THERAPY:
Sample collection, Diagnostic methods (microscopy, culture, serology), Antibiotics and mechanisms, antimicrobial resistance (AMR), Infection control.

UNIT VI CURRENT CONTOURS (For Continuous Internal Assessment Only):
Current developments related to the Clinical Microbiology 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.Paniker C.K.J (2005) *Textbook of Microbiology*. Orient and Longman, Hyderabad.
2.Jawetz, Melnick and Adelberg (2025) *Medical Microbiology, McGraw Hill Publishing Company,* 28th Edition.
3.Joanne Willey, Linda Sherwood, and Christopher Woolverton. Prescott – *Microbiology* (2020). McGraw-Hill Education

Reference Books:
1.Dubey R Cand Maheshwari DK. (2004). *A text book of microbiology*. S. Chand New Delhi.
2.Pelczar J Chan ECS and Krieg, R. (1999). *Microbiology*, Tata McGraw Hill, New Delhi.

3.Sullia S Band Shantharam S (2005). *General microbiology*. Oxford & IBH

Web Resources:

- NCBI Bookshelf – Free microbiology and medical books
- World Health Organization (WHO) – Disease updates and guidelines
- Centres for Disease Control and Prevention (CDC) – Clinical case studies
- Khan Academy Health & Medicine – Concept videos

COURSE OUTCOMES:

Course Outcomes	On successful completion of this course, the students will be able to	Cognitive Levels
CO1	Explain and evaluate the fundamental principles, scope, and applications of clinical microbiology in disease diagnosis, prevention, and healthcare management.	**K1**
CO2	Identify, classify, and assess disease-causing microorganisms based on their morphological, physiological, and pathogenic characteristics and evaluate their clinical significance.	**K2**
CO3	Investigate and analyze host–pathogen interactions, mechanisms of pathogenicity, and disease progression and evaluate their impact on human health.	**K3**
CO4	Apply and interpret microbiological diagnostic techniques for the detection, identification, and characterization of clinically important microorganisms.	**K4**
CO5	Analyze and evaluate the mechanisms of antimicrobial action, antimicrobial resistance, and strategies for effective infection control and disease management.	**K5**

Mapping with POs:

Relationship Matrix											
Semester	**Course Code**	**Title of the Course**							**Hours**		**Credits**
V		**5. Clinical Microbiology (Theory)**							**2**		**2**
Course Outcomes	**Programme Outcomes (POs)**										**Mean Score**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	
CO1	1	3	3	2	3	1	2	2	2	1	**2.0**
CO2	1	3	3	3	3	1	2	2	3	1	**2.2**
CO3	1	3	3	3	3	1	2	3	2	1	**2.2**
CO4	1	3	3	3	3	2	2	3	3	1	**2.4**
CO5	1	3	3	3	3	1	3	3	3	2	**2.5**
Mean Overall Score											**2.26 (High)**

SKILL ENHANCEMENT COURSE

Code: **6. BIOLOGICAL TECHNIQUES (Theory)** **Credits: 2**

COURSE OBJECTIVES:

- To understand the principle, operation and maintenance of various tools/equipments 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, analyse and evaluate data generated 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 that they would help students gain confidences to instantly commence research careers and/or start entrepreneurial ventures.

UNIT I PRINCIPLES AND TYPES OF MICROSCOPY:
Basic principles of Light microscope – Compound microscope, Phase contrast microscope, Scanning and Transmission Electron microscopes. Micrometry. Hemocytometer.

UNIT II SECTIONING AND STAINING TECHNIQUES:
Microtechnique – preparation for microscopic slides – Whole mount, Smears, Squash. Microtomy: Fixation, Dehydration, Infiltration, Embedding, Sectioning. Stains and Staining techniques – Simple, double and compared staining.

UNIT III TECHNIQUES OF SEPARATION:
Centrifugation: Principles, components, mechanism and application of clinical, Refrigerated and ultracentrifuge.

UNIT IV PRINCIPLES OF CHROMATOGRAPHY:
Chromatography: Basic principles, types – Paper, Column, Thin layer. Electrophoresis (SDS
–PAGE). Blotting techniques – Southern, Northern and Western Blotting.

UNIT V ANALYSIS OF SPECTRA:
Principle and Application of Colorimetry and Spectrophotometer. Basic principles of pH meter and its applications.

UNIT VI CURRENT CONTOURS (For Continuous Internal Assessment Only):
Current developments related to the biological techniques 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. Sharma, V.K. 1991. Techniques in microscopy and cell biology, Tata McGraw Hill, New Delhi.

2. Sawhney, S.K and Randhir Singh. 2000. Introductory practical biochemistry, Narosa Publishing House.
3. Asokan, P. 2001. Basics of analytical biochemistry. Chinna Publications.
4. Bajpai, P.K. 2006. Biological instrumentation and methodology. S. Chand & Company, New Delhi.
5. Veerakumari, L. 2009. Bioinstrumentation. MJP Publications.

Reference Books:

1.Patki L.R, Bhalchandra B.L, Jeevaji I.H. (1987). An introduction to Microtechnique, S.Chand and company (Pvt)ltd, New Delhi
2.Marimuthu, R. (2008). Microscopy and Micro technique. MJP Publishers, Chennai Wilson K, Walker, J. (1994). Principle and techniques of practical biochemistry,4th ed) Cambridge university press, Cambridge
3.Palanivelu P (2013). Analytical Biochemistry and Separation techniques, 20th century publications, Palkalai Nagar, Madurai
4.Plummer DT (2003). An introduction to practical Biochemistry. 3rd Edn. Tata McGraw Hill Publishing Company Ltd. New Delhi

Web resources:

1.https://epdf.tips/biotechnology-a-laboratory-course.html
2.https://www.amazon.in/Bioinstrumentation-Webster/dp/8126513691

COURSE OUTCOMES:

Course Outcomes:	On successful completion of this course, the students will be able to	Cognitive Levels
CO1	Explain and evaluate various biological techniques and assess their applications and significance in biological research, diagnostics, and scientific investigations.	**K1**
CO2	Examine and evaluate the principles, instrumentation, and applications of light, compound, fluorescence, and electron microscopy in biological studies.	**K2**
CO3	Apply appropriate strategies for scientific data collection, analysis, interpretation, and effective dissemination of research findings using modern research tools and methodologies.	**K3**
CO4	Compare, analyze and evaluate different chromatographic techniques and assess their effectiveness in the separation, identification, and quantification of biological compounds.	**K4**
CO5	Design, apply, and evaluate methodologies for the extraction, purification, and analysis of biochemical compounds using standard laboratory and analytical techniques.	**K5**

Mapping with POs:

Relationship Matrix											
Semester	**Course Code**	**Title of the Course**							**Hours**	**Credits**	
VI		**6.Biological Techniques (Theory)**							**2**	**2**	
Course Outcomes	**Programme Outcomes (POs)**										**Mean Score**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	
CO1	2	3	3	2	3	1	2	2	3	1	**2.2**
CO2	2	3	3	3	3	1	2	2	3	1	**2.3**
CO3	3	3	3	3	3	2	2	3	3	2	**2.7**
CO4	2	3	3	3	3	1	2	3	3	1	**2.4**
CO5	2	3	3	3	3	2	2	3	3	2	**2.6**
Mean Overall Score											**2.44 (High)**

SKILL ENHANCEMENT COURSE

Code: 7. AGRI BASED BIO-ENTREPRENEURSHIP (Theory) Credits: 2

COURSE OBJECTIVES:

- To introduce the scope and significance of bio-entrepreneurship in various biotech industries.
- To develop business planning and market analysis skills for biotech startups.
- To explore entrepreneurial opportunities and regulatory frameworks in the faunal sector.
- To understand innovations in bioproducts and their market potential.
- To familiarize students with funding opportunities and intellectual property rights in biotechnology.

UNIT I BIO ENTREPRENEURSHIP:

Introduction of Bio entrepreneurship: Scope, Importance and Bio entrepreneurs in the biotech industry, Types of bio-based industries: Pharmaceuticals, Agriculture, Healthcare, Environmental, Emerging trends in the bio economy.

UNIT II BIO BUSINESS:

Bio Business Planning & Market Analysis: Biotech Start-ups in India, Identifying target customers and market segmentation, Risk assessment and mitigation strategies, Patent laws and intellectual property rights (IPR).

UNIT III ENTREPRENEURIAL OPPORTUNITIES:

Entrepreneurial opportunities, Regulatory in faunal sector: Sustainable aquaculture and fisheries, Eco-friendly pest management and biological control, Wildlife photography and documentation business, Pet industry and veterinary services.

UNIT IV BIO PRODUCTS:

Bio products and Innovations: Gene therapy products, 3D bio printing, Sericulture and Apiculture Products: Silk and honey. Bioactive compounds from marine organisms, designing new biological parts (Synthetic Biology), Polymers derived from cornstarch (Bio plastic).

UNIT V FUNDING AGENCIES:

Funding openings in Biotech start-ups: Government funding (DBT, NABARD, DST,) NGOs and international conservation fund agencies (WWF, IUCN, UNEP), Loans for organic farming start-ups, Private investors and crowd funding for bio-businesses development.

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

Recommended Textbooks:

1. Arvind Kumar Bhatt, Ravi Kant Bhatia, and Tek Chand Bhalla (2020) Basic Biotechniques for Bioprocess and Bio-entrepreneurship, Elsevier Science & Technology, Amsterdam, Netherlands.
2. Dr. N. Yogananth, Dr. Sheeba E, Dr. T. Sivakumar, and Dr. R. Bhakyaraj **(**2022) *Bioentrepreneurship in Biosciences-Recent Approaches,* Darshan Publishers, Tamil Nadu, India.
3. Shreya Sanghvi Malik and Shiv Kant Shukla (2020) *Bioentrepreneurship Development: A Resource Book,* Biotech Consortium India Limited (BCIL), New Delhi, India

Reference Books:

1. Swati Agarwal, Sonu Kumari, and Suphiya Khan (2021*) Bioentrepreneurship and Transferring Technology into Product Development*, Business Science Reference, Hershey, Pennsylvania, USA.
2. Madhura N. Hegde, Jayapadmini Kanchan, Ganaraj K., Asha B. Shetty, and Rajatha (2021) *Bioentrepreneurship Globally*, IGI Global, Hershey, Pennsylvania, USA
3. Jyoti Gogte (2024) *Roadmap for an Entrepreneur*, Vishwakarma Publications, Pune, India.

Web Resources:

1.https://www.cbehx.co.uk/product/bioentrepreneurship/
2.https://ep.jhu.edu/courses/585761-bioentrepreneurship/
3.https://www.bizmove.com/start-business/biotech.htm
4.https://businessplan-templates.com/blogs/write-plan/biotech-startup-consulting

COURSE OUTCOMES:

Course Outcomes	On successful completion of this course, the students will be able to	Cognitive Levels
CO1	Apply biotechnology knowledge and entrepreneurial principles to analyze, design, and develop innovative solutions for biological, industrial, and societal challenges.	**K1**
CO2	Explain and evaluate bio-business opportunities using critical thinking, analytical tools, and strategic decision-making approaches to address complex biotechnology-related problems.	**K2**
CO3	Demonstrate effective communication, leadership, teamwork, and managerial skills in multidisciplinary environments for successful planning and execution of biotechnology enterprises.	**K3**
CO4	Evaluate ethical, legal, regulatory, environmental, and social issues associated with biotechnology enterprises and apply responsible practices in professional decision-making.	**K4**
CO5	Develop self-directed learning abilities and assess emerging trends, technologies, and innovations to support lifelong learning, entrepreneurship, and career advancement in the biotechnology sector**.**	**K5**

Mapping with POs:

Relationship Matrix											
Semester	**Course Code**	**Title of the Course**								**Hours**	**Credits**
VI		**7. Agri based Bio-entrepreneurship (Theory)**								**2**	
Course Outcomes	**Programme Outcomes (POs)**										**Mean Score**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	
CO1	2	3	3	3	3	2	2	3	2	2	2.5
CO2	2	3	3	3	3	2	2	3	3	2	2.6
CO3	3	2	2	2	2	3	2	2	2	2	2.2
CO4	2	2	3	2	3	2	3	2	2	2	2.3
CO5	2	2	2	2	2	3	2	2	2	3	2.2
Mean Overall Score											**2.36 (High)**

Year: First **INTERDISCIPLINARY COURSE 1** **Semester: I**

Code: **MUSHROOM CULTIVATION** **Credits: 2**
(Theory)

COURSE OBJECTIVES:

- To assess the history and scope of edible mushroom cultivation.
- To recognize the preparation of mother spawn in saline bottle.
- To analyse the infra structure of mushroom bed preparation.
- To learn the economic importance of mushroom in various fields.
- To examine the nutritive value of various types of mushrooms.

UNIT I INTRODUCTION:

Introduction – history and scope of edible mushroom cultivation – Types of edible mushrooms, medicinal and poisonous mushroom available in India – *Calocybe indica* and *Volvariella volvacea* - Nutritive value – proteins, amino acids, mineral elements, Carbohydrates, Crude fiber content and Vitamins.

UNIT II PURE CULTURE TECHNIQUES:

Preparation of medium (PDA and Oatmeal agar medium) - sterilization – preparation of test tube slants to store mother culture – culturing of *Pleurotus* mycelium on Petri plates, preparation of mother spawn in saline bottle and polypropylene bag and their multiplication.

UNIT III CULTIVATION TECHNOLOGY:

Design and infrastructure of mushroom farm – 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 HARVESTING TECHNOLOGY:

Storage: Short-term storage (Refrigeration – up to 24 hours) Long term Storage (canning, pickles, papads), drying, storage in salt solutions; Value added products from mushroom.

UNIT V FOOD PREPARATION:

Types of food prepared from mushroom; Soup, Cutlet, Omlette, Samosa, Curry, and Biriyani – Research Centers – National level and regional level – Cost benefit ratio – Marketing in India and abroad and Export value.

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

Growing edible mushrooms like *Calocybe indica* and *Volvariella volvacea* – to create your own seed or spawn using sorghum grains and wheat – Bed preparation using locally available substrates – waste to wealth – spent mushroom substrate – vermicomposting.

Recommended Textbooks:

1. Marimuthu, T., Krishnamoorthy, A.S., Sivaprakasam, K. and Jayaranjan, R., (1991). Oyster Mushrooms, Department of Plant Pathology, Tamil Nadu Agricultural University, Coimbatore
2. Swaminathan, M., (1960). Food and Nutrition. Bappco, The Bangalore Printing and Publishing Co. Ltd., No.88, Mysore Road, Bangalore 560 018.

3. Tewari, Pankaj Kapoor, S.C., (1988). Mushroom Cultivation, Mittal Publications, Delhi.
4. Nita Bahi (1984-1988). Handbook of Mushrooms, II Ed, Vol. I & II.
5. Paul Stamets, J.S and Chilton J.s (2004). Mushroom cultivation. A practical guide to graining mushroom at home Agarikon Press

Reference Books:

1. Tiwari.,SC., Pandey K. 2018.Mushroom cultivation. Mittal publisher, New Delhi.
2. Philips,G., Miles, Chang,S-T. 2004.Mushrooms: Cultivation, nutritional value, medicinal effect and environmental effect. 2nded. CRC Press.
3. Paul Stamets, J.S and Chilton J.s (2004). Mushroom cultivation. A practical guide to graining mushroom at home Agarikon Press.
4. Swaminathan, M., (1960). Food and Nutrition. Bappco, The Bangalore Printing and Publishing Co. Ltd., No.88, Mysore Road, Bangalore 560 018.

Web Resources:

1. https://en.wikipedia.org/wiki/Mushroom
2. http://nrcmushroom.org/book-cultivation-merged.pdf
3. https://www.agricultureinindia.net/cultivation/mushroom-cultivation/mushroom-cultivation-introductionclassification-steps-pests-and-diseases-agriculture/20733
4. https://beef2live.com/story-an-introduction-mushrooms-0-220270
5. https://www.techno-preneur.net/technology/project-profiles/food/mush-cult.html#:~:text=The%20basic%20raw%20material%20for,will%20be%20required%20for%20processing.
6. https://agricoop.nic.in/sites/default/files/ICAR_8.pdf

COURSE OUTCOMES:

Course Outcomes	On successful completion of this course, the students will be able to	Cognitive Levels
CO1	Explain and evaluate the morphology, diversity, classification, and economic significance of mushrooms and assess their role in food, health, and sustainable agriculture.	**K1**
CO2	Examine and evaluate the prospects, scope, and commercial potential of mushroom cultivation and assess its contribution to entrepreneurship and rural development	**K2**
CO3	Apply and evaluate techniques involved in mushroom production, including culture media preparation, spawn production, compost preparation, cultivation, and crop management.	**K3**
CO4	Assess and compare the cultivation requirements, production technologies, nutritional value, and economic importance of different edible and medicinal mushrooms.	**K4**
CO5	Analyze the economics, marketing strategies, and entrepreneurial opportunities in mushroom cultivation and develop sustainable business models for mushroom-based enterprises.	**K5**

Mapping with POs:

Relationship Matrix											
Semester	**Course Code**	**Title of the Course**								**Hours**	**Credits**
		1.MUSHROOM CULTIVATION (Theory)								**2**	**2**
Course Outcomes	**Programme Outcomes (POs)**										**Mean Score**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	
CO1	1	3	3	2	3	1	2	2	2	1	**2.0**
CO2	2	3	3	2	2	2	3	3	2	2	**2.4**
CO3	2	3	3	3	3	2	2	3	3	2	**2.6**
CO4	1	3	3	3	3	1	2	2	2	1	**2.1**
CO5	2	3	3	3	3	2	3	3	2	3	**2.7**
Mean Overall Score											**2.36 (High)**

Year: First **INTERDISCIPLINARY COURSE 2** **Semester: II**

Code: **HORTICULTURE AND LANDSCAPE GARDENING (Theory)** **Credits: 2**

COURSE OBJECTIVES:

- To know about the brief history, divisions, classification and structure of horticultural plants.
- To develop practical skills in lawn making techniques.
- To apply indoor and outdoor gardening and the techniques of flower decoration.
- To know the various types of horticultural garden practices.
- To apply knowledge about the landscape designing and its types

UNIT I HORTICULTURE:

Importance of scope of horticulture - Divisions of horticulture, famous gardens in world & India; Horticultural Crops - Conservation and Management. Post harvest Management of Horticultural Crops.

UNIT II HORTICULTURE:

Lawn making and maintenance, water garden, glass house, rockery, hanging baskets. Layout a model of Landscape design.

UNIT III PROPAGATION METHODS:

Nursery: Preparation of Nursery beds. Xeriscaping. Vegetative Propagation: Cutting, Layering, Grafting and Budding. Steps and Methods involved in Transplantation. Bonsai, Terrarium and Topiary techniques. Floriculture: Dry and wet flower decoration.

UNIT IV GARDENING:

Gardening; Designing outdoor garden-hedges, edges, fences, terrace garden, fruit garden, Vegetable Garden: Tomato, brinjal, and snake guard, Fruit crops: Induction of flowering, flower thinning and fruit setting. Medicinal plant garden.

UNIT V LANDSCAPE DESIGNING:

Layout model of outdoor college garden. Vertical, roof and terrace garden, Biodiversity parks, Designing of Indoor kitchen garden. Field Visit; Horticultural Department of India.

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

Create a small garden (home, terrace / campus space)
Experiment with: Plant combinations, Soil mixes and fertilizers and Irrigation techniques. Visit parks, nurseries, botanical gardens and report preparation

Recommended Textbooks:

1. Bose, TK., Maiti, RG., Dhua, RS and Das, P. (1999). Floriculture and Landscaping. Naya Prokash, Calcutta.
2. Anusuya S and Senthilkumar S.R. (2025). Urban roots and Green spaces. The new age of Horticulture. Genic Books. Agra

Reference Books:

1. Ashman, M. A. and Puri, G. (2002). Essential soil science- A clear and concise introduction to soil science. Blackwell scientific publishers, London.

2. Subba Rao, N. S. (1997). Biofertilizers in Agriculture and Forestry. India Book House Limited, Oxford and IBH publishing Co. Pvt. Ltd, New Delhi.

Web Resources:

1. https://guides.stlcc.edu/horticulture/web?utm_source
2. https://www.kslandscapes.co.nz
3. https://agritech.tnau.ac.in/horticulture/horti_related%20websites_national.html

COURSE OUTCOMES:

Course Outcomes	On successful completion of this course, the students will be able to	Cognitive Levels
CO1	Explain and evaluate the structure, functions, and management practices of horticultural divisions and assess the importance of post-harvest technologies in maintaining crop quality and reducing losses.	**K1**
CO2	Apply and evaluate landscape design principles and techniques for planning, developing, and managing different types of landscapes and green spaces.	**K2**
CO3	Demonstrate and assess various nursery management techniques, including plant propagation, nursery establishment, maintenance, and quality planting material production.	**K3**
CO4	Design, develop, and evaluate different types of horticultural gardens and assess their applications in ornamental horticulture, urban greening, environmental management, and sustainable development.	**K4**
CO5	Examine and evaluate the characteristics of various garden types and assess the role of horticultural departments in garden management, biodiversity conservation, and public welfare.	**K5**

Mapping with POs:

Relationship Matrix											
Semester	**Course Code**	**Title of the Course**							**Hours**	**Credits**	
		2. Horticulture and Landscape Gardening (Theory)							**2**	**2**	
Course Outcomes	**Programme Outcomes (POs)**										**Mean Score**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	
CO1	1	3	3	2	2	1	3	2	2	1	**2.0**
CO2	1	3	3	3	3	1	2	2	2	1	**2.1**
CO3	1	3	2	3	3	2	2	2	3	1	**2.2**
CO4	1	3	3	3	3	1	2	3	2	1	**2.2**
CO5	1	3	3	3	3	1	2	3	3	1	**2.3**
Mean Overall Score											**2.16 (High)**

Year: Second **INTERDISCIPLINARY COURSE 3** **Semester: III**

Code: **SOLID WASTE MANAGEMENT (Theory)** **Credits: 2**

COURSE OBJECTIVES:

- To know about the various types of solid wastes.
- To understand the composting methodologies.
- To impart knowledge on biogas production.
- To know the importance of vermi composting in agricultural practices.
- To apply knowledge about the cultivation practices of mushrooms

UNIT I TYPES OF SOLID WASTES:

Definition-scope and importance of solid waste management-Types of solid wastes: garbage, rubbish, agricultural, hospital and domestic wastes. Collection-transport and processing of solid wastes.

UNIT II COMPOSTING TECHNIQUES:

Composting techniques: Types of composting, anaerobic and aerobic composting, Factors affecting aerobic composting, Techniques for effective aerobic composting, Salient features of selected small- scale aerobic composting techniques-Role of microbes in composting

UNIT III SOLID WASTE MANAGEMENT:

Solid waste management - methods of solid waste management - open dumping, land filling, incineration, pyrolysis Biogas production-mechanism of methane gas formation. Factors affecting methane formation Utilization of Biogas.

UNIT IV VERMICOMPOSTING:

Vermicomposting-Earthworm and its characteristics-internal anatomy-digestive, excretory, respiratory and reproductive systems. Preparatory methods of vermiculture. Economic and ecological importance of vermicompost and vermi wash.

UNIT V MUSHROOM CULTIVATION:

Mushroom culture - Characteristics of common edible mushrooms - Nutritive value of mushrooms. Culture techniques-preparation of spawn - Preparation compost-spawn running and harvesting. Preservation and storage. Recipes of mushroom.

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

Converting biodegradable waste into compost using microbes. Using earthworms to decompose organic waste. Reusing fallen leaves instead of burning them. Identifying and categorizing waste types. Replacing plastic with plant-based materials. Visit to nearest station for field exposure.

Recommended Textbooks:

1.Dubey, R.C. (2009). *A Text book of microbiology*. S. Chand & Co. Ltd.

Reference Books:

1. NIIR Board. (2004). *The Complete Technology Book on Biofertilizers and Organic Farming*. National Institute of Industrial Research.
2. David, S.V., & Kumaraswamy, T. (1998). *Elements of Economic Entomology*. Popular Book Depo.

3. Mohoney, R. (1966). *Lab Techniques in Zoology*. Butterworth.

Web Resources:

1. https://www.fao.org/3/y5104e/y5104e05.htm
2. https://www.gasum.com/en/our-operations/biogas-production/how-is-biogas-produced/
3. https://www.legit.ng/1128248-economic-importance-earthworm-vermiculture.html

COURSE OUTCOMES:

Course Outcomes	On successful completion of this course, the students will be able to	Cognitive Levels
CO1	Explain and evaluate different types of solid wastes and assess their environmental impact, resource potential, and significance in sustainable waste management.	**K1**
CO2	Investigate and evaluate the processes involved in the decomposition of organic matter and assess their role in nutrient recycling and ecosystem sustainability.	**K2**
CO3	Apply and evaluate vermicomposting technologies for the efficient conversion of organic wastes into value-added products and assess their agricultural and environmental applications.	**K3**
CO4	Demonstrate and evaluate mushroom cultivation techniques and develop value-added mushroom products for nutritional, commercial, and entrepreneurial applications.	**K4**
CO5	Apply, compare, and assess various composting methods for organic waste management and evaluate their effectiveness in promoting sustainable agriculture and environmental conservation.	**K5**

Mapping with POs:

Relationship Matrix											
Semester	**Course Code**	**Title of the Course**								**Hours**	**Credits**
		3.Solid Waste Management (Theory)								**2**	**2**
Course Outcomes	**Programme Outcomes (POs)**										**Mean Score**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	
CO1	1	3	3	2	3	1	3	2	2	1	**2.1**
CO2	1	3	3	3	3	1	3	2	2	1	**2.2**
CO3	2	3	3	3	3	2	3	3	3	2	**2.7**
CO4	2	3	3	3	2	3	2	3	2	3	**2.6**
CO5	2	3	3	3	3	2	3	3	3	2	**2.7**
Mean Overall Score											**2.46 (High)**

Year: Second **INTERDISCIPLINARY COURSE 4** **Semester: IV**

Code: **BIOFERTILIZERS AND BIOPESTICIDES (Theory)** **Credits: 2**

COURSE OBJECTIVES:

- To describe the importance of biofertilizers and their cultivation.
- To learn mass cultivation of different bio fertilizers.
- To identify the types of mycorrhizae and its advantages.
- To assess the knowledge about the types of biopesticides and its advantages.
- To understand the mechanism and action of biopesticides.

UNIT I BIOFERTILIZERS:

Definition, Classification of fertilizers (Synthetic and Natural fertilizers), organic fertilizers, Biofertilizers – General account and importance, Fertilizers application methods (Foliar, seed dressing, soil drenching), Dry and wet formulation. Nano-fertilizers and smart nutrient delivery systems. Precision agriculture approaches in fertilizer management

UNIT II MASS CULTIVATION OF BIOFERTILIZERS:

Mass cultivation: Bacterial biofertilizers *Azospirillum, Azotobacter* and Rhizobium and Cyanobacterial biofertilizers – *Anabaena and nostoc.* Genetic improvement and strain enhancement of biofertilizer microorganisms. Bioreactor technologies for large-scale biofertilizer production.

UNIT III MYCORRHIZAE:

Fungal biofertilizers, Mycorrhizal Classification, isolation and its importance, VAM-Inoculum production and its field applications. Molecular signalling in plant–mycorrhizal symbiosis. Role of mycorrhizae in abiotic stress tolerance and sustainable agriculture.

UNIT IV BIOPESTICIDES:

Biopesticides – Definition, types and mass production of biopesticides, methods and application of biopesticides. Methods of quality control and Techniques of biopesticides. Advantages of biopesticides and commercialization. Nano biopesticides and controlled-release formulations. Regulatory frameworks and global market trends in biopesticide commercialization

UNIT V BIOPESTICIDES:

Mechanism of action and application of biopesticides – viral origin (*NPV*) – fungal origin (*Trichoderma*) – bacterial origin (*Pseudomonas* and *Bacillus*). Molecular mechanisms of pathogen suppression and induced systemic resistance. CRISPR and biotechnology applications in advanced biopesticide development

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. AI and digital agriculture innovations in biofertilizer and biopesticide applications

Recommended Textbooks:

1.Joshi, S.R. (2018). Biopesticides: A Biotechnological Approach. New Age International (P) Ltd.,
Publishers.
2. Koul, O. and Dhaliwal, G.S. 2012. Biopesticides and Pest Management. Campus Books
International.
3. Subba Rao, N.S. (2000). Soil Microbiology. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.
4.Varma, A. and Hock, B. (1995). Mycorrhiza Springer – Verlag, Berlin.

Reference Books:

1.Biofertilizers Advances in Bio- Inoculants (volume I)2021 by Amitava
Rakshit, Vijay Meena, Manoj Parihar, H.B. Singh, A.K Singh.
2.Biopesticides Advances in Bio- Inoculants (volume II) 2021, by Amitava
Rakshit, Vijay Meena, P.C.Abhilash, B.K Sarma, H B Singh, Anand kumar.
3.Biofertilizers Technology by Kannaiyan, S., Kumar, K., Govindarajan, K.– 2010.

Web Resources:

1.https://microbialcellfactories.biomedcentral.com/articles/10.1186/1475-2859-13-66
2.https://www.toppr.com/guides/biology/microbes-in-human
welfare/ biofertilizers
3.https://www.vedantu.com/biology/biofertilizers

COURSE OUTCOMES:

Course Outcomes	On successful completion of this course, the students will be able to	**Cognitive Levels**
CO1	Explain and evaluate the principles, importance, and applications of biofertilizers in sustainable agriculture, soil fertility improvement and environmental conservation.	**K1**
CO2	Apply and assess the techniques involved in the mass cultivation, production, formulation, and quality control of biofertilizers for agricultural applications.	**K2**
CO3	Classify, compare, and evaluate different types of biofertilizers and determine their suitability for specific crops, soils and agroecosystems.	**K3**
CO4	Assess and apply strategies for the commercialization, marketing, and entrepreneurial utilization of biofertilizers in sustainable agricultural systems.	**K4**
CO5	Analyze and evaluate the mechanisms, modes of action, and applications of biopesticides and assess their role in eco-friendly pest management and crop protection.	**K5**

Mapping with POs:

Relationship Matrix											
Semester	**Course Code**			**Title of the Course**						**Hours**	**Credits**
				4.Biofertilizers and Biopesticides (Theory)						**2**	**2**
Course Outcomes	**Programme Outcomes (POs)**										**Mean Score**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	
CO1	1	3	3	2	3	1	3	2	2	1	**2.1**
CO2	2	3	3	3	3	2	2	3	3	1	**2.5**
CO3	1	3	3	3	3	1	2	3	2	1	**2.2**
CO4	2	3	3	2	2	3	3	3	2	3	**2.6**
CO5	1	3	3	3	3	1	3	3	3	1	**2.4**
Mean Overall Score											**2.36 (High)**