LEARNING OUTCOMES BASED CURRICULUM FRAMEWORK (LOCF) FOR UNDERGRADUATE PROGRAMMES

(Academic Year 2025-2026 onwards)

PG & RESEARCH DEPARTMENT OF BOTANY

(DST FIST Sponsored Department)
(Supported under DBT's STAR COLLEGE SCHEME)

B.Sc., BOTANY

Estd. 1919

NATIONAL COLLEGE

(AUTONOMOUS)

(Nationally Re-accredited at 'A' Grade by NAAC in 4th Cycle)

TIRUCHIRAPPALLI - 620 001

VISION AND MISSION OF
THE PG & RESEARCH DEPARTMENT OF BOTANY

VISION	Develop the students with solid knowledge in Botany for efficient use and management of biological resources towards sustainable development.
MISSION	Spread knowledge and transmit skills for employability, innovation in research and entrepreneurship in Botany.

PG & RESEARCH DEPARTMENT OF BOTANY
PROGRAMME OUTCOMES

PO1	**Disciplinary Knowledge:** Students will be capable of demonstrating comprehensive knowledge and understanding of various concepts of Plant and Allied Sciences through Undergraduate and Postgraduate Programmes of study. As a result of this student get transformed into skilled professionals adhering to the values of sustainable living.
PO2	**Communication Skills:** Students will acquire the ability to express thoughts and ideas effectively in writing and orally. They will be able to communicate with others using appropriate media and also confidently share one's views and express herself / himself. Students will demonstrate the ability to listen carefully, read and write analytically, and present complex information in a clear and concise manner to different groups.
PO3	**Critical thinking, Problem-Solving and Analytical Reasoning:** The capacity of the students to apply analytic thoughts through analyses, evaluation, arguments, claims, and beliefs on the basis of empirical evidence will be strengthened. The students will be able to identify relevant assumptions or implications and shall formulate coherent arguments. They will be able to critically evaluate practices, policies and theories by following scientific approach to knowledge development. Students will have the capacity to extrapolate from what one has learned and apply their competencies to solve different kinds of non-familiar problems, rather than replicate curriculum content knowledge; and apply one's learning to real life situations. Student will attain the ability to evaluate the reliability and relevance of evidence; identify logical flaws and holes in the arguments of others; analyse and synthesise data from a variety of sources; draw valid conclusions and support them with evidence and examples, and addressing opposing viewpoints in the field of Plant and Applied Sciences.
PO4	**Reflective thinking & Scientific Reasoning. Teamwork with Leadership qualities:** Students will develop critical sensibility to lived experiences, with self-awareness and reflexivity of both self and society. They will be able to analyze, interpret and draw conclusions from quantitative/ qualitative data; and critically evaluate ideas, evidence and experiences from an open-minded and reasoned perspective. Students will acquire the ability to work effectively and respectfully with diverse teams; facilitate cooperative or coordinated effort on the part of a group, and act together as a group or a team in the interests of a common cause and work efficiently as a member of a team. They will have the potential of mapping out the tasks of a team or an organization, setting direction, formulating an inspiring vision, building a team who can help achieve the vision, motivating and inspiring team members to engage with that vision, and using management skills to guide people to the right destination, in a smooth and efficient way.
PO5	**Moral and Ethical Awareness - Appreciating Environmental and Sustainability Issues** Students will understand and contextualize environmental and ethical issues and contribute towards the betterment of the environment and sustainable growth. They will have the ability to embrace moral / ethical values in conducting one's life, formulate a position/ argument about an ethical issue from multiple perspectives, and use ethical practices in all work. They will become capable of demonstrating the ability to identify ethical issues related to one's work, avoid unethical behaviour such as fabrication, falsification or misrepresentation of data or committing plagiarism, not adhering to intellectual property rights; appreciating environmental and sustainability issues; and adopting objective, unbiased and truthful actions in all aspects of work.
PO6	**Multicultural competency and Self-directed lifelong learning:** Students will develop multicultural competency and will engage in self-paced and self-directed lifelong learning through digital literacy for personal development and professional accomplishment. Students will possess knowledge of the values and beliefs of multiple cultures and a global perspective; and will develop capability to effectively engage in a multicultural society and interact respectfully with diverse groups. They will have the ability to work independently, identify appropriate resources required for a project, and manage a project through to completion. They will also be able to acquire knowledge and skills, including 'learning how to learn', that are necessary for participating in learning activities throughout life, through self-paced and self-directed learning aimed at personal development, meeting economic, social and cultural objectives, and adapting to changing trades and demands of work place through knowledge/skill development/reskilling and deskilling.

PG & RESEARCH DEPARTMENT OF BOTANY

(DST FIST Sponsored Department)
(Supported under DBT's STAR COLLEGE SCHEME)

PROGRAMME SPECIFIC OUTCOMES

PSO 1	Understand biodiversity and gain knowledge on morphological and anatomical features of microorganisms, algae, fungi, bryophytes, pteridophytes, gymnosperms and angiosperms.
PSO 2	Describe the process of morphogenesis and reproduction in microorganisms, algae, fungi, bryophytes, pteridophytes, gymnosperms and angiosperms.
PSO 3	Create the awareness on the ecosystems, plant resources and conservation of plant wealth.
PSO 4	Strengthening the knowledge on the internal structure of the plants, plant systematics, evolution and comprehend the basics of genetics, inheritance and molecular biology.
PSO 5	Acquire knowledge on the function of plants, interaction between plants and microbes and plant disease management.
PSO 6	Demonstrate skills in advanced techniques in plant sciences and biotechnology and acquire academic excellence in plant sciences to pursue higher studies, research and employability.

PG & RESEARCH DEPARTMENT OF BOTANY
(DST FIST Sponsored Department) (Supported under DBT's STAR COLLEGE SCHEME)
NATIONAL COLLEGE (AUTONOMOUS)
(Nationally Re-accredited at 'A+' Grade by NAAC in 3rd Cycle) (College with Potential for Excellence)
TIRUCHIRAPPALLI - 620 001.

B.Sc., BOTANY

Learning Outcomes based Curriculum Framework (LOCF)
Choice Based Credit System (CBCS)
(Applicable to the candidates admitted from the academic year 2025-2026 onwards)

COURSE PATTERN

S.No.	Course Code	Part	Hours/ Week	Credit	Course Type	Course Title	Course Kind	Hours of Exam		IE Marks (25)		E/E Marks (75)		Remarks
								Theory	Practical	Theory	Practical	Theory	Practical	
SEMESTER - I														
1.	U25T1/H1/S1	I	6	3	Theory	Tamil/Hindi/Sanskrit		3	-	25	-	75	-	
2.	U25E1	II	6	3	Theory	English		3	-	25	-	75	-	
3.	U25BO1	III	5	5	Theory	Algae and Bryophytes	CC	3	-	25	-	75	-	
4.	U25BO2P	III	3	-	Practical	Practical – 1 (U25BO1 & U25BO3)	CC	-	-	-	-	-	-	
5.	U25ACH1	III	5	3	Theory	Allied Chemistry-I	AC	3	-	25	-	75	-	
6.	U25ACH2P	III	3	-	Practical	Allied Chemistry Practical (U25ACH)	AC	-	-		-		-	
7.	U25ES	IV	2	2	Theory	Environmental Studies	ES	3	-	25	-	75	-	
SEMESTER - II														
8.	U25T2/H2/S2	I	6	3	Theory	Tamil/Hindi/Sanskrit		3		25		75		
9.	U25E2	II	6	3	Theory	English		3		25		75		
10.	U25BO2P	III	3	6	Practical	Practical - 1 (U25BO1 & U25BO3)	CC		3	-	25		75	
11.	U25BO3	III	5	5	Theory	Fungi and Plant Pathology	CC	3	-	25		75		
12.	U25ACH2P	III	3	3	Practical	Chemistry Practical (U25ACH1 & U25ACH3)	CC		3	-	25		75	
13.	U25ACH3	III	5	3	Theory	Allied Chemistry –II	CC	3		25		75		
14.	U25BOSBE1	IV	2	2	Theory	Biofertilizer and Biopesticides	SBE	3		25		75		

SEMESTER - III														
15.	U25T3/H3/S3	II	6	3	Theory	Tamil/Hindi/Sanskrit		3		25		75		
16.	U25E3	II	6	3	Theory	English		3		25		75		
17.	U25BO4	III	4	4	Theory	Pteridophytes, Gymnosperms & Paleobotany	CC	3		25		75		
18.	U25BO5P	III	3	-	Practical	Practical - 2 (U25BO4 & U25BO6)	CC	-	-	-				
19.	U25AZY1	III	4	3	Theory	Allied Zoology –I	CC	3		25		75		
20.	U25AZY2P	III	3	-	Practical	Allied Zoology Practical (U25AZY1)	CC	-	-	-				
21.	U25BOSBE2	IV	2	2	Theory	Mushroom Technology	SBE	3		25		75		
22.	U25BOSBE3P	IV	2	2	Practical	SBE – PRACTICAL (U25BOSBE1 & U25BOSBE2)	SBEP	-	3	-	25		75	
SEMESTER - IV														
23.	U25T4/H4/S4	I	6	3	Theory	Tamil/Hindi/Sanskrit		3		25		75		
24.	U25E4	II	6	3	Theory	English		3		25		75		
25.	U25BO5P	III	3	5	Practical	Practical - 2 (U25BO4 & U25BO6)	CC	-	3	-	25		75	
26.	U25BO6	III	4	4	Theory	Plant Anatomy and Embryology	CC	3		25		75		
27.	U25AZY2P	III	3	3	Practical	Allied Zoology Practical (U25AZY1 & U25AZY3)	CC	3		-	25		75	
28.	U25AZY3	III	5	3	Theory	Allied Zoology – -III	CC	3		25		75		
29.	U25BONME1	IV	2	2	Theory	Horticulture	NME	3		25		75		
30.	U25VE	IV	1	2	Theory	Value Education	VE	3		25		75		
SEMESTER - V														
31.	U25BO7	III	5	5	Theory	Morphology, Taxonomy and Economic Botany	CC	3		25		75		
32.	U25BO8	III	5	5	Theory	Cell and Molecular Biology	CC	3		25		75		
33.	U25BO9E	III	5	4	Theory	Biochemistry, Biophysics and Bioinstrumentation	CCE	3		25		75		
34.	U25BO10E	III	5	4	Theory	Microbiology	CCE	3		25		75		

35.	U25BO11P	III	3	-	Practical	Practical – 3 (U25BO7, U25BO9E & U25BO10E)	CC	-	-	-				
36.	U25BO12P	III	3	-	Practical	Practical – 4 (U25BO8, U25BO13, U25BO14, U25BO15)	CC	-	-	-				
37.	U25BONME2	IV	2	2	Theory	Bioinoculants and Biopesticides	NME	3		25		75		
38.	U25SS	IV	2	2	Theory	Soft Skills	SS	3		25		75		
SEMESTER – VI														
39.	U25BO11P	III	3	5	Practical	Practical - 3 (U25BO7, U25BO9E & U25BO10E)	CC	-	3	-	25		75	
40.	U25BO12P	III	3	6	Practical	Practical – 4 (U25BO8, U25BO13, U25BO14, U25BO15)	CC	-	3	-	25		75	
41.	U25BO13	III	6	6	Theory	Genetics, Evolution and Plant Breeding	CC	3		25		75		
42.	U25BO14	III	6	6	Theory	Plant Physiology	CC	3		25		75		
43.	U25BO15	III	6	6	Theory	Plant Biotechnology	CC	3		25		75		
44.	U25BO16E	III	5	4	Theory	Biostatistics and Bioinformatics	CCE	3		25		75		
45.	U25GS	V	1	1	Theory	Gender Studies	GS	3		25		75		
46.	Extension Activities	V		1			EA							
			180	**140**										

COURSES OFFERED TO OTHER DEPARTMENT

S.No.	Course Code	Part	Hours/ Week	Credit	Course Type	Course Title	Course Kind	Hours of Exam		IE Marks (25)		E/E Marks (75)		Remarks
								Theory	Practical	Theory	Practical	Theory	Practical	
SEMESTER - III														
1.	U25ABO1	III	5	3	Theory	Plant Diversity, Taxonomy, Anatomy, Embryology, Plant Pathology and Ethnobotany	AC	3	-	25	-	75	-	
2.	U25ABO2P	III	3	-	Practical	Allied Botany Practical (U25BOA1)	ACP	-	-	-	-	-	-	
SEMESTER – IV														
3.	U25ABO2P	III	3	3		Allied Botany Practical (U25BOA1 & U25BOA3)	ACP	-	3	-	25	-	75	
4.	U25ABO3	III	5	3		Cytology, Genetics, Evolution, Plant Physiology, Ecology and Biotechnology	AC	3	-	25	-	75	-	
5.	U25BONME1	IV	2	2		Horticulture	NME	3	-	25	-	75	-	
SEMESTER – V														
6.	U25BONME2	IV	2	2		Bioinoculants and Biopesticides	NME	3	-	25	-	75	-	

EXTRA CREDIT COURSES OFFERED

S.No.	Course Code	Part	Hours/ Week	Credit	Course Type	Course Title	Course Kind	Hours of Exam		IE Marks (25)		E/E Marks (75)		Remarks
								Theory	Practical	Theory	Practical	Theory	Practical	
SEMESTER - IV														
1.	U25BOECC1	IV	1	4	Theory	Microbes in History	ECC	3	-	25	-	75	-	
SEMESTER - V														
2.	U25BOECC2	IV	1	4	Theory	Geomicrobiology	ECC	3	-	25	-	75	-	

Sem.	Programme Code	Course Code	Course Type	Course Title	Category	Hrs. / Week	Credits
I	BOTUG1982	U25BO1	Core Course	**ALGAE AND BRYOPHYTES**	Theory	5	5

Course Description:

The course introduces the diversity, structure, reproduction, classification, and life cycles of algae and bryophytes—two major groups of lower plants. Students will study representative genera to understand morphological variations and ecological adaptations. The course also highlights the economic and evolutionary significance of these groups, including fossil forms like stromatolites. Emphasis is placed on recognising their vital roles in ecosystems, such as oxygen production, soil formation, and water retention. This course lays the groundwork for advanced studies in plant biology and taxonomy.

Course Objectives:

1. *To understand the general characteristics, distribution, and classification of algae and bryophytes.*
2. *To study the morphology, cell structure, pigmentation, and life cycles of representative algal genera.*
3. *To learn about the reproductive strategies and ecological adaptations of both algae and bryophytes.*
4. *To explore the economic and environmental significance of algae and bryophytes, including fossil forms.*
5. *To compare different classes within algal and bryophyte groups based on structural and reproductive features.*
6. *To develop foundational knowledge for identifying, classifying, and analysing lower cryptogams in laboratory and field settings.*

UNIT-I Introduction to Algae (Teaching-1 h / week)

General Characteristics and distribution (habit and habitats), Outline of F.E. Fritsch (1935) Classification. Salient features of Cyanophyceae (Myxophyceae), Chlorophyceae, Xanthophyceae, Chrysophyceae, Phaeophyceae, Rhodophyceae, Bacillariophyceae.

UNIT-II Algae – structure and life cycle (Teaching-1 h / week)

A detailed study of vegetative forms, cell structure, pigmentation, food reserves and life cycle of the following algae genera - *Oscillatoria, Nostoc, Volvox, Oedogonium, Caulerpa* and Diatoms – centric, pennate.

UNIT-III Algae – organization and reproduction (Teaching-1 h / week)

A detailed study of structure, reproduction and life cycle of the following algae genera - *Ectocarpus, Dictyota, Polysiphonia, Gracilaria* and *Sargassum*. Economic importance of algae. Fossil algae – Stromatolites.

UNIT-IV Bryophytes (Teaching-1 h / week)

General characteristics, occurrence, distribution and classification (Rothmaler -1951). Salient features of Hepaticopsida, Anthocerotopsida and Bryopsida. Economic importance of bryophytes.

UNIT-V Bryophytes – Structure and life cycle (Teaching-1 h / week)

A detailed study of the External and Internal structure, reproduction and life cycles of the following genera - *Marchantia, Porella, Anthoceros*, *Funaria* and *Polytrichum*.

Course Outcomes:

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

CO1	*Understand the fundamental concepts and analyze the general structure of algae and bryophytes*
CO2	*Extend the knowledge on classification, occurrence and pigmentation of Algae*
CO3	*Develop understanding on classification, morphology of Bryophytes*
CO4	*Acquire knowledge about the reproduction and life cycle of Algae*
CO5	*Elucidate the reproduction, life cycle and economic importance of Bryophytes*
CO6	*Creating the awareness and appreciation human friendly Algae and their economic importance*

Text Book:

- Kumar, H.D. (1999). Introductory Phycology. Affiliated East-West. Press Pvt. Ltd. Delhi.

  2nd edition. Sharma, O.P. (2017). Bryophyte. McGraw Hill, New Delhi, India.
- Vashishta B.R., Sinha A.K. and Singh V. P. (2008). Botany for Degree Students. Algae. S Chand and Co, New Delhi.
- Sharma, O.P. 2017. Bryophyta, MacMillan India Ltd. Delhi.
- Alam, A. 2020. Contemporary Research on Bryophytes Book Series: Recent Advances in Botanical Science. 10.2174/9789811433788120010l.
- Alain Vanderpoorten. 2009. Introduction to Bryophytes, 1st Edition, Cambridge University Press.

References:

- Lee, R.E. (2008). Phycology, Cambridge University Press, Cambridge. 4th edition.
- Parihar, N.S. (1991). An introduction to Embryophyta. Vol. I. Bryophyta. Central Book Depot, Allahabad.
- Rashid, A. (1998). An Introduction to Bryophyta. Vikas Publishing House Pvt. Ltd., New Delhi.
- Watson, E.V. 1963. The structure and Life of Bryophytes. Hutchinson *&* Co, UK.
- Parihar, N.S. 1991. Bryophytes. Central Book Depot, Allahabad.

Web resources:

- https://www.crcpress.com/Therapeutic-and-Nutritional-Uses-of-Algae/Pereira/p/book/9781498755382
- https://www.crcpress.com/Therapeutic-and-Nutritional-Uses-of-Algae/Pereira/p/book/9781498755382
- https://www.crcpress.com/Algae-Anatomy-Biochemistry-and-Biotechnology-Second-Edition/Barsanti-Gualtieri/p/book/9781439867327
- https://www.crcpress.com/Marine-Algae-Biodiversity-Taxonomy-Environmental-Assessment-and-Biotechnology/Pereira-Neto/p/book/9781466581678
- https://www.kopykitab.com/Botany-For-Degree-Students-ALGAE-by-B-R-Vashishta-Dr-A-K-Sinha-Dr-V-P-Singh

CO- PO Mapping (Course Articulation Matrix)

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	1	0
CO2	9	3	1	3	0	1
CO3	9	9	3	3	1	0
CO4	3	3	9	9	0	1
CO5	9	3	3	3	1	1
CO6	3	3	0	0	0	0
Weightage	**36**	**22**	**19**	**21**	**3**	**3**
Weighted percentage of Course contribution to POs	42.52%	18.89%	14.96%	9.45%	7.09%	7.09%

Level of Correlation between CO's and PO's } 1 – Low 3 – Medium 9 – High 0 – No Correlation (Suggested by UGC as per Six Sigma Tool – Cause and Effect Matrix)

Course Outcomes mapped with Knowledge level (Revised Bloom's Taxonomy) and POs

CO/ K-Level	Level of Correlation			
	High	**Medium**	**Low**	**Zero**
CO1/ K1	PO1, PO2	PO3, PO4, PO5	PO6	_
CO2/ K2	PO1, PO2	PO3, PO4	PO5, PO6	_
CO3/ K3	PO1	PO2, PO3,	PO4, PO5	PO6
CO4/ K4	PO1	PO2, PO3	PO4, PO5	PO6
CO5/ K5		PO1, PO2	PO3, PO4	PO5, PO6
CO6/ K6		PO1, PO2	PO3, PO4,	PO5, PO6

Course Outcome (CO) Attainment Assessment Tools & Evaluation Procedure:

K Levels	C1	C2	C3	C4	Total scholastic marks	Non Scholastic Marks C5	CIA Total	% of Assessment
	T1 4 Marks	**T2 10 Marks**	**Assignment 6 Marks**	**Seminar 5 Marks**	**20 Marks**	**5 Marks**	**25 Marks**	
K1	1	2	1	--	4	--	**4**	**16**
K2	1	2	1	--	4	--	**4**	**16**
K3	1	2	1	--	4	--	**4**	**16**
K4	1	2	1	--	4	--	**4**	**16**
K5		1	1	--	2	--	**2**	**8**
K6		1	1	--	2	--	**2**	**8**
Non Scholastic	--	--	--	--	--	**5**	**5**	**20**
Total	**4**	**10**	**6**	--	**20**	**5**	**25**	**100%**

***C = Component**

The COs and POs for the **ALGAE AND BRYOPHYTES** course in the B.Sc. Botany Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge Signature of the Coordinator

Sem.	Programme Code	Course Code	Course Type	Course Title	Category	Hrs. / Week	Credits
I & II	BOTUG1982	U25BO2P	Core Course	**PRACTICAL – 1 (**U25BO1 & U25BO3**)**	Practical	3	6

Course Outcomes:

On completion of this course, the students will be able to

CO1	*Outline basic botany laboratory etiquette.*
CO2	*Understand the effective use of microscope, sectioning and staining techniques used to study the lower plant groups.*
CO3	*To study the internal and external structures of lower plant groups.*
CO4	*Identify the common plant diseases*
CO5	*Discuss the plant protection and their importance*
CO6	*Apprise with writing and maintaining an observation note.*

1. **BOTANY LABORATORY ETIQUETTE**
2. **NECESSARY EQUIPMENTS**
3. **MICROSCOPY**
4. **SECTIONING, FIXING AGENTS AND PRESERVATIVES**
   (Introduced under the aegis of DBT Star College Scheme)
5. **ALGAE:** Micro preparation and detailed microscopic analysis of vegetative and reproductive parts of *Oscillatoria, Volvox, Oedogonium, Caulerpa, Ectocarpus, Dictyota,* and *Polysiphonia*
6. **BRYOPHYTES:** Micro preparation and detailed microscopic analysis of vegetative and reproductive parts of *Marchantia, Porella, Anthoceros*, *Funaria* and *Polytrichum*.
7. **FUNGI:** Micro preparation and detailed microscopic analysis of vegetative and reproductive parts of *Aspergillus, Peziza, Puccinia, Polyporus* and *Usnea.*
8. **PLANT DISEASES:** Mycoplasma - Little leaf of brinjal; Virus - Tobacco Mosaic Virus; Bacteria - Citrus canker; Fungi: Red rot of sugarcane, Tikka disease of Groundnut; Blast disease of paddy.
9. **PLANT PROTECTION:** Pesticides, Sprayer-Hand sprayer, Fungicide – Bordeaux mixture.
10. **RECORD OF WORK: MAINTAINING AN OBSERVATION**
11. **ONE DAY FIELD TRIP – ALGAL SAMPLE COLLECTION - SEASHORE**

Textbooks:

- Kumar, H.D. 1999. Introductory Phycology. Affiliated East-West Press, Delhi.
- Bendre, M. Ashok and Ashok Kumar, A. 2020. Text Book of Practical Botany-1 (10th ed). Rastogi Publications, Meerut.
- Round, FE. 1984.The Ecology of Algae. Cambridge University Press.
- Pandey, B.P. 1997. College Botany. Vol. I Fungi & Pathology.

Reference Books:

- Chmielewski, J.G and Krayesky, D. 2013. General Botany laboratory Manual. Author House, Bloomington, USA.
- Das, S and Saha, R. 2020. Microbiology Practical Manual. CBS Publishers and Distributors (P) Ltd., New Delhi, India.
- Webster, J and Weber, R. 2007. Introduction to Fungi, 3rd Ed. Cambridge University Press, Cambridge.
- Nair, L.N. 2007. Topics in Mycology and Pathology, New Central Book agency, Kolkata.

Web resources:

- https://www.amazon.in/Practical-Manual-Fungi-Fungicides/dp/B0025AEFP4
- https://books.google.co.in/books/about/Practical_Mycology.html?id=5ycJAQAAMAAJ&redir_esc=y
- https://www.flipkart.com/colour-handbook-practical-plant-pathology/p/itmefsn6dyhfhs9b
- https://books.google.co.in/books/about/Practical_Botany.html?id=T5narQEACAAJ&redir_esc=y
- https://www.kobo.com/us/en/ebook/introduction-to-fungi

CO- PO Mapping (Course Articulation Matrix)

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	6	3	3	3	1	0
CO2	9	3	1	3	0	1
CO3	9	9	3	3	1	0
CO4	6	3	9	9	0	1
CO5	9	3	6	3	3	1
CO6	3	3	0	0	0	0
Weightage	**42**	**24**	**22**	**21**	**5**	**3**
Weighted percentage of Course contribution to POs	35.90	20.51	18.80	17.95	4.27	2.56

Level of Correlation between CO's and PO's: 1 – Low, 3 – Medium, 9 – High, 0 – No Correlation
(Suggested by UGC as per Six Sigma Tool – Cause and Effect Matrix)

Course Outcomes mapped with Knowledge level (Revised Bloom's Taxonomy) and POs

CO/ K-Level	Level of Correlation			
	High	**Medium**	**Low**	**Zero**
CO1/ K1	PO1, PO2	PO3, PO4, PO5	PO6	_
CO2/ K2	PO1, PO2	PO3, PO4	PO5, PO6	_
CO3/ K3	PO1	PO2, PO3,	PO4, PO5	PO6
CO4/ K4	PO1	PO2, PO3	PO4, PO5	PO6
CO5/ K5		PO1, PO2	PO3, PO4	PO5, PO6
CO6/ K6		PO1, PO2	PO3, PO4,	PO5, PO6

Course Outcome (CO) Attainment Assessment Tools & Evaluation Procedure:

K Levels	C1	C2	C3	C4	Total scholastic marks	Non Scholastic Marks C5	CIA Total	% of Assessment
	T1 4 Marks	T2 10 Marks	Assignment 6 Marks	Seminar 5 Marks	20 Marks	5 Marks	25 Marks	
K1	1	2	1	--	4	--	**4**	**16**
K2	1	2	1	--	4	--	**4**	**16**
K3	1	2	1	--	4	--	**4**	**16**
K4	1	2	1	--	4	--	**4**	**16**
K5		1	1	--	2	--	**2**	**8**
K6		1	1	--	2	--	**2**	**8**
Non Scholastic	--	--	--	--	--	**5**	**5**	**20**
Total	**4**	**10**	**6**	--	**20**	**5**	**25**	**100%**

***C = Component**

The COs and POs for the **PRACTICAL 1** course in the B.Sc. Botany Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge

Signature of the Coordinator

Sem.	Programme Code	Course Code	Course Type	Course Title	Category	Hrs. / Week	Credits
I	BOTUG1982	U25ES	ABILITY ENHANCEMENT COMPULSORY COURSE (AECC)	**ENVIRONMENTAL STUDIES**	Theory	2	2

(2019 Revised Syllabus as per UGC Letter Dt. 22nd May 2019)

Unit 1: Introduction to environmental studies

• Multidisciplinary nature of environmental studies; components of environment – atmosphere, hydrosphere, lithosphere and biosphere.

• Scope and importance; Concept of sustainability and sustainable development.

Unit 2: Ecosystems

• What is an ecosystem? Structure and function of ecosystem; Energy flow in an ecosystem: food chain, food web and ecological succession. Case studies of the following ecosystems:

a) Forest ecosystem

b) Grassland ecosystem

c) Desert ecosystem

d) Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries)

Unit 3: Natural Resources: Renewable and Non-renewable Resources

• Land Resources and land use change; Land degradation, soil erosion and desertification.

• Deforestation: Causes and impacts due to mining, dam building on environment, forests, biodiversity and tribal populations.

• Water: Use and over-exploitation of surface and ground water, floods, droughts, conflicts over water (international & inter-state).

• Heating of earth and circulation of air; air mass formation and precipitation.

• Energy resources: Renewable and non-renewable energy sources, use of alternate energy sources, growing energy needs, case studies.

Unit 4: Biodiversity and Conservation

• Levels of biological diversity :genetic, species and ecosystem diversity; Biogeography zones of India; Biodiversity patterns and global biodiversity hot spots

• India as a mega-biodiversity nation; Endangered and endemic species of India

• Threats to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts, biological invasions; Conservation of biodiversity: In-situ and Ex-situ conservation of biodiversity.

• Ecosystem and biodiversity services: Ecological, economic, social, ethical, aesthetic and Informational value.

Unit 5: Environmental Pollution

• Environmental pollution: types, causes, effects and controls; Air, water, soil, chemical and noise pollution

• Nuclear hazards and human health risks

• Solid waste management: Control measures of urban and industrial waste.

• Pollution case studies.

Unit 6: Environmental Policies & Practices

• Climate change, global warming, ozone layer depletion, acid rain and impacts on human communities and agriculture.

• Environment Laws : Environment Protection Act; Air (Prevention & Control of Pollution) Act; Water (Prevention and control of Pollution) Act; Wildlife Protection Act; Forest Conservation Act; International agreements; Montreal and Kyoto protocols and conservation on Biological Diversity (CBD). The Chemical Weapons Convention (CWC).

• Nature reserves, tribal population and rights, and human, wildlife conflicts in Indian context

Unit 7: Human Communities and the Environment

• Human population and growth: Impacts on environment, human health and welfares.
• Carbon foot-print.
• Resettlement and rehabilitation of project affected persons; case studies.
• Disaster management: floods, earthquakes, cyclones and landslides.
• Environmental movements: Chipko, Silent valley, Bishnios of Rajasthan.
• Environmental ethics: Role of Indian and other religions and cultures in environmental conservation.
• Environmental communication and public awareness, case studies (e.g., CNG vehicles in Delhi).

Unit 8: Field work

• Visit to an area to document environmental assets; river/forest/flora/fauna, etc.
• Visit to a local polluted site – Urban/Rural/Industrial/Agricultural.
• Study of common plants, insects, birds and basic principles of identification.
• Study of simple ecosystems-pond, river, Delhi Ridge.

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Text Book

- Gleeson,B. and Low, N. (eds.) 1999. Global Ethics and Environment, London, Routledge.
- Gleick, P.H. 1993. Water in *Crisis*. Pacific Institute for Studies in Dev., Environment & Security. Stockholm Env. Institute, Oxford Univ. Press.
- Singh, J.S., Singh, S.P. and Gupta, S.R. 2014. Ecology, Environmental Science and Conservation. S. Chand Publishing, New Delhi.

Reference

- Groom, Martha J. Gary K. Meffe, and Carl Ronald carroll. *Principles of Conservation Biology.* Sunderland: Sinauer Associates, 2006.
- Odum, E.P., Odum, h.T. & Andrews, J.1971. Fundamentals of Ecology. Philadelphia: Saunders.
- Pepper, I.L., Gerba, C.P. & Brusseau, M.L. 2011. Environmental and Pollution Science. Academic Press.
- Rao, M.N. & Datta, A.K. 1987. Waste Water Treatement. Oxford and IBH Publishing Co. Pvt. Ltd.
- Rosencranz, A., Divan, S., & Noble, M.L. 2001. Environmental law and policy in India. Tripathi 1992.
- Sengupta, R. 2003.Ecology and economics: An approach to sustainable development. OUP.
- Sodhi, N.S., Gibson, L. & Raven, P.H. (eds). 2013. Conservation Biology: Voices from the Tropics. John Wiley & Sons.

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Sem.	Programme Code	Course Code	Course Type	Course Title	Category	Hrs. / Week	Credits
II	BOTUG1982	U25BO3	Core Course	**FUNGI AND PLANT PATHOLOGY**	Theory	5	5

Course Description:

This course provides a foundational understanding of fungi, covering classification of fungi and also deals with the fungal diseases in plants. Course explores the structure of Lichens, Mycorrhizae and their significance, Factors influencing plant diseases, symptoms, and Basic concept of Plant quarantine.

Course Objectives:

1. *To study the habit and Habitat of Fungi, thallus organization, Cell wall composition and classification of fungi.*
2. *To analyze the structure and morphology of Mastigomycotina, Zygomycotina and Ascomycotina.*
3. *To explain the structure and Reproduction of lichens and mycorrhizae and their significance.*
4. *To define the scope of plant protection and pest management.*
5. *To identify the common plant diseases, their symptoms, pathogens, and fundamental management strategies.*

UNIT-I FUNGI: (Teaching-1 h / week)

General characteristics, classification (Outline of Ainsworth 1973 – up to classes), Habit and Habitat, thallus organization, cell wall composition, nutrition and reproduction.Economic importance of fungi.

UNIT-II STRUCTURE AND REPRODUCTION: (Teaching-1 h / week)

General features and life cycle of the following classes: Mastigomycotina – *Albugo*; Zygomycotina – *Mucor*; Ascomycotina – *Aspergillus, Peziza*; Basidiomycotina - *Puccinia, Polyporus*; Deuteromycotina – *Alternaria*.

UNIT-III LICHEN AND MYCORRHIZAE: (Teaching-1 h / week)

Lichens - General Characters, Habit and Habitat, types, structure and reproduction of *Usnea* – significance. General Characters, Habit and Habitat of Mycorrhizae - ecto, endo and ectendomycorrhizae and their significance.

UNIT-IV PLANT PATHOLOGY AND PLANT PROTECTION: (Teaching-1 h / week)

Objectives, factors influencing plant diseases, disease triangle. Symptoms, Plant quarantine - method of plant protection – certificate - agencies. Basic concepts of Integrated Pest Management (IPM).

UNIT-V PLANT DISEASES: (Teaching-1 h / week)

Causative organism, symptoms, life cycle and control measures: Bacteria - Citrus Canker; Fungus - Red rot of Sugarcane, Tikka disease of Groundnut, Blast disease of Paddy; Virus – Yellow Vein Mosaic Disease of Bhindi; Mycoplasma - Little leaf of Brinjal.

COURSE OUTCOMES:

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

CO1	*Understand the general characteristics of fungi and its economic importance.*
CO2	Acquire knowledge on the structure and reproduction of genera mentioned in syllabus.
CO3	Study the principles of plant pathology and plant protection
CO4	Acquire knowledge on common plant diseases mentioned in the syllabus
CO5	Discuss the plant protection and their importance
CO6	Develop an understanding of plant pathogens and appreciate their adaptive strategies

Text Book

- Sethi, I.K. and Walia, S.K. (2011). Text book of Fungi and Their Allies, Macmillan, Publishers India
- Ltd.
- Sharma, P.D. (2011). Plant Pathology, Rastogi Publication, Meerut, India.
- Rangaswami, G and Mahadevan, A. (1998). Diseases of Crop Plants in India, Prentice Hall India Learning Private Limited, New Delhi.

Reference

- Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996). Introductory Mycology. 4th edition. John Wiley & Sons (Asia) Singapore.
- Webster, J. and Weber, R. (2007). Introduction to Fungi. 3rd edition. Cambridge, University Press, Cambridge.
- Agrios, G.N. (1997). Plant Pathology, 4th edition, Academic Press, U.K.

Web resources:

- https://gacbe.ac.in/pdf/ematerial/18BBO13C-U3.pdf
- https://www.rlsycollegebettiah.ac.in/wp-content/uploads/2023/02/file_63e4d906bf75e.pdf
- https://www.slideshare.net/vaishalidandge3/classification-of-fungi-250737959

CO- PO Mapping (Course Articulation Matrix)

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	3	3	3	1	0
CO2	9	3	1	3	0	1
CO3	9	9	3	3	3	0
CO4	9	3	9	9	0	1
CO5	3	9	9	3	3	1
CO6	3	3	0	0	0	0
Weightage	**42**	**30**	**25**	**21**	**7**	**3**
Weighted percentage of Course contribution to POs	32.81	23.44	19.53	16.41	5.47	2.34

Level of Correlation Between CO's and PO's: 1 – Low, 3 – Medium, 9 – High, 0 – No Correlation (Suggested by UGC as per Six Sigma Tool – Cause and Effect Matrix)

Course Outcomes mapped with Knowledge level (Revised Bloom's Taxonomy) and POs

CO/ K-Level	Level of Correlation			
	High	Medium	Low	Zero
CO1/ K1	PO1,	PO2, PO3,PO4	PO5	PO6
CO2/ K2	PO1,	PO2, PO4	PO3, PO6	PO5
CO3/ K3	PO1, PO2	PO3, PO4,PO5	_	PO6
CO4/ K4	PO1,PO3,PO4	PO2	PO6	PO5,
CO5/ K5	PO2,PO3,	PO1,PO4, PO5	PO6	_
CO6/ K6	-	PO1,PO2	-	PO3, PO4, PO5, PO6

Course Outcome (CO) Attainment Assessment Tools & Evaluation Procedure:

K Levels	C1	C2	C3	C4	Total scholastic marks	Non Scholastic Marks C5	CIA Total	% of Assessment
	T1 4 Marks	T2 10 Marks	Assignment 6 Marks	Seminar 5 Marks	20 Marks	5 Marks	25 Marks	
K1	1	2	1	--	4	--	4	16
K2	1	2	1	--	4	--	4	16
K3	1	2	1	--	4	--	4	16
K4	1	2	1	--	4	--	4	16
K5		1	1	--	2	--	2	8
K6		1	1	--	2	--	2	8
Non Scholastic	--	--	--	--	--	5	5	20
Total	4	10	6	--	20	5	25	100%

***C = Component**

The COs and POs for the **FUNGI AND PLANTPATHOLOGY** course in the **B.Sc. Botany** Programme is effectively matched by the Course In-charge.

Signature of the Course In- charge

Signature of the Coordinator

Sem.	Programme Code	Course Code	Course Type	Course Title	Category	Hrs. / Week	Credits
II	BOTUG1982	U25BOSBE1	SKILL BASED ELECTIVE	**BIOFERTILIZER AND BIOPESTICIDES**	Theory	2	2

Course Description:

This course offers a comprehensive introduction to biofertilizers and biopesticides, highlighting their types, microbial sources, and roles in sustainable agriculture. It covers the characteristics and applications of key bacterial and fungal biofertilizers, cyanobacteria, and microbial biopesticides. Emphasis is given to their mechanisms, environmental benefits, and integration into eco-friendly

Course Objectives:

1. *To understand the types, scope, and significance of biofertilizers and biopesticides in agriculture.*
2. *To study the characteristics and field applications of bacterial biofertilizers like Rhizobium, Azospirillum, and Phosphobacter.*
3. *To explore the role of fungal biofertilizers (VAM) and cyanobacteria in plant growth and soil health.*
4. *To examine the mode of action and agricultural use of microbial biopesticides such as Bacillus thuringiensis and Trichoderma viride.*
5. *To learn the techniques of mass cultivation and evaluate the environmental benefits of biofertilizers and biopesticides.*

Unit 1: Introduction to Biofertilizers and Biopesticides - (Teaching-1 h / week)

General account of microbes used as biofertilizers. Types of biofertilizers and biopesticides. Scope and importance of biofertilizers and biopesticides in sustainable agriculture.

Unit 2: Bacterial Biofertilizers - (Teaching-1 h / week)

Rhizobium: Characteristics, role in nitrogen fixation, and field application. *Azospirillum* and *Phosphobacter*: Characteristics, role in nitrogen fixation, and field application.

Unit 3: Fungal Biofertilizers and Cyanobacteria - (Teaching-1 h / week)

VAM: Characteristics, role in plant growth promotion, and application. Cyanobacteria (e.g., *Anabaena*): Role in nitrogen fixation and organic matter enrichment.

Unit 4: Microbial Biopesticides - (Teaching-1 h / week)

Characteristics, mode of action, and application of *Bacillus thuringiensis* and *Trichoderma viride.*

Unit 5: Applications and Environmental Benefits - (Teaching-1 h / week)

Applications of biofertilizers and biopesticides in integrated pest management and sustainable agriculture. Mass cultivation of *Rhizobium* and *Azolla.*

For units 1 & 2 : Teaching - 1 h / week ; For units 3, 4 & 5 : Teaching - 1 h / week.

Course Outcomes:

On completion of this course, the students will be:

CO1 *Understand the application of different microorganisms in agriculture*

CO2 Develop their understanding on the concept of bio-fertilizer and Biopesticides.

CO3 Identify the different forms of biofertilizers

CO4 Interpret and explain the components, patterns, and processes of microbes for growth in crop production

CO5 Illustrate the mass production of algal, fungal and bacterial biofertilizers

CO6 Empowered with entrepreneurial skills through the production of various biofertilizer and biopesticides

List of Text Books:

- Dubey, R.C. (2011). A Textbook of Microbiology. S. Chand Publishing.
- Alexopoulos, C.J., Mims, C.W., & Blackwell, M. (1996). Introductory Mycology. John Wiley & Sons.
- Rangaswami, G. (2002). Agricultural Microbiology. Prentice-Hall of India.
- Prescott, L.M., Harley, J.P., & Klein, D.A. (2002). Microbiology. McGraw-Hill Education.
- Atlas, R.M. (2009). Principles of Microbiology. W.W. Norton & Company.
- Burns, R.G., & Slater, J.H. (1981). Experimental Microbiology for Students. Butterworths.

List of Reference Books:

- Pasricha, N. S., Bahl, G. S., & Aulakh, M. H. (n.d.). *Fertilizer-Use Research in Oilseed and Pulse Crops in India*. India Book House Pvt Ltd. (Accn. No. 00054914)
- Jaiswal, A. P., Kant Prasad, & Deo. (n.d.). *Handbook of Soil Fertilizer and Manure*. Enkat Publication. (Accn. No. 22017070)
- Sen, S. P., & Palit, P. (1988). *Biofertilizers Potentialities and Problems*. Plant Physiology Forum. (Accn. No. 33004239)
- United States Department of Agriculture. (1969). *Plant Diseases the Yearbook of Agriculture*. Oxford University Press. (Accn. No. 00001302)
- Singh, A. (1982). *Practical Plant Physiology*. Kalyani Publishers. (Accn. No. 00002458)
- Bilgrami, K. S. (1992). *Textbook of Modern Plant Pathology*. Vikas Publishing House. (Accn. No. 00004300)

Correlation Levels:

Mapping COs consistency with POs: Course Articulation Matrix

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	3	3	1	3	1
CO2	9	3	3	1	3	1
CO3	9	3	3	1	3	1
CO4	9	3	3	1	3	1
CO5	9	3	3	1	3	1
CO6	9	3	3	1	3	1
Weightage	54	18	18	6	18	6
Weighted percentage of Course contribution to POs	45%	15%	15%	5%	15%	5%

Course Outcomes mapped with Knowledge level (Revised Bloom's Taxonomy) and POs

CO / K - Level	Level of Correlation			
	High	Medium	Low	Zero
CO 1 / K1	PO1, PO3	PO2	PO4, PO5, PO6	-
CO 2 / K2	PO1, PO3	PO2	PO4, PO5, PO6	-
CO 3 / K3	PO1, PO3	PO2	PO4, PO5, PO6	-
CO 4 / K4	PO1, PO3	PO2	PO4, PO5, PO6	-
CO 5 / K5	PO1, PO3	PO2	PO4, PO5, PO6	-
CO 6 / K6	PO1, PO3, PO5	PO2	PO4, PO6	-

Course Outcome (CO) Attainment Assessment Tools & Evaluation Procedure:

K Levels	C1	C2	C3	C4	Total scholastic marks	Non Scholastic Marks C5	CIA Total	% of Assessment
	T1 4 Marks	T2 10 Marks	Assignment 6 Marks	Seminar 5 Marks	20 Marks	5 Marks	25 Marks	
K1	1	2	1	--	4	--	**4**	**16**
K2	1	2	1	--	4	--	**4**	**16**
K3	1	2	1	--	4	--	**4**	**16**
K4	1	2	1	--	4	--	**4**	**16**
K5		1	1	--	2	--	**2**	**8**
K6		1	1	--	2	--	**2**	**8**
Non Scholastic	--	--	--	--	--	**5**	**5**	**20**
Total	**4**	**10**	**6**	--	**20**	**5**	**25**	**100%**

***C = Component**

The COs and POs for the **BIOFERTILIZER AND BIOPESTICIDES** course in the B.Sc. Botany Programme is effectively matched by the Course In-charge.

Signature of the Course In- charge

Signature of the Coordinator

Sem.	Programme Code	Course Code	Course Type	Course Title	Category	Hrs. / Week	Credits
III	BOTUG1982	U25BO4	Core Course	**PTERIDOPHYTES, GYMNOSPERMS AND PALEOBOTANY**	Theory	4	4

Course Description:

This course explores the structural, reproductive, and evolutionary features of Pteridophytes and Gymnosperms, alongside their ecological and economic significance. Students will examine representative genera of plant groups, focusing on life cycles (excluding developmental stages) and internal anatomy. The course also delves into Paleobotany, offering insights into fossil types, geological timelines, and contributions of key scientists. Emphasis is placed on the role of these plant groups in plant evolution and their practical applications in medicine and industry.

Course Objectives:

1. *Understand the general characteristics, classification systems, and life cycles of both homosporous and heterosporous Pteridophytes.*
2. *Analyze the structural and reproductive features of selected Pteridophytes and Gymnosperms (Psilotum, Lycopodium, Selaginella, Equisetum, Adiantum, Marsilea, Cycas, Pinus, and Gnetum).*
3. *Evaluate the evolutionary trends in Pteridophytes, including stelar and sorus evolution, and the significance of heterospory in the origin of the seed habit.*
4. *Explore the economic and medicinal importance of Pteridophytes and Gymnosperms in historical and modern contexts.*
5. *Examine fossil formation processes, methods of fossil dating, and the contributions of pioneers like Birbal Sahni in the field of Paleobotany.*

UNIT-I: Pteridophytes – Structure and Life cycle – **(** Teaching – 1 h / week)

General characteristics - Classification - Reimers (1954) - Life cycle pattern of homosporous and heterosporous –Detailed study of External and internal features, reproduction and life- cycle of (Excluding the developmental stages of sporophyte and gametophyte) *Psilotum, Lycopodium, Selaginell*a.

UNIT-II: Pteridophytes – Organization and Reproduction – **(** Teaching – 1 h / week)

Detailed study of External and internal features, reproduction and life-cycle of (Excluding the developmental stages of sporophyte and gametophyte) *Equisetum, Adiantum* and *Marsilea*. Stelar evolution in Pteridophytes. Evolution of sori in ferns. Heterospory and origin of seed habit. Economic importance of Pteridophytes.

UNIT-III: Introduction to Gymnosperms

General characteristics of Gymnosperms – Classification of Gymnosperms by K. R. Sporne (1965) - Economic importance of gymnsoperms

UNIT-IV: Gymnosperms – Structure and reproduction

Structure, mode of reproduction and lifecycles (excluding the developmental stages**)** pattern in *Cycas, Pinus* and *Gnetum*.

UNIT-V: Paleobotany – **(** Teaching – 1 h / week)

Definition, contribution of Birbal Sahni - Fossils - types of fossils and methods of fossilization - Geological

timescale - Age of fossils - Radio- Carbon Dating – Uses of fossils. Study of the fossil forms - *Rhynia, Lepidodendron, Calamites* and *Williamsonia*. Importance of Paleobotany.

Unit 3 & 4 - Teaching- 1 h / week;

Course Outcomes:

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

CO1	Demonstrate an understanding the characters and economic importance of Pteridophytes and Gymnosperms
CO2	Develop critical understanding on morphology, anatomy and reproduction of Pteridophytes and Gymnosperms
CO3	Comparative studies of steles, sporangia and gametangia in eusporangiate and leptosporangiate groups.
CO4	Understand the plant evolution and their transition to land habitat
CO5	Conceptualize plant fossilization
CO6	Recognize the importance of paleobotany as an interdisciplinary science

Text Book:

- Sporne, K. R. (1970). The Morphology of Pteridophytes (The structure of Ferns and Allied Plants). Hutchinson University Library, London.
- Shukla, A. C. and Misra, .S P. (1975). Essentials of Paleobotany. Vikas Publishing House (P) Ltd., Delhi.
- Vashishta, P.C., Sinha, A.K., Kumar, A., (2010). Pteridophyta, S. Chand. Delhi, India.
- Vashista, P. C. (1996). Botany for Degree Students - Gymnosperms (2nd ed). S. Chand & Co. Ltd., New Delhi.
- Stewart, W. N. (1983). Paleobotany and the Evolution of Plants. Cambridge University Press, London.

References:

- Sharma, O. P. (1990). Textbook of Pteridophytes. MacMillan India Ltd., Delhi.
- Sundara Rajan, S. (1994). Introduction to Pteridophyta. New Age International Publishers Ltd., New Delhi.
- Bhatnagar, S. P. and Alok Moitra (1997). Gymnosperms. New Age International (P) (Ltd.) Publisher, New Delhi.
- Srivastava, H. N. (1998). Gymnosperms. Pradeep Publications, Jalandhar, India.
- Venkatachala, B. S., Shukla, M. and Sharma, M. (1992). Plant Fossils: A link with the past (A Birbal Sahni Birth Centenary Tribute) Birbal Sahni Institute of Paleobotany, Lucknow, India.

Web Resources:

1. https://www.digitalatlasofancientlife.org
2. https://www1.biologie.uni-hamburg.de/b-online/e00/contents.htm

CO- PO Mapping (Course Articulation Matrix)

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	6	3	3	3	1	0
CO2	9	3	1	3	0	1
CO3	9	9	3	3	3	0
CO4	6	3	9	9	0	1
CO5	3	6	6	3	3	1
CO6	3	3	0	0	0	0
Weightage	**36**	**27**	**22**	**21**	**7**	**3**
Weighted percentage of Course contribution to POs	**31.03**	**23.28**	**18.97**	**18.10**	**6.03**	**2.59**

Level of Correlation between CO's and PO's } 1 – Low 3 – Medium 9 – High 0 – No Correlation (Suggested by UGC as per Six Sigma Tool – Cause and Effect Matrix)

Course Outcomes mapped with Knowledge level (Revised Bloom's Taxonomy) and POs

CO/ K-Level	Level of Correlation			
	High	**Medium**	**Low**	**Zero**
CO1/ K1	PO1,	PO2, PO3,PO4	PO5	PO6
CO2/ K2	PO1, PO4	PO2, PO5	PO3,PO6	_
CO3/ K3	PO1, PO2	PO3,PO4 PO5	_	PO6
CO4/ K4	PO1, PO2,	PO3,PO4	PO6	PO5
CO5/ K5	PO1,PO3, PO4	PO2, PO5	PO6	_
CO6/ K6	PO2	PO1	PO4	PO3, PO5, PO6

Course Outcome (CO) Attainment Assessment Tools & Evaluation Procedure:

K Levels	C1	C2	C3	C4	Total scholastic marks	Non Scholastic Marks C5	CIA Total	% of Assessment
	T1 4 Marks	T2 10 Marks	Assignment 6 Marks	Seminar 5 Marks	20 Marks	5 Marks	25 Marks	
K1	1	2	1	--	4	--	**4**	**16**
K2	1	2	1	--	4	--	**4**	**16**
K3	1	2	1	--	4	--	**4**	**16**
K4	1	2	1	--	4	--	**4**	**16**
K5		1	1	--	2	--	**2**	**8**
K6		1	1	--	2	--	**2**	**8**
Non Scholastic	--	--	--	--	--	**5**	**5**	**20**
Total	**4**	**10**	**6**	--	**20**	**5**	**25**	**100%**

***C = Component**

The COs and POs for the **Pteridophytes, Gymnosperms and Paleobotany** course in the **B.Sc. Botany** Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge

Signature of the Coordinator

Sem.	Programme Code	Course Code	Course Type	Course Title	Category	Hrs. / Week	Credits
III & IV	BOTUG1982	U25BO5P	Core Course	**PRACTICAL - 2** **(**U25BO4 & U25BO6)	Practical	3	5

Course Description:

This course provides hands-on laboratory experience in the micropreparation and microscopic examination of representative Pteridophytes, Gymnosperms, and fossil plants. It includes anatomical studies of monocot and dicot plant parts, focusing on normal and anomalous secondary growth, and nodal anatomy types. The course also covers essential embryological techniques such as anther sectioning, embryo dissection, and study of endosperm and ovule types.

Course Objectives:

6. To develop skills in preparing and examining microscopic slides of selected Pteridophytes and Gymnosperms.
7. To identify and interpret fossil plants through spotter studies.
8. To analyze anatomical structures of monocot and dicot stems, roots, and leaves.
9. To understand patterns of anomalous secondary growth and nodal anatomy in plants.
10. To perform embryological techniques and identify reproductive structures in angiosperms.

Pteridophyta:

Micropreparation and detailed microscopic study of *Psilotum, Lycopodium, Selaginella, Equisetum, Adiantum* and *Marsilea*

Gymnosperms:

Micropreparation and detailed microscopic study of *Cycas, Pinus* and *Gnetum*

Paleobotany:

Fossils – *Rhynia, Lepidodendron, Calamites* and *Williamsonia* (spotters only)

Anatomy:

Monocot- Stem, leaf and root
Dicot- Stem, leaf and root

Anomalous secondary growth - Dicot: *Nyctanthus, Boerhaavia*; Monocot: *Dracaena*

Nodal anatomy: i) Unilacunar ii) Trilacunar iii) Multilacunar

Embryology:

T.S of Anther; Dissection of embryo (*Tridax*); Types of Endosperms; Ovule types.

Course Outcomes:
On completion of this course, the students will be able to:

CO1	Understand the fundamental concepts of plant anatomy and embryology
CO2	Develop critical understanding on morphology, anatomy and reproduction of Pteridophytes and Gymnosperms prescribed in the syllabus
CO3	Demonstrate proficiency in the methods of appropriate analysis of Pteridophytes, Gymnosperms
CO4	Evaluate the competency in the experimental techniques in Plant anatomy including secondary growth, anomalous secondary growth and nodal anatomy.

CO5 Develop the knowledge the reproductive structures in plants.
CO6 Justify the different fossils forms and their course of formation

CO- PO Mapping (Course Articulation Matrix)

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	6	3	3	3	1	0
CO2	9	3	1	3	0	1
CO3	6	9	3	3	3	0
CO4	6	6	9	9	0	1
CO5	3	6	9	3	1	1
CO6	3	3	0	0	0	0
Weightage	**33**	**30**	**25**	**21**	**5**	**3**

Level of Correlation between CO's and PO's } 1 – Low 3 – Medium 9 – High 0 – No Correlation (Suggested by UGC as per Six Sigma Tool – Cause and Effect Matrix)

Course Outcomes mapped with Knowledge level (Revised Bloom's Taxonomy) and POs

CO/ K-Level	Level of Correlation			
	High	**Medium**	**Low**	**Zero**
CO1/ K1	PO1, PO2	PO3, PO4, PO5	PO6	_
CO2/ K2	PO1, PO2	PO3, PO4	PO5, PO6	_
CO3/ K3	PO1	PO2, PO3,	PO4, PO5	PO6
CO4/ K4	PO1	PO2, PO3	PO4, PO5	PO6
CO5/ K5		PO1, PO2	PO3, PO4	PO5, PO6
CO6/ K6		PO1, PO2	PO3, PO4,	PO5, PO6

Course Outcome (CO) Attainment Assessment Tools & Evaluation Procedure:

K Levels	C1	C2	C3	C4	Total scholastic marks	Non Scholastic Marks C5	CIA Total	% of Assessment
	T1 4 Marks	**T2 10 Marks**	**Assignment 6 Marks**	**Seminar 5 Marks**	**20 Marks**	**5 Marks**	**25 Marks**	
K1	1	2	1	--	4	--	**4**	**16**
K2	1	2	1	--	4	--	**4**	**16**
K3	1	2	1	--	4	--	**4**	**16**
K4	1	2	1	--	4	--	**4**	**16**
K5		1	1	--	2	--	**2**	**8**
K6		1	1	--	2	--	**2**	**8**
Non Scholastic	--	--	--	--	--	**5**	**5**	**20**
Total	**4**	**10**	**6**	--	**20**	**5**	**25**	**100%**

***C = Component**

The COs and POs for the **PRACTICAL 2** course in the B.Sc. Botany Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge Signature of the Coordinator

Sem.	Programme Code	Course Code	Course Type	Course Title	Category	Hrs. / Week	Credits
III	BOTUG1982	U25BOSBE2	SKILL BASED ELECTIVE	**MUSHROOM TECHNOLOGY**	Theory	2	2

Course Description:

This course provides a fundamental knowledge of mushrooms, covering history and scope of mushroom. It explores the nutrition of mushroom and different cultivation methods. Essential infrastructure of mushroom cultivation. Factors affecting the mushroom bed preparation- Low cost technology; composting technology in mushroom production.

Course Objectives:

1. *To master optimal harvesting techniques and implement various short-term and long-term preservation and storage methods for mushrooms.*
2. *To identify and apply effective control measures against common bacterial and fungal diseases impacting mushroom cultivation.*
3. *To explore the diversity of mushroom-based food products and analyze strategies for their successful marketing.*
4. *To recognize leading national and regional research centers dedicated to mushroom science and cultivation in India.*
5. *To comprehend recent scientific and technological advancements in the field of mushroom cultivation and processing.*

Unit I: General characters of Mushroom

Introduction, History and Scope of Mushroom cultivation. Identification, of edible and poisonous mushroom. Nutritional and economical importance of mushroom.

Unit II: Mushroom cultivation technology

Cultivation Technology: Infrastructure for cultivation of mushroom - vessels, Inoculation hood, inoculation loop, low cost stove, sieves, culture rack, mushroom unit (Thatched house) water sprayer, tray, small polythene bag. Pure culture: Medium, sterilization, preparations of spawn and spawning techniques.

Unit III: Mushroom production

Mushroom bed preparation – paddy straw, sugarcane trash, maize straw, banana leaves. Factors affecting the mushroom bed preparation- Low cost technology; Composting technology in mushroom production.

Unit IV: Mushroom preservation

Harvesting and Storage.: Short-term storage (Refrigeration – up to 24 hours) Long term Storage (canning, pickels, papads), drying, Nutritional Value of Mushroom - Diseases in mushrooms – Bacteria (Brown spot /blotch), Fungi (Dry bubble).

Unit V: Application of Mushroom

Mushroom recipes - Types of foods prepared from mushroom. Research Centres - National level and Regional level. Marketing in India and management. Recent research in mushroom.

Unit 1, 2 & 3 - Teaching- 1 h / week; Unit 4 & 5 - Teaching- 1 h / week;

Course Outcomes:

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

CO1	Understand the various types and categories of mushrooms.
CO2	Demonstrate various types of mushroom cultivating technologies.
CO3	Examine various types of food technologies associated with mushroom industry.
CO4	Value the economic factors associated with mushroom cultivation
CO5	Develop new methods and strategies to contribute to mushroom production.
CO6	Evaluate the knowledge on the marketing potential of the produced mushroom and composts

Text Book:

- Bahl, N. (1988). Hand book of Mushrooms, II Edition, Vol. I & Vol. II.
- Marimuthu, T., Krishnamoorthy, A.S., Sivaprakasam, K. and Jayarajan. R. (1991). Oyster Mushrooms, Department of Plant Pathology, Tamil Nadu Agricultural University, Coimbatore.
- Kapoor, J.N. (2016) Mushroom cultivation. Indian Council of Agricultural Research, New Delhi.

References:

- Swaminathan, M. (1990). Food and Nutrition. Bappco, The Bangalore Printing and Publishing Co. Ltd., No. 88, Mysore Road, Bangalore - 560018.
- Tewari, P. and Kapoor, S.C., (1988). Mushroom cultivation, Mittal Publications, Delhi.
- Suman B.C and V.P Sharma (2007). Mushroom cultivation in India. Daya Publishing House, New Delhi

Web Resources:

- https://agritech.tnau.ac.in/farm_enterprises/Farm%20enterprises_%20Mushroom_Disease.html
- https://agmarknet.gov.in/Others/phmmushroom.pdf
- https://smallfarms.cornell.edu/projects/mushrooms/value-added-products/

CO- PO Mapping (Course Articulation Matrix)

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	3	3	3	1	0
CO2	9	3	1	3	0	1
CO3	9	9	3	3	3	0
CO4	9	9	9	9	0	1
CO5	9	3	9	9	3	1
CO6	3	3	0	0	0	0
Weightage	**48**	**30**	**25**	**27**	**7**	**3**
Weighted percentage of Course contribution to POs	34.29	21.43	17.86	19.29	5.00	2.14

Level of Correlation Between CO's and PO's } 1 – Low 3 – Medium 9 – High 0 – No Correlation (Suggested by UGC as per Six Sigma Tool – Cause and Effect Matrix)

Course Outcomes mapped with Knowledge level (Revised Bloom's Taxonomy) and POs

CO/ K-Level	Level of Correlation			
	High	Medium	Low	Zero
CO1/ K1	PO1,	PO2, PO3,PO4	PO5	PO6
CO2/ K2	PO1,	PO2, PO4	PO3, PO6	PO5
CO3/ K3	PO1, PO2	PO3, PO4,PO5	_	PO6
CO4/ K4	PO1,PO3,PO4	PO2	PO6	PO5,
CO5/ K5	PO2,PO3,	PO1,PO4, PO5	PO6	_
CO6/ K6	-	PO1,PO2	-	PO3, PO4, PO5, PO6

Course Outcome (CO) Attainment Assessment Tools & Evaluation Procedure:

K Levels	C1	C2	C3	C4	Total scholastic marks	Non Scholastic Marks C5	CIA Total	% of Assessment
	T1 4 Marks	T2 10 Marks	Assignment 6 Marks	Seminar 5 Marks	20 Marks	5 Marks	25 Marks	
K1	1	2	1	--	4	--	**4**	**16**
K2	1	2	1	--	4	--	**4**	**16**
K3	1	2	1	--	4	--	**4**	**16**
K4	1	2	1	--	4	--	**4**	**16**
K5		1	1	--	2	--	**2**	**8**
K6		1	1	--	2	--	**2**	**8**
Non Scholastic	--	--	--	--	--	**5**	**5**	**20**
Total	**4**	**10**	**6**	--	**20**	**5**	**25**	**100%**

***C = Component**

The COs and POs for the **MUSHROOM TECHNOLOGY** course in the B.Sc. Botany Programme is effectively matched by the Course In-charge.

Signature of the Course In- charge

Signature of the Coordinator

Sem.	Programme Code	Course Code	Course Type	Course Title	Category	Hrs. / Week	Credits
III	BOTUG1982	U25BOSBE3P	SKILL BASED ELECTIVE	**SBE - PRACTICAL** (U25BOSBE1 & U25BOSBE2)	Practical	2	2

Course Description:

This course provides hands-on training in the production and mass cultivation of important biofertilizers such as *Rhizobium*, *Azolla*, and VAM fungi, essential for sustainable agriculture. It also introduces mushroom cultivation technology, covering substrate preparation, spawn production, and bed preparation, with practical experience in cultivating paddy straw mushrooms. The course emphasizes skill development for eco-friendly and income-generating agricultural practices.

Course Objectives:

1. To acquire practical skills in the production of *Rhizobium* biofertilizer.
2. To learn mass cultivation techniques of *Azolla* and VAM fungi.
3. To understand the preparation of suitable substrates for mushroom growth.
4. To gain experience in spawn preparation and mushroom bed setup.
5. To develop competency in the cultivation of paddy straw mushrooms for commercial purposes.

Biofertilizer and Biopesticides

1. Production of *Rhizobium.*
2. Mass production of *Azolla*
3. Mass production of VAM fungi

Mushroom Cultivation Technology

1. Preparation of substrate.
2. Preparation of Spawn.
3. Preparation of Mushroom Bed
4. Cultivation of paddy straw mushroom

Course Outcomes:
On completion of this course, the students will be able to:

CO1	*Understanding the concepts of bio-fertilizer and Biopesticides*
CO2	*Train the students to gain hands on experience in Mass culture of biofertilizers and Biopesticides*
CO3	*Demonstrate various types of mushroom cultivating technologies and Value the economic factors associated with mushroom cultivation.*
CO4	*Analyze various techniques and substrates for cultivation of mushroom*
CO5	*Identify various commercials potentials of Biofertilizer, biopesticides and mushroom.*
CO6	Impart in students the ability and skills required to become self-employed / entrepreneur.

CO- PO Mapping (Course Articulation Matrix)

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	6	3	3	3	1	0
CO2	6	3	1	3	3	1
CO3	6	9	3	3	3	0
CO4	6	6	9	9	0	1
CO5	6	3	9	6	3	1
CO6	3	6	1	0	0	0
Weightage	**33**	**30**	**26**	**24**	**10**	**3**
Weighted percentage of Course contribution to POs	**26.19**	**23.81**	**20.63**	**19.05**	**7.94**	**2.38**

Level of Correlation between CO's and PO's } 1 – Low 3 – Medium 9 – High 0 – No Correlation (Suggested by UGC as per Six Sigma Tool – Cause and Effect Matrix)

Course Outcomes mapped with Knowledge level (Revised Bloom's Taxonomy) and POs

CO/ K-Level	Level of Correlation			
	High	**Medium**	**Low**	**Zero**
CO1/ K1	PO1, PO2	PO3, PO4, PO5	PO6	_
CO2/ K2	PO1, PO2	PO3, PO4	PO5,	PO6
CO3/ K3	PO1	PO2, PO3,	PO4, PO5, PO6	-
CO4/ K4	PO1	PO2, PO3	PO4, PO5	PO6
CO5/ K5		PO1, PO2	PO3, PO4	PO5, PO6
CO6/ K6		PO1, PO2	PO3, PO4,	PO5, PO6

Course Outcome (CO) Attainment Assessment Tools & Evaluation Procedure:

K Levels	C1	C2	C3	C4	Total scholastic marks	Non Scholastic Marks C5	CIA Total	% of Assessment
	T1 4 Marks	T2 10 Marks	Assignment 6 Marks	Seminar 5 Marks	20 Marks	5 Marks	25 Marks	
K1	1	2	1	--	4	--	**4**	**16**
K2	1	2	1	--	4	--	**4**	**16**
K3	1	2	1	--	4	--	**4**	**16**
K4	1	2	1	--	4	--	**4**	**16**
K5		1	1	--	2	--	**2**	**8**
K6		1	1	--	2	--	**2**	**8**
Non Scholastic	--	--	--	--	--	**5**	**5**	**20**
Total	**4**	**10**	**6**	--	**20**	**5**	**25**	**100%**

***C = Component**

The COs and POs for the **SBE** - **PRACTICAL** course in the B.Sc. Botany Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge Signature of the Coordinator

Sem.	Programme Code	Course Code	Course Type	Course Title	Category	Hrs. / Week	Credits
IV	BOTUG1982	U25BO6	Core Course	**PLANT ANATOMY AND EMBRYOLOGY**	Theory	4	4

Course Description:

This course explores the internal structure and development of higher plants, with a focus on the organization and classification of meristems, tissue systems, and plant organs such as roots, stems, and leaves. Emphasis is placed on primary and secondary growth, anatomical adaptations, and embryological processes including micro- and megasporogenesis, fertilization mechanisms, and embryogenesis. Special attention is given to double fertilization, endosperm formation, and types of polyembryony. Comparative embryological development in dicots and monocots is also included to provide comprehensive insight into plant reproduction.

Course Objectives:

1. *Understand the structure, classification, and function of meristems and explain key theories related to shoot and root apical meristem organization.*
2. *Classify and describe different plant tissues, including simple, complex, mechanical, and secretory tissues along with vascular tissue systems.*
3. *Interpret the primary and secondary anatomical structures of roots, stems, and leaves in dicots and monocots, and explain normal and anomalous secondary growth.*
4. *To study the development and function of male and female gametophytes, pollination, fertilization, and double fertilization, including triple fusion and endosperm development.*
5. *To know the embryological development in dicot (e.g.,* **Capsella***) and monocot (e.g.,* **Luzula***) plants, and describe the phenomenon of polyembryony and its significance.*

UNIT-I Meristem and Classification – **(** Teaching – 1 h / week)

Meristems: Characteristics, Classification, distribution, structure and function. Shoot apex and Root apex organization. Theories: Histogen, Tunica - Corpus and Concept of quiescent center.

UNIT-II Tissues – **(** Teaching – 1 h / week)

Classification of plant tissues – Structure and function of Simple permanent tissues and complex permanent tissues, Types of Mechanical tissues, Epidermal tissues, Secretory tissues, stomata types – laticifers. Tissue system – Vascular.

UNIT-III Anatomy of Root, Stem and Node – **(** Teaching – 1 h / week)

Primary structure of root, stem and leaf in dicot and monocot. Normal Secondary growth in stem and root, heartwood, sapwood, annual rings, Periderm formation. Anomalous secondary growth in dicot stems (*Nyctanthus* and *Boerhaavia*) and monocot stem (*Dracaena*). Nodal anatomy – unilacunar, trilacunar and multilacunar types.

UNIT IV: Embryology - Development of gametes

Ontogeny of flower. Microsporangium: Microsporogenesis, development of Male gametophyte – Megasporangium: Megasporogenesis, development of Female gametophyte.

UNIT-V: Fertilization and embryo development

A brief account on pollination, Fertilization, Double fertilization and Triple fusion. Endosperm: Nuclear, Cellular, Helobial and Ruminate. Development of Embryo in Dicot (Capsella) and monocot (Luzula). Polyembryony.

Units - IV & V - Teaching- 1 h / week

Course Outcomes:
On completion of this course, the students will be able to:

CO1	*Understand the cellular composition of plant cell and reproduction of angiospermic plants*
CO2	*Know the fundamental concepts of plant internal architecture.*
CO3	*Gain the knowledge on the anatomy of stem, root and node.*
CO4	*Analyze and recognize the different types of tissue in plant and normal & anomalous secondary growth in plants*
CO5	*Examine the structure and functions of male and female gametophytes.*
CO6	*Evaluate the structural organization of flower and the process of pollination and fertilization.*

Text Book:

- Agarwal, S. B. (1990). Embryology of Angiosperms - a fundamental approach. Sahitya Bhawan, Agra.
- Pandey, B. P. (1989). Plant Anatomy. S. Chand and Co. Ltd., New Delhi.
- Pandy, S.N. (1997). Plant Anatomy and Embryology. S Chand and Co. Ltd., New Delhi

References:

- Bhojwani, S. S. and Bhatnagar, S. P. (1981). Embryology of Angiosperms. Vikas Publishing House Pvt. Ltd., New Delhi.
- Dwivedi, J. N. (1998). Embryology of Angiosperms. Rastogi and Co., Meerut.
- Maheswari, P. (1963). An Introduction to Embryology of Angiosperms. International Society of Plant Morphologies, University of Delhi.
- Mauseth, J.D. (1988). Plant Anatomy. The Benjamin/Cummings Publisher, USA

Web Resources:

- https://ncert.nic.in
- https://www1.biologie.uni-hamburg.de/b-online/e00/contents.htm
- http://plantbiology.siu.edu/facilities/microscopy.html
- https://nptel.ac.in/courses/102/103/102103017/

CO- PO Mapping (Course Articulation Matrix)

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	6	3	3	3	1	0
CO2	6	3	1	3	3	1
CO3	9	9	6	3	3	0
CO4	6	6	9	9	0	1
CO5	9	6	9	6	1	1
CO6	3	6	1	0	0	0
Weightage	**39**	**33**	**29**	**24**	**5**	**3**
Weighted percentage of Course contribution to POs	**29.32**	**24.81**	**21.80**	**18.05**	**3.76**	**2.26**

Level of Correlation between CO's and PO's } 1 – Low 3 – Medium 9 – High 0 – No Correlation (Suggested by UGC as per Six Sigma Tool – Cause and Effect Matrix)

Course Outcomes mapped with Knowledge level (Revised Bloom's Taxonomy) and POs

CO/ K-Level	Level of Correlation			
	High	**Medium**	**Low**	**Zero**
CO1/ K1	PO2,	PO1, PO3,PO4	PO5	PO6
CO2/ K2	PO3,	PO2, PO4 PO5	PO1,PO6	_
CO3/ K3	PO1, PO2	PO3,PO4	PO5	PO6
CO4/ K4	PO1, PO2, PO3,PO4	_	PO6	PO5,
CO5/ K5	PO1,PO3, PO4	PO2, PO5	_	PO6
CO6/ K6	PO2	PO1	PO3	PO4, PO5, PO6

Course Outcome (CO) Attainment Assessment Tools & Evaluation Procedure:

K Levels	C1	C2	C3	C4	Total scholastic marks	Non Scholastic Marks C5	CIA Total	% of Assessment
	T1 4 Marks	T2 10 Marks	Assignment 6 Marks	Seminar 5 Marks	20 Marks	5 Marks	25 Marks	
K1	1	2	1	--	4	--	**4**	**16**
K2	1	2	1	--	4	--	**4**	**16**
K3	1	2	1	--	4	--	**4**	**16**
K4	1	2	1	--	4	--	**4**	**16**
K5		1	1	--	2	--	**2**	**8**
K6		1	1	--	2	--	**2**	**8**
Non Scholastic	--	--	--	--	--	**5**	**5**	**20**
Total	**4**	**10**	**6**	--	**20**	**5**	**25**	**100%**

***C = Component**

The COs and POs for the **Plant Anatomy and Embryology** course in the **B.Sc. Botany** Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge

Signature of the Coordinator

Sem.	Programme Code	Course Code	Course Type	Course Title	Category	Hrs. / Week	Credits
V	BOTUG1982	U25BO7	Core Course	**MORPHOLOGY, TAXONOMY AND ECONOMIC BOTANY**	Theory	5	5

Course Description:

This course introduces the structural features and modifications of plant organs, with a focus on leaf, root, stem, inflorescence, and fruit types. It covers the principles and systems of plant classification, nomenclature rules, and modern taxonomic approaches including APG-IV and chemotaxonomy. Detailed taxonomic study of selected angiosperm families is emphasized, highlighting their morphological traits and economic uses. The course also explores economically important plants used for food, fibre, medicine, and other industrial applications.

Course Objectives:

1. Understand the morphology of various plant parts and their modifications, including fruit and seed dispersal mechanisms.
2. Learn principles of binomial nomenclature, ICN rules, and classical and modern systems of plant classification.
3. Study key flowering plant families with emphasis on diagnostic features and economic importance.
4. Explore the role of institutions like BSI and recent trends in plant systematics, including herbarium techniques.
5. Recognize the significance of economically valuable plants used in food, beverages, fibres, medicine, and forest products.

UNIT- I Morphology – **(** Teaching – 1 h / week)

Morphology of leaf, root, stem and its modifications - Phyllotaxy - Taxonomic description of a flower and floral parts. Aestivation types. Placentation types. Inflorescence - Racemose, Cymose, Mixed and Special types. Fruit-simple, fleshy, dry dehiscent and dry indehiscent. Dispersal mechanism of seeds.

UNIT- II Taxonomy – **(** Teaching – 1 h / week)

Binomial nomenclature - ICN rules and regulations. BSI – significance – role - centres. Systems of Classification - Bentham & Hooker classification, merits and demerits. General concept of APG - IV. Herbarium techniques, floras, monograph. Recent trends in Plant systematics - Cytotaxonomy, Chemotaxonomy and Numerical taxonomy.

UNIT- III Taxonomy – **(** Teaching – 1 h / week)

A detailed study of the following families with their economic importance - Annonaceae, Capparidaceae, Rutaceae, Anacardiaceae, Leguminosae (Papilionoideae, Caesalpinioideae, Mimosoideae), Cucurbitaceae and Apiaceae,

UNIT- IV Taxonomy – **(** Teaching – 1 h / week)

A detailed study of the following families with their economic importance -Rubiaceae, Asteraceae, Apocynaceae, Solanaceae, Acanthaceae Verbenaceae, Euphorbiaceae, Orchidaceae and Poaceae.

UNIT-V Economic Botany – **(** Teaching – 1 h / week)

Food- Cereals (*Oryza*), Pulses (*Phaseolus*), Edible oil (*Arachis*) and Sugar (*Saccharum*).

Beverages- Tea (*Camellia*) and Coffee (*Coffea*). Spices - Pepper (*Piper*), Cardamom (*Eletteria).*

Fibres- Cotton (*Gossypium*) and Jute (*Chorcorus*).

Medicinal plants - *Ocimum*, *Phyllanthus* and *Azhadirachta.*

Forest products - Timber (*Tectona)* and Rubber (*Hevea).*

Course Outcomes:

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

CO1	*Develop critical understanding on plant morphology*
CO2	*Comprehend the basic concepts of plant taxonomy and botanical nomenclature*
CO3	*Know the fundamental knowledge of taxonomic diversity and important families of useful plants*
CO4	*Increase the awareness and appreciation of plants & plant products encountered in everyday life*
CO5	*Expound the evolutionary relationship involved in the origin of plant diversity*
CO6	*Enrich the students' knowledge on the economic importance of plants in terms of food, medicine and commerce.*

Text Book:

- Pandey, B. P. (1997). Taxonomy of Angiosperms. S. Chand & Co. Ltd., New Delhi.
- Subramaniyan, N. S. (1999). Laboratory Manual of Plant Taxonomy. (2nd ed.). Tata McGraw Hill Publishing Co. Ltd., New Delhi.
- Pandey, B. P. (2000). Economic Botany. S. Chand & Co. Ltd., New Delhi.

References:

- Matthew, K. M. (1987). Flora of Tamil Nadu and Carnatic (Vol. I-V). Rapinat Herbarium, St. Joseph's College, Tiruchirappalli.
- Vashista, P. C. (1997). Taxonomy of Angiosperms. S. Chand & Co. Ltd., New Delhi.
- Jaques, H. E. (1999). Plant Families - How to know them? Agro Botanical Publishers (India), Bikaner.
- Verma, V. (1974). A Textbook of Economic Botany. Emkay Publications, New Delhi.
- Govinda Prakash and Sharma, S. K. (1975). Introductory Economic Botany. Jai Prakash Nath & Co. Meerut.
- Sambamurthy, A. V. V. S. and Subramanyan, N. S. (1989). A Textbook of Economic Botany. Wiley Eastern Ltd., New Delhi.
- Ashok Bendre and Ashok Kumar (1998). Economic Botany. Rastogi and Co., Meerut.

Web Resources:

- https://www.mobot.org/MOBOT/research/APweb/
- https://www.mobot.org/MOBOT/research/APweb/
- http://www.botany.wisc.edu/courses/botany_422/Syllabus.htm (Navigate to the relevant morphology topics).
- https://archive.org/details/MorphologyOfFloweringPlantsByBotanyByL.w.Coutler1
- https://archive.org/details/plant-taxonomy-khullar-s.p

CO- PO Mapping (Course Articulation Matrix)

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	3	3	3	1	0
CO2	9	3	1	3	3	1
CO3	9	9	3	3	3	0
CO4	9	9	9	9	0	1
CO5	9	3	9	9	3	1
CO6	3	9	1	0	0	0
Weightage	**48**	**36**	**26**	**27**	**10**	**3**
Weighted percentage of Course contribution to POs	**32.00**	**24.00**	**17.33**	**18.00**	**6.67**	**2.00**

Level of Correlation between CO's and PO's } 1 - Low 3 - Medium 9 - High 0 - No Correlation (Suggested by UGC as per Six Sigma Tool - Cause and Effect Matrix)

Course Outcomes mapped with Knowledge level (Revised Bloom's Taxonomy) and POs

CO/ K-Level	Level of Correlation			
	High	**Medium**	**Low**	**Zero**
CO1/ K1	PO1	PO2, PO3,PO4	PO5	PO6
CO2/ K2	PO1	PO2, PO4 PO5	PO3,PO6	_
CO3/ K3	PO1, PO2	PO3, PO4 PO5	-	PO6
CO4/ K4	PO, PO2, PO3,PO4	-	PO6	PO5,
CO5/ K5	PO1, PO3, PO4	PO2, PO5	PO6	-
CO6/ K6	PO2	PO1	PO3	PO4, PO5, PO6

Course Outcome (CO) Attainment Assessment Tools & Evaluation Procedure:

K Levels	C1	C2	C3	C4	Total scholastic marks	Non Scholastic Marks C5	CIA Total	% of Assessment
	T1 4 Marks	**T2 10 Marks**	**Assignment 6 Marks**	**Seminar 5 Marks**	**20 Marks**	**5 Marks**	**25 Marks**	
K1	1	2	1	--	4	--	**4**	**16**
K2	1	2	1	--	4	--	**4**	**16**
K3	1	2	1	--	4	--	**4**	**16**
K4	1	2	1	--	4	--	**4**	**16**
K5		1	1	--	2	--	**2**	**8**
K6		1	1	--	2	--	**2**	**8**
Non Scholastic	--	--	--	--	--	**5**	**5**	**20**
Total	**4**	**10**	**6**	--	**20**	**5**	**25**	**100%**

***C = Component**

The COs and POs for the **Morphology, Taxonomy and Economic Botany** course in the **B.Sc. Botany** Programme is effectively matched by the Course In-charge.

Signature of the Course In- charge Signature of the Coordinator

Sem.	Programme Code	Course Code	Course Type	Course Title	Category	Hrs. / Week	Credits
V	BOTUG1982	U25BO8	Core Course	**CELL AND MOLECULAR BIOLOGY**	Theory	5	5

Course Description:

This course provides an in-depth understanding of prokaryotic and eukaryotic cell structures, their organelles, and nuclear functions. It covers the cell cycle, chromosome organization, and programmed cell death in plants. Students will explore the molecular basis of heredity, including DNA/RNA structure, replication, and gene expression. Key concepts like the Central Dogma, transcription, translation, and gene regulation (e.g., Lac Operon) are emphasized through theoretical and experimental approaches.

Course Objectives:

1. *Differentiate the ultrastructure of prokaryotic and eukaryotic cells and describe the functions of major cellular organelles*
2. *Analyze the structure and types of chromosomes and understand the stages of the cell cycle including mitosis, meiosis, and PCD in plants.*
3. *Explain the molecular structure of DNA and RNA, and validate DNA as genetic material through key experiments.*
4. *Describe the Central Dogma and prokaryotic transcription mechanisms, and explore techniques like Northern blotting and qPCR*
5. *Interpret the features of the genetic code, mechanism of translation, and analyze gene regulation via the Lac Operon.*

*Let me know if you want a version suitable for printing or a slide.*UNIT-I: Cell structure and Organelles

Ultra structure of Prokaryotic and Eukaryotic cells. Structure and functions of plasma membrane, cellular organelles (mitochondria, endoplasmic reticulum, Golgi apparatus, lysosomes, peroxisomes). Nucleus - Nucleolus –Nuclear membrane, Nuclear pore complex and its functions.

UNIT-II: Cell Cycles

Structure of chromosomes - euchromatin and heterochromatin. Special types - Lamp brush chromosomes and polytene chromosomes. Karyotyping, Cell cycle - Mitosis, and Meiosis. Basic concept of Programmed cell death (PCD) in plants

UNIT-III: Nucleic acid

Nucleic acids – DNA and RNA – DNA as the genetic material - Experimental evidences (Griffith's Transformation Experiment, Avery, McCarty's Experiment, Meselson and Stahl experiment). Forms of DNA. RNA - Structure, types (rRNA, mRNA and tRNA) - properties and functions. Replication of DNA – types, enzymes involved.

Unit-IV: Molecular Biology

Central dogma of molecular biology. Transcription: RNA polymerases, transcription factors, and mechanisms in prokaryotes – initiation, elongation and termination. Techniques for studying

gene expression: Northern blotting, qPCR, and microarrays.

UNIT-V: Genetic code and Translation

Genetic code: Introduction and features. Prokaryotic translation. Mechanisms of translation. Post-transcriptional modifications: Splicing, capping, and polyadenylation. Gene regulation in prokaryotes: - Operon concept – *Lac* Operon.

Course Outcomes:

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

CO1	*Impart information on the plant cell organelles*
CO2	*Understand the fundamental concepts of cell division.*
CO3	*Classify the structures and chemical properties of DNA and RNA through various historic experiments.*
CO4	*Evaluate the fundamental aspect of central dogma and genetic code.*
CO5	*Gain the knowledge of mechanisms of transcription in molecular biology*
CO6	*Evaluate the various steps in transcription, protein synthesis and protein modification.*

Text Book:

- Grierson, D. and Convey, S. N. (1989). Plant Molecular Biology. Blackie Publishers, New York.
- Verma, P. S. and Agarwal, V. K. (1986). Cell Biology and Molecular Biology (Cytology). S. Chand & Co. Ltd., New Delhi.
- Sharma, N. S. (2005). Molecular Cell Biology, International Book Districutors, Dehradun.

References

- Old, R. W. and Primrose, S. B. (1994). Principles of Gene Manipulation. Blackwell Science, London.
- Lea, P. J. and Leegood, R. C. (1999). Plant Biochemistry and Molecular Biology. John Wile & Sons, London.
- Power, C. B. (1984). Cell Biology. Himalayas Publishing Co., Mumbai.
- De, Robertis and De Robertis (1998). Cell and Molecular Biology. K. M. Verghese and Co.

Web Resources:

- Khan Academy – Prokaryotic vs Eukaryotic cells](https://www.khanacademy.org/science/biology/structure-of-a-cell)
- Nature Education – The Cell Cycle](https://www.nature.com/scitable/topicpage/the-cell-cycle-14046241/)
- YourGenome – DNA Experiments](https://www.yourgenome.org/facts/what-is-dna/)
- NCBI – Gene Expression Techniques](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4464020/)
- HHMI Biointeractive – Lac Operon Animation](https://www.biointeractive.org/classroom-resources/lac-operon)

CO- PO Mapping (Course Articulation Matrix)

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	6	3	3	3	1	0
CO2	6	3	1	3	3	1
CO3	6	9	3	3	3	0
CO4	6	6	9	9	0	1
CO5	6	3	9	6	3	1
CO6	3	6	1	0	0	0
Weightage	**33**	**30**	**26**	**24**	**10**	**3**
Weighted percentage of Course contribution to POs	**26.19**	**23.81**	**20.63**	**19.05**	**7.94**	**2.38**

Level of Correlation between CO's and PO's } 1 – Low 3 – Medium 9 – High 0 – No Correlation (Suggested by UGC as per Six Sigma Tool – Cause and Effect Matrix)

Course Outcomes mapped with Knowledge level (Revised Bloom's Taxonomy) and POs

CO/ K-Level	Level of Correlation			
	High	**Medium**	**Low**	**Zero**
CO1/ K1	PO1	PO2,PO3, PO6	PO4, PO5	-
CO2/ K2	PO1, PO3	PO2,PO4, PO6	PO5	-
CO3/ K3	PO3	PO1, PO4, PO5, PO6	_PO2	-
CO4/ K4	PO1	PO2, PO3, PO4	PO5	PO6
CO5/ K5	PO4	PO1, PO2, PO3, PO5	PO6	_
CO6/ K6	PO3, PO4,	PO1,	PO2	PO1, PO5

Course Outcome (CO) Attainment Assessment Tools & Evaluation Procedure:

K Levels	C1	C2	C3	C4	Total scholastic marks	Non Scholastic Marks C5	CIA Total	% of Assessment
	T1 4 Marks	**T2 10 Marks**	**Assignment 6 Marks**	**Seminar 5 Marks**	**20 Marks**	**5 Marks**	**25 Marks**	
K1	1	2	1	--	4	--	**4**	**16**
K2	1	2	1	--	4	--	**4**	**16**
K3	1	2	1	--	4	--	**4**	**16**
K4	1	2	1	--	4	--	**4**	**16**
K5		1	1	--	2	--	**2**	**8**
K6		1	1	--	2	--	**2**	**8**
Non Scholastic	--	--	--	--	--	**5**	**5**	**20**
Total	**4**	**10**	**6**	--	**20**	**5**	**25**	**100%**

***C = Component**

The COs and POs for the **CELL AND MOLECULAR BIOLOGY** Elective course in the M**.Sc. Botany** Programme is effectively matched by the Course In-charge.

Signature of the Course In- charge Signature of the Coordinator

Sem.	Programme Code	Course Code	Course Type	Course Title	Category	Hrs. / Week	Credits
V	BOTUG1982	U25BO9E	Elective Course	**BIOCHEMISTRY, BIOPHYSICS AND BIOINSTRUMENTATION**	Theory	5	4

Course Description:

This course explores the structure, classification, and functions of major biomolecules including carbohydrates, amino acids, proteins, enzymes, lipids, and secondary metabolites. It provides insight into enzyme kinetics, thermodynamics, and bioenergetics essential for understanding biochemical processes. The course also introduces foundational concepts in biophysics and principles of biological instrumentation. Students will gain knowledge of separation and analytical techniques like chromatography, electrophoresis, centrifugation, and spectrophotometry.

Course Objectives:

1. *Understand the structure, classification, and functions of carbohydrates, amino acids, proteins, lipids, and enzymes.*
2. *Explain enzyme kinetics, inhibition, and the factors influencing enzymatic activity.*
3. *Differentiate primary and secondary metabolites and describe their biosynthesis, functions, and significance in plants.*
4. *Apply principles of thermodynamics, redox reactions, and ATP dynamics to biological systems.*
5. *Gain practical knowledge of bioinstrumentation techniques used in the separation and analysis of biomolecules.*

UNIT-I Carbohydrates: Concepts and properties of biological molecules Chemical bonds: Electrovalent, Covalent, Polar Coordinate, and non-covalent bonds and their importance in biological organisms. Carbohydrates: Definition, Classification. Properties, Structures and functions of Monosaccharides, (Glucose, fructose), Disaccharides (Sucrose), Polysaccharides (Pectin, Cellulose and Starch).

UNIT-II Amino acids: Definition, Structure, classification (Serine, Pyruvate, Aspartate, Aromatic and Glutamate families) and properties. Stress related amino acids.

Proteins: Definition Formation of protein - Structure- primary, secondary, tertiary and quaternary structures; Classification and functions of protein.

UNIT-III Enzymes: Nomenclature, classification and properties. Mechanism of action – active site-Fischer's Lock and Key model. Enzyme kinetics – Km Value and V max. Enzyme inhibitors - competitive, uncompetitive and non-competitive. Factors affecting enzyme activity.

Lipids–Definition, Structure, (Physical & Chemical Properties) Function, classification, properties and functions of lipids.

UNIT-IV Secondary metabolites in plants: Definition, Brief comparison on Primary and secondary metabolites, Biosynthesis functions and uses of secondary metabolites: alkaloids, terpenoids, phenols,

lignin, flavonoids and anthocyanins.

Biophysics: Electromagnetic radiation. Properties and components of light. Laws of Thermodynamics – first, second and third laws. Enthalpy and entropy. Bioenergetics – redox potential, Dynamics ATP.

UNIT-V Bioinstrumentation: Separation technique: Principle and applications of Centrifuges, chromatography and electrophoresis -PAGE Analytical technique: Principle and applications of Colorimeter and UV-visible spectrophotometer.

Course Outcomes:

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

CO1	*Comprehend different fundamental concepts related to biochemistry*
CO2	*Understanding the terms and concepts related to biophysics*
CO3	*Evaluate the process of ATP Synthesis, nitrogen metabolism and lipid metabolism*
CO4	*Expound the importance of Plant Secondary Metabolites*
CO5	*Learn the working principle of the various instruments used in biological studies*
CO6	*Gain the in-depth knowledge on the various separation techniques and spectroscopic methods*

Text Book:

- Jain, J. L. (1979). Fundamentals of Biochemistry. S. Chand & Co. Ltd., New Delhi.
- Narayanan, P. (2000). Essentials of Biophysics. New Age international Publishers (P) Ltd., New Delhi.
- Bajpai, P.K. 2006. Biological Instrumentation and methodology. S. Chand & Co. Ltd.
- Sathiyanarayana, U. (2013). Biochemistry, Elseiver 4th edition.

References:

- Heldt, H. W. and Piechulla, B. (2010). Plant Biochemistry. 4th Edition. Paperback. Academic Press.
- Buchanan, B., Gruissem, W. and Jones R. L. (Eds) (2015). Biochemistry and Molecular Biology of Plants. 2nd Edition. Paper back. Wiley-Blackwell.
- Palanivelu P 2009. Analytical Biochemistry and Separation Techniques. Twenty-first Century Publications, Madurai.
- David L. Nelson, Michael M. Cox (2013). Lehninger Principles of Biochemistry, W. H. Freeman, 6th edition.

We Resources:

- http://www.whfreeman.com/lehninger/
- https://www.khanacademy.org/science/biology
- https://www.ncbi.nlm.nih.gov/books/
- https://archive.org/details/principlesofbiochemistrylehninger
- https://archive.org/details/BiochemistryStryer

CO- PO Mapping (Course Articulation Matrix)

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	6	3	3	3	1	0
CO2	9	6	3	3	3	1
CO3	9	9	3	6	3	0
CO4	9	6	9	9	0	1
CO5	6	3	9	6	1	1
CO6	3	6	1	0	0	0
Weightage	**41**	**33**	**28**	**27**	**8**	**3**
Weighted percentage of Course contribution to POs	**29.29**	**23.57**	**20.00**	**19.29**	**5.71**	**2.14**

Level of Correlation between CO's and PO's } 1 – Low 3 – Medium 9 – High 0 – No Correlation (Suggested by UGC as per Six Sigma Tool – Cause and Effect Matrix)

Course Outcomes mapped with Knowledge level (Revised Bloom's Taxonomy) and POs

CO/ K-Level	Level of Correlation			
	High	Medium	Low	Zero
CO1/ K1	PO1, PO4,	PO2	PO3	PO5, PO6
CO2/ K2	PO1	PO2, PO3	PO4	PO5, PO6
CO3/ K3	PO1, PO2	PO3, PO4		PO5, PO6
CO4/ K4	PO2, PO3	PO1, PO4	PO5,	PO6
CO5/ K5	PO4	PO2, PO3	PO1, PO6	PO5,
CO6/ K6	PO4, PO5,	PO2, PO3	PO1, PO6	-

Course Outcome (CO) Attainment Assessment Tools & Evaluation Procedure:

K Levels	C1	C2	C3	C4	Total scholastic marks	Non Scholastic Marks C5	CIA Total	% of Assessment
	T1 4 Marks	T2 10 Marks	Assignment 6 Marks	Seminar 5 Marks	20 Marks	5 Marks	25 Marks	
K1	1	2	1	--	4	--	**4**	**16**
K2	1	2	1	--	4	--	**4**	**16**
K3	1	2	1	--	4	--	**4**	**16**
K4	1	2	1	--	4	--	**4**	**16**
K5		1	1	--	2	--	**2**	**8**
K6		1	1	--	2	--	**2**	**8**
Non Scholastic	--	--	--	--	--	**5**	**5**	**20**
Total	**4**	**10**	**6**	--	**20**	**5**	**25**	**100%**

***C = Component**

The COs and POs for the **BIOCHEMISTRY, BIOPHYSICS AND BIOINSTRUMENTATION** course in the **M.Sc. Botany** Programme is effectively matched by the Course In-charge.

Signature of the Course In- charge

Signature of the Coordinator

Sem.	Programme Code	Course Code	Course Type	Course Title	Category	Hrs. / Week	Credits
V	BOTUG1982	U25BO10E	Elective Course	**MICROBIOLOGY**	Theory	5	4

Course Description:

This course introduces the history, classification, and structural biology of microorganisms including bacteria, viruses, viroids, and prions. It provides hands-on knowledge of microscopy, staining techniques, microbial isolation, cultivation, and sterilization. Emphasis is placed on the applications of microbiology in food, dairy, and soil ecosystems, highlighting microbial roles in fermentation, spoilage, disease, and nutrient cycling. Students also learn microbial growth dynamics and preservation methods.

Course Objectives:

1. *Understand the historical development and classification of microorganisms, including the structure of bacteria and viruses.*
2. *Learn microscopy techniques and staining methods used in the observation and identification of microbes.*
3. *Acquire practical knowledge of microbial isolation, cultivation, growth measurement, and preservation techniques.*
4. *Explore the role of microbes in food production, spoilage, foodborne diseases, and preservation strategies.*
5. *Study soil microflora and understand the microbial role in soil fertility, organic matter decomposition, and nutrient cycling.*

UNIT – I: INTRODUCTION TO MICROBIOLOGY AND MICROTECHNIQUE (Teaching-1 h / week)

History and Scope of Microbiology. R.H. Whittaker system of classification. Morphology and ultra structure of bacteria and virus – Bacteriophage. Introduction to viroids, and Prions. Microscopy - Light and Electron Microscope (SEM & TEM). Specimen preparation for Light Microscopy - Smear Preparation – Wet mount techniques and Staining - simple, negative, Gram's, Acid fast.

UNIT – II: TECHNIQUES IN MICROBIOLOGY - ISOLATION AND CULTIVATION (Teaching-1 h / week)

Bacterial culture media – serial dilution technique - isolation of pure culture. Nutritional types of microorganisms. Growth curve: phases of growth - measurement of microbial growth: Turbidity, Plate count and Direct Microscopic count. Factors influencing microbial growth. Cultivation of moulds and yeast.

UNIT - III: TECHNIQUES IN MICROBIOLOGY - STERILIZATION AND PRESERVATION (Teaching-1 h / week)

Physical and chemical methods of sterilization. Overview of Antimicrobials - determination of levels of antimicrobial activity - mechanisms of action of antimicrobial agents. Bacterial spores (Endospores). Maintenance and preservation of microorganisms – Long term and short term techniques.

UNIT - IV: FOOD AND DAIRY MICROBIOLOGY (Teaching-1 h / week)

Microorganisms in food production: Fermented foods and probiotics. Food spoilage and preservation techniques. Factors influencing food spoilage – Extrinsic and Intrinsic. Control of food spoilage – Heat, Radiation, Water activity, Preservatives and Packaging. General account on Food Borne Disease – Botulism. Food borne infection

and food intoxication, detection of food borne pathogens.

UNIT – V: SOIL MICROBIOLOGY (Teaching-1 h / week)

Overview of soil microflora - Role of microorganism in soil formation and soil fertility. Role of microbes in nutrient cycling – C, N, P and S. Role of microbes in decomposition of organic matters – Cellulose, Lignin, Starch. Syntrophism in soil.

Course Outcomes:

- *On completion of this course, the students will be able to:*

CO1 Enhance the knowledge on microbiology and microscopy
CO2 Impart skills on various microbiological techniques involved
CO3 Critically analyze the importance of sterilization and disinfection
CO4 Understand the role of microbes in biogeochemical cycle and soil fertility.
CO5 Acquire knowledge on nutritional requirements of microorganisms
CO6 Apply the knowledge of the Microbiology in food and beverages

Text Book:

- Pelczar, J., Chan, E. C. S. and Krieg, R. (1999). Microbiology. Tata McGraw Hill Publishing Co. Ltd., New Delhi.
- Purohit, S. S. (1997). Microbiology. Bikanar.
- Dubey, R. C. and Maheswari, D. K. (2004). A Textbook of Microbiology. S. Chand & Co. Ltd., New Delhi

References:

- Sullia, S. B. and Shantharam, S. (2005). General Microbiology. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
- Martin Alexander (1978). Introduction to Soil Microbiology. Wiley Eastern, New Delhi.
- Casida, L. E. (1989). Industrial Microbiology. Wiley Eastern, New Delhi.
- Fraziel, N. C. (1974). Food Microbiology (2nd ed). Tata McGraw Hill Publishing Co. Ltd., New Delhi.
- Aneja, K.R. (2013). Laboratory Manual of Microbiology & Biotechnology, Scientific International Pvt. Ltd.- New Delhi

Web Resources:

- https://microbewiki.kenyon.edu/index.php/MicrobeWiki
- https://www.cdc.gov/microbe-of-the-month/index.html
- https://asm.org/
- https://archive.org/details/microbiologyanintroductorytextbooktortorafunkecase-1
- https://www.microbiologybook.org/

CO- PO Mapping (Course Articulation Matrix)

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	6	3	3	3	1	0
CO2	6	3	1	3	3	1
CO3	6	3	3	3	1	0
CO4	9	6	9	6	0	1
CO5	6	3	6	6	1	1
CO6	3	6	1	0	0	0
Weightage	**36**	**27**	**24**	**21**	**5**	**3**
Weighted percentage of Course contribution to POs	**31.03**	**23.28**	**20.69**	**18.10**	**4.31**	**2.59**

Level of Correlation between CO's and PO's } 1 – Low 3 – Medium 9 – High 0 – No Correlation (Suggested by UGC as per Six Sigma Tool – Cause and Effect Matrix)

Course Outcomes mapped with Knowledge level (Revised Bloom's Taxonomy) and POs

CO/ K-Level	Level of Correlation			
	High	**Medium**	**Low**	**Zero**
CO1/ K1	PO1, PO2	PO3, PO4, PO5	PO6	_
CO2/ K2	PO1, PO2	PO3, PO4	PO5, PO6	_
CO3/ K3	PO1	PO2, PO3, PO4,	PO5	PO6
CO4/ K4	PO1	PO2, PO3, PO4	PO5	PO6
CO5/ K5	PO1	PO2	PO3, PO4	PO5, PO6
CO6/ K6	PO1	PO2	PO3, PO4,	PO5, PO6

Course Outcome (CO) Attainment Assessment Tools & Evaluation Procedure:

K Levels	C1	C2	C3	C4	Total scholastic marks	Non Scholastic Marks C5	CIA Total	% of Assessment
	T1 4 Marks	T2 10 Marks	Assignment 6 Marks	Seminar 5 Marks	20 Marks	5 Marks	25 Marks	
K1	1	2	1	--	4	--	**4**	**16**
K2	1	2	1	--	4	--	**4**	**16**
K3	1	2	1	--	4	--	**4**	**16**
K4	1	2	1	--	4	--	**4**	**16**
K5		1	1	--	2	--	**2**	**8**
K6		1	1	--	2	--	**2**	**8**
Non Scholastic	--	--	--	--	--	**5**	**5**	**20**
Total	**4**	**10**	**6**	--	**20**	**5**	**25**	**100%**

***C = Component**

The COs and POs for the **MICROBIOLOGY** course in the **B.Sc. Botany** Programme is effectively matched by the Course In-charge.

Signature of the Course In- charge

Signature of the Coordinator

Sem.	Programme Code	Course Code	Course Type	Course Title	Category	Hrs. / Week	Credits
V	BOTUG1982	U25BO11P	Core Course	**PRACTICAL - 3** (U25BO7, U25BO9E & U25BO10E)	Practical	3	5

Course Description:

This integrated practical course trains students in plant morphology and taxonomy, emphasizing the identification and technical description of flowering plants. It includes field-based herbarium preparation and the economic significance of selected plant species. The biochemistry and bioinstrumentation component focuses on the estimation of biomolecules and the use of electrophoresis and chromatography in biological analysis. The microbiology section introduces fundamental lab techniques, microbial isolation, staining methods, and visits to fermentation facilities to understand applied microbiology.

Course Objectives:

1. To identify and describe inflorescence types, fruits, and floral structures through dissection and floral diagramming.
2. To recognize economically important plants and prepare herbarium specimens through structured fieldwork.
3. To quantify proteins, carbohydrates, lipids, and pigments using standard biochemical techniques.
4. To apply chromatography and electrophoresis for biomolecule separation and understand blotting procedures.
5. To develop microbiological skills including media preparation, sterilization, microbial isolation, staining, and visit industrial setups for practical exposure.

Morphology, Taxonomy and Economic Botany - (CC-VII)

1. Study on inflorescence types and fruits as given in theory (spotters only)
2. Morphological description of plants, training in dissection, observation, identification, sketching of floral parts, drawing floral diagram and describing it technically in terms of floral formula of different plants belonging to the families mentioned in theory
3. Study on the economic importance of plants, covered in Core Course (spotters)
4. Study of flora and submission of 10 herbarium specimens (Field trip not less than three days).

Biochemistry, Biophysics and Bioinstrumentation - (EC1)

1. Estimation Protein – Lowery *et al.* method
2. Estimation of Carbohydrate
3. Quantification of total lipid
4. Estimation of chlorophyll and carotenoids.
5. Amino acids separation by paper chromatography
6. SDS-PAGE and Blotting technique – Western.

Microbiology – (EC2)

1. Principles and functioning of instruments in microbiology laboratory
2. Hands on sterilization techniques and preparation of culture media.
3. Isolation of bacteria and fungi by serial dilution technique.
4. Pure culture technique – streak plate
5. Gram's staining technique
6. A visit to any educational institute/ industry to see an industrial fermentor, and other downstream processing operations.

Course Outcomes:

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

CO1	*Develop critical understanding on plant taxonomy, and botanical nomenclature and economic importance.*
CO2	*Learn the estimation of plant macromolecules.*
CO3	*Acquire the knowledge about the separation of amino acids and protein by chromoatography and SDS-PAGE*
CO4	*Develop the basic knowledge on bioinstrumentation.*
CO5	*Increase the awareness and appreciation of microbiological techniques.*
CO6	Apply the knowledge in related to large scale production using the fermentor

CO- PO Mapping (Course Articulation Matrix)

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	6	3	3	3	1	0
CO2	6	6	1	3	3	1
CO3	6	9	3	3	3	0
CO4	9	6	9	9	0	1
CO5	6	3	9	6	3	1
CO6	3	6	1	0	0	0
Weightage	**36**	**33**	**26**	**24**	**10**	**3**

Level of Correlation between CO's and PO's } 1 – Low 3 – Medium 9 – High 0 – No Correlation (Suggested by UGC as per Six Sigma Tool – Cause and Effect Matrix)

Course Outcomes mapped with Knowledge level (Revised Bloom's Taxonomy) and POs

CO/ K-Level	Level of Correlation			
	High	**Medium**	**Low**	**Zero**
CO1/ K1	PO1, PO2	PO3, PO4, PO5	PO6	_
CO2/ K2	PO1, PO2	PO3, PO4	PO5,	PO6
CO3/ K3	PO1	PO2, PO3,	PO4, PO5, PO6	-
CO4/ K4	PO1	PO2, PO3	PO4, PO5	PO6
CO5/ K5		PO1, PO2	PO3, PO4	PO5, PO6
CO6/ K6		PO1, PO2	PO3, PO4,	PO5, PO6

Course Outcome (CO) Attainment Assessment Tools & Evaluation Procedure:

K Levels	C1	C2	C3	C4	Total scholastic marks	Non Scholastic Marks C5	CIA Total	% of Assessment
	T1 4 Marks	T2 10 Marks	Assignment 6 Marks	Seminar 5 Marks	20 Marks	5 Marks	25 Marks	
K1	1	2	1	--	4	--	**4**	**16**
K2	1	2	1	--	4	--	**4**	**16**
K3	1	2	1	--	4	--	**4**	**16**
K4	1	2	1	--	4	--	**4**	**16**
K5		1	1	--	2	--	**2**	**8**
K6		1	1	--	2	--	**2**	**8**
Non Scholastic	--	--	--	--	--	**5**	**5**	**20**
Total	**4**	**10**	**6**	--	**20**	**5**	**25**	**100%**

***C = Component**

The COs and POs for the **PRACTICAL - 3** course in the B.Sc. Botany Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge

Signature of the Coordinator

Sem.	Programme Code	Course Code	Course Type	Course Title	Category	Hrs. / Week	Credits
V	BOTUG1982	U25BO12P	Core Course	**PRACTICAL - 4** (U25BO8, U25BO13, U25BO14, U25BO15)	Practical	3	5

Course Description:

This course offers practical exposure to key biological techniques and experiments in cell and molecular biology, genetics, physiology, and biotechnology. It includes microscopic observation of plant cells, stages of mitosis, and organelle ultrastructure, alongside problem-solving in genetics, plant breeding practices, and physiological processes in plants. The biotechnology section focuses on in vitro techniques, tissue culture, molecular biology experiments, and DNA analysis through electrophoresis and blotting methods. The course equips students with essential laboratory skills for academic and applied biosciences.

Course Objectives:

1. To observe plant cell structures, inclusions, and mitotic stages using classical microscopy and squash techniques.
2. To solve genetic problems, understand chromosomal mapping, and perform basic plant breeding techniques like emasculation.
3. To perform physiological experiments on water potential, transpiration, pigment separation, and study of plant hormones.
4. To develop practical skills in plant tissue culture, media preparation, in vitro techniques, and callus induction.
5. To understand and demonstrate core molecular biology tools including DNA isolation, electrophoresis, blotting, and cloning methods.

Cell and Molecular Biology - (CC-VIII)

1. Observation of plant cells in the onion scale leaf peeling and *Rheo* Leaf epidermis
2. Non-living inclusions: Raphides, cystolith and Starch grains (spotters).
3. Cell division: Observation of mitotic stages - Squash technique in onion root tips
4. Study of ultra-structure of organelles using photographs (spotters)

Genetics, Plant Breeding and Evolution - (CC-XI)

1. Problems on Mendelian Genetics: Monohybrid, Di-hybrid cross and incomplete dominance.
2. Mapping of chromosomes.
3. Percent of seed germination study.
4. Demonstration on emasculation.
5. Chromosomal aberration using onion root tip.

Plant Physiology - (CC-XII)

1. Measurement of water potential
2. Determination of osmotic pressure.
3. Separation of pigments by paper chromatography
4. Absorption and transpiration ratio – side tube experiment

5. Transpiration / Ganong's potometer
6. Photosynthesis – different lights
7. Ganong's Respiroscope - Demonstration
8. Plant growth regulators - Demonstration.

Biotechnology – (CC-XIII)

1. (a) Preparation of liquid and solid MS medium.
   (b) Demonstration of in vitro sterilization of seeds and germination in MS media.
   (c) *in vitro* selection and inoculation methods using leaf and nodal explants.
2. Callus formation in rice using MS medium containing phytohormones.
3. Study of anther, embryo and endosperm culture, micropropagation, somatic embryogenesis & artificial seeds through photographs.
4. Isolation of Plasmid DNA.
5. Agarose Gel Electrophoresis and SDS-PAGE
6. Blotting techniques and GFB cloning.- Demo
7. Restriction digestion and restriction mapping.- Demo

Course Outcomes:

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

CO1 *Develop critical understanding on cell and molecular biology*
CO2 *Comprehend the basic concepts of Mendelian Genetics and Plant Breeding*
CO3 *Develop a basic knowledge on water potential, photosynthesis and respiration in plants*
CO4 *Increase the awareness and appreciation of various methods of plant propagation.*
CO5 *Learn the technique of isolation of genomic and plasmid DNA.*
CO6 Get an in-depth knowledge in blotting technique, restriction digestion and mapping

CO- PO Mapping (Course Articulation Matrix)

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	6	3	3	3	1	0
CO2	6	3	1	3	3	1
CO3	6	9	3	3	3	0
CO4	9	9	9	9	0	1
CO5	9	3	9	6	3	1
CO6	6	6	1	0	0	0
Weightage	**42**	**33**	**26**	**24**	**10**	**3**

Level of Correlation between CO's and PO's: 1 – Low, 3 – Medium, 9 – High, 0 – No Correlation (Suggested by UGC as per Six Sigma Tool – Cause and Effect Matrix)

Course Outcomes mapped with Knowledge level (Revised Bloom's Taxonomy) and POs

CO/ K-Level	Level of Correlation			
	High	**Medium**	**Low**	**Zero**
CO1/ K1	PO1, PO2	PO3, PO4, PO5	PO6	_
CO2/ K2	PO1, PO2	PO3, PO4	PO5,	PO6
CO3/ K3	PO1	PO2, PO3,	PO4, PO5, PO6	-
CO4/ K4	PO1	PO2, PO3	PO4, PO5	PO6
CO5/ K5		PO1, PO2	PO3, PO4	PO5, PO6
CO6/ K6		PO1, PO2	PO3, PO4,	PO5, PO6

Course Outcome (CO) Attainment Assessment Tools & Evaluation Procedure:

K Levels	C1	C2	C3	C4	Total scholastic marks	Non Scholastic Marks C5	CIA Total	% of Assessment
	T1 4 Marks	T2 10 Marks	Assignment 6 Marks	Seminar 5 Marks	20 Marks	5 Marks	25 Marks	
K1	1	2	1	--	4	--	**4**	**16**
K2	1	2	1	--	4	--	**4**	**16**
K3	1	2	1	--	4	--	**4**	**16**
K4	1	2	1	--	4	--	**4**	**16**
K5		1	1	--	2	--	**2**	**8**
K6		1	1	--	2	--	**2**	**8**
Non Scholastic	--	--	--	--	--	**5**	**5**	**20**
Total	**4**	**10**	**6**	--	**20**	**5**	**25**	**100%**

***C = Component**

The COs and POs for the **PRACTICAL - 4** course in the B.Sc. Botany Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge

Signature of the Coordinator

Sem.	Programme Code	Course Code	Course Type	Course Title	Category	Hrs. / Week	Credits
VI	BOTUG1982	U25BO13	Core Course	**GENETICS, EVOLUTION AND PLANT BREEDING**	Theory	6	6

Course Description:

This course explores the foundational and advanced principles of genetics, including Mendelian inheritance, gene interactions, linkage, mutation, and cytoplasmic inheritance. It examines key genetic experiments and mechanisms influencing heredity, recombination, and gene function. Evolutionary biology is discussed through classical and modern theories, population genetics, and factors affecting gene frequency. The course also introduces plant breeding methods, focusing on genetic improvement through hybridization, selection, polyploidy, and mutation breeding techniques.

Course Objectives:

1. *Understand Mendelian genetics, allelic and non-allelic interactions, and their role in heredity.*
2. *Explain recombination, linkage, sex linkage, cytoplasmic inheritance, and sex determination in plants.*
3. *Describe gene structure, gene types, mutations, mutagens, and their significance in genetic variation and crop improvement.*
4. *Interpret evolutionary theories, principles of population genetics, and factors influencing gene frequencies.*
5. *Apply knowledge of plant breeding methods including selection, hybridization, polyploidy, and mutation for crop improvement.*

UNIT-I GENETICS - I (Teaching - 15 Hours)

Genetics: Mendel's laws - monohybrid cross, dihybrid cross, back cross and test cross. Allelic interactions - Incomplete dominance and Co-dominance - Non allelic interaction - Lethal factor. Complementary factor hypothesis, Dominant epistasis and Recessive epistasis. Multiple factor hypothesis - blood groups.

UNIT-II GENETICS - II (Teaching - 15 Hours)

Recombination - Linkage & crossing over. Mechanism of crossing over - terminalization of chiasma. Crossing over. Linkage in *Lathyrus odoratus* - linkage mapping of genes - sex linkage in plant. - Cytoplasmic inheritance - Sex determination in plants and *Drosophila*.

UNIT-III GENETICS - III (Teaching - 15 Hours)

Biochemical genetics - Experiment in *Neurospora*, Types of genes -mobile genes split genes Functional units of gene - cistron, recon, muton, codon and operon. Mutation - classification, types. mutagens -physical and chemical. Role of mutation in crop improvement.

UNIT-IV EVOLUTION (Teaching - 15 Hours)

Evolution - Evolutionary concepts- Theories of Lamarck, Charles Darwin and the modern

synthetic theories. Population genetics - gene pool, gene frequency and Hardy- Weinberg law. Factors affecting gene frequencies.

UNIT-V PLANT BREEDING (Teaching - 30 Hours)

Introduction and objectives of Plant Breeding. Self-Incompatibility, Mechanism of self-incompatibility and its overcoming, and its utilization in plant breeding.

Methods of Plant Breeding: Introduction, Acclimatization; Domestication; Selection methods for: Self- pollinated, Cross-pollinated and vegetative and clonal propagated. Hybridization: For self, cross and vegetatively propagated plants. Mass selection - Pure line selection. Polyploidy - autopolyploidy and allopolyploidy. Somatic mutation in sugarcane and rice crops.

Course Outcomes:

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

CO1 *Acquire broad knowledge on basic and recent trends of genetics*
CO2 *Enlighten Mendelian inheritance, their deviations and the concepts of evolution*
CO3 *Analyze the effect of mutations on gene functions*
CO4 *Understand the various aspects of genetic principles in plant breeding*
CO5 *Have a conceptual understanding of evolutionary concepts.*
CO6 *Explain the principles of plant breeding, selection methods and hybridization*

Text Book:

- Chandrasekaran, S. N. and Parthasarathy, S. V. (1965). Cytogenetics and Plant Breeding. P. Varadhachari & Co., Madras.
- Verma, P. S. and Agarwal, V. K. (1999). Concepts of Evolution. S. Chand & Co. Ltd., New Delhi.
- Jain, H. K. (1999). Genetics: Principles, Concepts and Implications. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
- Daniel Sundararaj, D. and Thulsidas, G. (1972). Introduction to Cytogenetics and Plant Breeding. (3rd ed). Popular Book Depot, Madras.

References:

- Agarwal, V. K. (2000). Simplified Course in Genetics. S. Chand & Co. Ltd., New Delhi.
- Shukla, R.S. and Chandel, P.S. (1996). Cytogenetics, Evolution and Plant Breeding. S. Chand & Co. Ltd., New Delhi.
- Savage, J. M. (1969). Evolution (2nd ed). Amarind Publishing (P) Ltd., New Delhi.
- Gottlieb, L. D. and Jain, S. K. (1988). Plant Evolutionary Biology. Chapman & Hill, London.

Web Resources:

- https://www.khanacademy.org/science/biology/cellular-molecular-biology
- https://le.ac.uk/vgec/topics/cell-cycle/the-cell-cycle-higher-education
- https://www.britannica.com/science/plant-breeding
- https://davuniversity.org/images/files/study-material/Fundamentals%20of%20Plant%20Breeding%20AGS127.pdf
- https://archive.org/details/in.ernet.dli.2015.271669

CO- PO Mapping (Course Articulation Matrix)

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	3	3	3	1	0
CO2	9	3	1	3	3	1
CO3	9	9	3	3	3	0
CO4	9	9	9	9	0	1
CO5	9	3	9	9	3	1
CO6	3	9	1	0	0	0
Weightage	**48**	**36**	**26**	**27**	**10**	**3**
Weighted percentage of Course contribution to POs	**32.00**	**24.00**	**17.33**	**18.00**	**6.67**	**2.00**

Level of Correlation between CO's and PO's } 1 - Low 3 - Medium 9 - High 0 - No Correlation (Suggested by UGC as per Six Sigma Tool - Cause and Effect Matrix)

Course Outcomes mapped with Knowledge level (Revised Bloom's Taxonomy) and POs

CO/ K-Level	Level of Correlation			
	High	**Medium**	**Low**	**Zero**
CO1/ K1	PO1,	PO2, PO3,PO4	PO5	PO6
CO2/ K2	PO1,	PO2,PO4, PO5	PO3,PO6	_
CO3/ K3	PO1, PO2	PO3, PO4 PO5	_	PO6
CO4/ K4	PO1, PO2, PO3,PO4	_	PO6	PO5,
CO5/ K5	PO1,PO3, PO4	PO2, PO5	PO6	_
CO6/ K6	PO2	PO1	PO3	PO4, PO5, PO6

Course Outcome (CO) Attainment Assessment Tools & Evaluation Procedure:

K Levels	C1	C2	C3	C4	Total scholastic marks	Non Scholastic Marks C5	CIA Total	% of Assessment
	T1 4 Marks	T2 10 Marks	Assignment 6 Marks	Seminar 5 Marks	20 Marks	5 Marks	25 Marks	
K1	1	2	1	--	4	--	**4**	**16**
K2	1	2	1	--	4	--	**4**	**16**
K3	1	2	1	--	4	--	**4**	**16**
K4	1	2	1	--	4	--	**4**	**16**
K5		1	1	--	2	--	**2**	**8**
K6		1	1	--	2	--	**2**	**8**
Non Scholastic	--	--	--	--	--	**5**	**5**	**20**
Total	**4**	**10**	**6**	--	**20**	**5**	**25**	**100%**

***C = Component**

The COs and POs for the **Genetics, Evolution and Plant Breeding** course in the **B.Sc. Botany** Programme is effectively matched by the Course In-charge.

Signature of the Course In- charge Signature of the Coordinator

Sem.	Programme Code	Course Code	Course Type	Course Title	Category	Hrs. / Week	Credits
VI	BOTUG1982	U25BO14	Core Course	**PLANT PHYSIOLOGY**	Theory	6	6

Course Description:
cThis course provides an in-depth understanding of plant physiology, covering essential topics such as water relations, mineral nutrition, photosynthesis, respiration, and plant growth regulators. It explores the physiological processes involved in plant growth, development, and responses to environmental stimuli.

Course Objectives:

1. To explain the mechanisms of water absorption, transport, and transpiration.
2. To identify essential plant nutrients and describe mineral uptake and nitrogen metabolism.
3. To describe the key biochemical pathways of photosynthesis, including light and dark reactions.
4. To outline the major stages of aerobic respiration, from glycolysis to oxidative phosphorylation.
5. To analyze how plant hormones and environmental cues regulate plant growth and flowering.

Unit I: Water Relations (15 hours)

Water potential: Concept and components. Water absorption by roots: Osmosis and OP-TP water potential. Transpiration: Significance of transpiration, factors affecting transpiration, mechanisms of stomatal opening and closing. Ascent of sap: Cohesion-tension theory and root pressure.

Unit II: Mineral Nutrition (15 hours)

Essential elements and their functions. Mechanisms of mineral salt absorption: Ion exchange, passive and active transport. Role of major and minor elements: Mineral deficiency symptoms. Nitrogen metabolism: Role of nitrogen in plants, sources of nitrogen, Biological & Non biological nitrogen fixation.

Unit III: Photosynthesis (30 hours)

Definition- Raw Materials for Photosynthesis – structure of Chloroplast – Excitation of chlorophyll, The role of water in photosynthesis. Absorption spectrum, Action spectrum, role of pigments. Light reaction: Photosystems I & II, Photophosphorylation, electron transport chain. Dark reaction: Carbon Assimilation: Calvin cycle. C4 photosynthesis, CAM photosynthesis, Photorespiration. Factors affecting photosynthesis.

Unit IV: Respiration (15 hours)

Definition-Outline of respiration. Respiratory substrates. Respiratory quotient, Aerobic and anaerobic respiration (fermentation). Glycolysis, Krebs' cycle, and electron transport - oxidative phosphorylation, energetics of respiration.

Unit V: Plant Growth Regulators (15 hours)

Define growth regulators- Brief history. Study of auxins, gibberellins, cytokinins, abscisic acid, ethylene and their physiological role. Photoperiodism: concepts and flowering mechanism. Phytochrome properties and role in flowering. Vernalization, Biological clock and rhythm.

Course Outcomes:

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

CO1 *Understand Water relation of plants with respect to various physiological processes.*
CO2 *Explain chemical properties and deficiency symptoms in plants*
CO3 *Classify aerobic and anaerobic respiration*
CO4 *Enlighten the significance of Photosynthesis and photorespiration*
CO5 *Assess the physiological mechanism and significance of respiration*
CO6 *Comprehend the role of plant growth regulator*

List of Text Books:

- Verma, S. K. (1999) Plant Physiology. S. Chand & Co., New Delhi.
- Taiz, L., & Zeiger, E. (2015). Plant Physiology. Sinauer Associates.
- Moore, T.C. 1979. Biochemistry and physiology of plant hormones. Narosabook Distributors, New Delhi.
- Hopkins, W.G. (2000). Introduction to Plant Physiology. John Wiley & Sons.

List of Reference Books:

- Singh, A. (1982). Practical Plant Physiology. Kalyani Publishers. (Accn. No. 00002458)
- Hess, D. (n.d.). Plant Physiology. Narosa Publishing House. (Accn. No. 00006099)
- Curtis, O. F. (1950). Introduction to Plant Physiology. McGraw-Hill Book Co. (Accn. No. 00025421)
- Rao, K. N., & Partha, T. S. (1969). Outlines of Plant Physiology. S Chand. (Accn. No. 00029647)
- Verma, V. (1969). Plant Physiology. Emkay Publisher. (Accn. No. 00029655)
- Rao, K. N., Partha, T. S., & Rao, G. S. (n.d.). Outlines of Plant Physiology. S. Chand & Publishing. (Accn. No. 00029737)
- Singh, A. (n.d.). Plant Physiology. Asia Publications House. (Accn. No. 00029738)
- Meyer, B. D., Anderson, D. B., & Swanson, C. A. (1966). Laboratory Plant Physiology. D. Van Nostrand. (Accn. No. 00029758)

Digital Open Educational Resources:

- Khan Academy: https://www.khanacademy.org/science/biology
- OpenStax Biology: https://openstax.org/books/biology/pages/1-introduction

Photosynthesis Education: https://photosynthesiseducation.com/

CO- PO Mapping (Course Articulation Matrix)

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	1	3	1	1	1
CO2	9	1	3	1	1	1
CO3	9	1	3	1	1	1
CO4	9	1	3	1	1	1
CO5	9	1	3	1	1	1
CO6	9	1	3	1	1	1
Weightage	54	6	18	6	6	6
Weighted percentage of Course contribution to POs	75%	8.33%	25%	8.33%	8.33%	8.33%

Level of Correlation between CO's and PO's: 1 – Low, 3 – Medium, 9 – High, 0 – No Correlation (Suggested by UGC as per Six Sigma Tool – Cause and Effect Matrix)

Course Outcomes mapped with Knowledge level (Revised Bloom's Taxonomy) and POs

CO / K - Level	Level of Correlation			
	High	Medium	Low	Zero
CO 1 / K1	PO1, PO3	PO2	PO4, PO5, PO6	-
CO 2 / K2	PO1, PO3	PO2	PO4, PO5, PO6	-
CO 3 / K3	PO1, PO3	PO2	PO4, PO5, PO6	-
CO 4 / K4	PO1, PO3	PO2	PO4, PO5, PO6	-
CO 5 / K5	PO1, PO3	PO2	PO4, PO5, PO6	-
CO 6 / K6	PO1, PO3	PO2	PO4, PO5, PO6	-

Course Outcome (CO) Attainment Assessment Tools & Evaluation Procedure:

K Levels	C1	C2	C3	Total scholastic Marks	Non-Scholastic Marks C4	CIA Total	% of Assessment
	T1 7 Marks	T2 7 Marks	Assignment 6 Marks	20 Marks	5 Marks	25 Marks	
K1	2	0	1	3	--	3	**12**
K2	2	1	1	4	--	4	**16**
K3	1	2	1	4	--	4	**16**
K4	1	2	1	4	--	4	**16**
K5	1	1	1	3	--	3	**12**
K6	0	1	1	2	--	2	**8**
Non-Scholastic	--	--	--	--	5	5	**20**
Total	**7**	**7**	**6**	**20**	**5**	**25**	**100%**

*C = Component

The COs and POs for the **Plant Physiology** course in the **B.Sc. Programme** is effectively matched by the Course In-charge.

Signature of the Course In-charge

Signature of the Coordinator

Sem.	Programme Code	Course Code	Course Type	Course Title	Category	Hrs. / Week	Credits
VI	BOTUG1982	U25BO15	Core Course	**PLANT BIOTECHNOLOGY**	Theory	6	6

Course Outcomes:

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

CO1 *Understandthecoreconceptsandfundamentalsofplantbiotechnologyandgenetic Engineering and Restriction Enzymes and vectors*
CO2 *Developthesuitablegenecloningmethods*
CO3 *Examplethedifferentgenetransfermethodsandtheirmechanisms*
CO4 *Gaintheknowledgeonplanttissueculturetechnique*
CO5 *Analysethegeneralprinciplesofbiosafetyandbioethics*
CO6 *Criticallyanalyzethemajorconcernsandapplicationsoftransgenictechnology*

Unit I: Basic in gene transfer technology Restriction Enzymes & Vectors

Definition – Gene, genome and gene edition. The genome structure in molecular model plants: (*Arabidopsis thaliana*) and (*Zea mays*); Restriction *Exo* and *Endo* nucleases (History, Types I- IV and sub types of II, Structures, biological role, Mechanism, and usages in cloning).Ligases enzymes, Cloning Vectors: History, basic sequences of any vector, types of bacterial vectors (pBR322, BAC); Viral vectors- Lambda phage, Cosmid; Eukaryotic Vectors–YAC, Shuttle vector.

Unit II: Gene Cloning methods

Advantages of gene cloning, Bacterial Transformation methods and selection of recombinant clones using various strategies, PCR-mediated gene cloning; Gene Construct. Construction of genomic and cDNA libraries, Screening DNA libraries to obtain gene of interest by genetic selection.

Unit III :Methods of gene transfer and Selection

Direct gene transfer method by Electroporation, Microinjection, Microprojectile bombardment; *Agrobacterium* mediated gene transfer mechanism. Selection of transgenics–selectable marker and reporter genes (Luciferase, GUS, GFP), Marker-free and novel selection strategies.

Unit I V:Plant tissue culture as tool for gene transfer in plants

Scope of Plant tissue culture components and preparation of MS medium cultured conditions; Totipotency - callus culture, Organogenesis (Direct and indrect); Somatic Embryogenesis – direct and indirect. Protoplast Isolation culture methods- Germplasm conservation.

Unit V: Bio safety and Bioethics

History of transgenic development across the world, Bio safety and bioethics concerns with transgenic

technology, Transgenic technology and sustainable agriculture, Major concerns with implementation of transgenic technology in India. Applications such as Bt-cotton and golden rice.

Text Book:

- Satyanarayana, U. (2020). Biotechnology, Books & Allied Ltd, Kolkata.
- Dodds, J.H.and Roberts, I.W.(1985) Experiments in Plant Tissue Culture Cambridge University Press, UK.
- Gupta, P.K.(1994):Elements of Biotechnology. Rastogi and Co., Meerut.
- Dubey, R.C. (2008). A Textbook of Biotechnology. S.Chand & Co., New Delhi.
- Gamborg, O.L. and Phillips, G.C. (1995) Plant Cell Tissue and Organ Culture: A Fundamental Methods. Narosa Publishing House, New Delhi.

References:

- Fowler, M.W.(1986).Industrial Application of Plant Cell Culture In:Yeoman, M.M (ed.) Plant Cell Culture technology. Blackwell, Oxford, London.
- Hammoond, J., McGarvey, P.and Yusibov, V.(2000).Plant Biotechnology. Springer Verlag, New York.
- John, B.M. (1982) Experimental Embryology of Vascular Plants. Narosha Publishing House, New Delhi.
- Ketchum, P.A.(1988). Microbiology: Concepts and Application. John Wiley & Sons Inc., New York.

CO- PO Mapping (Course Articulation Matrix)

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	3	3	3	1	0
CO2	9	3	1	3	3	1
CO3	9	9	3	3	3	0
CO4	9	9	9	9	0	1
CO5	9	3	9	9	3	1
CO6	3	9	1	0	0	0
Weightage	**48**	**36**	**26**	**27**	**10**	**3**
Weighted percentage of Course contribution to POs	**32.00**	**24.00**	**17.33**	**18.00**	**6.67**	**2.00**

Level of Correlation between CO's and PO's } 1 - Low 3 - Medium 9 - High 0 - No Correlation (Suggested by UGC as per Six Sigma Tool - Cause and Effect Matrix)

Course Outcomes mapped with Knowledge level (Revised Bloom's Taxonomy) and POs

CO/ K-Level	Level of Correlation			
	High	**Medium**	**Low**	**Zero**
CO1/ K1	PO1,	PO2, PO3,PO4	PO5	PO6
CO2/ K2	PO1,	PO2,PO4, PO5	PO3,PO6	_
CO3/ K3	PO1, PO2	PO3, PO4 PO5	_	PO6
CO4/ K4	PO1, PO2, PO3,PO4	_	PO6	PO5,
CO5/ K5	PO1,PO3, PO4	PO2, PO5	PO6	_
CO6/ K6	PO2	PO1	PO3	PO4, PO5, PO6

Course Outcome (CO) Attainment Assessment Tools & Evaluation Procedure:

K Levels	C1	C2	C3	Total scholastic Marks	Non-Scholastic Marks C4	CIA Total	% of Assessment
	T1 7 Marks	T2 7 Marks	Assignment 6 Marks	20 Marks	5 Marks	25 Marks	
K1	2	0	1	3	--	3	**12**
K2	2	1	1	4	--	4	**16**
K3	1	2	1	4	--	4	**16**
K4	1	2	1	4	--	4	**16**
K5	1	1	1	3	--	3	**12**
K6	0	1	1	2	--	2	**8**
Non-Scholastic	--	--	--	--	5	5	**20**
Total	**7**	**7**	**6**	**20**	**5**	**25**	**100%**

*C = Component

The COs and POs for the **PLANT BIOTECHNOLOGY** course in the **B.Sc. Botany** Programme is effectively matched by the Course In-charge.

Signature of the Course In- charge

Signature of the Coordinator

Sem.	Programme Code	Course Code	Course Type	Course Title	Category	Hrs. / Week	Credits
VI	BOTUG1982	U25BO16E	Elective Course	**BIOSTATISTICS AND BIOINFORMATICS**	Theory	5	4

Course Description:

This elective course, introduces students to the principles and applications of Biostatistics and Bioinformatics. It equips learners with skills in data collection, representation, analysis, and interpretation, essential for biological research. Students explore statistical tools such as measures of central tendency, dispersion, correlation, and regression, with practical exposure to graphical methods. The bioinformatics component covers key biological databases (NCBI, EMBL, DDBJ), sequence alignment tools (BLAST, FASTA), and methods for phylogenetic analysis. By bridging statistics and computational biology, the course enhances students' ability to handle and interpret biological data in research and applied plant sciences.

Course Objectives:

1. *To introduce students to the basic concepts and scope of biostatistics and bioinformatics.*
2. *To enable understanding of data types, sampling methods, and graphical presentation techniques.*
3. *To develop skills in applying measures of central tendency and dispersion to biological data.*
4. *To equip students with tools for correlation, regression, and probability distribution analysis.*
5. *To familiarize students with major biological databases and data retrieval tools in bioinformatics.*
6. *To provide training in sequence alignment techniques and construction of phylogenetic trees.*

UNIT-I (Teaching-1 h / week)

DATA COLLECTION AND PRESENTATION: Biostatistics **-** Definition, Scope, Basic concepts - Population, Data, Sample - types, Variables, common notations used. Data Collection – primary, secondary, qualitative, quantitative, analog and digital. Sampling and Survey Techniques – Random and non-random. Graphical representation of data – bar, line, pictographs, histograms, pie charts. Dot, scatter, stem and leaf plots. Frequency distribution – cumulative tables and graphs.

UNIT-II (Teaching-1 h / week)

MEASURES OF CENTRAL TENDENCIES: Arithmetic mean, median and Mode - grouped frequencies. Measures of dispersion - Standard Deviation and Standard Error (Theory and Problem),

UNIT-III (Teaching-1 h / week)

DATA COMPARISON AND DISTRIBUTION: Univariate and Bivariate Data - Scatter (x,y) Plots - Outliers. Correlation – Types. Regression Analysis. Distribution – Binomial and Normal (Theory and Problem).

UNIT-IV (Teaching-1 h / week)

BIOINFORMATICS: Definition, Components and Application.

Databases – Introduction, properties, classification of data bases and functions. Biological databases-

NCBI, EMBL and DDBJ. Data Generation and Data Retrieval.

UNIT-V (Teaching-1 h / week)

TECHNIQUES IN BIOINFORMATICS: BLAST, FASTA, Multiple Sequence Analysis. Phylogenetic analysis: Construction of phylogenetic tree, dendrograms, methods of construction of phylogenetic trees.

Course Outcomes:

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

CO1	*Acquire knowledge on basic concepts in Biostatistics and Bioinformatics*
CO2	*Understand the different measures of central value and spread.*
CO3	*Acquire knowledge on data comparison, distribution and representation.*
CO4	*Know and understand the importance of various bioinformatics databases available.*
CO5	*Get familiarized with tools and software packages in bioinformatics.*
CO6	Evaluate the sequence analysis like multiple sequence aliment and similarity search tools.

Text Book:

- Andreas D Baxevanis and Francis, B. F. (2001) - Bioinformatics - John Willy & Sons
- Bryan Bergeron (2003) - Bioinformatics Computing. Prentice Hall of India Pvt. Ltd., New Delhi.
- Murthy, C. S. V. (2003) - Bioinformatics - Himalayas Publishing House.
- Shanmugavel (2005) - Principles of Bioinformatics - Pointer Publisher, India.
- Khan and Khanum, Shiba Khan (2018). Fundamental of Biostatistics, Ukaaz /BSP books, Hyderabad.

References:

- Gautham, N. (2006) - Bioinformatics Database and Algorithms – Narosa Publishing House, New Delhi.
- Ranga (2003) - Bioinformatics - Agrobios, India.
- David E. Mount (2001) - Bioinformatics Sequence and Genome Analysis – Cold Spring Harbour Laboratory Press, New Delhi.
- Westhead (2003) - Bioinformatics - Viva Books Pvt. Ltd.
- Ignacimuthu, S. (2005) - Basic Bioinformatics - Narsa Publishing House.

Web resources:

- https://www.kobo.com/us/en/ebooks/biostatistics
- https://www.amazon.in/Biostatistics-Veer-Bala-Rastogi-ebook/dp/B07LDCPXDG
- http://www.agrimoon.com/introduction-to-computer-applications-pdf-book/
- https://www.ebooks.com/en-us/subjects/computers/
- https://it.careers360.com/download/ebooks
- http://www.aun.edu.eg/molecular_biology/Procedure%20Bioinformatics22.23-4-2015/Xiong%20-%20Essential%20Bioinformatics%20send%20by%20Amira.pdf
- http://www.freebookcentre.net/Biology/BioInformatics-Books.html
- https://courses.cs.ut.ee/MTAT.03.242/2017_fall/ uploads/Main/Basics_of_Bioinformatics.pdf

CO- PO Mapping (Course Articulation Matrix)

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	6	3	3	3	1	1
CO2	6	3	1	3	3	1
CO3	9	9	3	3	3	0
CO4	6	6	9	3	1	1
CO5	9	6	6	6	3	1
CO6	6	6	1	0	0	1
Weightage	**42**	**33**	**23**	**19**	**11**	**5**
Weighted percentage of Course contribution to POs	31.58	24.81	17.29	14.29	8.27	3.76

Level of Correlation between CO's and PO's } 1 – Low 3 – Medium 9 – High 0 – No Correlation (Suggested by UGC as per Six Sigma Tool – Cause and Effect Matrix)

Course Outcomes mapped with Knowledge level (Revised Bloom's Taxonomy) and POs

CO/ K-Level	Level of Correlation			
	High	**Medium**	**Low**	**Zero**
CO1/ K1	PO1, PO2	PO3, PO4, PO5	PO6	_
CO2/ K2	PO1, PO2	PO3, PO4	PO5, PO6	_
CO3/ K3	PO1	PO2, PO3,	PO4, PO5	PO6
CO4/ K4	PO1	PO2, PO3	PO4, PO5	PO6
CO5/ K5	PO1	PO2, PO3, PO4	PO5, PO6	-
CO6/ K6	PO1	PO2, PO3, PO4	PO5, PO6	-

Course Outcome (CO) Attainment Assessment Tools & Evaluation Procedure:

K Levels	C1	C2	C3	C4	Total scholastic marks	Non Scholastic Marks C5	CIA Total	% of Assessment
	T1 4 Marks	**T2 10 Marks**	**Assignment 6 Marks**	**Seminar 5 Marks**	**20 Marks**	**5 Marks**	**25 Marks**	
K1	1	2	1	--	4	--	**4**	**16**
K2	1	2	1	--	4	--	**4**	**16**
K3	1	2	1	--	4	--	**4**	**16**
K4	1	2	1	--	4	--	**4**	**16**
K5		1	1	--	2	--	**2**	**8**
K6		1	1	--	2	--	**2**	**8**
Non Scholastic	--	--	--	--	--	**5**	**5**	**20**
Total	**4**	**10**	**6**	--	**20**	**5**	**25**	**100%**

***C = Component**

The COs and POs for the **BIOSTATISTICS AND BIOINFORMATICS** course in the B.Sc. Botany Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge Signature of the Coordinator

COURSES OFFERED TO OTHER DEPARTMENTS

Sem.	Programme Code	Course Code	Course Type	Course Title	Category	Hrs. / Week	Credits
III	BOTUG1982	U25ABO1	Allied Course	**PLANT DIVERSITY, TAXONOMY, PLANT PATHOLOGY & ETHNOBOTANY**	Theory	5	3

Course Description:
This course provides a foundational understanding of plant diversity, covering major plant groups, their characteristics, and their significance in the ecosystem and human life. It explores key concepts in plant taxonomy, anatomy, embryology, plant pathology, and ethnobotany.

Course Objectives:

1. *To classify the major divisions of the plant kingdom and detail their general characteristics.*
2. *To examine plant morphology, taxonomy, and the characteristics of key plant families.*
3. *To detail the functions of major plant tissues and the reproductive process of angiosperms.*
4. *To recognize common plant disease symptoms, pathogens, and fundamental management strategies.*
5. *To outline the scope of ethnobotany and its significant role in the development of modern medicine.*

UNIT-I PLANT DIVERSITY (Teaching-1 h / week)

General characteristics and economic importance of Algae, Fungi, Bryophytes, Pteridophytes and Gymnosperms. Brief account on *Chlorella* (Algae), *Polyporus* (Fungus), *Anthoceros* (Bryophyte), *Lycopodium (*Pteridophyte) and *Cycas* (Gymnosperm).

UNIT-II TAXONOMY (Teaching-1 h / week)

Angiosperm – Flower - Floral parts and their functions. Classification of angiosperms - Bentham and Hooker's system. Characteristic features and economic importance of Fabaceae, Apocynaceae, Solanaceae, Cucurbitaceae, Asteraceae and Poaceae.

Unit III: Anatomy and Embryology

Anatomy: Tissue system – Meristem - Parenchyma, Collenchyma, Sclerenchyma, Xylem and Phloem - Anatomical structure of root and stem in dicots and monocots.

Embryology: Structure of mature anther, Types of Ovule and embryosac. Double fertilization - definition.

UNIT-IV PLANT PATHOLOGY (Teaching-1 h / week)

General symptoms; Host-Pathogen relationships; Disease cycle and prevention and control of plant diseases: Viral disease – Bunchy top of Banana. Bacterial disease - Citrus canker. Fungal disease - Cotton wilt.

UNIT V: ETHNOBOTANY (Teaching-1 h / week)

Introduction, concept, scope and objectives; Medico Ethnobotany Source in India; Significance of the following plants in Ethnobotanical practices, *Azadirachta indica* and *Ocimum sanctum*. Role of Ethnobotany in modern Medicines, Role of Ethinic groups in conservation of plant genetic resources, Endangered taxa and forest management.

Course Outcomes:

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

CO1 Understand the fundamental concepts related to plant diversity
CO2 Comprehend the basic concepts of plant taxonomy
CO3 Gain knowledge on the anatomy of stem and root
CO4 Comprehend the structure of anther and ovule.
CO5 Know the principles and application of plant pathology in the control of plant disease
CO6 Distinguish the basic and fundamental aspect of ethnobotany

List of Text Books:

- Ganguly, A. K. (1971). General Botany - Vol. I. The New Book Stall, Calcutta.
- Pullaiah, T, Krishnamurthy, K.V., Bir Bahadur (2021). Ethnobotany of India. Vol. 1 Eastern Ghats and Deccan, Apple Academic Press

List of Reference Books:

- Sharma, O. P. (1993). Plant Taxonomy. Mccrawhill Publication. (Accn. No. 00004476)
- Shukla, P., & Misra, S. P. (n.d.). Introduction to Taxonomy of Angiosperms. Vikas Publishing House. (Accn. No. 00056129)
- Subrahmanyam, N. S. (1999). Modern Plant Taxonomy. Vikas. (Accn. No. 00056134)
- Khurana, A. D. (1996). Experiments in Microbiology Plant Pathology Tissue Culture and Mushroom Cultivation. Wishwa Prakashan. (Accn. No. 00057692)
- Aneja, K. R. (2012). Experiments in Microbiology, Plant Pathology and Biotechnology. New Age International (p) Lim. (Accn. No. 00062673)
- Pandey, B. P. (2021). Plant Pathology. S Chand & Company Ltd. (Accn. No. 00063982)
- Pandey, B. P. (2014). Plant Pathology Pathogen and Plant Disease. S. Chand and Co. (Accn. No. 22012893)

Digital Open Educational Resources:

- OpenStax Biology: https://openstax.org/books/biology/pages/1-introduction
- Khan Academy: https://www.khanacademy.org/science/biology

Correlation Levels:

Mapping COs consistency with POs: Course Articulation Matrix

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	3	3	1	1	1
CO2	9	1	3	1	1	1
CO3	9	1	3	1	3	1
CO4	9	1	1	1	1	1
CO5	9	1	3	1	1	1
CO6	9	1	3	1	3	1
Weightage	54	24	19	12	9	9
Weighted percentage of Course contribution to POs	42.52%	18.89%	14.96%	9.45%	7.09%	7.09%

Course Outcomes mapped with Knowledge level (Revised Bloom's Taxonomy) and POs

CO / K - Level	Level of Correlation			
	High	Medium	Low	Zero
CO 1 / K1	PO1, PO2, PO3, PO4	PO5, PO6	-	-
CO 2 / K2	PO1, PO2, PO3, PO4	PO5, PO6	-	-
CO 3 / K3	PO1, PO2, PO3	PO4	PO5	PO6
CO 4 / K4	PO1, PO2	PO3	PO4, PO6	PO5
CO 5 / K5	PO1, PO2	PO5	PO3	PO4, PO6
CO 6 / K6	PO1, PO2, PO3	PO4, PO5, PO6	-	-

Course Outcome (CO) Attainment Assessment Tools & Evaluation Procedure:

K Levels	C1	C2	C3	Total scholastic Marks	Non-Scholastic Marks C4	CIA Total	% of Assessment
	T1 7 Marks	T2 7 Marks	Assignment 6 Marks	20 Marks	5 Marks	25 Marks	
K1	2	0	1	3	--	3	12
K2	2	1	1	4	--	4	16
K3	1	2	1	4	--	4	16
K4	1	2	1	4	--	4	16
K5	1	1	1	3	--	3	12
K6	0	1	1	2	--	2	8
Non-Scholastic	--	--	--	--	5	5	20
Total	7	7	6	20	5	25	100%

*C = Component

The COs and POs for the **Allied Course - I: Plant Diversity, Taxonomy, Plant Pathology & Ethnobotany** course in the **B.Sc. Programme** is effectively matched by the Course In-charge.

Signature of the Course In-charge

Signature of the Coordinator

Sem.	Programme Code	Course Code	Course Type	Course Title	Category	Hrs. / Week	Credits
III & IV	BOTUG1982	U25ABO2P	Allied Course	**PRACTICAL (AC-I & III)**	Practical	3	3

Course Description:

This practical course complements the theoretical aspects of Allied Course - I (U25ABO1). It aims to provide hands-on experience in plant identification, microscopy, plant anatomy, and field studies, reinforcing the theoretical concepts learned in the theory course.

Course Objectives:

1. *To identify the anatomy and morphology of plants through specimen preparation and analysis.*
2. *To observe the stages of mitosis and solve problems demonstrating Mendelian inheritance.*
3. *To demonstrate photosynthesis and respiration through simple physiological experiments.*
4. *To identify plants, common disease symptoms, and ecological adaptations in the field.*
5. *To execute foundational techniques for initiating a plant tissue culture experiment.*

Allied Course - I (U25ABO1)

1. Microscopic study of plants mentioned in theory syllabus.
2. morphological and floral description of plants - Fabaceae, Apocynaceae, Solanaceae, Cucurbitaceae, Asteraceae and Poaceae.
3. Anatomical preparation of dicot and monocot stem.
4. Identification of disease of infected plant materials.
5. Visit to the field and botanical garden in the nearby area and attempt to identify the plants.

Allied Course - II (U25ABO3)

1. Study of the cell organelles using photographs.
2. Cell division - Mitosis in onion root tip (observation of mitosis stage).
3. Monohybrid, dihybrid, monohybrid-test cross and back cross and ratios from the genetic charts.
4. Simple experimental set-ups in photosynthesis and respiration.
5. Tissue culture experimental set up (Callus and multiple shoots).
6. Study of ecological adaptations in:

   Hydrophytes (eg.: *Hydrilla*)

   Xerophytes (eg.: *Nerium*)

   Halophytes (eg.: *Avecinia* - Spotter only)

Course Outcomes:

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

CO1	Comprehend the basic concepts of plant diversity and taxonomy and botanical nomenclature
CO2	Understand the plant anatomical structure in monocot and dicot stem.
CO3	Evaluate some of the plant diseases and also field visit to useful for the plant identification and observe the plant disease.
CO4	Acquire the knowledge about the cell organelles and cell divisions.
CO5	Know the basic concept in genetics, evolution, plant physiology and ecology.
CO6	Comprehend the knowledge in callus and multiple shoot induction in plant tissue culture

CO- PO Mapping (Course Articulation Matrix)

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	3	3	1	1	1
CO2	9	3	3	1	1	1
CO3	9	3	3	1	1	1
CO4	9	3	3	1	1	1
CO5	9	3	3	1	1	1
CO6	9	3	3	1	1	1
Weightage	54	18	18	6	6	6
Weighted percentage of Course contribution to POs	48.21%	16.07%	16.07%	5.36%	5.36%	5.36%

Level of Correlation between CO's and PO's } 1 – Low 3 – Medium 9 – High 0 – No Correlation
(Suggested by UGC as per Six Sigma Tool – Cause and Effect Matrix)

The COs and POs for the **Allied Course - II: Practical** course in the **B.Sc. Programme** is effectively matched by the Course In-charge.

Signature of the Course In-charge Signature of the Coordinator

Sem.	Programme Code	Course Code	Course Type	Course Title	Category	Hrs. / Week	Credits
IV	BOTUG1982	U25ABO3	Allied Course	**CYTOLOGY, GENETICS, EVOLUTION, PLANT PHYSIOLOGY, ECOLOGY, AND BIOTECHNOLOGY**	Theory	5	3

Course Description:

This course provides an introduction to fundamental concepts in cell biology, genetics, plant physiology, ecology, and biotechnology. It covers key aspects of plant cell structure, cell division, inheritance patterns, plant growth and development, interactions within ecosystems, and the principles of plant biotechnology.

Course Objectives:

1. *To identify plant cell organelles and illustrate the processes of mitosis and meiosis.*
2. *To apply Mendel's laws to solve monohybrid and dihybrid cross problems.*
3. *To analyze the mechanisms of plant water transport, photosynthesis, and respiration.*
4. *To classify plants based on their ecological adaptations using core principles.*
5. *To outline plant biotechnology applications and describe basic tissue culture techniques.*

UNIT-I CYTOLOGY: (Teaching-1 h / week)

Ultrastructure of plant cell. Structure and function of cell wall, plasma membrane, chloroplast, mitochondria, ribosome, lysosome, golgi complex, endoplasmic reticulum and nucleus. Cell division – Mitosis and Meiosis.

UNIT-II GENETICS: (Teaching-1 h / week)

Mendel’s laws. Monohybrid, Dihybrid cross, Monohybrid test cross and back cross. Interaction of factors-Complementary factor hypothesis. Mutation – types – general concept. Evolution: Theories of evolution – Lamarckism and Darwinism

UNIT-III PHYSIOLOGY: (Teaching-1 h / week)

Absorption of water. Transpiration - Factors affecting transpiration. Mechanism of opening and closing of stomata.

Photosynthesis: Pigments - light reaction – dark reaction (Calvin cycle only). Respiration: Glycolysis - Kreb’s cycle. Electron transport system

UNIT-IV ECOLOGY: (Teaching-1 h / week)

Autecology and synecology. Ecological factors (biotic and abiotic) and Ecological groups of plants- Hydrophytes (*Hydrilla*), Xerophytes (*Nerium*), Mesophytes (*Hibiscus*) and Halophytes (*Rhizophora*). Pollution – Air, Water - Pollutants and control measures.

UNIT-V BIOTECHNOLOGY: (Teaching-1 h / week)

Scope, history and importance of biotechnology. Plant tissue culture - *In vitro* culture techniques: Sterilization methods, Culture media composition (MS medium). Gene cloning: Vectors - Ti plasmid - Use of *Agrobacterium* in genetic transformation of plants.

Course Outcomes:
On the completion of the course the students will be able to:

CO1	*Provide the basic information on plant cell and its internal organelles*
CO2	*Have conceptual understanding of laws of inheritance, genetic basis of loci and alleles and their linkage.*
CO3	*Understand water relation of plants with respect to various physiological processes and explain the significance of Photosynthesis and respiration*
CO4	*Understand the adaptation strategies of plants to various ecological conditions*
CO5	*Know the concept of modern technology in plant propagation*
CO6	*Understand the scope and importance of plant tissue culture in plant sciences.*

List of Text Books:

- Ganguly, A. K. (1971). General Botany - Vol. I. The New Book Stall, Calcutta.
- Gardner et al. (2004). Principles of Genetics. John Wiley and Sons Inc., Singapore.
- Jain, V. K. (2007). Fundamentals of Plant Physiology. S. Chand & Co., New Delhi.

List of Reference Books:

- Gupta, P. K. (1976). Text Book of Cytology Genetics and Evolutions. Rastogi Publications. (Accn. No. 00010452)
- Srb, A. D., Owen, R. D., & Edgar, R. S. (1979). General Genetics. Eurasia Publishing House (P) Ltd. (Accn. No. 00000423)
- Meyyan, R. P. (2002). Genetics & Genetic Engineering. Saras Publications. (Accn. No. 00006521)
- Renganathan, T. K. (1987). Evolution. Rastogi Publications. (Accn. No. 00002698)
- Singh, A. (1982). Practical Plant Physiology. Kalyani Publishers. (Accn. No. 00002458)
- Kormondy, E. J. (1986). Concepts of Ecology. Prentice Hall. (Accn. No. 00003146)
- Vittal, R. R., & Bhat, R. (2009). Biotechnology Concepts and Application. Narosa Publishing House. (Accn. No. 00010938)
- Kumarasan, V. (1986). Biotechnology (1st ed.). Saras Publications. (Accn. No. 00008517)

Digital Open Educational Resources:

- OpenStax Biology: This comprehensive online textbook covers a wide range of biological concepts, including cell biology, genetics, plant physiology, and ecology. (URL: https://openstax.org/books/biology/pages/1-introduction)
- Khan Academy: Offers a wealth of video Theorys, practice exercises, and articles on various biological topics, including those relevant to this course. (URL: https://www.khanacademy.org/science/biology)

Correlation Levels:

Mapping COs consistency with POs: Course Articulation Matrix

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	1	3	1	1	1
CO2	9	1	3	1	1	1
CO3	9	1	3	1	1	1
CO4	9	1	3	1	1	1
CO5	9	1	3	3	1	1
CO6	9	1	3	1	3	1
Weightage	54	6	18	6	8	6
Weighted percentage of Course contribution to POs	55.10%	6.12%	18.37%	6.12%	8.16%	6.12%

Course Outcomes mapped with Knowledge level (Revised Bloom's Taxonomy) and POs

CO / K - Level	Level of Correlation			
	High	**Medium**	**Low**	**Zero**
CO 1 / K1	PO1, PO3	PO2	PO4, PO5, PO6	-
CO 2 / K2	PO1, PO3	PO2	PO4, PO5, PO6	-
CO 3 / K3	PO1, PO3	PO2	PO4, PO5, PO6	-
CO 4 / K4	PO1, PO3	PO2	PO4, PO5, PO6	-
CO 5 / K5	PO1, PO3	PO2	PO4, PO5, PO6	-
CO 6 / K6	PO1, PO3	PO2	PO4, PO5, PO6	-

Course Outcome (CO) Attainment Assessment Tools & Evaluation Procedure:

K Levels	C1	C2	C3	Total scholastic Marks	Non-Scholastic Marks C4	CIA Total	% of Assessment
	T1 7 Marks	T2 7 Marks	Assignment 6 Marks	20 Marks	5 Marks	25 Marks	
K1	2	0	1	3	--	3	12
K2	2	1	1	4	--	4	16
K3	1	2	1	4	--	4	16
K4	1	2	1	4	--	4	16
K5	1	1	1	3	--	3	12
K6	0	1	1	2	--	2	8
Non-Scholastic	--	--	--	--	5	5	20
Total	7	7	6	20	5	25	100%

*C = Component

The COs and POs for the **Allied Course - III: Cytology, Genetics, Evolution, Plant Physiology, Ecology, and Biotechnology** course in the **B.Sc. Programme** is effectively matched by the Course In-charge.

Signature of the Course In-charge

Signature of the Coordinator

Sem.	Programme Code	Course Code	Course Type	Course Title	Category	Hrs. / Week	Credits
IV	BOTUG1982	U25BONME1	Non-Major Elective	**HORTICULTURE**	Theory	2	2

Course Description:

This course provides an introductory overview of horticulture, emphasizing its importance, scope, and classification of horticultural crops. Students will gain knowledge of the factors influencing crop growth, including climate, soil, and nutrient management. The course covers traditional and modern plant propagation techniques, principles of garden design, and maintenance of different garden types including greenhouses. It also includes practical insights into the cultivation of key flowers, vegetables, and fruits, along with post-harvest handling, storage, and marketing practices. The aim is to equip students with foundational horticultural knowledge for both academic and practical applications.

Course Objectives:

1. *To understand the importance, scope, and classification of horticultural crops and recognize the factors affecting crop growth such as climate, soil, and nutrition.*
2. *To gain knowledge of traditional and modern plant propagation methods, including nursery management, grafting, layering, and micropropagation techniques.*
3. *To apply the principles of garden design and understand the tools, techniques, and maintenance practices for various types of gardens and protected structures like greenhouses.*
4. *To learn the cultivation practices for key ornamental, vegetable, and fruit crops, with a focus on economically important species such as marigold, brinjal, banana, and mango.*
5. *To understand harvest and post-harvest handling, including storage, marketing, and the application of horticultural produce in industry and society.*

UNIT-I: Introduction to Horticulture

Horticulture - Importance and scope of Horticulture - Classification of horticultural crops - Factors affecting horticultural crops- climatic, soil and nutritional. Organic, inorganic and biofertilizers. - methods for controlling pest and diseases.

UNIT-II: Plant Propagation

Nursery and its structure - Plant propagation methods: cutting, layering, grafting and budding. Modern plant propagation method: Micropropagation - uses of plant growth regulators in horticulture.

UNIT-III: Garden making

Garden making – Principle, Tools and implement. Garden types: Ornamental, Kitchen, indoor gardens. Lawn making and maintenance. Establishment and maintenance of green house and poly house. Brief account on Bonsai.

UNIT-IV: Cultivation of Flowers, Vegetables and Fruits

Floriculture - cultivation of commercial flowers and Cut flowers – Marigold and chrysanthemum

Olericulture: Cultivation methods of Brinjal and Tomato.

Pomology: Cultivation of commercial fruits – Mango and Citrus.

UNIT-V: Harvest and Post-harvest techniques

Harvest, transport, preservation and Marketing of vegetables and fruits. Applications of Horticulture.

Units 1, 2 & 3: Teaching - 1 h / week ; Unit 4 & 5: Teaching - 1 h / week

Course Outcomes:

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

CO1	*Develop conceptual understanding scopes and employment opportunities of horticulture*
CO2	*Analyze various nursery management practices with routine garden operations*
CO3	*Evaluate garden designs of different geographical locations*
CO4	*Explains the various components of nursery, management and propagation techniques.*
CO5	*Understand the cultivation techniques in commercial flower and cut flowers*
CO6	*Distinguish among the various fruits, vegetables, Ornamental Plants and their seasoning, cultivation and preservation*

Text Book:

- Kumar, N. (1997). Introduction to Horticulture. Rajalakshmi Publications, Nagercoil
- Sheela, V.L (2011). Horticulture. MJP Publication, Chennai.
- Manibushan Rao, K. (1991). Textbook of Horticulture. Macmillan Publishing Co., New York.
- Rao KM. 2000. Text Book of Horticulture, MacMillan India Ltd., New Delhi.

References

- Adams, C., M. Early and J. Brrok (2011). Principles of Horticulture. Routledge, U.K.
- Sundararajan, J. S., Muthuswamy, J., Shanmugavelu, K. G. and Balakrishnan, R.: A Guide to Kumar N. Introduction to Horticulture. Rajalakshmi Publications, Nagarcoil, 1994.
- George Acquaah (2002). Horticulture Principles and Practices. 2nd ed. Pearson Education, Delhi

Web Resources:

- NPTEL – Fundamentals of Horticulture - https://nptel.ac.in/courses/126/105/126105015/
- ICAR eCourse – Fundamentals of Horticulture - http://ecourses.icar.gov.in

CO- PO Mapping (Course Articulation Matrix)

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	6	3	3	3	1	1
CO2	6	3	1	3	3	0
CO3	6	6	3	3	3	0
CO4	6	6	6	3	0	1
CO5	3	3	6	3	1	1
CO6	3	6	1	0	0	0
Weightage	**30**	**27**	**20**	**15**	**8**	**3**
Weighted percentage of Course contribution to POs	**29.13**	**26.21**	**19.42**	**14.56**	**7.77**	**2.91**

Level of Correlation between CO's and PO's } 1 – Low 3 – Medium 9 – High 0 – No Correlation (Suggested by UGC as per Six Sigma Tool – Cause and Effect Matrix)

Course Outcomes mapped with Knowledge level (Revised Bloom's Taxonomy) and POs

CO/ K-Level	Level of Correlation			
	High	Medium	Low	Zero
CO1/ K1	-	PO1, PO2, PO3,PO4	PO5	PO6
CO2/ K2	PO3,	PO1, PO3 PO5	PO4,PO6	_
CO3/ K3	PO1, PO2	PO3,PO4 PO5	_	PO6
CO4/ K4	PO1, PO2, PO3,PO4	PO5,PO6	-	-
CO5/ K5	PO1,PO3, PO4	PO2, PO5	-	PO6
CO6/ K6	-	PO1, PO4,	PO3, PO5	PO2, PO6

Course Outcome (CO) Attainment Assessment Tools & Evaluation Procedure:

K Levels	C1	C2	C3	C4	Total scholastic marks	Non Scholastic Marks C5	CIA Total	% of Assessment
	T1 4 Marks	T2 10 Marks	Assignment 6 Marks	Seminar 5 Marks	20 Marks	5 Marks	25 Marks	
K1	1	2	1	--	4	--	**4**	**16**
K2	1	2	1	--	4	--	**4**	**16**
K3	1	2	1	--	4	--	**4**	**16**
K4	1	2	1	--	4	--	**4**	**16**
K5		1	1	--	2	--	**2**	**8**
K6		1	1	--	2	--	**2**	**8**
Non Scholastic	--	--	--	--	--	**5**	**5**	**20**
Total	**4**	**10**	**6**	--	**20**	**5**	**25**	**100%**

***C = Component**

The COs and POs for the **Horticulture** course in the **B.Sc. Botany** Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge Signature of the Coordinator

Sem.	Programme Code	Course Code	Course Type	Course Title	Category	Hrs. / Week	Credits
V	BOTUG1982	U25BONME2	Non-Major Elective	**BIOINOCULANTS AND BIOPESTICIDES**	Theory	2	2

Course Description:

This course provides an introduction to bioinoculants and biopesticides, their role in sustainable agriculture, and their applications in enhancing crop productivity and protecting plants from pests and diseases.

Course Objectives:

1. *To identify key nitrogen-fixing biofertilizers and explain their roles in agriculture.*
2. *To describe methods for isolating and mass-multiplying key microbial biofertilizers.*
3. *To explain the role of VAM in plant nutrient uptake and its methods of application.*
4. *To analyze the function and application of key biopesticides for pest and disease control.*
5. *To compare the agricultural benefits and application methods of various bio-agents.*

UNIT-I

Scope and importance of biofertilizers - *Rhizobium* - isolation, Mass Multiplication. Application of *Rhizobium* in agriculture.

UNIT-II

Introduction to Azospirillum and Azotobacter and their role in nitrogen fixation. Isolation and mass multiplication of *Azospirillum* and *Azotobacter*. Application of Azospirillum and Azotobacter in agriculture.

UNIT-III

Introduction to Cyanobacteria (Anabaena) and *Azolla* - role in nitrogen fixation. Isolation and mass multiplication of *Azolla pinnata*. Application of *Azolla* in agriculture.

UNIT-IV

Introduction to AM fungi and their role in plant growth and development. Types of AM fungi. Isolation and multiplication of AM fungi. Application of AM fungi in agriculture.

UNIT-V

Scope and importance of biopesticides. Introduction to *Bacillus thuringiensis* and *Trichoderma viride* and their role in pest and disease control. Application of *Bacillus thuringiensis* and *Trichoderma viride* in agriculture.

Units 1 -3: Teaching - 1 h / week; Unit 4 & 5: Teaching - 1 h / week;

Course Outcomes:

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

CO1	*Develop their understanding on the concept of bio-fertilizer*
CO2	*Identify the different forms of biofertilizers and their uses*
CO3	*Equip the students with skills in biofertilizer production.*
CO4	*Demonstrate algal growth in different types of natural water*
CO5	*Develop the integrated management for better crop production by using both nitrogenous and phosphate bio fertilizers and vesicular arbuscular mycorrhizal (VAM).*
CO6	*Interpret and explain the components, patterns, and processes of microorganisms for biocontrol agents*

List of Text Books:

- Dubey, R.C. (2011). A Textbook of Microbiology. S. Chand Publishing.
- Alexopoulos, C.J., Mims, C.W., & Blackwell, M. (1996). Introductory Mycology. John Wiley & Sons.
- Rangaswami, G. (2002). Agricultural Microbiology. Prentice-Hall of India.

List of Reference Books:

- Jaiswal, A. P., Kant Prasad, & Deo. (n.d.). *Handbook of Soil Fertilizer and Manure*. Enkat Publication. (Accn. No. 22017070)
- Sen, S. P., & Palit, P. (1988). *Biofertilizers Potentialities and Problems*. Plant Physiology Forum. (Accn. No. 33004239)
- Singh, A. (1982). *Practical Plant Physiology*. Kalyani Publishers. (Accn. No. 00002458)
- Bilgrami, K. S. (1992). *Textbook of Modern Plant Pathology*. Vikas Publishing House. (Accn. No. 00004300)
- Baudoin, A. B. A. M. (1990). *Laboratory Exercises in Plant Pathology an Instructional Kit*. Scientific Publishers. (Accn. No. 00004584)
- Vidyasekaran, P. (1993). *Principles of Plant Pathology*. CBS. (Accn. No. 00004595)
- Roberts, A. D. (1987). *Fundamentals of Plant Pathology Second Edition*. CBS. (Accn. No. 00006810)

Digital Open Educational Resources:

- **NCBI (National Center for Biotechnology Information):** Provides access to a wealth of information on microbiology, genetics, and biotechnology.
- **USDA Agricultural Research Service:** Offers resources on agricultural microbiology, including information on biofertilizers and biopesticides.
- **Khan Academy:** Provides video lectures and articles on various biological topics, including microbiology and biotechnology.
- **OpenStax Biology:** Provides a comprehensive online textbook covering various biological concepts, including microbiology.

Correlation Levels:

Mapping COs consistency with POs: Course Articulation Matrix

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	3	3	1	3	1
CO2	9	3	3	1	3	1
CO3	9	3	3	1	3	1
CO4	9	3	3	1	3	1
CO5	9	3	3	1	3	1
CO6	9	3	3	1	3	1
Weightage	54	18	18	6	18	6
Weighted percentage of Course contribution to POs	45%	15%	15%	5%	15%	5%

Course Outcomes mapped with Knowledge level (Revised Bloom's Taxonomy) and POs

CO / K - Level	Level of Correlation			
	High	Medium	Low	Zero
CO 1 / K1	PO1, PO3	PO2	PO4, PO5, PO6	-
CO 2 / K2	PO1, PO3	PO2	PO4, PO5, PO6	-
CO 3 / K3	PO1, PO3	PO2	PO4, PO5, PO6	-
CO 4 / K4	PO1, PO3	PO2	PO4, PO5, PO6	-
CO 5 / K5	PO1, PO3	PO2	PO4, PO5, PO6	-
CO 6 / K6	PO1, PO3, PO5	PO2	PO4, PO6	-

Course Outcome (CO) Attainment Assessment Tools & Evaluation Procedure:

K Levels	C1	C2	C3	Total scholastic Marks	Non-Scholastic Marks C4	CIA Total	% of Assessment
	T1 7 Marks	T2 7 Marks	Assignment 6 Marks	20 Marks	5 Marks	25 Marks	
K1	2	0	1	3	--	3	**12**
K2	2	1	1	4	--	4	**16**
K3	1	2	1	4	--	4	**16**
K4	1	2	1	4	--	4	**16**
K5	1	1	1	3	--	3	**12**
K6	0	1	1	2	--	2	**8**
Non-Scholastic	--	--	--	--	5	5	**20**
Total	**7**	**7**	**6**	**20**	**5**	**25**	**100%**

*C = Component

The COs and POs for the Non-Major Elective - II: Bioinoculants and Biopesticides course in the B.Sc. Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge

Signature of the Coordinator

EXTRA CREDIT COURSE (ECC-1)

Title	**:**	**MICROBES IN HISTORY**
Offered to	**:**	**Students of UG**
programme Semester in which offered	**:**	**4th Semester**
Credits	**:**	**4**
Instruction Hrs	**:**	**1 hr per week (3 Hrs per Unit)**
Self study Hrs	**:**	**3 Hrs per week (9 Hrs per unit)**

Course Outcomes:

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

CO1	Understand how microbes have manipulated human history.
CO2	Appreciate that microbes deserve a place in history texts as kings, presidents and generals.
CO3	Understand how microbes have influenced scientific and religious ideas in the past.
CO4	Compare and contrast factual and conceptual historical interpretations.
CO5	Instill the knowledge on microbes as a healing agents in twentieth century
CO6	Construct and communicate historical arguments in the context in which the syllabus is created.

UNIT I: RUTHLESS MICROBES

Plague and the End of the Golden Age of Greece; Disease and the Downfall of Rome; Typhoid Mary - The most wanted.

UNIT II: MICROBES IN WAR

Microbes as Allies of Napoleon Walcheren; Microbial fermentation that kept Napoleon's guns functioning; World WarI – The prestigious reward – Birth of Israel.

UNIT III: MICROBES IN AMERICAN HISTORY

American Revolution - George Washington - Colonial Army against smallpox; Making American Presidential Possible – The Great Famine; A Gift to the U.S. from the Yellow Fever Virus.

UNIT IV: SAVIOUR MICROBES

An ordinary mold - the greatest healing agent of World War II; 1939 - Rozwadow - War of intellect - Bacteria that saved a town;

UNIT V: MICROBES IN RELIGION

Red Mystery - Blood of Christ - Miracle at Bolsena; Assyrian King Sennacherib in the Middle East - Judaism, Christianity and Islam saved by a Microbe.

REFERENCES:

1. Zinsser, H. 1934. Rats, lice, and history, p. 152. Little, Brown & Co., Boston.
2. McNeil, W.H. 1976. Plagues and peoples, p. 2, 121-123. Anchor Press/Doubleday, Garden City, NY.
3. Bennett, J.W. and R. Bentley. 2000. Seeing red: the story of prodigiosin. Adv. Appl. Microbiol. 47:1-32.
4. McNeill, W.H. 2000. The plague that saved Jerusalem, p. 1-14. In R. Cowley (ed.), What if? Berkeley Books, New York.
5. Kitchen, K.A. 2003. On the reliability of the Old Testament, p. 41. William B. Eerdmans, Grand Rapids, MI.
6. Thucydides. 1991. History of the PeloponnesianWar, translated by R. Crawley, revised by R. Feetham, p. 399. In M.J. Adler (ed.), Great books of the Western world. University of Chicago Press, Chicago.
7. Thucydides. 1991. History of the Peloponnesian War, translated by R. Crawley, revised by R. Feetham, p. 400 - 402. In M.J. Adler (ed.), Great books of the Western world. University of Chicago Press, Chicago.
8. McNeil, W.H. 1976. Plagues and peoples, p. 106. Anchor Press/Doubleday, Garden City, NY.
9. Russell, T.R. 2000. Roads and highways: 5. Road systems of the world, p. 562. Encyclopedia Americana. Grolier, Inc., Danbury, CT.

CO- PO Mapping (Course Articulation Matrix)

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	6	3	3	3	1	1
CO2	6	3	1	3	3	0
CO3	6	6	3	3	3	0
CO4	3	6	6	3	1	1
CO5	6	3	3	3	1	1
CO6	3	3	1	0	0	0
Weightage	**30**	**24**	**19**	**15**	**9**	**3**

Level of Correlation between CO's and PO's } 1 – Low 3 – Medium 9 – High 0 – No Correlation (Suggested by UGC as per Six Sigma Tool – Cause and Effect Matrix)

Course Outcomes mapped with Knowledge level (Revised Bloom's Taxonomy) and POs

CO/ K-Level	Level of Correlation			
	High	**Medium**	**Low**	**Zero**
CO1/ K1	PO1, PO2	PO3, PO4, PO5	PO6	_
CO2/ K2	PO1, PO2	PO3, PO4	PO5, PO6	_
CO3/ K3	PO1	PO2, PO3,	PO4, PO5	PO6
CO4/ K4	PO1	PO2, PO3	PO4, PO5	PO6
CO5/ K5	PO1, PO2	PO3, PO4	PO5, PO6	--
CO6/ K6	PO1, PO2	PO3, PO4,	PO5, PO6	--

Course Outcome (CO) Attainment Assessment Tools & Evaluation Procedure:

K Levels	C1	C2	C3	C4	Total scholastic marks	Non Scholastic Marks C5	CIA Total	% of Assessment
	T1 4 Marks	T2 10 Marks	Assignment 6 Marks	Seminar 5 Marks	20 Marks	5 Marks	25 Marks	
K1	1	2	1	--	4	--	**4**	**16**
K2	1	2	1	--	4	--	**4**	**16**
K3	1	2	1	--	4	--	**4**	**16**
K4	1	2	1	--	4	--	**4**	**16**
K5		1	1	--	2	--	**2**	**8**
K6		1	1	--	2	--	**2**	**8**
Non Scholastic	--	--	--	--	--	**5**	**5**	**20**
Total	**4**	**10**	**6**	--	**20**	**5**	**25**	**100%**

***C = Component**

The COs and POs for the **MICROBES IN HISTORY** course in the B.Sc. Botany Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge

Signature of the Coordinator

EXTRA CREDIT COURSE (ECC-2)

Title	**:**	**GEOMICROBIOLOGY**
Offered to	**:**	**Students of UG**
Semester in which offered	**:**	**5th Semester**
Credits	**:**	**4**
Instruction Hrs	**:**	**1 hr per week (3 Hrs per Unit)**
Self study Hrs	**:**	**3 Hrs per week (9 Hrs per unit)**

Course Outcomes:

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

CO1 Understand the importance of microorganism in the establishment of life on our planet.

CO2 Appreciate the role that microbes play and have played in specific geological processes

CO3 Search for microbial signatures in our planet for mining and energy exploration

CO4 Comprehend the recent developments in the search for geo-biological signatures in paleo-sea level reconstructions.

CO5 Appreciate the link between two majors, the geology and microbiology

CO6 Impart the knowledge on geobiotechnology

UNIT I: MICROBIAL WORLD

Evolution of life – Classification of living things – Kingdom concepts - microbial diversity - Archaebacteria.

UNIT II: MICROBES IN SOIL

Soil microorganisms – role of microbes in soil formation; Biogeochemical activity of microbes - decomposition.

UNIT III: MICROBES IN MINING

Biomining - Microbial assimilation of metals – Bioleaching - Copper – Gold – Uranium.

UNIT IV: MICROBES AND ENERGY

Recovery of petroleum – Production of fuels – Ethanol – methane – Hydrogen and other hydrocarbons.

UNIT V: GEOBIOTECHNOLOGY

Biotechnological concepts for Geologists – metagenomic analysis - Future of scientific drilling; Case study – Bacterial proxies for paleo-sea level reconstruction.

REFERENCES:

1. Kurt O. Konhauser. 2009. Introduction to Geomicrobiology. Wiley. ISBN 1444309021, 9781444309027.
2. Henry Lutz Ehrlich, Dianne K. Newman, Andreas Kappler. 2015. Ehrlich's Geomicrobiology, Sixth Edition. Taylor & Francis. ISBN: 1466592400, 9781466592407.
3. Henry Lutz Ehrlich. 2002. Geomicrobiology, Fourth Edition. CRC Press. ISBN 0824744454, 9780824744458.

4. Janice P. L. Kenney, Harish Veeramani, Daniel S. Alessi. 2019. Analytical Geomicrobiology. Cambridge University Press. ISBN: 1107070333, 9781107070332.
5. S. K. Jain, A. A. Khan, M. K. Rai. 2016. Geomicrobiology. CRC Press. ISBN : 1439845107, 9781439845103.
6. Andrew H. Knoll, Don E. Canfield, Kurt O. Konhauser. 2012. Fundamentals of Geobiology. John Wiley & Sons. ISBN: 1118280881, 9781118280881.
7. Tom Fenchel, Gary M. King, Henry Blackburn. 1998. Bacterial Biogeochemistry: The Ecophysiology of Mineral Cycling. Elsevier Science. ISBN 0121034550, 9780121034559.
8. Urvashi Swami, Vijay Singh Gondil. 2019. Geomicrobiology. Arcler Education Incorporated. ISBN: 1774071681, 9781774071687.
9. Frank Reith, Jeremiah Shuster. 2018. Geomicrobiology and Biogeochemistry of Precious Metals. MDPI. ISBN: 3038973467, 9783038973461.
10. Gerard J. Tortora, Berdell R. Funke, Christine L. Case. 2015. Microbiology: An Introduction. Pearson Education. ISBN: 0133923398, 9780133923391.

CO- PO Mapping (Course Articulation Matrix)

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	6	3	3	3	1	1
CO2	6	3	1	3	3	0
CO3	6	6	3	3	1	0
CO4	6	6	6	1	0	1
CO5	6	6	3	3	3	1
CO6	3	3	1	0	0	0
Weightage	**33**	**26**	**17**	**13**	**8**	**3**

Level of Correlation between CO's and PO's } 1 – Low 3 – Medium 9 – High 0 – No Correlation (Suggested by UGC as per Six Sigma Tool – Cause and Effect Matrix)

Course Outcomes mapped with Knowledge level (Revised Bloom's Taxonomy) and POs

CO/ K-Level	Level of Correlation			
	High	**Medium**	**Low**	**Zero**
CO1/ K1	PO1, PO2	PO3, PO4, PO5	PO6	_
CO2/ K2	PO1, PO2	PO3, PO4	PO5, PO6	_
CO3/ K3	PO1	PO2, PO3,	PO4, PO5	PO6
CO4/ K4	PO1	PO2, PO3	PO4, PO5	PO6
CO5/ K5	PO1, PO2	PO3, PO4	PO5, PO6	--
CO6/ K6	PO1, PO2	PO3, PO4,	PO5, PO6	--

Course Outcome (CO) Attainment Assessment Tools & Evaluation Procedure:

K Levels	C1	C2	C3	C4	Total scholastic marks	Non Scholastic Marks C5	CIA Total	% of Assessment
	T1 4 Marks	T2 10 Marks	Assignment 6 Marks	Seminar 5 Marks	20 Marks	5 Marks	25 Marks	
K1	1	2	1	--	4	--	**4**	**16**
K2	1	2	1	--	4	--	**4**	**16**
K3	1	2	1	--	4	--	**4**	**16**
K4	1	2	1	--	4	--	**4**	**16**
K5		1	1	--	2	--	**2**	**8**
K6		1	1	--	2	--	**2**	**8**
Non Scholastic	--	--	--	--	--	**5**	**5**	**20**
Total	**4**	**10**	**6**	--	**20**	**5**	**25**	**100%**

***C = Component**

The COs and POs for the **GEOMICROBIOLOGY** course in the B.Sc. Botany Programme is effectively matched by the Course In-charge.

Signature of the Course In-charge

Signature of the Coordinator