WEST BENGAL STATE UNIVERSITY

DRAFT SYLLABUS FOR FOUR YEAR UG PROGRAMME (Honours, Honours with Research) and Three Year Multi-Disciplinary Course

IN

BOTANY

Under National Education Policy (NEP)

Effective from 1.08.2023

Structure of the 4-year Undergraduate Programme (Honours)

Table1: Semester-wise and Course category-wise distribution of credits

SEM	Major (DSC)	Minor	MDC	AEC	SEC	VAC	Internship	Total Credits
I	DS-1(5)	MA-1(5) MB-1(5)	MD-1 (3)	AE-1 (3)	SE-1 (3)	VA-1 (3)		27
II	DS-2(5)	MA-2(5) MB-2(5)	MD-2 (3)	AE-2 (3)	SE-2 (3)	VA-2 (3)	(4**)	27
Exit with certificate								(4**) + 54
III	DS-3(5)	MA-3(5) MB-3(5)	MD-3 (3)	AE-3 (3)	SE-3 (3)			24
IV	DS-4(5),DS-5(5) DS-6(5),DS-7(5)						(4**)	20
Exit with diploma								(4**) + 98
V	DS-8(5),DS-9(5) DS-10(5), DS-11(5)							20
VI	DS-12(5), DS-13(5) DS-14(5), DS-15(5)						(4**)	20
Exit with Major	75	30	9	9	9	6		(4**)+138
VII	DS-16(5) DS-17(5)	SMA(5) SMB (5)						20
VIII	DS-18(5) DS-19(5) DS-20(5) DS-21(5)							20
Credit	105	40	9	9	9	6	4	182

DS: Discipline specific core course,

MA: Minor discipline1, MB: Minor discipline2

SM: Special Minor courses from the two different disciplines either MA or MB, but of higher level.

Structure of the 4-year Undergraduate Programme (Honours with Research)

Table1A: Semester-wise and Course category-wise distribution of credits

SEM	Major (DSC)	Minor	MDC	AEC	SEC	VAC	Internship/ Research	Total Credits
I	DS-1(5)	MA-1(5) MB-1(5)	MD-1 (3)	AE-1 (3)	SE-1 (3)	VA-1 (3)		27
II	DS-2(5)	MA-2(5) MB-2 (5)	MD-2 (3)	AE-2 (3)	SE-2 (3)	VA-2 (3)	(4**)	27
Exit with certificate								(4**) + 54
III	DS-3(5)	MA-3(5) MB-3(5)	MD-3 (3)	AE-3 (3)	SE-3 (3)			24
IV	DS-4(5), DS-5(5) DS-6(5), DS-7(5)						(4**)	20
Exit with diploma								(4**) + 98
V	DS-8(5), DS-9(5) DS-10(5), DS-11(5)							20
VI	DS-12(5), DS-13(5), DS-14(5), DS-15(5)						(4**)	20
Exit with Major	75	30	9	9	9	6	(4**)	(4**) + 138
VII	DS16(5), DS-17(5)	SMA(5) SMB (5)						20
VIII	DS-18(5),						15	20
Credit	90	40	9	9	9	6	19	182

DS: Discipline specific core course,

MA: Minor discipline1, MB: Minor discipline2

SM: Special Minor courses from the two different disciplines either MA or MB, but of higher level.

Structure of the3-YearMultidisciplinaryUGProgramme

Table2:Semester-wise and course category-wise distribution of credits

SEM	Core course(A)	Core course(B)	Core course (C)	MDC	AEC	SEC	VAC	Inten-ship	Total credits
I	MA-1(5)	MB-1(5)	MC-1(5)		AE-1(3)		VA-1(3)		21
II	MA-2(5)	MB-2(5)	MC-2(5)		AE-2(3)		VA-2(3)	(4**)	21
Exit with Certificate									(4*)+ 42
III	MA-3(5)	MB-3(5)	MC-3(5)		AE-3(3)	SE-1 (3)			21
IV	MA-4(5)	MB-4(5)	MC-4(5)	MD-1(3)		SE-2(3)		(4**)	21
Exit with diploma									(4**)+ 84
V	MA-5(5)	MB-5(5)	MC-5(5)	MD-2(3)		SE-3(3)			21
VI	MA-6(5)	MB-6(5)	MC-6(5)	MD-3(3)		SE-4(3)		(4**)	21
Credits	30	30	30	9	9	12	6	4	(4**) + 126

MA: Core course from discipline 1,

MB: Core course from discipline 2

MC: Core course from discipline 3.

Semester-wise Course Structures of Botany (NEP)

(Major, Honours, Honours with research and MDC)

Semester	Major (Credit Point:5), Marks:100, (L:T:P=3:0:2) - Theory+Practical	Minor (Credit point:5) Marks:100, (L:T:P=3:0:2)	SEC (Credit point:3) Marks:50,	MDC (CP:3) Marks:50 (L:T:P=2:1:0)
I	DS-1: (BOTDSC101T/P) Microbiology and Phycology	MA -1 (BOTMIN202T/P) (BOTCOR202T/P) Biodiversity (Microbes, Algae, Fungi & Archegoniate)	SE- 1 (BOTHSE101M) Floriculture & Gardening OR SE- 1 (BOTHSE102M) Mushroom Cultivation Technique	Life Sciences (LIFHMD101M)
II	DS-2: (BOTDSC202T/P) Mycology & Phytopathology	MA-2 (BOTMIN202T/P) (BOTCOR202T) Plant Ecology & Taxonomy	SE- 2 (BOTHSE203M) Vermicomposting OR SE- 2 (BOTHSE204M) Tissue culture technique & Micropropagation	Life Sciences (LIFHMD201M)
III	DS-3: (BOTDSC303T/P) Archegoniate I (Bryophytes & Pteridophytes)	MA-3 (BOTMIN303T/P) (BOTCOR303T/P) Plant Anatomy & Embryology	SE- 3 (BOTHSE301M) (SE-1 BOTGSE301M) Floriculture & Gardening OR SE- 3 (BOTHSE302M) (SE-1 BOTGSE302M) Mushroom Cultivation Technique	Life Sciences (LIFHMD301M)
IV	DS-4: Archegoniatae II [Gymnosperms, Paleobotany & Palynology] (BOTDSC404T/P)	MA-4 Plant Physiology & Metabolism (BOTCOR404T/P)	SE- 2 (BOTGSE403M) Vermicomposting OR SE- 2 (BOTGSE404M) Tissue culture technique & Micropropagation	Life Sciences (LIFHMD401M)
	DS-5 (BOTDSC405T/P) Economic Botany, Ethnobotany and Pharmacognosy			
	DS-6 (BOTDSC406T/P) Morphology & Plant Systematics			
	DS-7 (BOTDSC407T/P) Plant Ecology and Phytogeography			

V	DS-8 (BOTDSC508T/P) Plant Ecology and Phytogeography	MA-5 (BOTCOR505T/P) Cell and Molecular Biology	SE- 3 (BOTGSE501M) Floriculture & Gardening OR SE- 3 (BOTGSE502M) Mushroom Cultivation Technique	Life Sciences (LIFHMD501M)
	DS-9 (BOTDSC509T/P) Cell Biology and Genetics			
	DS-10 (BOTDSC510T/P) Plant Physiology			
	DS-11(BOTDSC511T/P) Plant Breeding and Biostatistics			
VI	DS-12 (BOTDSC612T/P) Molecular Biology	MA-6 (BOTCOR606T/P) Analytical Techniques in Plant Sciences	SE- 4 (BOTGSE603M) Vermicomposting OR SE- 4 (BOTGSE604M) Tissue culture technique & Micropropagation	Life Sciences (LIFHMD601M)
	DS-13 (BOTDSC613T/P) Plant Biochemistry and Metabolism			
	DS-14 (BOTDSC614T/P) Biotechnology and Plant Tissue Culture			
	DS-15 (BOTDSC615T/P) Analytical techniques in Plant Sciences			

Last two Semester-wise Course Structures of Botany (NEP)

(Honours and Honours with Research)

Semester	Major (Credit Point:5), Marks:100, (L:T:P=3:0:2)	Special Minor BOTSMC701/702/703T/P (CP:5) Marks:100, (L:T:P=3:0:2)
VII	DS-16 (BOTDSC716T/P) Research Principles and Techniques in Plant Biology	Biostatistics (BOTSMC701T/P)
	DS-17 (BOTDSC717T/P) Integrated Biology	
VIII	DS-18 (BOTDSC818T/P) Industrial & Environmental Biology	
	For Honours only DS-19 (BOTDSC819T/P); Bioinformatics DS-20 (BOTDSC820T/P); Plant Morpho-evo-devo Biology & Molecular Systematics	For Hons with Research Research Project/Dissertation (BOTRES801M)

	DS-21 (BOTDSC821T/P); Advanced & Translational Plant Biology	**Credit Points:15, Marks: 300**

WEST BENGAL STATE UNIVERSITY

PART I

B.Sc. (Honours/ Honours with Research) in Botany

Details of Courses offered

Major Discipline Specific Core Courses (DSC)

1. Microbiology and Phycology (DS-1; BOTDSC101T, BOTDSC101P)
2. Mycology and Phytopathology(DS-2; BOTDSC202T, BOTDSC202P)
3. Archegoniatae I [Bryophytes and Pteridophytes] (DS-3; BOTDSC303T, BOTDSC303P)
4. Archegoniatae II [Gymnosperms, Paleobotany, Palynology] (DS-4; BOTDSC404T, BOTDSC404P)
5. Economic Botany, Ethnobotany and Pharmacognosy (DS-5; BOTDSC405T, BOTDSC405P)
6. Plant Anatomy and Embryology (DS-6; BOTDSC406T, BOTDSC406P)
7. Morphology and Plant Systematics (DS-7; BOTDSC407T, BOTDSC407P)
8. Plant Ecology and Phytogeography (DS-8; BOTDSC508T, BOTDSC508P)
9. Cell Biology and Genetics (DS-9; BOTDSC509T, BOTDSC509P)
10. Plant Physiology (DS-10; BOTDSC510T, BOTDSC510P)
11. Plant Breeding and Biostatistics (DS-11; BOTDSC511T, BOTDSC511P)
12. Molecular Biology (DS-12; BOTDSC612T, BOTDSC612P)
13. Plant Biochemistry and Metabolism (DS-13; BOTDSC513T, BOTDSC613P)

14. Biotechnology and Plant Tissue Culture (DS-14; BOTDSC614T, BOTDSC614P)
15. Analytical Techniques in Plant Sciences (DS-15; BOTDSC615T, BOTDSC615P)
16. Research Principles and Techniques in Plant Biology (DS-16; BOTDSC716T, BOTDSC716P)
17. Integrated Biology (DS-17; BOTDSC717T, BOTDSC717P)
18. Industrial and Environmental Microbiology (DS-18; BOTDSC818T, BOTDSC818P) for both Honours and Honours with Research
19. Bioinformatics (DS-19; BOTDSC819T, BOTDSC819P) only for Honours
20. Plant Morpho-evo-devo Biology and Molecular Systematics (DS-20; BOTDSC820T, BOTDSC820P) only for Honours
21. Advanced and Translational Plant Biology (DS-21; BOTDSC821T, BOTDSC821P) only for Honours
22. Research/Dissertation/Project work (BOTRES801M) only for Honours with Research.

Multidisciplinary Course (MDC)

1. Life Science

MDC in Life Science will have multiple codes. The detail is worked out below.

a. LIFHMD101M if taken in Sem I for Honours and Honours with Research.
b. LIFHMD201M if taken in Sem II for Honours and Honours with Research.
c. LIFHMD301M if taken in Sem III for Honours and Honours with Research.

Ability Enhancement Course Compulsory (AECC)

1. English/Modern Indian Language (MIL)

Skill Enhancement Course (SEC)

1. Floriculture and Gardening or Mushroom Cultivation Technique (SE-1: BOTHSE101M/BOTHSE102M; SE-3: BOTHDE301M/BOTHSE302M)
2. Techniques of Vermicomposting or Tissue Culture Technique and Micropropagation (SE-2: BOTHSE203M/BOTHSE204M)

Value Added Course (VAC)

1. Environmental Studies (VAC 1; ENVSVAC101T/ENVSVAC201T)
2. Introduction to Cyber Securities (VAC 2: ICSVAC202T/ICSVAC102T)
3. Value of Yoga and Meditation in Life: VAC 3 (VYMVAC203M/VYMVAC103M)

Marks and Credit Distribution Chart for Major Discipline Specific Core Courses (DSC)

SEMESTER I

Course Title	Course Code	Credits	Lecture/ Contact Hours	Marks		
				Endterm	Internal Assessment	Total
MICROBIOLOGY AND PHYCOLOGY	DS-1 BOTDSC101T Theory	3	45	50	0	50
	BOTDSC101P Practical	2	60	25	25	50

SEMESTER II

Course Title	Course Code	Credits	Lecture/ Contact Hours	Marks		
				Endterm	Internal Assessment	Total
MYCOLOGY AND PHYTOPATHOLOGY	DS-2 BOTDSC101T Theory	3	45	50	0	50
	BOTDSC101P Practical	2	60	25	25	50

SEMESTER III

Course Title	Course Code	Credits	Lecture/ Contact Hours	Marks		
				Endterm	Internal Assessment	Total
ARCHEGONIATAE I [BRYOPHYTES, PTERIDOPHYTES]	DS-3 BOTDSC303T Theory	3	45	50	0	50
	BOTDSC303P Practical	2	60	25	25	50

SEMESTER IV

Course Title	Course Code	Credits	Lecture/ Contact Hours	Marks		
				Endterm	Internal Assessment	Total
ARCHEGONIATAE II [GYMNOSPERMS, PALEOBOTANY, PALYNOLOGY]	DS-4 BOTDSC404T Theory	3	45	50	0	50
	BOTDSC404P Practical	2	60	25	25	50
ECONOMIC BOTANY, ETHNOBOTANY, AND PHARMACOGNOSY	DS-5 BOTDSC405T Theory	3	45	50	0	50
	DS-6 BOTDSC405P Practical	2	60	25	25	50
PLANT ANATOMY AND EMBRYOLOGY	BOTDSC406T Theory	3	45	50	0	50
	DS-7 BOTDSC406P Practical	2	60	25	25	50
MORPHOLOGY AND PLANT SYSTEMATICS	BOTDSC407T Theory	3	45	50	0	50
	BOTDSC407P Practical	2	60	25	25	50

SEMESTER V

Course Title	Course Code	Credits	Lecture/ Contact Hours	Marks		
				Endterm	Internal Assessment	Total
PLANT ECOLOGY AND PHYTOGEOGRAPHY	DS-8 BOTDSC508T Theory	3	45	50	0	50
	BOTDSC508P Practical	2	60	25	25	50
CELL BIOLOGY AND GENETICS	DS-9 BOTDSC509T Theory	3	45	50	0	50
	BOTDSC509P Practical	2	60	50	0	50

PLANT PHYSIOLOGY	DS-10 BOTDSC510T Theory	3	45	25	25	50
	BOTDSC510P Practical	2	60	50	0	50
PLANT BREEDING AND BIOSTATISTICS	DS-11 BOTDSC511T Theory	3	45	25	25	50
	BOTDSC511P Practical	2	60	50	0	50

SEMESTER VI

Course Title	Course Code	Credits	Lecture/ Contact Hours	Marks		
				Endterm	Internal Assessment	Total
MOLECULAR BIOLOGY	DS-12 BOTDSC612T Theory	3	45	50	0	50
	BOTDSC612P Practical	2	60	25	25	50
PLANT BIOCHEMISTRY AND METABOLISM	DS-13 BOTDSC613T Theory	3	45	50	0	50
	BOTDSC613P Practical	2	60	25	25	50
PLANT BIOTECHNOLOGY AND TISSUE CULTURE	DS-14 BOTDSC614T Theory	3	45	50	0	50
	BOTDSC614P Practical	2	60	25	25	50
ANALYTICAL TECHNIQUES IN PLANT SCIENCES	DS-15 BOTDSC615T Theory	3	45	50	0	50
	BOTDSC615P Practical	2	60	25	25	50

SEMESTER VII

Course Title	Course Code	Credits	Lecture/ Contact Hours	Marks		
				Endterm	Internal Assessment	Total
RESEARCH PRINCIPLES AND TECHNIQUES IN PLANT BIOLOGY	DS-16 BOTDSC716T Theory	3	45	50	0	50
	BOTDSCN716P Practical	2	60	25	25	50
INTEGRATED BIOLOGY	DS-17 BOTDSC717T Theory	3	45	50	0	50
	BOTDSCN717P Practical	2	60	25	25	50

SEMESTER VIII (HONOURS)

Course Title	Course Code	Credits	Lecture/ Contact Hours	Marks		
				Endterm	Internal Assessment	Total
INDUSTRIAL AND ENVIRONMENTAL MICROBIOLOGY	DS-18 BOTDSC818T Theory	3	45	50	0	50
	BOTDSC818P Practical	2	60	25	25	50
BIOINFORMATICS	DS-19 BOTDSC819T Theory	3	45	50	0	50
	BOTDSCN819P Practical	2	60	25	25	50
PLANT MORPHO-EVO- DEVO-BIOLOGY AND MOLECULAR SYSTEMATICS	DS-20 BOTDSC820T Theory	3	45	50	0	50
	BOTDSCN820P Practical	2	60	25	25	50
ADVANCED AND TRANSLATIONAL PLANT BIOLOGY	DS-21 BOTDSC821T Theory	3	45	50	0	50
	BOTDSC821P Practical	2	60	25	25	50

SEMESTER VIII (HONOURS WITH RESEARCH)

Course Title	Course Code	Credits	Lecture/ Contact Hours	Marks		
				Endterm	Internal Assessment	Total
INDUSTRIAL AND ENVIRONMENTAL MICROBIOLOGY	DS-18 BOTDSC818T Theory	3	45	50	0	50
	BOTDSCN818P Practical	2	60	25	25	50
RESEARCH/DISSERTATION/PROJECT WORK	BOTRES801M Dissertation/ Project report	15		200		300
	BOTRES801M Presentation			50		
	BOTRES801M Viva-voce			50		

Evaluation Scheme for End-Term Examination

Theory

QUESTION PAPER PATTERN FOR MAJOR

Duration	Type	Total No. of Questions	No. of Questions to be Answered	Marks for Each Question	Total marks Allotted
2 Hours	Short Answer	10	10 out of 10	1	10X1 = **10**
	Short notes/ Paragraph	6	4 out of 6	5	4X5 = **20**
	Descriptive/ Long Answer	2	2 out of 3	10 (Part markings 6+4 or 7+3)	2X10 = **20**
Full Marks					**50**

Semester-I

DS-1: MICROBIOLOGY AND PHYCOLOGY
Course Code: BOTDSC101T
(Credits: Theory -3, Practical – 2)
THEORY
(50 Marks; Lecture Hours: 45)

Microbiology: 30 Marks **(25 lectures)**

Unit 1: Introduction to the microbial world
Binomial nomenclature; Differences between Prokaryotic and Eukaryotic microorganisms; Development of Microbiology as a discipline; Spontaneous generation vs Biogenesis; Contributions of Anton Von Leeuwenhoek, Louis Pasteur, Robert Koch, and Alexander Fleming; Primary concept of microorganism: the 3-domain concept.

Unit 2: Viruses
Physicochemical and biological characteristics; General structure with emphasis on subviral particles (Satellite virus, Viroids and Prions); Groups of viruses: DNA viruses (T-phage, λ phage) with lytic and lysogenic cycles; RNA viruses (TMV), emphasizing its physicochemical properties and modes of multiplication.

Unit 3: Bacteria
General characteristics; Microbial nutrition, growth, and metabolism; Types: Archaebacteria, Eubacteria, and Mycoplasma; Cell structure; Nutritional types; and Reproduction: Vegetative, asexual, and genetic recombination (conjugation, transformation, transduction).

Unit 4: Industrial and Environmental Microbiology
Bioreactors/Fermenters and fermentation processes, different types of fermentation processes, parts of fermenters and their functions, downstream processing and industrial production of ethanol, penicillin, citric acid, and amylase. Economic importance of bacteria with reference to their role in agriculture; Role of viruses in vaccines.

Unit 5: Microbes and Quality of the Environment
Distribution of microbes in air, water, and soil; Water pollution, role of microbes in sewage and domestic wastewater systems; Microorganisms as indicators of water quality; Microbes in agriculture and remediation of contaminated soil.

Phycology: 20 Marks **(20 lectures)**

Unit 5: Algal Introduction
General characteristics; Ecology and distribution; Range of thallus; Cell structure and components: cell wall, pigment system, reserve food (only groups represented in the syllabus), flagella and flagellar roots;

Methods of reproduction; Evolution of sex in algae; Serial Endosymbiotic Theory (SET); Classification criteria; Classification of Lee 2015 up to class; Significant contributions of important Phycologists (F.E. Fritsch, G.M. Smith, M.O.P. Iyengar).

Unit 6: Cyanophyta and Xanthophyta
Ecology and occurrence; Range of thallus organization; Cell structure; Reproduction, Morphology, and life-cycle of *Nostoc* and *Vaucheria*.

Unit 7: **Chlorophyta and Charophyta**
General characteristics; Occurrence; Range of thallus organization; Cell structure; Reproduction. Morphology and life-cycles of *Volvox*, *Oedogonium*, *Chara*. Evolutionary significance of *Prochloron*.

Unit 4: Bacillariophyta
General characteristics; Occurrence; Range of thallus organization; Cell structure; Reproduction and life cycle of Diatom; Economic importance.

Unit 8: Phaeophyta and Rhodophyta
Characteristics; Occurrence; Range of thallus organization; Cell structure; Reproduction. Morphology and life-cycles of *Ectocarpus*, *Fucus* and *Polysiphonia*.

Unit 9: Applied Phycology
Role of algae in the environment, agriculture, biotechnology, industry, biofuels, and bioremediation.

PRACTICAL
Course Code: BOTDSC101P
(50 Marks; 60 Hours)

Microbiology

1. Study of electron micrographs or models of viruses: T-phage and TMV. Line drawings/ Photographs of Lytic and Lysogenic Cycle.
2. Identification of bacterial types using temporary or permanent slides and photographs.
3. Examination of electron micrographs of bacteria showing binary fission, endospore formation, conjugation, and root nodules.
4. Demonstration of media preparation, sterilization techniques, and subculturing methods.
5. Gram staining of bacteria from curd samples or pure culture.
6. Endospore staining with malachite green using endospores obtained from soil bacteria.
7. Principles and functioning of instruments in the microbiology laboratory (Hands-on sterilization techniques and preparation of culture media.
8. Isolation of bacteria from soil, water, and air; Isolation of antibiotic-producing microbes from soil;
9. Determination of BOD, COD, TDS, and TOC of water sample.
10. Visit to any educational institute/ industry to see an industrial fermenter.

Phycology

1. Study of vegetative and reproductive structures of *Nostoc, Volvox, Oedogonium, Chara, Vaucheria, Ectocarpus, Fucus* (Preserve specimen/ permanent slides), and *Polysiphonia,* through temporary preparations and permanent slides; study of diatoms (permanent slide) and *Fucus* (museum

specimens and permanent slides).
2. Observation of *Prochloron* through electron micrographs;
3. Illustration of vegetative and reproductive structures of *Oedogonium*, *Chara*, and *Vaucheria* using a drawing prism with magnification.

Suggested Readings

Microbiology

1. Atlas, R.M. *Principles of Microbiology*. McGraw Hill.
2. Willey, M.J., Sherwood, L.M. & Woolverton, C.J. *Prescott, Harley and Klein's Microbiology*. McGraw Hill.
3. Madigan, M.T., Martinko, J.M. & Parker, J. *Brock: Biology of Microorganisms*. Prentice Hall.
4. Tortora, G.J., Funke, B.R. & Case, C.L. *Microbiology – An Introduction*. Dorling Kindersley India Pvt. Ltd. for Pearson Education.
5. Pelczar, M.J., Chan, P.C.S. & Krieg, N.R. *Microbiology*. Tata McGraw Hill.
6. Stanier, R.Y., Ingraham, J.L., Wheelis, M.L. & Painter, P.R. *General Microbiology*. Macmillan Education Ltd.
7. Banerjee, A.K. & Banerjee, N. *Fundamentals of Microbiology and Immunology*. New Central Book Agency.
8. Dey, N.C., Dey, T.K. & Sinha, D. *Medical Bacteriology, Mycology*.

Phycology

1. Chapman, V.J. & Chapman, D.J. *The Algae*. Macmillan, London.
2. Lee, R.E. (2015). *Phycology* (5th Edition). Cambridge University Press.
3. Kumar, H.D. & Singh, H.N. *Introductory Phycology*. East-West Press Pvt. Ltd.
4. Sharma, O.P. *Textbook of Algae*. Tata McGraw Hill.
5. Smith, G.M. *Cryptogamic Botany, Vol. 1*. McGraw Hill.
6. Vashistha, B.R., Singh, A.K. & Singh, V.P. *Algae*. S. Chand & Co. Pvt. Ltd.
7. Bold, H.C. & Wynne, M.J. *Introduction to Algae: Structure & Reproduction*. Prentice Hall.
8. Ganguly, H.C. & Kar, A.K. *College Botany, Vol. I*. New Central Book Agency.
9. Chopra, G.L. *A Textbook of Algae*. S. Nagin & Co., New Delhi.
10. Hoek, C., Mann, D.G. & Jahns, H.M. (1995). *Algae*. Cambridge University Press

Semester-II

DS-2: MYCOLOGY AND PHYTOPATHOLOGY
Course Code: BOTDSC202T
(Credits: Theory -3, Practical – 2)
THEORY
(50 Marks; Lecture Hours: 45)

Fungi: 25 Marks **(20 lectures)**

Unit 1: Introduction to true fungi
General characteristics; Affinities with plants and animals; Idea of Fungi as a separate kingdom of life; Thallus organization; Cell wall composition; Nutrition; Sexual (with reference to sporocarp) and asexual (spore-forming bodies in deuteromycetes) reproduction; Classification (Hawksworth et al 1995); Concepts of Molecular identification, Barcoding, and Tree of Life.

Unit 2: Chytridiomycota and Zygomycota
Characteristic features, Ecology and significance; Thallus organisation; Reproduction; Life cycle of *Synchytrium,* and *Rhizopus*.

Unit 3: Ascomycota
General characteristics (asexual and sexual fruiting bodies); Ecology; Heterokaryosis and Parasexuality; Life cycles of *Saccharomyces, Penicillium, Neurospora,* and *Ascobolus.*

Unit 4: Basidiomycota
General characteristics; Ecology; Life cycle of Black stem rust of Wheat with reference to spore forms; Concept of macrocylic, microcyclic, demicyclic, heteroecious, and autoecious rusts; Physiological specialization in *Puccinia*; Loose and covered smut (symptoms only); *Agaricus*; Bioluminescence; Fairy rings and Mushroom cultivation (general account).

Unit 5: Allied Fungi
General characteristics; Status of slime molds; Occurrence; types of plasmodia; types of fruiting bodies.

Unit 6: Oomycota
General characteristics; Ecology; Concept as a separate kingdom of life (reasons for exclusion from Fungi); Life cycle of *Phytophthora, Saprolegnia.*

Unit 7: Symbiotic associations
Lichen: Occurrence; General characteristics; Growth forms and Range of thallus organization; Nature of associations of algal and fungal partners; Reproduction; Ecological and Economic significance; Mycorrhiza: Ectomycorrhiza, endomycorrhiza and their significance.

Unit 8: Applied Mycology

Role of fungi in biotechnology; Application of fungi in food industry (Flavour & texture, Fermentation, Baking, Organic acids, Enzymes, Mycoproteins); Secondary metabolites (Pharmaceutical preparations); Agriculture (Biofertilizers); Mycotoxins; Biological control (Mycofungicides, mycoherbicides, mycoinsecticides and myconematicides); Medical mycology.

Phytopathology: 25 Marks **(25 lectures)**

Unit 9: Introduction
Definitions and Concepts of Plant Disease: Parasite, Pathogen and Vector, Inoculum and Inoculum density, Infection, Susceptibility and Virulence, Etiology; Symptoms types; Necrotroph, biotroph & hemibiotroph; disease, disease types, disease triangle, disease cycle (monocyclic & polycyclic); sporadic, endemic, epidemic and pandemic diseases with examples that had significant impact in human history; Koch's Postulates; Plant pathologist's contribution to crops and society.

Unit 10: Host - Parasite Interaction
Recognition concept and infection; Disease development: Role of enzymes, toxins, growth regulators. Defense strategies: Structural and biochemical mechanisms (Constitutive and Induced); Roles of Phytoalexins, Phytoanticipins & PR proteins, elicitors, HR response. Genetics of Plant - Pathogen Interaction: Flor's gene-for-gene hypothesis, Concept of R gene, Avr gene, and Effectors. Resistance: Systemic Acquired Resistance and Induced Systemic Resistance.

Unit 11: Plant Disease Management
Chemical, Biological, Cultural & Integrated management methods; Quarantine; D isease diagnosis, disease clinics.

Unit 12: Plant Diseases
Casual organism, disease cycle, and management of selected diseases: Bacterial diseases (*Citrus canker*, *Ralstonia* wilt of tomato); Viral disease (*Tobacco mosaic virus*); Fungal diseases (Black stem rust of wheat, Blast of rice, Early blight of potato); and Oomycete diseases (late blight of potato, downy mildew of cucurbits, powdery mildew of cucurbits).

Unit 13: **Plant Disease Epidemiology**
Basic concepts, elements of disease, disease forecasting (preliminary ideas).

Practical
Course Code: BOTDSC202P
(50 Marks; 60 Hours)

Fungi:

1. Introduction to the world of fungi (unicellular, coenocytic/septate mycelium, ascocarps & basidiocarps) through temporary slide preparation and permanent slides.
2. Micrometry (measurement of reproductive unit).
3. *Rhizopus*: Study of the asexual stage from temporary mounts and sexual structures through temporary slide preparation and permanent slides.
4. *Ascobolus*: Sectioning through ascocarp and micrometry.

5. *Agaricus* : Specimens of button stage and full-grown mushroom; sectioning of gills of *Agaricus*, fairy rings, and bioluminescent mushrooms to be shown.
6. Lichens: Study of growth forms of lichens (crustose, foliose, and fruticose) on different substrates.
7. Mycorrhizae: Ectomycorrhiza and endomycorrhiza (Photographs).

Phytopathology

8. *Puccinia* - Herbarium specimens of Black Stem Rust of Wheat and infected Barberry leaves; sections/ mounts of spores on wheat and permanent slides of both the hosts.
9. Herbarium specimens of Bacterial diseases: *Citrus* canker; Viral diseases: TMV, Vein clearing symptom from any available specimen; Fungal diseases: Early and Late blight of potato, Black stem rust of wheat, and Blast of Rice, Oomycete diseases: Powdery and downy mildew from any available specimen.
10. Isolation of the pathogen from diseased leaf, inoculation of fruit, demonstration of media preparation, and pure culture isolation.

Suggested Readings

Mycology and Phytopathology

1. Ainsworth, G.C., Sparrow, F.K., & Sussman, A.S. (Eds.). *The Fungi: An Advanced Treatise*, Vol. IVA & B. Academic Press.
2. Hawksworth, D.L., Kirk, P.M., Pegler, D.N., & Sutton, B.C. (1995). *Ainsworth & Bisby's Dictionary of Fungi* (8th ed.). CAB International.
3. Webster, J. *Introduction to Fungi*. Cambridge University Press.
4. Alexopoulos, C.J., Mims, C.W., & Blackwell, M. *Introductory Mycology*. John Wiley & Sons Inc.
5. Moore-Landecker, E. *Fundamentals of the Fungi* (4th ed.). Prentice Hall.
6. Ingold, C.T., & Hudson, H.J. *The Biology of the Fungi* (6th ed.). Chapman & Hall.
7. Vashistha, B.R. *Fungi*. S. Chand & Co. Ltd.
8. Sharma, P.D. *Fungi and Allied Organisms*. Narosa Publishing House.
9. Ganguly, H.C., & Kar, A.K. *College Botany*, Vol. II. New Central Book Agency.
10. Chopra, G.L., & Verma, V. *A Textbook of Fungi*. Pradeep Publication.
11. Agrios, G.N. (2006). *Plant Pathology* (5th ed.). Academic Press, U.K.
12. Chaube, H.S., & Pundhir, V.S. (2009). *Crop Diseases and Their Management*. Prentice Hall (India).

Semester-III

DS-3: ARCHEGONIATAE I [BRYOPHYTES, PTERIDOPHYTES]
Course Code: BOTDSC303T
(Credits: Theory -3, Practical – 2)
THEORY
(50 Marks; Lecture Hours: 45)

Bryophytes: 25 Marks **(23 lectures)**

Unit 1: Introduction

Unifying features of Archegoniates: Transition to land habit; Alternation of generations.

Unit 2: Bryophytes

General characteristics; Adaptations to land habit; Classification of Proskauer 1954 (up to class); Range of thallus organization.

Unit 3: Type Studies of Bryophytes

Systematic position, morphology, anatomy, and reproduction of *Riccia, Marchantia, Pellia, Porella, Anthoceros, Sphagnum, and Funaria*; reproduction and evolutionary trends in *Riccia, Marchantia, Anthoceros,* and *Funaria* (developmental stages not included).

Unit 4: Importance of Bryophytes

Ecological and economic importance of Bryophytes with special reference to *Sphagnum*. Model plant- *Phycometrium patens.*

Unit 5: Pteridophytes **(22 lectures)**

General characteristics; Classification: Concept of Pichi Sermolli and modern concept of molecular phylogeny; Pteridophyte phylogeny group I 2016; Early land plants (*Agalophyton, Rhynia, Cooksonia, Lepidodendron, Calamites.*).

Unit 6: Type Studies of Pteridophytes

Systematic position, morphology, anatomy, and reproduction of *Psilotum*, *Lycopodium, Selaginella*, *Equisetum Pteris* and *Marsilea* (developmental details not to be included). Apogamy and apospory, Heterospory and seed habit, telome theory, stelar evolution; ecological and economic importance.

Unit 7: **Importance of Pteridophytes**

Apogamy and apospory, Heterospory and origin of seed habit, telome theory, stelar evolution; ecological and economic importance; fern gametophyte and sporophyte culture and uses. Model plant *Ceratopteris.*

Practical
Course Code: BOTDSC303P
(50 Marks; 60 Hours)

Bryophytes

1. *Riccia*: Morphology of thallus;
2. *Marchantia*: Morphology of the thallus; whole mount of rhizoids and scales; vertical section of thallus through gemma cup (temporary slides); vertical section of antheridiophore, archegoniophore, and sporophyte (permanent slides).
3. *Anthoceros*: Morphology of the thallus; vertical section of thallus (temporary and permanent slides); longitudinal section of sporophyte (permanent slide); dissection of sporophyte to show stomata, pores, pseudoelaters, and columella (permanent slides).
4. *Sphagnum*: Morphology of the plant; whole mount of leaf; longitudinal section of sporophyte (permanent slide).
5. *Funaria*: Morphology; whole mount of leaf, rhizoids, operculum, peristome, annulus, and spores; longitudinal section of capsule (temporary slides); permanent slides showing antheridial and archegonial heads.

Pteridophytes

1. *Psilotum*: Study from preserved specimen; transverse section of synangium (permanent slide).
2. *Selaginella*: Morphology; whole mount of leaf with ligule; transverse section of stem; whole mount of strobilus; whole mount of microsporophyll and megasporophyll (temporary slides); longitudinal section of strobilus (permanent slide).
3. *Equisetum*: Morphology; transverse section of internode; longitudinal and transverse sections of strobilus; whole mount of sporangiophore; whole mount of spores (temporary slides).
4. *Pteris*: Morphology; transverse section of sporophyll; whole mount of sporangium; whole mount of spores (temporary slides).
5. One botanical excursion shall be organized at a suitable location, with the timing adjusted as appropriate.

Suggested Readings

Bryophytes

1. Chopra, R.N. and Kumar, P.K. (1988). Biology of Bryophyta, Wiley Eastern.
2. Ganguly, H. C., & Kar, A. K. *College Botany Vol. II*. New Central Book Agency
3. Parihar, N.S. (1959). Introduction to Embryophyta (Vol. 1 Bryophyta), Central Book Distributors
4. Puri, P. (1980). Bryophyte. Atmaram & Sons.
5. Rashid, A. (1998). An Introduction to Bryophyta, Vikas Publishing House.
6. Ray, S. & Bhattacharya, S. (2016). Manual for Bryophytes: Morphotaxonomy, diversity, spore germination, conservation. Levants Books, Sarat Book Distributors, Kolkata.
7. Schofield, W.B. (2001). Introduction to Bryology, Blackburn Press.
8. Shaw, A. Jonathan and Goffinet Bernard (2009). Bryophyte Biology, Cambridge University Press.
9. Smith, A.J.E. (ed.) (1982). Bryophyte Ecology, Chapman and Hall.
10. Vanderpoorten, A. and Goffinet, B. (2009). Introduction to Bryophytes, Cambridge University Press.
11. Vashista, B.R. (2001). Bryophyta, S. Chand & Company.

Pteridophytes

1. Gifford, E. M. and Foster, A. S. (1998). Morphology & Evolution of Vascular Plants (3rd ed.), Freeman and Co.
2. Ganguly, H. C., & Kar, A. K. *College Botany Vol. II*. New Central Book Agency

3. Mukherjee, R.N. and Chakraborty, K.A. (1995). Introduction to Vascular Cryptogams (Pteridophyta) Kalyani Publications.
4. Parihar, N.S. (1989). The Biology & Morphology of Pteridophytes(2nd ed.), Central Book Distributors.
5. Rashid, A. (1998). An Introduction to Pteridophyta, Latest Ed., Vani Educational Books.
6. Sporne, K.R. (1962). The Morphology of Pteridophyte, Latest Ed., Hutchinson & Co. Ltd. 6.
7. Vashista, P.C. (2006). Pteridophyta. S. Chand & Company Pvt. Ltd

Semester-IV

DS-4: ARCHEGONIATAE II [GYMNOSPERMS, PALEOBOTANY, PALYNOLOGY]
Course Code: BOTDSC404T
(Credits: Theory -3, Practical – 2)
THEORY
(50 Marks; Lecture Hours: 45)

Gymnosperms: 20 Marks **(20 lectures)**

Unit 1: **Gymnosperms**
General characteristics; Classification of Bhatnagar and Maitra 2013 (up to family), Morphology, Anatomy and Reproduction of *Cycas, Pinus, Ginkgo* and *Gnetum* (developmental details not to be included); Ecological and Economic importance; Evolutionary significance of gymnosperm with special reference to Progymnospermopsida, Lyginopteridales, Cordaitales, Glossopteridales and Bennetitales; Distribution of extant taxa; Conservation strategy of gymnosperm.

Paleobotany: 15 marks **(15 lectures)**

Unit 1: **Fossils**
Definition, types, and modes of preservation; conditions required for fossilization; Palaeobotany and its applications.

Unit 2: **Geological Time Scale**
Geological time scale and major events in plant life through geological ages.

Unit 3: **Indian Gondwana system**
The 3-fold division of the Indian Gondwana system and the major mega-fossil assemblages.

Unit 4: **Plate Tectonics and Continental Drift**
Brief concept of plate-tectonic movements and the Continental Drift Theory.

Unit 5: **Fossil Dating Methods**
Principles of fossil dating (brief idea); radioactive dating techniques including uranium-lead, potassium-argon, radiocarbon, and fission track dating methods.

Palynology: 15 Marks **(10 lectures)**

Unit 1: Basic concept; spore & pollen; polarity, symmetry, shape and size, aperture types, pollen wall – chemical nature, stratification & ornamentation**;**

i. NPC classification;
ii. Application of Palynology
iii. Basic concepts of Aeropalynology, Melissopalynology, Palaeopalynology, and Forensic palynology (brief idea and application).

Practical
Course Code: BOTDSC404P
(50 Marks; 60 Hours)

Gymnosperms

1. ***Cycas*** - Morphology and transverse section of leaflet, morphology of microsporophyll and megasporophyll (temporary slides), whole mount of spore (temporary slides); T.S. of coralloid root, L.S. of ovule (permanent slides).
2. ***Pinus*** - Morphology of long and dwarf shoots, male and female cones, transverse section of needle (temporary slide), L.S. of male cone and female cone (permanent slide); microspores (permanent slides),
3. ***Gnetum*** - Morphology (shoot, male & female cones), V.S. of ovule (permanent slide).
4. One long Botanical excursion to an appropriate location and time schedule to be suitably adjusted.

Palaeobotany

1. Study from permanent slides: T.S. of stem of *Rhynia, Calamites, Lyginopteris*,
2. Study of some megafossils: *Ptilophyllum* and *Glossopteris* leaves, *Vertebraria* root system.

Palynology

1. Study of dispersal units of spores and pollen (slides/photographs): monads (*Senna/Cassia*), tetrads (pteridophytes), polyads (Mimosaceae), and pollinia (Asclepiadaceae, Orchidaceae).
2. Morphological study of spores and pollen from selected pteridophytes, gymnosperms, and angiosperms using fresh and dry specimens.
3. Study of fresh and acetolyzed pollen grain samples showing ornamentation and apertures; ultrastructure of the pollen wall (micrographs);
4. Assessment of pollen viability using sucrose and $Ba(OH)_2$ solutions, germination studies with calculation of percentage germination in different media using the hanging drop method.
5. Study of pollen viability using the tetrazolium test.

Suggested Readings

Gymnosperms

1. Bhatnagar, S.P. and Moitra, A. (1997). Gymnosperm, New Age International.
2. Biswas, C. and Johri, P.M. (1997). The Gymnosperm, Narosa Publishing House.
3. Dutta, S.C. (1984). An Introduction to Gymnosperms (3rd ed.), Kalyani Publishers.
4. Chamberlain, C. J. (1935). Gymnosperms: Structure and Evolution. CBS Publishers.
5. Friedman, W.E. (1996). Biology and Evolution of the Gnetales, University of Chicago Press.
6. Ganguly, H.C. & Kar, A.K College Botany Vol. II [New Central Book Agency]
7. Gifford, E.M. and Foster, A.S. (1989). Morphology and Evolution of Vascular Plants (3rd ed.), Freeman and Co.
8. Norstag, J. and Nicholls. T.J. (1997). The Biology of the Cycads, Cornell University Press.
9. Sporne, K.R. (1965). The Morphology of Gymnosperms, Hutchinson and Co. Ltd.
10. Vashishta, P.C. (2006). Gymnosperm, S. Chand and Company Pvt.

Paleobotany

1. Agashe S.N. (1997). Paleobotany: Plants of the Past, Their Evolution, Paleoenvironment and Application in Exploration of Fossil Fuels. Science Publishers, U.S.

2. Andrews, H.N. (1961). Studies in Palaeobotany, John Wiley and Sons.
3. Arnold, C. A. (1947). An Introduction to Paleobotany. McGraw-Hill Book Company.
4. Gifford Ernest M. & Foster Adriance S. (1989). Morphology and Evolution of vascular plants. 3rd edn. New York: Freeman Publ.
5. Meyen, S.V. (1987). Fundamentals of Palaeobotany, Chapman and Hill.
6. Stewart W. N. & Rothwell G. W. (1993). Palaeobotany and the evolution of plants. 2nd edn. Cambridge: Cambridge University Press.
7. Taylor Thomas N., Taylor Edith L. & Krings Michael. (2009). Palaeobotany: The biology and Evolution of fossil plants. 2nd edn. Elsevier Publication.
8. Thomas, B.A. and Spicer, R.A. (1987). The Evolution and Palaeobotany of Land Plants, Croomhelm.
9. Willis K. J. and McElwain J. C. (2002). The evolution of plants. 1st edn. New York: Oxford University Press.

Palynology

1. Mehra, P. N. (Year). Evolution of Spore Through the Ages. Palynological Society of India, National Botanic Garden, Lucknow.
2. Nair, P. K. K. ar). Pollen Morphology of Angiosperms. Scholar Publication.
3. Erdtman, G. (1952). Pollen Morphology and Plant Taxonomy. Leiden: E. J. Brill.
4. Faegri, K., & Iversen, J. (1964; later ed. 1989). Textbook of Pollen Analysis. Oxford: Blackwell Scientific Publications.

DS-5: ECONOMIC BOTANY, ETHNOBOTANY, AND PHARMACOGNOSY
Course Code: BOTDSC405T
(Credits: Theory -3, Practical – 2)
THEORY
(50 Marks; Lecture Hours: 45)

Economic Botany: 25 Marks **(20 lectures)**

Unit 1: Origin of Cultivated Plants

Concept of centres of origin, their importance with reference to Vavilov's Work; Examples of major plant Introductions.

Unit 2: Cereals

Origin, Morphology, Cultivation & Uses of Rice; Brief account on Millets.

Unit 3: Legumes

Origin, Morphology, and Uses of Chick Pea; Importance to man and ecosystem.

Unit 4: Sources of Sugars and Starches

Morphology of Sugarcane; Products and by-products of Sugarcane Industry.

Unit 5: Spices

Economic Importance with special reference to Saffron, Clove, and Black Pepper

Unit 6: Beverages
Tea and Coffee - Morphology, Processing & Uses.

Unit 7: Sources of Oils and Fats
General Description, Classification, their Uses and Health implications of Sesame, Mustard and Coconut (Botanical Name, Family & Uses); Essential oils: General account of *Santalum* and *Citronella*.

Unit 8: Natural Rubber
Para Rubber tapping, processing, and uses.

Unit 9: Drug-Yielding Plants
Therapeutic and habit-forming drugs with special reference to *Cinchona*, Cannabis: Tobacco (Health hazards).

Unit 10: Timber plants
General account with special reference to Teak (*Tectona grandis*), Sal (*Shorea robusta*).

Unit 11: Fibres
Classification of Fibres based on the Origin; Uses of Cotton, Jute and allied fibres.

Ethnobotany: 15 marks **(15 classes)**

Unit 1: Introduction
Introduction, Concept, Scope, and Objectives; Ethnobotany as an Interdisciplinary Science; Plants used by the Tribals as Food plants, Intoxicants and Beverages, Resins and Oils, and Miscellaneous uses.

Unit 2: Role of Ethnobotany in Modern Medicine
Medico-ethnobotanical sources in India: Significance of selected plants in ethnobotanical practices, their habitat and uses: *Azadiractha indica, Ocimum sanctum, Vitex Negundo, Gloriosa superba, Tribulus terrestris, Pongamia pinnata, Cassia auriculata, Indigofera tinctoria*; Validation of ethnobotanical sources in modern medicine.

Unit 3: Ethnobotany and legal aspects: Biopiracy, Intellectual Property Rights and Traditional Knowledge.

Pharmacognosy: 10 marks **(Lectures: 10)**

Unit 1: General account:
Pharmacognosy and its Importance in Modern Medicine; Crude drugs; Pharmacological and Chemical Classification of Drugs; Drug evaluation methods (Definitions with examples): Organoleptic, Microscopic, Chemical & Physical; Bioassay of drug; Adulteration (Definitions with examples).

Unit 2: Secondary Metabolites of Plants:
Definitions and differences between primary and secondary metabolites; Utilization of major types of metabolites as drugs: Phenolics & Quinones, Terpenoids, Flavonoids, and Alkaloids.

Unit 3: Active constituents:
Source plants, parts used, chemical nature & uses of Glycosidic anthraquinone (Barbaloin), Tannic acid derivative (Catechin), Resins (Gingerol, Curcuminoids), Steroids (Diosgenin, Digitoxin), and Alkaloids (Quinine, Strychnine, Reserpine, Vinblastine).

Practical
Course Code: BOTDSC405P
(50 Marks; 60 Hours)

Economic Botany

1. **Cereals**: Rice [Habit sketch, study of paddy grain, starch grain types, and microchemical tests (Iodine spot test)].
2. **Legumes**: Chickpea [Habit sketch, fruit, and seed structure; Microchemical tests (Millon test)]
3. **Sources of oils and fats**: Coconut kernel and Mustard seeds (Tests for fats: Sudan IV test).
4. **Spices** - Black pepper and Clove [Demonstration, habit sketch and comments].
5. **Essential oil-yielding plants**: Habit sketch of *Santalum* and *Citronella* (specimens /photographs).
6. **Drug-Yielding Plants** – Specimen of Tobacco and *Cannabis.*
7. **Woods**: *Tectona* and *Shorea* [Section of young stem specimen (permanent slides/photographs)].

Pharmacognosy

1. Chemical Tests:
    a. Tannin (*Camellia sinensis* & *Terminalia chebula*): Any two confirmatory tests.
    b. Alkaloids (Quinine): Single test with Iodine Solution in KI (acidic medium)
2. Microscopic Study of Powder of Plant Parts Used in Drugs: *Zingiber officinale* (Rhizome powder) and *Holarrhena antidysenterica* (Bark powder).
3. Histo-chemical Tests:
    a. Curcumin (*Curcuma longa*)
    b. Starch in non- lignified vessels of *Zingiber officinale* and
    c. Alkaloids:
        i. Stem (*Catharanthus roseus*)
        ii. Bark (*Holarrhena antidysenterica)*.

Suggested Readings

Economic Botany

1. Kochhar, S. L. (2012). *Economic botany in tropics*. New Delhi: MacMillan & Co.
2. Wickens, G. E. (2001). *Economic botany: Principles & practices*. Dordrecht: Kluwer Academic Publishers.
3. Chrispeels, M. J., & Sadava, D. E. (1994). *Plants, genes and agriculture*. Boston: Jones & Bartlett Publishers.

Ethnobotany

1. Jain, S. K. (1995). *Manual of ethnobotany*. Jodhpur: Scientific Publishers.
2. Jain, S. K. (Ed.). (1981). *Glimpses of Indian ethnobotany*. New Delhi: Oxford & IBH.
3. Jain, S. K. (Ed.). (1989). *Methods and approaches in ethnobotany*. Lucknow: Society of Ethnobotanists.

4. Jain, S. K. (1990). *Contributions of Indian ethnobotany*. Jodhpur: Scientific Publishers.
5. Colton, C. M. (1997). *Ethnobotany: Principles and applications*. Chichester: John Wiley & Sons.
6. Rama Ro, N., & Henry, A. N. (1996). *The ethnobotany of Eastern Ghats in Andhra Pradesh, India*. Howrah: Botanical Survey of India.
7. Sinha, R. K. (1996). *Ethnobotany: The renaissance of traditional herbal medicine*. Jaipur: INA–SHREE Publishers.

Pharmacognosy

1. Wallis, T. E. (1946.). *Textbook of pharmacognosy*. New Delhi: CBS Publishers.
2. Evans, W. C. (1989). *Trease & Evans' pharmacognosy*. London: Saunders.
3. Melentyeva, G., & Antonova, L. (1988). *Pharmaceutical chemistry*. Moscow: MIR Publishers.
4. Beckett, A. H. (1988). *Practical pharmaceutical chemistry*. New Delhi: CBS Publishers.

DS-6: PLANT ANATOMY AND EMBRYOLOGY
Course Code: BOTDSC406T
(Credits: Theory -3, Practical – 2)
THEORY
(50 Marks; Lecture Hours: 45)

Plant Anatomy: 40 Marks **(30 lectures)**

Unit 1: Introduction and scope of Plant Anatomy
Applications in systematics, forensics, and pharmacognosy.

Unit 2: Structure and Development of Plant Body
Internal organization of plant body: the three tissue systems, types of cells, and tissues.

Unit 3: Tissues
Classification of tissues: simple and complex tissues (no phylogeny); cytodifferentiation of tracheary elements and sieve elements; pits and plasmodesmata; ergastic substances; hydathodes, cavities, lithocysts, and laticifers.

Unit 4: Apical Meristems
Evolution of the concept of organization of the root and shoot apex: Apical cell theory, Histogen theory, Tunica Corpus theory, Korper-Kappe theory: Types of vascular bundles; Structure of dicot and monocot stem; Structure of dicot and monocot leaf; Kranz anatomy; Root cap; Structure of dicot and monocot root.

Unit 5: Vascular Cambium and Wood
Structure, function, and seasonal activity of cambium; Secondary growth in root and stem; Anomalous secondary growth: types with examples; Sapwood and heartwood; Ring and diffuse porous wood; Early and late wood, Tyloses; Development and composition of periderm, rhytidome, and lenticels.

Unit 6: Adaptive and Protective Systems
Epidermal tissue system, cuticle, trichomes (unicellular and multicellular, glandular and nonglandular, two

examples of each), stomata (classification); Adcrustation and incrustation; Anatomical adaptations of xerophytes and hydrophytes.

Embryology: 10 Marks **(10 lectures)**

Unit 1: Sporogenesis & Gametogenesis
Microsporogenesis & Microgametogenesis; Megasporogenesis & Megagametogenesis; Fertilization Embryo types based on development. Development of endosperm and role of polycomb genes; apomixis and its application; Polyembryony

Practical
Course Code: BOTDSC406P
(50 Marks; 60 Hours)

1. **Study of anatomical details** using permanent slides, temporary stain mounts, macerations, or museum specimens with suitable representatives:

    a. Apical meristem of root, shoot, and vascular cambium.
    b. Distribution and types of parenchyma, collenchyma, and sclerenchyma.
    c. Xylem: tracheary elements—tracheids, vessel elements, thickenings, perforation plates, and xylem fibres (permanent slides).
    d. Wood: ring porous, diffuse porous, tyloses, heartwood, and sapwood (permanent slides).
    e. Phloem: sieve tubes, sieve plates, companion cells, and phloem fibres (permanent slides).
    f. Epidermal system: cell types, stomatal types, and trichomes—non-glandular and glandular (permanent slides).
    g. Periderm, lenticels, C4 leaves (Kranz anatomy), and secretory tissues such as cavities, lithocysts, and laticifers.
2. **Workout and Preparation of permanent slides** using the double staining method:
    a. Root anatomy: monocot (*Orchid*), dicot (*Sunflower* or *Gram*); secondary growth and anomalous secondary growth in the root of *Tinospora*.
    b. Stem anatomy: monocot (*Maize*), dicot (*Cucurbita*); primary and secondary growth, and anomalous growth in stems of *Bignonia*, *Boerhavia*, and *Dracaena*.
    c. Leaf anatomy: isobilateral (*Tube rose*) and dorsiventral (*Mango*).
    d. Adaptive anatomy: xerophytes (*Nerium* leaf) and hydrophytes (*Nymphaea* petiole).
3. **Study of anther development**: tapetum (amoeboid and glandular), spore tetrads, uninucleate, bicelled, and dehisced anther stages through slides or micrographs; male germ unit (MGU) through photographs and schematic representation.
4. **Study of ovules**: types—anatropous, orthotropous, amphitropous/campylotropous, circinotropous; unitegmic and bitegmic; tenuinucellate and crassinucellate; special structures including endothelium, obturator, hypostase, caruncle, and aril (permanent slides, specimens, photographs).
5. **Study of the female gametophyte** through permanent slides or photographs: types and ultrastructure of the mature egg apparatus.
6. **Study of endosperm**: dissections of developing seeds to observe endosperm with free-nuclear haustoria.

7. **Study of embryogenesis**: dicot embryo through permanent slides or photographs; embryos at various developmental stages through permanent slides or photographs; study of the suspensor through electron micrographs.

Suggested Readings

Anatomy

1. Dickison, W.C. (2000). Integrative Plant Anatomy. Harcourt Academic Press, USA.
2. Fahn, A. (1974). Plant Anatomy. Pergamon Press, USA.
3. Mauseth, J.D. (1988). Plant Anatomy. The Benjammin/Cummings Publisher, USA.
4. Evert, R.F. (2006). Esau's Plant Anatomy: Meristems, Cells, and Tissues of the Plant Body: Their Structure, Function, and Development. John Wiley and Sons, Inc.

Embryology

5. Bhojwani, S.S. and Bhatnagar, S.P. (2011). The Embryology of Angiosperms, Vikas Publishing House. Delhi. 5th edition.
6. Shivanna, K.R. (2003). Pollen Biology and Biotechnology. Oxford and IBH Publishing Co.Pvt.Ltd. Delhi.
7. Raghavan, V. (2000). Developmental Biology of Flowering plants, Springer, Netherlands.
8. Johri, B.M. l (1984). Embryology of Angiosperms, Springer-Verlag, Netherlands.

DS-7: MORPHOLOGY AND PLANT SYSTEMATICS
Course Code: BOTDSC407T
(Credits: Theory -3, Practical – 2)
THEORY
(50 Marks; Lecture Hours: 45)

Morphology **(15 lectures)**

Unit 1: Inflorescence

Types with examples; concept of advanced and primitive types.

Unit 2: Flower

Types with examples; aestivation; floral parts (calyx, corolla, androecium, gynoecium); various types of cohesion and adhesion with examples; carpel types (advanced and primitive); placentation types (advanced and primitive).

Unit 3: Fruits and Seeds

Types with examples; dispersal of seeds.

Plant systematics **(30 lectures)**

Unit 1: Significance of Plant Systematics

Introduction to systematics; plant identification, classification, and nomenclature; evidences from palynology, cytology, phytochemistry, and molecular data; functions of herbaria and botanical gardens; importance of herbaria and botanical gardens of the world and India; virtual herbarium; e-flora; documentation (flora, monographs, manuals, journals); keys (single-access and multi-access).

Unit 2: Taxonomic Hierarchy
Concept of taxa (family, genus, species); categories and taxonomic hierarchy; species concepts (taxonomic, biological, evolutionary).

Unit 3: Botanical Nomenclature
Principles and rules (ICN); ranks and names; typification, author citation, valid publication, rejection of names; principle of priority and its limitations; names of hybrids.

Unit 4: Systems of Classification
Major contributions of Theophrastus, Linnaeus, Hutchinson, Takhtajan, and Cronquist; classification systems of Bentham and Hooker (up to series) and Engler and Prantl (up to series); brief reference to Angiosperm Phylogeny Group (APG III) classification.

Unit 5: Biometrics, Numerical Taxonomy, and Cladistics
Characters, character states, variations; OTUs and OEUs; character weighting and coding; cluster analysis; phenograms and cladograms (definitions and differences).

Unit 6: Phylogeny of Angiosperms
Terms and concepts (primitive and advanced, homology and analogy, parallelism and convergence, monophyly, paraphyly, polyphyly, and clades); origin and evolution of angiosperms (brief idea).

Practical
Course Code: BOTDSC407P
(50 Marks; 60 Hours)

1. Study of vegetative and floral characters **of any fifteen species** from the list, with at least one from each family. Include description, vertical section of flower, section of ovary, floral diagrams, floral formula, and systematic position according to Bentham & Hooker's system of classification.
    a. Asteraceae (Compositae): *Sonchus/Launaea, Vernonia/Ageratum, Eclipta/Tridax/ Synedrella*
    b. Solanaceae: *Solanum spp., Withania, Physalis*
    c. Brassicaceae (Cruciferae): *Nasturtium* sp., Brassica
    d. Lamiaceae (Labiatae): *Salvia, Ocimum, Leucas, Leonurus, Anisomeles, Hyptis*
    e. Euphorbiaceae: *Euphorbia spp., Jatropha, Acalypha, Croton*
    f. Malvaceae: *Sida spp., Urena, Malachra capitata, Hibiscus vitifolius*
    g. Polygonaceae: *Polygonum spp., Rumex*
    h. Acanthaceae: *Justicia, Rungia, Ecbolium, Hygrophila*
    i. Scrophulariaceae*: Lindenbergia, Mazus, Vandellia (Lindernia)*
    j. Rubiaceae: *Oldenlandia, Dentella, Spermacoce*
2. **Botanical Excursions:** At least three excursions, with provision of funds from the college:
    a. Visit to the Acharya Jagadish Chandra Bose Indian Botanic Garden (BSI).
    b. Local field visit.
    c. Visits to two different ecological zones.

Suggested Readings

Morphology of Angiosperms

1. Mitra, D., Guha, J. & Chowdhury, S.K. *Studies in Botany*, Vol. I. Moulik Library.
2. Eames, A.J. *Morphology of Angiosperms*. McGraw Hill.
3. Lawrence, G.H.M. *Glossary in Taxonomy of Vascular Plants*. Oxford & IBH.

Plant Systematics

1. Singh, G. (2012). *Plant Systematics: Theory and Practice*. Oxford & IBH Pvt. Ltd., New Delhi. 3rd edition.
2. Jeffrey, C. (1982). *An Introduction to Plant Taxonomy*. Cambridge University Press, Cambridge.
3. Judd, W.S., Campbell, C.S., Kellogg, E.A., Stevens, P.F. (2002). *Plant Systematics: A Phylogenetic Approach*. Sinauer Associates Inc., U.S.A. 2nd edition.
4. Maheshwari, J.K. (1963). *Flora of Delhi*. CSIR, New Delhi.
5. Radford, A.E. (1986). *Fundamentals of Plant Systematics*. Harper and Row, New York.

Semester-V

DS-8: PLANT ECOLOGY AND PHYTOGEOGRAPHY
Course Code: BOTDSC508T
(Credits: Theory -3, Practical – 2)
THEORY
(50 Marks; Lecture Hours: 45)

Plant Ecology: 40 Marks **(20 lectures)**

Unit 1: Introduction
Basic concepts; levels of organization; homeostasis.

Unit 2: Soil
Importance; Origin; Formation; Composition; physical, chemical, and biological structures and properties; soil profile.

Unit 3: Water
Importance; states of water in the environment; atmospheric moisture; hydrological cycle; water in soil; water table.

Unit 4: Plant Adaptations
Adaptations to variations in light, temperature, wind, and fire.

Unit 5: Biotic Interactions
Trophic organization; symbiosis, commensalism, parasitism; food chains and food webs; ecological pyramids; biomass, standing crop.

Unit 6: Population Ecology
Characteristics and dynamics; r- and k-selection; ecological speciation.

Unit 7: Plant Communities and Successions
Concepts of ecological amplitude, habitat, and niche, analytical and synthetic characters, ecotone and edge effect.; process, process types

Unit 8: Functional Aspects of Ecosystems
Energy sources; principles and models of energy flow; production and productivity; ecological efficiencies; biogeochemical cycles (carbon, nitrogen, phosphorus).

Phytogeography: 10 Marks **(10 Lectures)**
Principles; continental drift; theory of tolerance (brief account); endemism; brief description of major terrestrial biomes – Tropical rain forest, Temperate grassland, and Tundra; Phytogeographical division of India (BSI 1996); Local Vegetation.

Practical
Course Code: BOTDSC508P
(50 Marks; 60 Hours)

1. Study of instruments used to measure microclimatic variables: Soil thermometer, maximum and minimum thermometer, anemometer, psychrometer/hygrometer, rain gauge and lux meter.
2. Determination of pH of various soil and water samples (pH meter, universal indicator/Lovibond comparator, and pH paper).
3. Analysis for carbonates, chlorides, nitrates, organic matter and base deficiency from two soil samples by rapid field tests.
4. Determination of organic carbon of different soil samples by Walkley & Black rapid titration method.
5. Determination of dissolved oxygen and carbon dioxide of water samples from polluted and unpolluted sources.
6. Study of biotic interactions of the following: Stem parasite (*Cuscuta*), Epiphytes (*Vanda* root), Predation (Insectivorous plants) – from permanent slides and preserved specimens.
7. Determination of minimum size of quadrate for the study of herbaceous vegetation by species area curve method (species to be listed).
8. Quantitative analysis of herbaceous vegetation for frequency and comparison with Raunkiaer's frequency distribution law.
9. Quantitative analysis of herbaceous vegetation for density and abundance.
10. Field visit to familiarize students with the ecology of different site

Suggested Readings

1. Odum, E.P. (2005). Fundamentals of ecology. Cengage Learning India Pvt. Ltd., New Delhi. 5th
2. edition.
3. Singh, J.S., Singh, S.P., Gupta, S. (2006). Ecology, Environment and Resource Conservation. Anamaya Publications, New Delhi, India.
4. Sharma, P.D. (2010). Ecology and Environment. Rastogi Publications, Meerut, India. 8th edition.
5. Wilkinson, D.M. (2007). Fundamental Processes in Ecology: An Earth Systems Approach. Oxford University Press. U.S.A.
6. Kormondy, E.J. (1996). Concepts of ecology. PHI Learning Pvt. Ltd., Delhi, India. 4th edition.
7. Misra R (1968) Ecology Workbook. Oxford and IBH Publ. Co., Calcutta
8. Ambasht and Ambasht (2012). A textbook of Plant Ecology. CBS Publ.
9. Flora of India, Introductory Volume. I, Botanical Survey of India, 1996, Kolkata

DS-9: CELL BIOLOGY AND GENETICS
Course Code: BOTDSC509T
(Credits: Theory -3, Practical – 2)
THEORY
(50 Marks; Lecture Hours: 45)

Cell Biology: 25 Marks **(20 lectures)**

Unit 1: The Cell
Cell as a unit of structure and function; origin of the eukaryotic cell (Endosymbiotic theory).

Unit 2: Cell Wall and Plasma Membrane
Chemistry, structure, and function of plant cell wall; overview of membrane function; fluid mosaic model; chemical composition of membranes; membrane transport: passive, active, and facilitated transport, endocytosis, and exocytosis

Unit 3: Cell Organelles, Cytoskeleton and Endomembrane system
Nucleus: Structure: nuclear envelope, nuclear pore complex, nuclear lamina, molecular organization of chromatin; nucleosome concept, nucleolus (ultrastructure and development). Nucleic acids: Structure of nitrogenous bases; structure and function of nucleotides; types of nucleic acids; structure of A, B, Z types of DNA; types of RNA; structure of tRNA; Chloroplast, mitochondria and peroxisomes**:** Structural organization; function; semiautonomous nature of mitochondria and chloroplast; Cytoskeleton: Role and structure of microtubules, microfilaments and intermediary filament; Endomembrane system: Endoplasmic reticulum: structure, targeting and insertion of proteins in the ER, protein folding, processing; smooth ER and lipid synthesis, export of proteins and lipids; Golgi apparatus: organization, protein glycosylation, protein sorting and export from Golgi apparatus; lysosomes.

Unit 4: Cell Division
Phases of eukaryotic cell cycle, mitosis and meiosis; regulation of cell cycle - checkpoints, role of protein kinases.

Genetics: 25 marks **(30 Lectures)**

Unit 5: Mendelian Genetics and its extension
Mendelism: Principles of inheritance; chromosome theory of inheritance; autosomes and sex chromosomes; probability and pedigree analysis; incomplete dominance and codominance; multiple alleles, lethal alleles, epistasis, pleiotropy, recessive and dominant traits, penetrance and expressivity, numericals; polygenic inheritance.

Unit 6: Extrachromosomal Inheritance
Chloroplast mutation: Variegation in Four o'clock plant; mitochondrial mutations in yeast; maternal effects-shell coiling in snail; infective heredity: kappa particles in *Paramecium*.

Unit 7: Linkage, Crossing Over, and Chromosome Mapping
Linkage and crossing over: Cytological basis of crossing over; recombination frequency: two-factor and three-factor crosses; interference and coincidence; numericals based on gene mapping; sex Linkage.

Unit 8: Variation in Chromosome Number and Structure - Deletion, duplication, inversion, translocation, position effect, euploidy, and aneuploidy

Unit 9: Gene Mutations
Types of mutations; molecular basis of mutations; mutagens: physical and chemical (Base analogs, deaminating, alkylating, and intercalating agents); detection of mutations: ClB method. Role of transposons in mutation; DNA repair mechanisms.

Unit 10: Fine Structure of Gene
Classical vs molecular concepts of gene; Cis-Trans complementation test for functional allelism; structure of phage T4, rII locus.

Unit 11. Population and Evolutionary Genetics
Allele frequencies, genotype frequencies, Law of probability, Hardy-Weinberg Law, role of natural selection, mutation, genetic drift. Genetic variation and speciation.

Practical
Course Code: BOTDSC509P
(50 Marks; 60 Hours)

1. Study of the cell and its organelles with the help of electron micrographs.
2. Study of staining technique, pretreatment chemical, fixation, mordant, stain, and their types.
3. Observation of mitosis through temporary squash preparation (*Allium cepa, Lens esculentus, Aloe vera*).
4. Observation of meiosis through temporary smear preparation (*Allium cepa, Rhoeo discolor*).
5. Observation of photographs and permanent slides showing translocation rings, laggards, inversion bridges, multipolarity, sticky bridges, fragmentation, and pollen mitosis.
6. Demonstration of Mendel's laws through seed ratios (3:1, 1:1, 9:3:3:1, 1:1:1:1); laboratory exercises in probability and chi-square.
7. Chromosome mapping using point test cross data.
8. Study of incomplete dominance and gene interaction through seed ratios (9:7, 9:6:1, 13:3, 15:1, 12:3:1, 9:3:4).
9. Study of aneuploidy: Down's, Klinefelter's, and Turner's syndromes (demonstration through pictures).
10. Study of human genetic traits: Sickle cell anemia, xeroderma pigmentosum, albinism, red-green colour blindness, widow's peak, rolling of tongue, Hitchhiker's thumb and attached ear lobe. (Demonstration through pictures).

Suggested Readings

1. Karp, G. (2010). Cell Biology, John Wiley & Sons, U.S.A. 6th edition.
2. Hardin, J., Becker, G., Skliensmith, L.J. (2012). Becker's World of the Cell, Pearson Education
3. Inc. U.S.A. 8th edition.
4. Cooper, G.M. and Hausman, R.E. (2009) The Cell: A Molecular Approach. 5th edition. ASM
5. Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.
6. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009) The World of the Cell. 7th

edition. Pearson Benjamin Cummings Publishing, San Francisco
7. Gardner, E.J., Simmons, M.J., Snustad, D.P. (1991). Principles of Genetics, John Wiley & sons, India. 8th edition.
8. Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics, John Wiley & Sons Inc., India. 5th edition.
9. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. Benjamin Cummings, U.S.A. 9th edition.
10. Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., Doebley, J. (2010).
11. Introduction to Genetic Analysis. W. H. Freeman and Co., U.S.A. 10th edition.

DS-10: PLANT PHYSIOLOGY
Course Code: BOTDSC510T
(Credits: Theory -3, Practical – 2)
THEORY
(50 Marks; Lecture Hours: 45)

Unit 1: Plant-Water Relations

Water potential and its components, water absorption by roots, aquaporins, pathway of water movement, symplast, apoplast, transmembrane pathways, root pressure, guttation. Ascent of sap– cohesion-tension theory; transpiration and factors affecting transpiration, antitranspirants, mechanism of stomatal movement.

Unit 2: Mineral Nutrition

Essential and beneficial elements, macro and micronutrients, methods of study and use of nutrient solutions, criteria for essentiality, mineral deficiency symptoms, roles of essential elements, chelating agents.

Unit 3: Nutrient Uptake

oil as a nutrient reservoir, transport of ions across cell membrane, passive absorption, electrochemical gradient, facilitated diffusion, active absorption, role of ATP, carrier systems, proton ATPase pump and ion flux, uniport, co-transport, symport, antiport.

Unit 4: Translocation in the Phloem

Experimental evidence in support of phloem as the site of sugar translocation; pressure flow model; phloem loading and unloading; source- sink relationship.

Unit 5: Plant Growth Regulators

Discovery, chemical nature (basic structure), bioassay, and molecular aspects of the physiological roles of auxin, gibberellins, cytokinin, abscisic acid, ethylene; a brief account of Brassinosteroids and Jasmonic acid.

Unit 6: Physiology of Flowering

Photoperiodism, flowering stimulus, florigen concept, vernalization, seed dormancy, and germination.

Unit 7: Phytochrome, Cryptochromes, and Phototropins

Discovery, chemical nature, role in photomorphogenesis, low energy responses (LER), and high irradiance responses (HIR), mode of action.

Practical
Course Code: BOTDSC510P
(50 Marks; 60 Hours)

Plant Physiology

1. Determination of water potential of given tissue (potato tuber) by the weight method.
2. Study of the effect of wind and light on the rate of transpiration in any leaf (*Basella*, *Hibiscus*)
3. Calculation of stomatal index and stomatal frequency from the two surfaces of leaves of a mesophyte (*Basella*), xerophytes (*Ficus*), and hydrophytes (*Eichornia*).
4. To determine the proportion of area covered by stomatal pores with respect to the total leaf area for mesophyte and xerophyte (both surfaces), and hydrophytes.
5. To study the phenomenon of epigeal and hypogeal seed germination with respect to light.
6. To study the induction of amylase activity in germinating wheat/barley grains

Demonstration experiments.

1. Demonstration of the osmotic potential of plant cell sap by the plasmolytic method.
2. To demonstrate suction due to transpiration.
3. Fruit ripening/rooting from cuttings (demonstration).

Suggested Readings

Biochemistry

1. Campbell, MK (2012) Biochemistry, 7th ed., Published by Cengage Learning
1. Campbell, P.N. & Smith, A.D. (2011). Biochemistry Illustrated. 4th edition. Churchill Livingstone.
2. Tymoczko, J.L., Berg, J.M. & Stryer, L. (2012). Biochemistry: A Short Course. 2nd edition. W.H. Freeman.
3. Berg, J.M., Tymoczko, J.L. & Stryer, L. (2011). Biochemistry. W.H. Freeman and Company.
4. Nelson, D.L. & Cox, M.M. (2008). Lehninger Principles of Biochemistry. 5th edition. W.H. Freeman and Company.

Plant Physiology

1. Hopkins, W.G. & Huner, A. (2008). Introduction to Plant Physiology. 4th edition. John Wiley and Sons, U.S.A.
2. Taiz, L., Zeiger, E., Møller, I.M. & Murphy, A. (2015). Plant Physiology and Development. 6th edition. Sinauer Associates Inc., U.S.A.
3. Bajracharya, D. (1999). Experiments in Plant Physiology: A Laboratory Manual. Narosa Publishing House, New Delhi.

DS-11: PLANT BREEDING AND BIOSTATISTICS
Course Code: BOTDSC511T
(Credits: Theory -3, Practical – 2)
THEORY
(50 Marks; Lecture Hours: 45)

Plant Breeding: 15 Marks **(15 lectures)**

Unit 1: Introduction
Aim and Objective of Plant Breeding.

Unit 2: Methods of Plant Breeding
Maintenance of germplasm; Methods of selection: Mass selection, Pureline selection; Methods of hybridization: Bulk method and Pedigree method, Backcross method; Marker-assisted selection (MAS); Male sterility and its use; Heterosis and hybrid vigour.

Biostatistics: 35 Marks **(35 lectures)**

Unit 1: Introduction
Definition, statistical methods and basic principles; Measurement of variables; Functions, limitations, and uses of statistics.

Unit 2: Collection, Classification and Representation of Data
Types and methods of data collection procedures, merits and demerits; Classification of data; Tabulation and presentation of data; Sampling methods.

Unit 3: Measures of Central Tendency
Mean, median, mode, geometric mean, merits & demerits. Measures of dispersion: range, standard deviation, mean deviation, quartile deviation; merits and demerits; Co-efficient of variations, concept of 'p' value and its limitations.

Unit 4: Correlation
Types and methods of correlation, regression, simple regression equation, fitting prediction, similarities and dissimilarities of correlation and regression.

Unit 5: Statistical Inference
Hypothesis: simple hypothesis; Student's t-test, chi-square test, and calculation of F-value.

Practical
Course Code: BOTDSC511P
(50 Marks; 60 Hours)

Biostatistics

1. Calculation of mean, standard deviation, and standard error.
2. Calculation of correlation coefficient values and finding out the probability.
3. Calculation of 'F' value
4. Calculation of the student's t –test

Suggested Readings

Plant Breeding

1. Chawdhuri, H. K. (1986). *Elementary principles of plant breeding*. New Delhi: Oxford & IBH Publishing.
2. Allard, R. W. (1960). *Principles of plant breeding*. New York: John Wiley & Sons.
3. Poehlman, J. M., & Barthakur, D. (1995). *Plant breeding*. New Delhi: Oxford & IBH Publishing.
4. Singh, B. D. (2005). *Plant breeding: Principles and methods* (7th ed.). New Delhi: Kalyani Publishers.

Biostatistics

1. Daniel, W. W. (1987). *Biostatistics*. New York: John Wiley & Sons.
2. Sundarrao, P. S. S., & Richards, J. (1997). *An introduction to biostatistics* (3rd ed.). Vellore: Christian Medical College.
3. Selvin, S. (1991). *Statistical analysis of epidemiological data*. New York: Oxford University Press.
4. Bishop, O. N. (1975). *Statistics for biology*. Boston: Houghton Mifflin.
5. Freedman, P. (1960). *The principles of scientific research*. New York: Pergamon Press.
6. Campbell, R. C. (1998). *Statistics for biologists*. Cambridge: Cambridge University Press.

Semester-VI

DS-12: MOLECULAR BIOLOGY
Course Code: BOTDSC612T
(Credits: Theory -3, Practical – 2)
THEORY
(50 Marks; Lecture Hours: 45)

Unit 1: Nucleic Acids: **Carriers of Genetic Information**
DNA as the carrier of genetic information, Griffith's experiment, Hershey & Chase experiment, Avery, McLeod & McCarty experiment, Fraenkel-Conrat's experiment.

Unit 2: Genetic Material
Types of genetic material, denaturation and renaturation, Cot curves; Organization of DNA in prokaryotes, viruses and eukaryotes; Mitochondrial DNA and chloroplast DNA; Chromatin structure with special reference to euchromatin and heterochromatin, constitutive and facultative heterochromatin

Unit 3: DNA Replication (Prokaryotic and Eukaryotic)
Chemistry of DNA synthesis (Kornberg's discovery); General principles: bidirectional, semi-conservative and semi-discontinuous replication, RNA priming; Various models of DNA replication including rolling circle, θ (theta) mode of replication, replication of linear ds-DNA, replication of the 5' end of linear chromosome; Enzymes involved in DNA replication

Unit 4: Central Dogma and Genetic Code
Key experiments establishing the central dogma (Adaptor hypothesis and discovery of mRNA template); Genetic code: salient features, deciphering genetic code (triplet binding assay)

Unit 5: Transcription
Transcription in prokaryotes and eukaryotes, principles of transcriptional regulation (Operon concept), inducible and repressible operon, regulation of lactose metabolism and tryptophan synthesis in *E. coli*, transcription factors, heat shock proteins, steroids and peptide hormones, gene silencing

Unit 6: RNA Processing and Modification
Split genes: concept of introns and exons, removal of introns, spliceosome machinery, splicing pathways: group I and group II intron splicing, alternative splicing, eukaryotic mRNA processing (5' cap, 3' polyA tail), ribozymes, RNA editing and mRNA transport

Unit 7: Translation
Ribosome structure and assembly, mRNA, charging of tRNA, aminoacyl tRNA synthetases, various steps in protein synthesis, proteins involved in initiation, elongation and termination of polypeptides, fidelity of translation, inhibitors of protein synthesis, post-translational modifications of proteins

Practical
Course Code: BOTDSC612P
(50 Marks; 60 Hours)

1. DNA isolation from cauliflower head, onion leaf and egg arrows gel electrophoresis
2. DNA estimation by Diphenylamine reagent/UV Spectrophotometry
3. RNA estimation by Orcinol method
4. Study of DNA replication mechanisms through photographs (Rolling circle, Theta replication and semi-discontinuous replication)
5. Study of structures of prokaryotic RNA polymerase and eukaryotic RNA polymerase II through photographs
6. Photographs establishing nucleic acid as genetic material (Messelson and Stahl's, Avery et al, Griffith's, Hershey & Chase's and Fraenkel & Conrat's experiments)
7. Study of the following through photographs: assembly of Spliceosome machinery, splicing mechanism in group I and group II introns, ribozyme and alternative splicing

Suggested Readings

1. Watson J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M., Losick, R. (2007). *Molecular Biology of the Gene*, Pearson Benjamin Cummings, CSHL Press, New York, U.S.A. 6th edition
2. Snustad, D.P. and Simmons, M.J. (2010). *Principles of Genetics*, John Wiley and Sons Inc., U.S.A. 5th edition
3. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). *Concepts of Genetics*, Benjamin Cummings, U.S.A. 9th edition
4. Russell, P. J. (2010). *i-Genetics – A Molecular Approach*, Benjamin Cummings, U.S.A. 3rd edition
5. Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., Doebley, J. (2010). *Introduction to Genetic Analysis*, W. H. Freeman and Co., U.S.A. 10th edition

DS-13: PLANT BIOCHEMISTRY AND METABOLISM
Course Code: BOTDSC613T
(Credits: Theory -3, Practical – 2)
THEORY
(50 Marks; Lecture Hours: 45)

Unit 1: Concept of Metabolism
Introduction, anabolic and catabolic pathways, regulation of metabolism, Types and significance of chemical bonds; structure and properties of water; pH and buffers. Enzymes: Structure of enzyme, holoenzyme, apoenzyme, cofactors, coenzymes and prosthetic group; classification of enzymes; features of active site, substrate specificity, mechanism of action (activation energy, lock and key hypothesis, induced - fit theory), Michaelis–Menten equation enzyme inhibition: types, Lineweaver-Burk Plot, factors affecting enzyme activity.

Unit 2: Bioenergenetics
Laws of thermodynamics, concept of free energy, endergonic and exergonic reactions, coupled reactions,

redox reactions. ATP structure, its role as an energy currency molecule.

Unit 3: Biomolecules
Nomenclature, structures and classification of carbohydrates: monosaccharides disaccharides; oligosaccharides polysaccharides and sugar derivatives, isomerism. Definition and major classes of storage and structural lipids; fatty acids structure and functions; essential fatty acids; triacylglycerols structure, functions and properties; phosphoglycerides**.** Structure of amino acids; levels of protein structure-primary, secondary, tertiary and quarternary; protein denaturation and biological roles of proteins.

Unit 4: Carbon Assimilation
Photosynthetic pigments, role of photosynthetic pigments (chlorophylls and accessory pigments), structure of chlorophyll, antenna molecules and reaction centres, photochemical reactions, photosynthetic electron transport, PSI, PSII, Q cycle, CO_2 reduction, photorespiration, C_2, C_4 pathways, crassulacean acid metabolism, factors affecting CO_2 reduction.

Unit 5: Carbohydrate metabolism
Synthesis and catabolism of sucrose and starch.

Unit 6: Carbon Oxidation
Glycolysis, fate of pyruvate, regulation of glycolysis, oxidative pentose phosphate pathway, oxidative decarboxylation of pyruvate, regulation of PDH, NADH shuttle; TCA cycle, amphibolic role, anaplerotic reactions, regulation of the cycle, mitochondrial electron transport, oxidative phosphorylation, cyanide-resistant respiration, factors affecting respiration.

Unit 7: ATP-Synthesis
Mechanism of ATP synthesis, substrate level phosphorylation, chemiosmotic mechanism (oxidative and photophosphorylation), ATP synthase; role of uncouplers.

Unit 8: Lipid metabolism
Synthesis and breakdown of triglycerides, β-oxidation, glyoxylate cycle, gluconeogenesis and its role in mobilisation of lipids during seed germination, α oxidation.

Unit 9: Nitrogen metabolism
Nitrate assimilation, biological nitrogen fixation (examples of legumes and non-legumes); Physiology and biochemistry of nitrogen fixation; ammonia assimilation and transamination.

Unit 10: Mechanisms of signal transduction
Receptor-ligand interactions; G protein; second messenger concept, calcium calmodulin, MAP kinase cascade.

Practical
Course Code: BOTDSC613P
(50 Marks; 60 Hours)

1. Qualitative tests for carbohydrates, reducing sugars, non-reducing sugars, lipids and proteins.

2. Chemical separation of photosynthetic pigments (Demonstration)
3. Demonstration of absorption spectrum of photosynthetic pigments (spectrophotometer).
4. To study the effect of light intensity on the rate of photosynthesis.
5. Effect of carbon dioxide on the rate of photosynthesis (volume measurement)
6. To compare the rate of respiration in different parts of a plant.
7. To demonstrate activity of Nitrate reductase in germinating leaves of different plant sources.
8. To study the activity of lipases in germinating oilseeds.

Suggested Readings

1. Hopkins, W. G., & Huner, N. P. A. (2008). *Introduction to plant physiology* (4th ed.). John Wiley & Sons.
2. Taiz, L., Zeiger, E., Møller, I. M., & Murphy, A. (2015). *Plant physiology and development* (6th ed.). Sinauer Associates.
3. Harborne, J. B. (1973). *Phytochemical methods*. John Wiley & Sons.

DS-14: PLANT BIOTECHNOLOGY AND TISSUE CULTURE
Course Code: BOTDSC614T
(Credits: Theory -3, Practical – 2)
THEORY
(50 Marks; Lecture Hours: 45)

Biotechnology: 35 Marks **(35 Lectures)**

Unit 1: Recombinant DNA technology
Restriction Endonucleases (Types I-IV, biological role and application); Restriction mapping (linear and circular); Cloning vectors: prokaryotic (pBR322, Ti plasmid, BAC), lambda phage, cosmid; eukaryotic vectors (YAC).

Unit 2: Gene Cloning
Recombinant DNA, bacterial transformation and selection of recombinant clones, PCR-mediated gene cloning; Gene construct; construction of genomic and cDNA libraries, screening DNA libraries to obtain gene of interest by genetic selection; Complementation, Colony hybridization; PCR.

Unit 3: Methods of Gene Transfer
Agrobacterium-mediated direct gene transfer by electroporation, microinjection, Microprojectile bombardment; selection of transgenics; selectable marker and reporter genes (luciferase, GUS, GFP).

Unit 4: Applications of Biotechnology
Pest resistant (Bt-cotton); herbicide resistant plants (roundup ready soybean); Transgenic crops with improved quality traits (Golden rice); Improved horticultural varieties (Moondust carnations); Role of transgenics in bioremediation (Superbug); Edible vaccines; Industrial enzymes (aspergillase, protease, lipase); genetically engineered products–human growth hormone; humulin; biosafety concerns.

Plant Tissue Culture: 15 marks **(15 Lectures)**

Historical perspective; Composition of media; Nutrient and hormone requirements (role of vitamins and hormones); Totipotency; Organogenesis; Embryogenesis (somatic and zygotic); Protoplast isolation, culture and fusion; Tissue culture applications (micropropagation, androgenesis, virus elimination, secondary metabolite production, haploids, triploids and hybrids; Cryopreservation; Germplasm conservation), hardening of the tissue culture raised plants for field plantation.

Practical
Course Code: BOTDSC614P
(50 Marks; 60 Hours)

1. (a) Preparation of MS medium. (b) Process of in vitro sterilization and inoculation methods by using different explants (leaf, nodal bud and seeds of tobacco, Datura, Brassica)
2. Study of anther, embryo and endosperm culture, micropropagation, somatic embryogenesis & artificial seeds through photographs.
3. Construction of restriction map of circular and linear DNA from the data provided.
4. Study of methods of gene transfer through photographs: Agrobacterium-mediated, direct gene transfer by electroporation, microinjection, microprojectile bombardment.
5. Study of steps of genetic engineering for production of Bt cotton, Golden rice, Flavr Savr tomato through photographs.
6. Isolation of genomic DNA and its gel electrophoresis.

Suggested Readings

1. Bhojwani, S. S., & Razdan, M. K. (1996). *Plant tissue culture: Theory and practice*. Elsevier Science, Amsterdam, The Netherlands.
2. Glick, B. R., & Pasternak, J. J. (2003). *Molecular biotechnology: Principles and applications of recombinant DNA*. ASM Press, Washington.
3. Bhojwani, S. S., & Bhatnagar, S. P. (2011). *The embryology of angiosperms* (5th ed.). Vikas Publication House Pvt. Ltd., New Delhi.
4. Snustad, D. P., & Simmons, M. J. (2010). *Principles of genetics* (5th ed.). John Wiley & Sons, U.K.
5. Stewart, C. N. Jr. (2008). *Plant biotechnology & genetics: Principles, techniques and applications*. John Wiley & Sons Inc., U.S.A.

DS-15: ANALYTICAL TECHNIQUES IN PLANT SCIENCES
Course Code: BOTDSC615T
(Credits: Theory -3, Practical – 2)
THEORY
(50 Marks; Lecture Hours: 45)

Unit 1: Imaging and related techniques
Principles of microscopy; Light microscopy; Fluorescence microscopy; Confocal microscopy; Use of fluorochromes: (a) Flow cytometry (FACS); (b) Applications of fluorescence microscopy: Chromosome banding, FISH, chromosome painting; Transmission and Scanning electron microscopy: sample preparation for electron microscopy, cryofixation, negative staining, shadow casting, freeze fracture, freeze etching.

Unit 2: Cell fractionation:
Centrifugation**:** Differential and density gradient centrifugation, sucrose density gradient, $CsCl_2$ gradient, analytical centrifugation, ultracentrifugation, marker enzymes.

Unit 3: Radioisotopes
Use in biological research, auto-radiography, pulse chase experiment.

Unit 4: Spectrophotometry
Principle and its application in biological research.

Unit 5: Chromatography
Principle; Paper chromatography; Column chromatography, TLC, GLC, HPLC, Ion-exchange chromatography; Molecular sieve chromatography; Affinity chromatography.

Unit 6: Characterization of proteins and nucleic acids
Mass spectrometry; X-ray diffraction; X-ray crystallography; Characterization of proteins and nucleic acids; Electrophoresis: AGE, PAGE, SDS-PAGE

Practical
Course Code: BOTDSC615P
(50 Marks; 60 Hours)

1. Study of Blotting techniques: Southern, Northern and Western, DNA fingerprinting, DNA sequencing, PCR through photographs.
2. To separate nitrogenous bases/amino acids/plant pigments (from leaf tissue) by paper chromatography.
3. To separate sugars/amino acids by thin layer chromatography.
4. To estimate protein concentration through Lowry's methods/ Bradford methods
5. To separate proteins using PAGE.
6. To separate DNA (marker) using AGE.
7. Study of different microscopic techniques using photographs/micrographs (freeze fracture, freeze etching, negative staining, positive staining, fluorescence and FISH).

Suggested Readings

1. Plummer, D. T. (1996). *An introduction to practical biochemistry* (3rd ed.). Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
2. Ruzin, S. E. (1999). *Plant microtechnique and microscopy*. Oxford University Press, New York, U.S.A.
3. Ausubel, F. M., Brent, R., Kingston, R. E., Moore, D. D., Seidman, J. G., Smith, J. A., & Struhl, K. (1995). *Short protocols in molecular biology* (3rd ed.). John Wiley & Sons.

Semester-VII

DS-16: RESEARCH PRINCIPLES AND TECHNIQUES IN PLANT BIOLOGY
Course Code: BOTDSC716T
(Credits: Theory -3, Practical – 2)
THEORY
(50 Marks; Lectures Hours: 45)

Unit 1: Biosafety and Laboratory Practices
Biosafety definition, Prudent biosafety practices in laboratory environment/institution, Discipline, safety, and care. Biological hazards and levels of biosafety. Biosafety regulations and Institutional Biosafety Committee.

Unit 2: IPR
Introduction and meaning of Intellectual Property Rights, Preliminary awareness about TRIPS and WTO. Kinds of Intellectual Property Rights: Copyright, Patent, Trade Mark, Trade Secret, Geographical Indication, Plant Varieties, and Traditional Knowledge. Patent rights and copyright rights: Meaning of Patent, Types, Inventions which are not patentable, Registration Procedure, Infringement, Remedies & Penalties, Examples of biological patents.

Unit 3: Research Paper writing
Research paper types; How to write a research paper; Journal publishing models, Publishing ethics and metrics: Open access, preprint, predatory journals. Research metrics. Publication misconduct and ethics. Plagiarism check and UGC penalties.

Unit 4: Research Grant Writing
Proforma to be taken from public-funded extramural funding agencies, viz., ICMR, DBT, CSIR, DST, ICAR, etc.

Unit 5: Literature Search and Databases
Search using scientific search engines; Indexing and citation databases.

Unit 6: Research Institutes in Life Sciences: Brief overview (location and mandate) of national research institutes and international institutes located in India, allied to Plant Sciences.

PRACTICAL
Course Code: BOTDSC716P
(50 Marks; 60 Hours)

1. Submission of a model proposal for funding based on the proforma to be taken from public-funded extramural funding agencies, viz., ICMR, DBT, CSIR, DST, ICAR, etc.

a. Only the introduction and the review portion are to be submitted first as a written proposal for internal evaluation for 10 marks. Subsequently, the rest of the proposal is to be submitted for internal evaluation for 15 marks
b. A PowerPoint presentation (15 marks) on the full grant proposal is to be evaluated by the external expert, which is to be followed by a viva voce (10 marks).

Suggested Readings

1. Hofmann, A., & Clokie, S. (Eds.). (2018). *Wilson and Walker's principles and techniques of biochemistry and molecular biology* (8th ed.). Cambridge University Press.

DS-17: INTEGRATED BIOLOGY
Course Code: BOTDSC717T
(Credits: Theory -3, Practical – 2)
THEORY
(50 Marks; Lecture Hours: 45)

Unit 1: Biomolecules:
Structure of atoms, molecules and chemical bonds, Composition, structure and function of biomolecules, Stabilizing interactions, Principles of biophysical chemistry

Unit 2: Membrane Structure and Function*:*
Structure of model membrane, lipid bilayer and membrane protein diffusion, osmosis, ion channels, active transport, ion pumps, mechanism of sorting and regulation ofintracellular transport, electrical properties of membranes.

Unit 3: Cellular Communication*:* Regulation of hematopoiesis, general principles of cell communication, cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix, integrins, neurotransmission and its regulation.

Unit 4: Plant Development Biology
Seed Germination and Seedling Growth: Metabolism of nucleic acids, proteins and mobilization of food reserves; tropisms; use of mutants in understanding seedling development; orthodox and recalcitrant seeds, types of seed dormancy, breaking of dormancy, biochemical changes during dormancy; Shoot Development: Organization of the shoot apical meristem (SAM); cytological and molecular analysis of SAM; control of cell division and cell to cell communication; control of tissue differentiation, especially xylem and phloem; secretory ducts and laticifers; wood development in relation to environmental factors; Reproduction: Induction of flowering; floral meristem and flower development; genetics of floral organ differentiation; homeotic mutants; Senescence and Programmed Cell Death (PCD): Basic concepts, types of cell death, PCD in life cycles of plants, metabolic changes associated with senescence and its regulation.

Unit 5: Methods in Biology

Isolation and purification of RNA, DNA (genomic and plasmid) and proteins; analysis of RNA, DNA and proteins by one and two dimensional gel electrophoresis, isoelectric focusing; molecular cloning of DNA or RNA fragments in bacterial and eukaryotic systems; expression of recombinant proteins using bacterial, animal and plant vectors; protein sequencing methods, detection of post-translation modification of proteins; DNA sequencing methods and its application.

Unit 6: Histochemical and Immunotechniques

Detection of molecules using ELISA, RIA, western blot, immunoprecipitation, flow cytometry, and immunofluorescence microscopy, detection of molecules in living cells, *in situ* localization by techniques such as FISH and GISH.

Practical
COURSE CODE: BOTDSC717P
(50 Marks; 60 Hours)

1. Quantitative estimation of protein (Bradford).
2. Quantitative estimation of reducing sugar (DNS method).
3. Plant Developmental Biology: Section/ staining.
4. Isolation of genomic DNA from two different plants. Restriction digestion of this DNA with EcoR1 or Hind III. Resolution of digested and undigested DNA by agarose gel electrophoresis and comparison of results.

References:

1. Voet, D., & Voet, J. G. (2011). *Biochemistry*. New York: Wiley.
2. Kalidas, C., & Sangaranarayanan, M. V. (2023). *Biophysical chemistry: Techniques and applications*. Singapore: Springer.
3. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2015). *Molecular biology of the cell* (6th ed.). New York: Garland Science.
4. Wardhan, R., & Mudgal, P. (2018). *Textbook of membrane biology*. Singapore: Springer.
5. Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Scott, M. P., Bretscher, A., … Darnell, J. (2021). *Molecular cell biology* (9th ed.). New York: Macmillan.
6. Shehzad, A. (2025). *Cell signaling: Interplay, mechanisms, and therapeutic implications*. Boca Raton: CRC Press.
7. Taiz, L., Zeiger, E., Møller, I. M., & Murphy, A. (2015). *Plant physiology and development* (6th ed.). Sunderland, MA: Sinauer Associates.
8. Pua, E. C., & Davey, M. R. (2010). *Plant developmental biology – Biotechnological perspectives*. Berlin: Springer.

9. Sambrook, J., & Russell, D. W. (2001). *Molecular cloning: A laboratory manual* (3rd ed.). Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
10. Debnath, M., & Swati. (2024). *A handbook on techniques of molecular biology*. New Delhi: OrangeBooks.
11. Harlow, E., & Lane, D. (1988). *Antibodies: A laboratory manual*. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
12. Mondal, S. K. (2025). *Manual of histological techniques* (3rd ed.). New Delhi: Jaypee Brothers Medical Publishers.

Semester-VIII

DS-18: INDUSTRIAL AND ENVIRONMENTAL MICROBIOLOGY
Course Code: BOTDSC818T
(Credits: Theory -3, Practical – 2)
THEORY
(50 Marks; Lecture Hours: 45)

Industrial Microbiology: 30 Marks **(30 Lectures)**

Unit 1: Scope of microbes in industry and environment
Isolation of Industrially Important Microbes.

Unit 2: Bioreactors/Fermenters and fermentation processes
Fermentation process optimization, Media formulation (C, N source), Strain improvement, Solid-state and liquid-state (stationary and submerged) fermentations; Batch and continuous fermentations. Components of a typical bioreactor, Types of bioreactors-laboratory, pilot scale and production fermenters; Constantly stirred tank fermenter, tower fermenter, fixed bed and fluidized bed bioreactors and air-lift fermenter.

Unit 3: Microbial production of industrial products
Microorganisms involved, media, fermentation conditions, downstream processing and uses; Filtration, centrifugation, cell disruption, solvent extraction, precipitation and ultrafiltration, lyophilization, spray drying; Hands on microbial fermentations for the production and estimation (qualitative and quantitative) of Enzyme: amylase or lipase activity, Organic acid (citric acid or glutamic acid), alcohol (Ethanol) and antibiotic (Penicillin).

Unit 4: Microbial enzymes of industrial interest and enzyme immobilization
Microorganisms for industrial applications and hands on screening microorganisms for casein hydrolysis; starch hydrolysis; cellulose hydrolysis. Methods of immobilization, advantages and applications of immobilization, large scale applications of immobilized enzymes (glucose isomerase and penicillin acylase).

Environmental Microbiology: 20 Marks **(20 lectures)**

Unit 5: Microbes and the Quality of the Environment
Distribution of microbes in air; Isolation of microorganisms from soil, air, and water.

Unit 6: Microbial flora of water
Water pollution, role of microbes in sewage and domestic wastewater treatment systems. Determination of BOD, COD, TDS, and TOC of water samples; Microorganisms as indicators of water quality, check coliform and faecal coliform in water samples.

Unit 7: Microbes in agriculture and remediation of contaminated soils.
Biological fixation; Mycorrhizae; Bioremediation of contaminated soils. Isolation of root nodulating

bacteria, arbuscular mycorrhizal colonization in plant roots.

Practical
COURSE CODE: BOTDSC818P
(50 Marks; 60 Hours)

1. Principles and functioning of instruments in a microbiology laboratory
2. Hands-on sterilization techniques and preparation of culture media.
3. Isolation of bacteria from soil for
    a. Starch hydrolysis (Amylase)
    b. Caesin hydrolysis (Protease)
    c. Cellulose hydrolysis (Cellulose)
4. Isolation of antibiotic-producing bacteria
5. Isolation of antibiotic-resistant bacteria.
6. Comparison of microbial flora from different (at least 3) soil/water sources.
7. Determination of BOD, COD, TDS, and TOC of water samples.
8. Bacterial examination of water by MPN method.
9. A visit to any educational institute/ industry to see an industrial fermenter, and other downstream processing operations, and submission of a report

Suggested Readings

1. Pelzar, M.J. Jr., Chen E.C. S., Krieg, N.R. (2010). Microbiology: An application-based approach. Tata McGraw Hill Education Pvt. Ltd., Delhi.
2. Tortora, G.J., Funke, B.R., Case. C.L. (2007). Microbiology. Pearson Benjamin Cummings, San Francisco, U.S.A., 9th edition.

DS-19: BIOINFORMATICS
Course Code: BOTDSC819T
(Credits: Theory -3, Practical – 2)
THEORY
(50 Marks; Lecture Hours: 45)

Unit 1. Introduction to Bioinformatics

Introduction, Branches of Bioinformatics, Aim, Scope, and Research areas of Bioinformatics.

Unit 2. Databases in Bioinformatics

Introduction, Biological Databases, Classification format of Biological Databases, Biological Database Retrieval System.

Unit 3. Biological Sequence Databases
National Center for Biotechnology Information (NCBI): Tools and Databases of NCBI, Database Retrieval Tool, Sequence Submission to NCBI, Basic Local Alignment Search Tool (BLAST), Nucleotide Database, Protein Database, Gene Expression Database; EMBL Nucleotide Sequence Database (EMBL-Bank): Introduction, Sequence Retrieval, Sequence Submission to EMBL, Sequence Analysis Tools; DNA Data Bank of Japan (DDBJ): Introduction, Resources at DDBJ, Data Submission at DDBJ; Protein Information Resource (PIR): About PIR, Resources of PIR, Databases of PIR, Data Retrieval in PIR. Swiss-Prot: Introduction and Salient Features.

Unit 4. Sequence Alignments
Introduction, Concept of Alignment, Multiple Sequence Alignment (MSA), MSA by CLUSTALW, Scoring Matrices, Percent Accepted Mutation (PAM), Blocks of Amino Acid Substitution Matrix (BLOSUM).

Unit 5. Molecular Phylogeny
Methods of Phylogeny, Software for Phylogenetic Analyses, and Consistency of Molecular Phylogenetic Prediction.

Unit 6. Applications of Bioinformatics
Structural Bioinformatics in Drug Discovery, Microbial genome applications, Crop improvement.

Practical
COURSE CODE: BOTDSC819P
(50 Marks; 60 Hours)

1. Nucleic acid and protein databases.
2. Sequence retrieval from databases.
3. Sequence alignment.
4. Sequence homology and Gene annotation.
5. Construction of phylogenetic tree.
6. Primer designing
7. ePCR

Suggested Readings

1. Ghosh Z. and Bibekanand M. (2008) Bioinformatics: Principles and Applications. Oxford University Press.
2. Pevsner J. (2009) Bioinformatics and Functional Genomics. II Edition. Wiley-Blackwell.
3. Campbell A. M., Heyer L. J. (2006). Discovering Genomics, Proteomics, and Bioinformatics. II Edition. Benjamin Cummings.
4. Mount, D. W. (2004). Bioinformatics: Sequence and genome analysis (2nd ed.). Cold Spring Harbor Laboratory Press.
5. Pevsner, J. (2015). Bioinformatics and functional genomics (3rd ed.). Wiley-Blackwell.
6. Rastogi, S. C. (2009). Bioinformatics: Methods and applications: Genomics, proteomics and drug discovery (4th ed.). PHI Learning.
7. Xiong, J. (2006). Essential bioinformatics. Cambridge University Press.

DS-20: PLANT MORPHO-EVO-DEVO- BIOLOGY AND MOLECULAR SYSTEMATICS
Course Code: BOTDSC820T
(Credits: Theory -3, Practical – 2)
THEORY
(50 Marks; Lecture Hours 45)

Unit 1: Origin, Transition, and Interrelationships of Land Plants,
including evidence from morpho-anatomical, ultrastructural, paleontological patterns of lineage, gene, and genome evolution.

a. Divergent evolutionary trajectories of bryophytes and tracheophytes from a complex common ancestor of land plants
b. Evolutionary dynamics of mycorrhizal symbiosis in land plant diversification.
c. Evolution and the Interrelationships of early land plants: insights from molecular studies on basal lineages.

Unit 2: Plant Pheno-Evolutionary Developmental Biology
An integrated approach using genetics, biophysics, and phylogenetics to understand the evolution of development as well as the continuity and complexity of plant form.

(a) Perspectives on methodologies for the study of the diversification of form and the divergence of species: Interspecies gene transfer (IGT) to test the divergence of the two species; Evolutionary transgenomics; Biophysical studies for understanding morphological evolution.
(b) Developmental hybridization: Phylloclades processes of shoots and leaves, evolution of compound leaves, diversity of androecia, heterotopy, carpel as a meristem.
(c) Concept of heterochrony and 'transference of function.'

Unit 3: Plant Molecular Systematics
Experimental Taxonomy, Modern inter-disciplinary approaches to experimental Taxonomy, DNA Barcoding, Gene targets (e.g., rbcL, matK, ITS), Application of population genetics methods in taxonomy.

Practical
COURSE CODE: BOTDSC820P
(50 Marks; 60 Hours)

Unit 1

1. Demonstration of the sequential evolutionary process by commenting on the following sequential presentation of fossil evidence (fossils, slides of fossil specimens, or photographs of fossils).
   i. **Biostratigraphy of Indian Gondwana sediments (Permian to Lower Cretaceous) with megafossil assemblage**: Glossopteris, Gangamopteris, Euryphyllum, Dicroidium, Lepidopteris, Ptylophyllum, Elatocladus). (Mention the megafossil assemblage as per the 3-fold classification of Gondwana)
   ii. **Arrange the successive fossil evidence from the free sporing stage to pre-ovule condition:** *Aneurophyton, Archaeopteris halliana, Archaeosperma arnldii, Elkinsia, Moresnetia*, mentioning the reasons for the same.
   iii. **Successive stages in the development of integument in preovules:** Rhynia-like free sporing form, Genomosperma kidstoni, G. latens, Eurystoma angulare, Stamnostoma huttonense.
   iv. **Diversification in the earliest life forms:** Osmo-heterotrophs (*Eobacterium isolatum, Archaeospheroides barbartonensi*s), chemosynthetic bacteria (Purple-sulphur bacteria), autotrophic chlorophyllous blue-green algae, the oldest eukaryote (*Eotetrahedron*), green algae. (Mention the gradual evolution of life forms through the Precambrian, in terms of complexity, habit, and physiology.
   v. **Origin and diversification of vascular land plants**: *Baragwanathia, Cooksonia, Aglaophyton* major, *Rhynia gwynne-vaughanii, Horneophyton, Zosterophyllum, Psilophyton* (Mention the evolutionary trend in terms of gradual complexity).

   Instructions: The students are required to demonstrate the trends of evolution using fossil specimens (e.g., megafossils, microfossils, fossil slides, or photographs of available fossils), with proper explanations and diagnostic features. The diagnostic features on which the derivation is based need to be clearly distinguishable.

Unit 2:

1. Comparative study of plant species using suitable vegetative and floral traits from at least five species within a family. Compute the data to show their phenetic relationships.
2. Compare the morphometric variations of leaves in response to light intensity and moisture contents of soil, considering two angiosperm species.
3. Morphological and anatomical study of phylloclade in *Opuntia, Euphorbia, Ruscus, Casuarina*, and *Phyllanthus*.
4. Comparative study of
   a) different types of androecia, including the nature of anthers and connectives from five different angiosperm taxa, and predict a line of their phenetic evolution.
   b) pistil diversity, including their placentation types, from five different angiosperm taxa to demonstrate their trend of evolution.
5. Study of different degrees of leaf incision patterns towards the evolution of compound leaves (pinnate, palmate) from suitable live specimens and or herbarium sheets supplied.

6. Studies on different types of heterotopic root development in angiosperms.
7. Study of different types of heterochrony in plants observed from field studies. Study of "Transference of Function" in Acacia and maize.

Unit 3

1. Construction of a phylogenetic tree with the help of the provided reference nucleotide sequence, through BLAST, and multiple sequence alignment and phylogenetic tree with the help of the software MEGA 12.

Suggested Readings

1. Bonacorsi, N.K., & Leslie, A.B. (2019). Functional diversity and convergence in the evolution of plant reproductive structures. *Annals of Botany*, 123(1), 145–152. https://doi.org/10.1093/aob/mcy151
2. Bowman, J.L. (2022). The origin of a land flora. *Nature Plants*, 8(12), 1352–1369.
3. Editorial. (2017). *Frontiers in Plant Science*, 8:61. https://doi.org/10.3389/fpls.2017.00061 (doi.org in Bing)
4. Feijen, F.A.A., Vos, R.A., Nuytinck, J., et al. (2018). Evolutionary dynamics of mycorrhizal symbiosis in land plant diversification. *Scientific Reports*, 8, 10698. https://doi.org/10.1038/s41598-018-28920-x
5. Graham, L.E. (1993). *Origin of Land Plants*. John Wiley & Sons, New York.
6. Harris, B.J., Clark, J.W., Schrempf, D., et al. (2022). Divergent evolutionary trajectories of bryophytes and tracheophytes from a complex common ancestor of land plants. *Nature Ecology & Evolution*, 6, 1634–1643. https://doi.org/10.1038/s41559-022-01885-x
7. Ishizaki, K. (2017). Evolution of land plants: insights from molecular studies on basal lineages. *Bioscience, Biotechnology, and Biochemistry*, 81(1), 73–80. https://doi.org/10.1080/09168451.2016.1224641
8. Iwatsuki, K., & Raven, P.H. (Eds.). (1997). *Evolution and Diversification of Land Plants*. Springer, Tokyo.
9. Niklas, K.J. (2013). Biophysical and size-dependent perspectives on plant evolution. *Journal of Experimental Botany*, 64(15), 4817–4827. https://doi.org/10.1093/jxb/ers379
10. Kenrick, P., & Crane, P.R. (1997). *The Origin and Early Diversification of Land Plants: A Cladistic Study*. Smithsonian Institution Press, Washington.
11. Minelli, A. (2018). *Plant Evolutionary Developmental Biology: The Evolvability of the Phenotype*. Cambridge University Press.
12. Rensing, S.A. (2018). Plant evolution: phylogenetic relationships between the earliest land plants. *Current Biology*, 28(5), R210–R213. https://doi.org/10.1016/j.cub.2018.01.034
13. Resources on the home page of Frederik Leliaert | Diversity and Evolution of Algae.
    a. Leliaert, F., Verbruggen, H., & Zechman, F.W. (2011). Into the deep: New discoveries at the base of the green plant phylogeny. *BioEssays*, 33, 683–692.
    b. Leliaert, F., Smith, D.R., Moreau, H., Herron, M.D., Verbruggen, H., Delwiche, C.F., & De Clerck, O. (2012). Phylogeny and molecular evolution of the green algae. *Critical Reviews in Plant Sciences*.
14. Specht, C.D., & Almeida, A.M.R. (2021). A process-based approach to the study of flower morphological variation. In: Nuño de la Rosa, L., & Müller, G.B. (Eds.), *Evolutionary Developmental Biology*. Springer, Cham. https://doi.org/10.1007/978-3-319-32979-6_61
15. Pandey, A.K., Chowdhury, R.K., Dwivedi, M.D., & Kasana, S. *Plant Molecular Systematics*. Routledge.
16. Soltis, P.E., Soltis, D.E., & Doyle, J.J. (Eds.). *Molecular Systematics of Plants*. Chapman & Hall.
17. Hollingsworth, P.M., Bateman, R.M., & Gornall, R.J. (Eds.). *Molecular Systematics and Plant Evolution*. CRC Press.

DS-21: ADVANCED AND TRANSLATIONAL PLANT BIOLOGY
Course Code: BOTDSC821T
(Credits: Theory -3, Practical – 2)
THEORY
(50 Marks; Lecture Hours: 45)

Unit 1: BioE3 Policy (Biotechnology for Economy, Environment, and Employment)
Brief overview: Key linkages of the BioE3 Policy and Plant Sciences: Climate-Resilient Agriculture, Smart Proteins and Functional Foods, Bio-based Products and Chemicals, Plant Genome Research, Bio-foundries and Genetic Resources to highlight plant-centric industrial approach, directly applying botanical knowledge to economic, environmental, and employment goals.

Unit 2: Blue Economy and Blue Revolution
Blue economy model and key projects in India, Botanical components in the Blue Economy, and it's role in the Blue revolution; Pradhan Mantri Matsya Sampada Yojana- significant intersections with botanical sciences.

Unit 3: Biobased (Circular) Economy
Brief overview, potential applications from botanical perspective in Renewable Feedstock, Waste Valorization, Regenerative Agriculture, Biodegradable Materials, Carbon Sequestration. Some examples in action-Industrial Use: Turning wood, algae, or crop waste into construction materials, chemicals, or energy; Agricultural Improvement: Using mycorrhizal fungi to enhance plant nutrient uptake, reducing reliance on chemical fertilizers; Waste-to-Value: Transforming agricultural residues (e.g., corn cobs) into valuable industrial chemicals.

Unit 4: Commercialisation of Bio-based Products
Initiation of a startup for plant-based products, the whole concept: License, funding, and marketing. Recent Examples of Algae-Based Innovation Products: Cloth dyes, Papers, Everyday use items, Medicinal products, Bioplastics, Natural Colorants and Pigments, Nutritional Supplements and Cosmetics, Biofertilizers and Soil Conditioners, Wastewater Treatment Agents, Biorefinery applications; Fungal innovations: Mycelium-based Textiles (Leather Alternatives), Insulation and Construction Materials, Packaging Materials, Food and Nutritional Products beyond traditional mushrooms, Biocontrol Agents, etc.. Future Challenges in production and commercialization.

Unit 5: National Initiatives and Regulatory Bodies
Nutritional Security through Intensive Millets Promotion (INSIMP); AYUSH large-scale cultivation of 140 prioritized medicinal plant species- Commonly cultivated prioritized species and high-value & subsidy-specific species. Key Miyawaki forest projects in India, National-Level Initiatives and Integration.

Regulatory Bodies: BioRRAP (Biological Research Regulatory Approval Portal), National Biodiversity Authority (NBA)

Unit 6: Translational Methodologies and Application
GM Crops: Methods, scope, limitations/challenges, Genome-edited crops.
Precision agriculture: Application of IoT and AI models in precision agriculture.
Genome editing: Biology, Tools/technologies: TnPB (Transposon-associated Protein B), ISDra2TnpB variant: Indigenous and IP-free alternative to globally patented CRISPR-Cas systems, CRISPR-Cas
Non- coding RNAs description, types, mechanisms (Basic biology)-Applications in plants.
Global warming and resilient crops.

Practical
COURSE CODE: BOTDSC821P
(50 Marks; 60 Hour)

1. Students are to prepare a brief project report of a minimum of 2000 words (Font: Times New Roman, size 12 and Line spacing: 1.5) on any one topic based on the theoretical syllabus of the paper. The student's report will be assessed.

   Marks allotment*: Continuous assessment: 10 Marks; Endterm (External evaluation): 7 Marks*

2. A PowerPoint presentation will also have to be prepared by the student based on the project report. The PowerPoint presentation will have a maximum time limit of 10 minutes, followed by an interaction, and will be assessed on the day of the final examination.

   Marks allotment*: Continuous assessment: No Marks; Endterm (External evaluation): 5 Marks*

3. A visit to any institution/farm/co-operative/commercial enterprise/ educational and /or research institute that addresses at least one topic or objective related to the theoretical syllabus is mandatory to orient students. Enterprises that partially address any one topic/objective are also eligible for a visit. A report of the visit is to be submitted and will be assessed.

   Marks allotment*: Continuous assessment: 10 Marks; Endterm (External evaluation): 5 Marks*

Evaluation scheme

Internal assessment FM: 25			**End term evaluation FM: 25**				**Total Marks**
CA		Attendance	Project Work (Hands on Experiment)		Viva voce	Lab notebook	
Project report	Institutional visit report	(Theory+Practical)	Project report	PPT presentation		Institutional visit report	
10	**10**	**5**	**7**	**5**	**8**	**5**	**50**

WEST BENGAL STATE UNIVERSITY

PART II

4- Year B.Sc. Honours from disciplines other than Botany/ 3-Year Multidisciplinary Undergraduate (UG) programme

Details of Courses offered

Minor Courses (MA)

1. Biodiversity [Microbes, Algae, Fungi, and Archegoniate] (MA I; BOTMIN101T/BOTCOR101T, BOTMIN101P/ BOTCOR101P)
2. Plant Ecology and Taxonomy (MA-II; BOTMIN202T/BOTCOR202T, BOTMIN202P/ BOTCOR202P)
3. Plant Anatomy and Embryology (MA-III; BOTMIN303T/BOTCOR303T, BOTMIN303P/ BOTCOR303P)
4. Plant Physiology and Metabolism (MA-IV; BOTCOR404T, BOTCOR404P)
5. Cell and Molecular Biology (MA-V; BOTCOR505T, BOTCOR505P)
6. Analytical Techniques in Plant Sciences ((MA-VI; BOTCOR606T, BOTCOR606P)

Special Minor Course (SMC)

(Only for Honours students from disciplines other than Botany)

1. Analytical Techniques in Plant Sciences (SMA; BOTSMC701T, BOTSMC701P)
2. Biostatistics (SM; BOTSMC702T, BOTSMC702P)
3. Bioinformatics (SM; BOTSMC703T, BOTSMC703P)

Multidisciplinary Course (MDC)

1. Life Science

MDC in Life Science will have multiple codes. The detail is worked out below.

a. LIFGMD301M if taken in Sem III for Graduation in Multidisciplinary Program.

b. LIFGMD401M if taken in Sem IV for Graduation in Multidisciplinary Program.

c. LIFGMD501M if taken in Sem V for Graduation in Multidisciplinary Program.

d. LIFGMD601M if taken in Sem VI for Graduation in Multidisciplinary Program

Ability Enhancement Course Compulsory (AECC)

1. English/Modern Indian Language (MIL)

Skill Enhancement Course (SE)

1. Floriculture and Gardening or Mushroom Cultivation Technique (SE-1: BOTGSEN301M/ BOTGSEN302M; SE-3: BOTGSEN501M/ BOTGSEN502M); SE-3(For Major other than Botany: BOTHSE301M/BOTHSE302M
2. Techniques of Vermicomposting or Tissue Culture Technique and Micropropagation (SE-2: BOTGSEN403M/BOTGSEN404M; SE-4: BOTGSEN603M/BOTGSEN604M)

Value Added Course (VAC)

1. Environmental Studies (VAC 1; ENVSVAC101T/ENVSVAC201T)
2. Introduction to Cyber Securities (VAC 2: ICSVAC202T/ICSVAC102T)
3. Value of Yoga and Meditation in Life: VAC 3 (VYMVAC203M/VYMVAC103M

Marks and Credit Distribution Chart for Minor Courses (MA)

SEMESTER I

Course Title	Course Code	Credits	Lecture/ Contact Hours	Marks		
				Endterm	Internal Assessment	Total
BIODIVERSITY [MICROBES, ALGAE, FUNGI, AND ARCHEGONIATE]	MA-1 BOTMINN101T/ BOTCORN101T Theory	3	45	50	0	50
	BOTMINN101P/ BOTCORN101P Practical	2	60	25	25	50

SEMESTER II

Course Title	Course Code	Credits	Lecture/ Contact Hours	Marks		
				Endterm	Internal Assessment	Total
PLANT ECOLOGY AND TAXONOMY	MA-1 BOTMINN202T/ BOTCORN202T Theory	3	45	50	0	50
	BOTMINN202P/ BOTCORN202P Practical	2	60	25	25	10

SEMESTER III

Course Title	Course Code	Credits	Lecture/ Contact Hours	Marks		
				Endterm	Internal Assessment	Total
PLANT ANATOMY AND EMBRYOLOGY	MA-III; BOTMINN303T/ BOTCORN303T, Theory	3	45	50	0	50
	BOTMINN303P/ BOTCORN303P Practical	2	60	25	25	10

SEMESTER IV

Course Title	Course Code	Credits	Lecture/ Contact Hours	Marks		
				Endterm	Internal Assessment	Total
PLANT PHYSIOLOGY AND METABOLISM	MA-IV; BOTCORN404T, Theory	3	45	50	0	10
	BOTCORN404P Practical	2	60	25	25	50

SEMESTER V

Course Title	Course Code	Credits	Lecture/ Contact Hours	Marks		
				Endterm	Internal Assessment	Total
CELL AND MOLECULAR BIOLOGY	MA-V; BOTCORN505T, Theory	3	45	50	0	50
	BOTCORN505P Practical	2	60	25	25	50

SEMESTER VI

Course Title	Course Code	Credits	Lecture/ Contact Hours	Marks		
				Endterm	Internal Assessment	Total
ANALYTICAL TECHNIQUES IN PLANT SCIENCES	MA-VI; BOTCORN606T Theory	3	45	50	0	50
	BOTCORN606P Practical	2	60	25	25	50

Semester-I

MA-1: BIODIVERSITY (MICROBES, ALGAE, FUNGI AND ARCHEGONIATE)
Course Code: BOTMIN101T/BOTCOR101T
(Credits: Theory -3, Practical – 2)
THEORY
(50 Marks; Lecture Hours: 45)

Microbiology

Unit 1: Microbes
Viruses – discovery, general structure, replication (general account), DNA virus (T-phage); Lytic and lysogenic cycle, RNA virus (TMV); economic importance; bacteria – discovery, general characteristics and cell structure; Reproduction: vegetative, asexual and recombination (conjugation, transformation and transduction); economic importance

Unit 2: Algae
General Characteristics; Ecology and Distribution; Range of Thallus Organization and Reproduction; Classification of Algae (Lee 2018); Morphology and Life-Cycles of *Nostoc, Oedogonium, Fucus*, *Polysiphonia*. Economic Importance of Algae

Unit 3: Fungi and Phytopathology
Introduction: General Characteristics, Ecology and Significance, Range of Thallus Organization, Cell Wall Composition, Nutrition, Reproduction and Classification (Hawksworth et al.,1995); True Fungi: General Characteristics, Ecology And Significance, Life Cycle of *Rhizopus* (Zygomycota) *Penicillium* (Ascomycota), *Puccinia, Agaricus* (Basidiomycota); Symbiotic Associations: Lichens: General Account, Reproduction and significance; Mycorrhiza: Ectomycorrhiza and Endomycorrhiza and their significance.

Phytopathology:

Terms & Definitions: Pathogen, Propagule, Vector, Inoculum, Infection, Symptoms (necrosis, wilt, spot, blight, hypoplastic & hyperplastic); Disease & Disease Cycle, Disease Triangle, Disease Management, Koch's postulates, Phytoalexins; Symptoms, Causal organisms, Disease cycle & Control measures of - (a) Tungro virus disease of rice & (b) Late blight of potato.

Unit 4: Introduction to Archegoniate
Unifying features of Archegoniates, Transition to land habit, alternation of generations.

Unit 5: Bryophytes
General Characteristics, Adaptations to Land Habit, Classification of Proskauer 1954, up to Class, Range of Thallus Organization. Systematic Position, Morphology, Anatomy, and Reproduction of *Marchantia*, *Anthoceros* and *Funaria* (Developmental details not to be included). Ecology and economic importance of Bryophytes with special mention of *Sphagnum*.

Unit 7: Gymnosperms

General characteristics, classification (Sporne), systematic position, morphology, anatomy, and reproduction of *Cycas* and *Pinus* (developmental details not to be included). Ecological and economic importance.

Practical
Course code: BOTMIN101P/BOTCOR101P
(50 Marks; 60 Hours)

1. Gram staining of Bacteria from the curd sample.
2. Study of vegetative and reproductive structures of *Nostoc* (electron micrographs), *Oedogonium* (Preparation of temporary slides), *Fucus,* and *Polysiphonia* through permanent slides.
3. *Rhizopus* and *Penicillium*: Asexual stage from temporary mounts and sexual structures through permanent slides.
4. *Puccinia*: Herbarium specimens of Black Stem Rust of Wheat and infected Barberry leaves (permanent slides) of both the hosts.
5. *Agaricus*: Specimens of button stage and full-grown mushroom; sectioning of gills of *Agaricus*.
6. Lichens: Study of growth forms of lichens (crustose, foliose, and fruticose).
7. Mycorrhiza: Ectomycorrhiza and endomycorrhiza (Photographs).
8. *Marchantia*: Morphology of thallus, w.m. rhizoids and scales, v.s. thallus through gemma cup, w.m. gemmae, V.S. antheridiophore, archegoniophore, L.S. sporophyte (all permanent slides).
9. *Funaria*: Morphology, w.m. leaf, rhizoids, operculum, peristome, annulus, spores, permanent slides showing antheridial and archegonial heads, L.S. capsule.
10. *Selaginella*: Morphology, w.m. leaf with ligule, T.S. stem, w.m. strobilus, w.m. microsporophyll and megasporophyll, L.S. strobilus (permanent slide).
11. *Equisetum*: Morphology, T.S. internode, L.S. strobilus, T.S. strobilus, w.m. sporangiophore, w.m. spores (wet and dry).
12. *Pteris*: Morphology, T.S. rachis, V.S. sporophyll, w.m. sporangium, w.m. spores,
13. Cycas: Morphology (coralloid roots, bulbil, leaf), T.S. coralloid root, T.S. rachis, v.s. leaflet, v.s. microsporophyll, w.m. spores, L.S. ovule, T.S. root (permanent slide).
14. *Pinus:* Morphology of long and dwarf shoots, male and female cones, T.S. Needle, Stem, w.m. microsporophyll, w.m. microspores, L.S. female cone, female cone (permanent slide).

Semester-II

MA-2: PLANT ECOLOGY AND TAXONOMY
Course Code: BOTMIN202T/BOTCOR202T
(Credits: Theory -3, Practical – 2)
THEORY
(50 Marks; Lecture Hours: 45)

Unit 1: Introduction to Plant Ecology

Unit 2: Ecological factors
Soil: Origin, composition, soil profile. Water: States of water in the environment, Light and temperature: Variation, Optimal and limiting factors; Shelford's law of tolerance; Adaptation of hydrophytes and xerophytes

Unit 3: Plant Communities
Characters; Ecotone and edge effect; Succession; Processes and types.

Unit 4: Ecosystem
Structure; Energy flow, Trophic organisation; Food chains and food webs, Ecological pyramids production and productivity; Biogeochemical cycling; Cycling of carbon, nitrogen.

Unit 5: Phytogeography
Principle, Biogeographical zones; Endemism.

Unit 6: Introduction to Plant Taxonomy

Identification, Classification, Nomenclature.

Unit 7: Identification
Functions of Herbarium, important herbaria and botanical gardens of the world and India; Documentation: Flora, Keys.

Unit 8: Taxonomic Evidence from Palynology, Cytology, Phytochemistry, and Molecular Data.

Unit 9: Taxonomic Hierarchy
Ranks, categories, and taxonomic groups.

Unit 10: Botanical Nomenclature
Principles and rules (ICN); ranks and names; binominal system, typification, author citation, valid publication.

Unit 11: Classification
Types of classification: Artificial, natural, and phylogenetic. Bentham and Hooker (up to series), General idea of Cronquist's classification (1981).

Unit 12 Numerical Taxonomy and Cladistics
Characters; Variations; Cluster analysis; Phenograms, Cladograms (definitions and differences).

PRACTICAL
Course Code: BOTMIN202P/BOTCOR202P
(50 Marks; 60 Hours)

1. Study of instruments used to measure microclimatic variables: Soil thermometer, Maximum and minimum thermometer, Anemometer, Psychrometer/Hygrometer, Rain Gauge, and Lux Meter.
2. Determination of pH, and analysis of two soil samples for carbonates, chlorides, nitrates, organic matter, and by a rapid field test.
3. (a) Study of morphological adaptations of hydrophytes (*Nymphaea* petiole) and xerophytes (*Nerium* leaf) (four each).
   (b) Study of biotic interactions of the following: Stem parasite (*Cuscuta)*, Epiphytes (Orchid root).
4. Determination of minimal quadrat size for the study of herbaceous vegetation in the College/ suitable site by the species area curve method. (Species to be listed).
5. Quantitative analysis of herbaceous vegetation in the college campus /suitable site for frequency and comparison with Raunkiaer's frequency distribution law.
6. Study of vegetative and floral characters of the following families (Description, V.S. of flower, section of ovary, floral diagram/s, floral formula/e and systematic position according to Bentham & Hooker's system of classification): Brassicaceae: *Nasturtium indicum;* Asteraceae: *Eclipta and Tridax;* Solanaceae – *Nicotiana plumbaginifolia*, *Solanum nigrum,* Lamiaceae: *Leonurus sibiricus, Leucas aspera and Ocimum sanctum*; Liliaceae:*Allium.*
7. Mounting of a properly dried and pressed specimen of any ten wild plant with herbarium label (to be submitted in the record book).

Suggested Readings

1. Kormondy, E.J. (1996). *Concepts of Ecology* (4th ed.). Prentice Hall, U.S.A.
2. Sharma, P.D. (2010). *Ecology and Environment* (8th ed.). Rastogi Publications, Meerut, India.
3. Simpson, M.G. (2006). *Plant Systematics*. Elsevier Academic Press, San Diego, CA, U.S.A.
4. Singh, G. (2012). *Plant Systematics: Theory and Practice* (3rd ed.). Oxford & IBH Pvt. Ltd., New Delhi.

Semester-III

MA-3: PLANT ANATOMY AND EMBRYOLOGY
Course Code: BOTMIN303T/BOTCOR303T
(Credits: Theory -3, Practical – 2)
THEORY
(50 Marks; Lecture Hours: 45)

Unit 1: Meristematic and Permanent Tissues
Root and shoot apical meristems; Simple and complex tissues.

Unit 2: Organs
Structure of dicot and monocot root stem and leaf.

Unit 3: Secondary Growth
Vascular cambium: Structure and function, seasonal activity. Secondary growth in root and stem, Wood (heartwood and sapwood).

Unit 4: Adaptive and Protective Systems
Epidermis, cuticle, stomata; General account of adaptations in xerophytes and hydrophytes.

Unit 5: Structural Organization of the Flower
Structure of anther and pollen; Structure and types of ovules; Types of embryo sacs, organization and ultrastructure of mature embryo sac.

Unit 6: Pollination and Fertilization-Pollination mechanisms and adaptations; Double fertilization; Seed-structure appendages and dispersal mechanisms.

Unit 7: Embryo and Endosperm–
Endosperm types, structure, and functions; Dicot and monocot embryo; Embryo endosperm relationship.

Unit 8: Apomixis and Polyembryony-
Definition, types, and practical applications.

PRACTICAL
Course Code: BOTMIN303P/BOTCOR303P
(50 Marks; 60 Hours)

1. Study of Meristems through permanent slides and photographs.
2. Tissues (Parenchyma, collenchyma, and sclerenchyma); Macerated Xylary elements, Phloem Permanent slides, photographs)
3. Stem: Monocot: Zea mays; Dicot: Helianthus; Secondary: Helianthus (only Permanent slides).
4. Root: Monocot: Zea mays; Dicot: Helianthus; Secondary: Helianthus (only Permanent slides).
5. Leaf: Dicot and Monocot leaf (only Permanent slides).
6. Adaptive Anatomy: Xerophyte (*Nerium* leaf); Hydrophyte (*Nymphaea* petiole).
7. Structure of Anther (young and mature), Tapetum (amoeboid and secretory)(Permanent slides).
8. Types of Ovules: Anatropous, Orthotropous, Circinotropous, Amphitropous Campylotropous from permanent slides.
9. Ultrastructure of mature egg apparatus cells through electron micrographs.
10. Pollination types and seed dispersal mechanisms (including appendages, aril, caruncle, (Photographs and specimens).
11. Calculation of the percentage of germinated pollen in a given medium.

Suggested Readings

1. Bhojwani, S.S. & Bhatnagar, S.P. (2011). Embryology of Angiosperms. Vikas Publication House Pvt. Ltd. New Delhi. 5th edition.
2. Mauseth, J.D. (1988). Plant Anatomy. The Benjamin/Cummings Publisher, USA.

Semester-IV

MA-4: PLANT PHYSIOLOGY AND METABOLISM
Course Code: BOTCOR404T
(Credits: Theory -3, Practical – 2)
THEORY
(50 Marks; Lecture Hours: 45)

Unit 1: Plant-water relations
Importance of water, water potential and its components; Transpiration and its significance;Factors affecting transpiration; Root pressure and guttation.

Unit 2: Mineral nutrition
Essential elements, macro and micronutrients; Criteria of essentiality of elements; Role of essential elements; Transport of ions across cell membrane, active and passive transport,carriers, channels and pumps.

Unit 3: Translocation in phloem
Composition of phloem sap, girdling experiment; Pressure flow model; Phloem loading and unloading.

Unit 4: Photosynthesis
Photosynthetic Pigments (Chl a, b, xanthophylls, carotene); Photosystem I and II, reaction center, antenna molecules; Electron transport and mechanism of ATP synthesis; C3, C4 and CAM pathways of carbon fixation; Photorespiration.

Unit 5: Respiration
Glycolysis, anaerobic respiration, TCA cycle; Oxidative phosphorylation, Glyoxylate, Oxidative Pentose Phosphate Pathway.

Unit 6: Enzymes
Structure and properties; Mechanism of enzyme catalysis and enzyme inhibition.

Unit 7: Nitrogen metabolism
Biological nitrogen fixation; Nitrate and ammonia assimilation.

Unit 8: Plant growth regulators
Discovery and physiological roles of auxins, gibberellins, cytokinins, ABA, ethylene.

Unit 9: Plant response to light and temperature
Photoperiodism (SDP, LDP, Day neutral plants); Phytochrome (discovery and structure), red and far red light responses on photomorphogenesis; Vernalization.

PRACTICAL
Course Code: BOTCOR404P
(50 Marks; 60 Hours)

1. Determination of osmotic potential of plant cell sap by weighing method.
2. To study the effect of two environmental factors (light and wind) on transpiration by an excised twig.
3. Calculation of stomatal index and stomatal frequency of a mesophyte (*Basella)*.
4. To study the effect of bicarbonate concentration on O_2 evolution in photosynthesis.
5. Comparison of the rate of respiration in any two parts of a plant.

Demonstration experiments

1. Effect of auxins on rooting.
2. Suction due to transpiration.

Suggested Readings

1. Taiz, L., Zeiger, E., (2010). Plant Physiology. Sinauer Associates Inc., U.S.A. 5th Edition.
2. Hopkins, W.G., Huner, N.P., (2009). Introduction to Plant Physiology. John Wiley & Sons, U.S.A. 4thEdition.
3. Bajracharya, D., (1999). Experiments in Plant Physiology- A Laboratory Manual.Narosa Publishing House, New Delhi.

Semester-V

MA-5: CELL AND MOLECULAR BIOLOGY
Course Code: BOTCOR505T
(Credits: Theory -3, Practical – 2)
THEORY
(50 Marks; Lecture Hours: 45)

Unit 1: Cell as a Unit of Life

The Cell Theory; Prokaryotic and eukaryotic cells; Cell size and shape; Eukaryotic Cell components.

Unit 2: Cell Organelles

Mitochondria: Structure, marker enzymes, composition; Semiautonomous nature; Symbiont hypothesis; Proteins synthesized within mitochondria; mitochondrial DNA. Chloroplast Structure, marker enzymes, composition; semiautonomous nature, chloroplast DNA. ER, Golgi body & Lysosomes: Structures and roles. Peroxisomes and Glyoxisomes: Structures, composition, functions in animals and plants and biogenesis. Nucleus: Nuclear Envelope-structure of nuclear pore complex; chromatin; molecular organization, DNA packaging in eukaryotes, euchromatin and heterochromatin, nucleolus and ribosome structure (brief).

Unit 3: Cell Membrane and Cell Wall- The functions of membranes; Models of membrane structure; The fluidity of membranes; Membrane proteins and their functions; Carbohydrates in the membrane; Faces of

the membranes; Selective permeability of the membranes; Cell wall.

Unit 4: Cell Cycle
Overview of the cell cycle, Mitosis and Meiosis; Molecular controls.

Unit 5: Genetic material
DNA: Miescher to Watson and Crick-historic perspective, Griffith's and Avery's transformation experiments, Hershey-Chase bacteriophage experiment, DNA structure, types of DNA, types of genetic material. DNA replication (Prokaryotes and eukaryotes): bidirectional replication, semi–conservative, semi-discontinuous RNA priming, Ø (theta) mode of replication, replication of linear, ds-DNA, replicating the 5′ end of linear chromosome, including replication enzymes.

Unit 6: Transcription (Prokaryotes and Eukaryotes)
Types of structures of RNA (mRNA, tRNA, rRNA), RNA polymerase- various types; Translation (Prokaryotes and eukaryotes), genetic code.

Unit 7: Regulation of gene expression
Prokaryotes:Lac operon and Tryptophan operon ; and in Eukaryotes

PRACTICAL
Course Code: BOTCOR505P
(50 Marks; 60 Hours)

1. To study prokaryotic cells (bacteria), viruses, eukaryotic cells with the help of light andelectron micrographs.
2. Study of the photomicrographs of cell organelles.
3. To study the structure of plant cell through temporary mounts.
4. Study of mitosis and meiosis (temporary mounts and permanent slides).
5. Study of plasmolysis and deplasmolysis on *Rhoeo* leaf.
6. Measure the cell size (either length or breadth/diameter) by micrometry.
7. Study the structure of nuclear pore complex by photograph (from Gerald Karp) Study of special chromosomes (polytene & lampbrush) either by slides or photographs.
8. Study DNA packaging by micrographs.
9. Preparation of the karyotype and ideogram from given photograph of somatic metaphase chromosome**.**

Suggested Readings

1. Karp, G. 2010. Cell and Molecular Biology: Concepts and Experiments. 6th Edition. John Wiley & Sons. Inc.
2. De Robertis, E.D.P. and De Robertis, E.M.F. 2006. Cell and Molecular Biology. 8th edition. Lippincott Williams and Wilkins, Philadelphia.
3. Cooper, G.M. and Hausman, R.E. 2009. The Cell: A Molecular Approach. 5th edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA
4. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. 2009. The World of the Cell. 7th edition. Pearson Benjamin Cummings Publishing, San Francisco.

Semester-VI

MA-6: ANALYTICAL TECHNIQUES IN PLANT SCIENCES
Course Code: BOTCOR606T
(Credits: Theory -3, Practical – 2)
THEORY
(50 Marks; Lecture Hours: 45)

Unit 1: Imaging and related techniques - Principles of microscopy; Light microscopy; Fluorescence microscopy; Confocal microscopy; Use of fluorochromes: (a) Flow cytometry (FACS); (b) Applications of fluorescence microscopy: Chromosome banding, FISH, chromosome painting; Transmission and Scanning electron microscopy – sample preparation for electron microscopy, cryofixation, negative staining, shadow casting, freeze fracture, freeze etching.

Unit 2: Cell fractionation
Centrifugation: Differential and density gradient centrifugation, sucrose density gradient, CsCl2 gradient, analytical centrifugation, ultracentrifugation, marker enzymes.

Unit 3: Radioisotopes
Use in biological research, Autoradiography, Pulse-chase experiment.

Unit 4: Spectrophotometry
Principle and its application in biological research.

Unit 5: Chromatography
Principle; Paper chromatography; Column chromatography, TLC, GLC, HPLC, Ion exchange chromatography; Molecular sieve chromatography; Affinity chromatography.

Unit 6: Characterization of Proteins and Nucleic acids - Mass spectrometry; X-ray diffraction; X-ray crystallography; Characterization of proteins and nucleic acids; Electrophoresis: AGE, PAGE, SDS-PAGE

Unit 7: Biostatistics- Statistics, data, population, samples, parameters; Representation of Data: Tabular, Graphical; Measures of central tendency: Arithmetic mean, mode, median; Measures of dispersion: Range, mean deviation, variation, standard deviation; Chi-square test for goodness of fit.

PRACTICAL
Course Code: BOTCOR606P
(50 Marks; 60 Hours)

1. Study of Blotting techniques: Southern, Northern and Western, DNA fingerprinting, DNA sequencing, PCR through photographs.
2. To separate nitrogenous bases/amino acids/plant pigments from leaf by paper chromatography.
3. Isolation of chloroplasts by differential centrifugation.

4. To estimate protein concentration through Lowry's method.
5. To separate proteins using PAGE.
6. To separate DNA (marker) using AGE.
7. Study of different microscopic techniques using photographs/micrographs (freeze fracture, freeze etching, negative staining, positive staining, fluorescence and FISH).
8. Demonstration of permanent slides (double staining) (any slide).

Suggested Readings

1. Plummer, D.T. (1996). *An Introduction to Practical Biochemistry* (3rd ed.). Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
2. Ruzin, S.E. (1999). *Plant Microtechnique and Microscopy*. Oxford University Press, New York, U.S.A.
3. Ausubel, F., Brent, R., Kingston, R.E., Moore, D.D., Seidman, J.G., Smith, J.A., & Struhl, K. (1995). *Short Protocols in Molecular Biology* (3rd ed.). John Wiley & Sons.
4. Zar, J.H. (2012). *Biostatistical Analysis* (4th ed.). Pearson Publications, U.S.A.

Semester-VII

SMA: SPECIAL MINOR COURSES OFFERED BY BOTANY

Evaluation Scheme for End-Term Examination

Theory

QUESTION PAPER PATTERN FOR SPECIAL MINOR

Duration	Type	Total No. of Questions	No. of Questions to be Answered	Marks for Each Question	Total marks Alloted
2 Hours	Short Answer	10	10 out of 10	1	10X1 = **10**
	Short notes/ Paragraph	6	4 out of 6	5	4X5 = **20**
	Descriptive/ Long Answer	2	2 out of 3	10 (Part markings 6+4 or 7+3)	2X10 = **20**
Full Marks					**50**

Any one paper from the three options below

Course Code: BOTSMC701T
THEORY
(50 Marks; 45 Hours)

ANALYTICAL TECHNIQUES IN PLANT SCIENCES

Unit 1: Imaging and related techniques

Principles of microscopy; Light microscopy; Fluorescence microscopy; Confocal microscopy; Use of fluorochromes: (a) Flow cytometry (FACS); (b) Applications of fluorescence microscopy: Chromosome banding, FISH, chromosome painting; Transmission and Scanning electron microscopy: sample preparation for electron microscopy, cryofixation, negative staining, shadow casting, freeze fracture, freeze etching.

Unit 2: Cell fractionation:

Centrifugation**:** Differential and density gradient centrifugation, sucrose density gradient, $CsCl_2$ gradient,

analytical centrifugation, ultracentrifugation, marker enzymes.

Unit 3: Radioisotopes
Use in biological research, auto-radiography, pulse chase experiment.

Unit 4: Spectrophotometry
Principle and its application in biological research.

Unit 5: Chromatography
Principle; Paper chromatography; Column chromatography, TLC, GLC, HPLC, Ion-exchange chromatography; Molecular sieve chromatography; Affinity chromatography.

Unit 6: Characterization of proteins and nucleic acids
Mass spectrometry; X-ray diffraction; X-ray crystallography; Characterization of proteins and nucleic acids; Electrophoresis: AGE, PAGE, SDS-PAGE

Practical
Course Code: BOTSMC701P
(50 Marks; 60 Hours)

8. Study of Blotting techniques: Southern, Northern and Western, DNA fingerprinting, DNA sequencing, PCR through photographs.
9. To separate nitrogenous bases/amino acids/plant pigments (from leaf tissue) by paper chromatography.
10. To separate sugars/amino acids by thin layer chromatography.
11. To estimate protein concentration through Lowry's methods/ Bradford methods
12. To separate proteins using PAGE.
13. To separate DNA (marker) using AGE.
14. Study of different microscopic techniques using photographs/micrographs (freeze fracture, freeze etching, negative staining, positive staining, fluorescence and FISH).

Suggested Readings

4. Plummer, D. T. (1996). *An introduction to practical biochemistry* (3rd ed.). Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
5. Ruzin, S. E. (1999). *Plant microtechnique and microscopy*. Oxford University Press, New York, U.S.A.
6. Ausubel, F. M., Brent, R., Kingston, R. E., Moore, D. D., Seidman, J. G., Smith, J. A., & Struhl, K. (1995). *Short protocols in molecular biology* (3rd ed.). John Wiley & Sons.

Biostatistics
Course Code: BOTSMC702T
THEORY

Unit 1: Introduction
Definition, statistical methods and basic principles; Measurement of variables; Functions, limitations, and uses of statistics.

Unit 2: Collection, Classification and Representation of Data

Types and methods of data collection procedures, merits and demerits; Classification of data; Tabulation and presentation of data; Sampling methods.

Unit 3: Measures of Central Tendency
Mean, median, mode, geometric mean, merits & demerits. Measures of dispersion: range, standard deviation, mean deviation, quartile deviation; merits and demerits; Co-efficient of variations, concept of 'p' value and its limitations.

Unit 4: Correlation
Types and methods of correlation, regression, simple regression equation, fitting prediction, similarities and dissimilarities of correlation and regression.

Unit 5: Statistical Inference
Hypothesis: simple hypothesis; Student's t-test, chi-square test, and calculation of F-value.

Practical
Course Code: BOTSMC702P

Biostatistics

5. Calculation of mean, standard deviation, and standard error.
6. Calculation of correlation coefficient values and finding out the probability.
7. Calculation of 'F' value
8. Calculation of the student's t –test

Suggested Readings

Plant Breeding

5. Chawdhuri, H. K. (1986). *Elementary principles of plant breeding*. New Delhi: Oxford & IBH Publishing.
6. Allard, R. W. (1960). *Principles of plant breeding*. New York: John Wiley & Sons.
7. Poehlman, J. M., & Barthakur, D. (1995). *Plant breeding*. New Delhi: Oxford & IBH Publishing.
8. Singh, B. D. (2005). *Plant breeding: Principles and methods* (7th ed.). New Delhi: Kalyani Publishers.

Biostatistics

7. Daniel, W. W. (1987). *Biostatistics*. New York: John Wiley & Sons.
8. Sundarrao, P. S. S., & Richards, J. (1997). *An introduction to biostatistics* (3rd ed.). Vellore: Christian Medical College.
9. Selvin, S. (1991). *Statistical analysis of epidemiological data*. New York: Oxford University Press.
10. Bishop, O. N. (1975). *Statistics for biology*. Boston: Houghton Mifflin.
11. Freedman, P. (1960). *The principles of scientific research*. New York: Pergamon Press.
12. Campbell, R. C. (1998). *Statistics for biologists*. Cambridge: Cambridge University Press.

Bioinformatics
Course Code: BOTSMC703T

Unit 1. Introduction to Bioinformatics
Introduction, Branches of Bioinformatics, Aim, Scope, and Research areas of Bioinformatics.

Unit 2. Databases in Bioinformatics
Introduction, Biological Databases, Classification format of Biological Databases, Biological Database Retrieval System.

Unit 3. Biological Sequence Databases
National Center for Biotechnology Information (NCBI): Tools and Databases of NCBI, Database Retrieval Tool, Sequence Submission to NCBI, Basic Local Alignment Search Tool (BLAST), Nucleotide Database, Protein Database, Gene Expression Database; EMBL Nucleotide Sequence Database (EMBL-Bank): Introduction, Sequence Retrieval, Sequence Submission to EMBL, Sequence Analysis Tools; DNA Data Bank of Japan (DDBJ): Introduction, Resources at DDBJ, Data Submission at DDBJ; Protein Information Resource (PIR): About PIR, Resources of PIR, Databases of PIR, Data Retrieval in PIR. Swiss-Prot: Introduction and Salient Features.

Unit 4. Sequence Alignments
Introduction, Concept of Alignment, Multiple Sequence Alignment (MSA), MSA by CLUSTALW, Scoring Matrices, Percent Accepted Mutation (PAM), Blocks of Amino Acid Substitution Matrix (BLOSUM).

Unit 5. Molecular Phylogeny
Methods of Phylogeny, Software for Phylogenetic Analyses, and Consistency of Molecular Phylogenetic Prediction.

Unit 6. Applications of Bioinformatics
Structural Bioinformatics in Drug Discovery, Microbial genome applications, Crop improvement.

Practical
Course Code: BOTSMC703P

1. Nucleic acid and protein databases.
2. Sequence retrieval from databases.
3. Sequence alignment.
4. Sequence homology and Gene annotation.
5. Construction of phylogenetic tree.
6. Primer designing
7. ePCR

Suggested Readings

8. Ghosh Z. and Bibekanand M. (2008) Bioinformatics: Principles and Applications. Oxford University Press.
9. Pevsner J. (2009) Bioinformatics and Functional Genomics. II Edition. Wiley-Blackwell.

10. Campbell A. M., Heyer L. J. (2006). Discovering Genomics, Proteomics, and Bioinformatics. II Edition. Benjamin Cummings.
11. Mount, D. W. (2004). Bioinformatics: Sequence and genome analysis (2nd ed.). Cold Spring Harbor Laboratory Press.
12. Pevsner, J. (2015). Bioinformatics and functional genomics (3rd ed.). Wiley-Blackwell.
13. Rastogi, S. C. (2009). Bioinformatics: Methods and applications: Genomics, proteomics and drug discovery (4th ed.). PHI Learning.
14. Xiong, J. (2006). Essential bioinformatics. Cambridge University Press.

WEST BENGAL STATE UNIVERSITY

PART III

(SKILL ENHANCEMENT COURSE)

(COURSE CODE: BOTHSE101M or BOTHSE102M; BOTHSE203M or BOTHSE204; BOTHSE301M or BOTHSE302M; BOTGSE301M or BOTGSE302M; BOTGSE403M or BOTGSE404M; BOTGSE501M or BOTGSE502M; BOTGSE603M or BOTGSE604M)

(CREDITS: 3)

50 Marks **45 Hours**

Skill Enhancement Course (SEC) Guidelines – Botany Department

1) **Eligibility**
    a. Students with a **Major in any discipline other than Botany** and without Botany as a minor discipline may choose this course in one of the first three semesters (**course code: BOTHSE101M/BOTHSE102M; BOTHSE203M/BOTHSE204M, and BOTHSE301M/ BOTHSE302M**).
    b. Students of the 3-Year Multidisciplinary stream who do not have Botany as a core discipline may choose the same course in one of the last three semesters (course code will be appropriately changed).
    c. Students who studied Botany at Higher Secondary (+2 level) are not allowed to choose this course.
2) **For Botany Major Students**
    a. Must study **BOTHSE101M/BOTHSE102M; BOTHSE203M/BOTHSE204M in** the **first two semesters**.
    b. In the third semester, they must take another SEC from one of the minor disciplines (Code: XXXMSE301M).
    c. *(This portion is applicable from the academic year 2024-25).*
3) For 3-Year Multidisciplinary Program Students
    a. Required to take two SECs (SE-1 & SE-2) from one discipline and two SECs (SE-3 & SE-4) from another discipline.
4) **Departmental SEC Offerings**
    a. Floriculture and Gardening or Mushroom Cultivation Technique (**SE-1: BOTHSE101M/ BOTHSE102M; BOTHSE301M/BOTHSE302M; BOTGSE301M/BOTGSE302M; BOTGSE501 M/BOTGSE502M**): Offered in all odd semesters up to the 5th semester. Any one of the two papers mentioned above can be chosen.
    b. Techniques in Vermicomposting or Tissue Culture Technique and Micropropagation (SE-2 **BOTHSE203M/BOTHSE204; BOTGSE203/BOTGSE204M; BOTGSE403M/BOTGSE404M; BOTGSE603M/BOTGSE604M**): Offered in all even semesters up to 6th semester. Any one of the two papers mentioned above can be chosen.

SE-1

(Offered in all odd semesters up to the 5th semester)

<u>Any one of the two papers</u> mentioned below can be chosen.

1. FLORICULTURE AND GARDENING

(COURSE CODE: BOTHSE101M / BOTHSE301M/BOTGSE301M /BOTGSE501M)
(Credits: 3)

50 Marks **(Classes 30+ Project)**

Unit 1: Introduction to Nursery and Gardening

Unit 2: Definition and types of nurseries; physical resources for nurseries; selection of nursery site, ecological conditions, important nursery operations.

Unit 3: Definition and components of gardens; types of gardening (landscape and home gardening). Scope and objective of gardening; garden landscaping with specific reference to Kew Botanical Garden, AJC Bose Indian Botanic Garden, Kolkata

Unit 4: Plant Propagation Methods- Seed dormancy – causes and methods of breaking it; seed germination, types and factors affecting it. Vegetative propagation; artificial and natural methods; Concept of soilless cultivation with special reference to sand culture and hydroponics.

Unit 5: Training/ Workshop/ Field visit, establishment of nursery.

References:

1. Randhawa, G. S., & Mukhopadhyay, T. P. (2001). *Floriculture in India*. Allied Publishers.
2. Kumar, N. (2006). *Introduction to horticulture*. Oxford & IBH Publishing.
3. Bose, T. K., & Yadav, L. P. (1989). *Commercial floriculture*. Naya Prokash.
4. Singh, B. (2006). *Nursery management and plant propagation*. Kalyani Publishers.
5. Bhattacharjee, S. K. (2006). *Advanced ornamental horticulture*. Pointer Publishers.
6. Randhawa, M. S., & Gupta, B. N. (1996). *Floriculture in India*. Allied Publishers.
7. Hartmann, H. T., Kester, D. E., Davies, F. T., & Geneve, R. L. (2011). *Plant propagation: Principles and practices* (8th ed.). Prentice Hall.
8. Bose, T. K., Maiti, R., Dhua, R. S., & Das, P. (2003). *Floriculture and landscaping*. Naya Udyog.
9. Chadha, K. L. (2001). *Handbook of horticulture*. Indian Council of Agricultural Research.

OR

2. MUSHROOM CULTIVATION TECHNIQUE

(COURSE CODE: BOTHSE102M / BOTHSE302M/BOTGSE302M /BOTGSEN502M)

(CREDITS: 3)

50 Marks **(Classes 30+ Project)**

Unit 1: Introduction to mushrooms

Unit 2: **Mushrooms**

Taxonomical rank; History and Scope of mushroom cultivation; Edible and Poisonous Mushrooms

Unit 3: Common Edible Mushrooms

Button mushroom (*Agaricus bisporus*), Milky mushroom (*Calocybe indica*), Oyster mushroom (*Pleurotus sajorcaju*), and Paddy straw mushroom (*Volvariella volvcea*).

Unit 4: Principles of Mushroom Cultivation

Structure and construction of mushroom house, sterilization and sanitation of mushroom house; instruments and substrates; Sterilization of substrates; Spawn production: Culture media preparation, production of pure culture, preparation of mother spawn, and multiplication of spawn; Composting technology: Mushroom bed preparation, spawning, spawn running, harvesting; Problems in mushroom cultivation: diseases (moulds), pests and nematodes, weeds and their management strategies.

Unit 5: Health benefits of Mushrooms:

Nutritional and medicinal values of mushrooms; Therapeutic aspects: antitumor effects.

Unit 6: Post-Harvest Technology and Entrepreneurship

Preservation of mushrooms: Freezing, dry freezing, drying, canning; Quality assurance; Value-added products of mushrooms; Entrepreneurship

Unit 7: Training/workshop/Field visit to mushroom unit

References:

1. Aggarwal, A., Sharma, Y. P., & Angra, E. (2021). *A textbook on mushroom cultivation: Theory and practices*. Newrays Publishing House.
2. Tiwari, S. C., & Kapoor, P. (2018). *Mushroom cultivation*. Mittal Publications. ISBN: 9788183249232
3. Bahl, N. (2015). *Handbook on mushroom* (pp. 1–166). Oxford & IBH Publishing Company. ISBN: 9788120413993
4. Russell, S. (2014). *The essential guide to cultivating mushrooms* (pp. 1–233). Storey Publishing. ISBN: 9781612121468
5. Chang, S. T., & Miles, P. G. (2004). *Mushrooms: Cultivation, nutritional value, medicinal effect, and environmental impact* (pp. 1–477). CRC Press.
6. Fletcher, J. T., & Gaze, R. G. (2007). *Mushroom pest and disease control*. CRC Press.
7. Rai, R. D., & Arumuganathan, Y. (2008). *Post-harvest technology of mushrooms* (pp. 1–72). National Research Center for Mushroom, Indian Council of Agricultural Research, Chambaghat, Solan, H.P.

SE-2

(Offered in all even semesters up to the 6th semester)

Any one of the two papers mentioned below can be chosen.

3. TECHNIQUE OF VERMICOMPOSTING

(COURSE CODE: BOTHSE203M /BOTGSE403M /BOTGSE603M)
(CREDITS: 3)

50 Marks **(Classes 30+ Project)**

Unit 1: Introduction to Vermiculture. Definition, meaning, history, economic importance and value in maintenance of soil structure. Choosing the right worm. Useful species of earth worms, local species

Unit 2: Vermicomposting materials and their classification. Feeding habits and food for composting worms.

Unit 3: Vermicomposting methods such as the small-scale and large-scale pit method, heap method, window method etc. Factors affecting vermicomposting such as pH, moisture, temperature.

Unit 4: Vermicomposting: general procedure in homes; Maintenance of vermicomposting beds. Harvesting the worms, Earthworm Predators, Parasites, and pathogens.

Unit 5: Application of vermicomposting in Agriculture and Horticulture practices. Advantages of vermicomposting.

Unit 6: Training/ Workshop/ Field visit/ establishment of vermicomposting unit.

References:

1. Badwaik, V. (2025). *Textbook of vermiculture and vermicomposting*. Bhumi Publishing. ISBN: 978-93-48620-26-2.
2. Walia, S. S., & Kaur, T. (2024). *Earthworms and vermicomposting: Species, procedures and crop application*. Springer Nature Singapore.
3. Edwards, C. A., & Arancon, N. Q. (2004). *Vermiculture technology: Earthworms, organic wastes, and environmental management*. CRC Press.
4. Ismail, S. A. (2005). *The earthworm book*. Other India Press.

OR

4. TISSUE CULTURE TECHNIQUE AND MICROPROPAGATION

(COURSE CODE: BOTHSE204M /BOTGSE404M /BOTGSE604M)

(CREDITS: 3)

50 Marks **(Classes 30+ Project)**

Unit 1: Introduction to Plant Tissue Culture: Definition, brief history, principle, and significance of tissue culture; cellular totipotency-Cytodifferentation: Factors affecting vascular tissue differentiation, cell cycle, and TE differentiation; Organogenic differentiation: Induction, factors affecting shoot bud differentiation.

Unit 2: Laboratory Organization and Instrumentation: Design and layout for wash area, media preparation, sterilization and storage room, transfer area for aseptic manipulations, culture rooms, and observation/data collection areas, labwares, good laboratory practices, good safety. Working principle, maintenance, and management of the following instruments: Laminar air flow, autoclave, distillation unit, pH meter, orbital shaker, microscope, deep freezer, growth chamber. Sterilization: Importance,

Unit 3: Tissue Culture Media: Introduction, Types of Media and its importance; Preparation of stocks, pH and Buffers and their significance in media. Media Constituents (Vitamins, Unidentified supplements, Carbohydrate for energy source, Nitrogen source, and Organic supplements, complex substances, Hormones, Activated charcoal).

Unit 4: Plant Hormones: Role of Plant Hormones (auxins, cytokinins, abscissic acid, ethylene, and Gibberellins) in Plant Development.

Unit 5: Aseptic techniques: Methods of sterilization of equipment, culture media, and explants:- Washing and preparation of glassware, packing and sterilization, media sterilization, surface sterilization, aseptic workstation, precautions to maintain aseptic conditions.

Unit 6: Micropropagation: Meristem culture for the production of virus-free plants. Nucellus culture for clonal propagation and large-scale multiplication, strategies of micropropagation. Stages of micropropagation via axillary shoot proliferation in monocots and dicots, and methods of micropropagation through organogenesis. Micropropagation - direct and indirect somatic embryogenesis. Low-cost methods for micropropagation.

References:

1. Bhojwani, S. S., & Razdan, M. K. (1996). *Plant tissue culture: Theory and practice*. Elsevier.
2. Reinert, J., & Bajaj, Y. P. S. (1997). *Applied and fundamental aspects of plant tissue culture*. Springer.
3. Thorpe, T. A. (2007). *History of plant tissue culture*. In *Plant Cell Culture Protocols* (pp. 9–32). Humana Press.
4. Pierik, R. L. M. (1997). *In vitro culture of higher plants*. Springer.
5. Gamborg, O. L., & Phillips, G. C. (1995). *Plant cell, tissue and organ culture: Fundamental methods*. Springer.
6. Klerk, G. J., & Pierik, R. L. M. (1990). *Micropropagation of ornamental plants*. Springer.
7. Chawla, H. S. (2009). *Introduction to plant biotechnology* (3rd ed.). Science Publishers.
8. Smith, R. H. (2012). *Plant tissue culture: Techniques and experiments* (3rd ed.). Academic Press.

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PART IV

Multidisciplinary Course (MDC) in Life Science

(Course code: LIFHMD101M/LIFHMD201M/LIFHMD301M/LIFGMD301M/ LIFGMD401M/LIFGMD501M/LIFGMD601M

(Credits: 3)

50 Marks **45 Lectures**

MDC (Zoology) Classes: 10

1. Vector borne infectious diseases
2. Climatic change and impact on biodiversity
3. Degradation of Wetland ecosystem and biodiversity
4. Major Indian ecosystems
5. Environmental movements in India

MDC (Microbiology) Classes: 10

1. Bioremediation.
2. Role of Microbes in One Health Concept.
3. Genetic Engineering in human welfare.
4. Industrial use of microbes.
5. Sustainable development in agriculture and environment.
6. Microbes in food safety and hygiene.

MDC (Physiology) Classes: 8

1. Community health education
2. Management of non-communicable diseases
3. Physiological & nutritional therapeutics as content of MDC from Physiology

MDC (Molecular Biology & Biotechnology) Classes: 8

1. Basic concept of gene and heredity (Historical illustrations)
2. History of Biotechnology
3. Milestone applications of Biotechnology

MDC (Botany) Classes: 9

1. One health concept and emerging plant diseases
2. Plants–importance and propagation in the ethnobotanical aspect
3. Biotechnological applications in Agriculture