

As per NEP 2020
M.Sc. Botany
(Effective from Academic Year 2024-2025 onwards)



Pandit Deendayal Upadhyaya Shekhawati University Sikar
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Dr. Registrar
Pandit Deendayal Upadhyaya
Shekhawati University,
Sikar (Rajasthan)

Curriculum Structure									
Session 2024-2025 onwards									
Name of the Program: Master of Botany									
Year: First							Semester: I (Pawas)		
Course Code	Course Title	Contact Hrs per Week			Credits	Weightage (%)			
		L	T	P		CWS	MTE	ETE	
Discipline Specific Core (DSC):									
24MBO9101T	Algae Fungi and Bryophyta	4	0	0	4	10	20	70	
24MBO9102T	Cell and Molecular Biology	4	0	0	4	10	20	70	
24MBO9103T	Principles of Plant Pathology & Microbiology	4	0	0	4	10	20	70	
24MBO9104P	Botany Practical	0	0	8	4	-	-	100	
Discipline Specific Elective(DSE):									
24MBO9105T	Evolutionary Biology and Phytogeography	4	0	0	4	10	20	70	
OR									
24MBO9106T	Applied Microbiology	4	0	0	4	10	20	70	
Value Added Course(VAC):									
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Seminar/Internship/Apprenticeship/Project/Community Outreach (S/I/A/P/C):									
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Total					22				

Summary: I Semester (Pawas)			Credits
S.N.	Particulars		
1.	Discipline Specific Core(DSC):	16	
2.	Discipline Specific Elective (DSE):	04	
3.	Value Added Course (VAC):	02	
4.	Seminar/Internship/Apprenticeship/Project/Community Outreach (S/I/A/P/C):	00	
Total		22	
\$CW (Class work): It would include attendance, class test/quiz test/assignments, ppt, play, learn by fun activities etc.			

Note: VAC to be selected from the list of VAC courses for PG, given on University website.


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Curriculum Structure									
Session 2024-2025 onwards									
Name of the Program: Master of Botany									
Year: First							Semester: II (Vasant)		
Course Code	Course Title	Contact Hrs per Week	Credits			Weightage (%)			
			L	T	P	CWS	MTE	ETE	
Vasant Semester II									
Discipline Specific Core (DSC):									
24MBO9201T	Research Methodology	4	0	0	4	10	20	70	
24MBO9202T	Pteridophytes, Gymnosperms and Paleobotany	4	0	0	4	10	20	70	
24MBO9203T	Plant Morphology and Developmental Anatomy	4	0	0	4	10	20	70	
24MBO9204P	Botany Laboratory	0	0	8	4	-	-	100	
Discipline Specific Elective(DSE):									
24MBO9205T	Ethnobotany	4	0	0	4	10	20	70	
OR									
24MBO9206T	Principles of Plant Breeding	4	0	0	4	10	20	70	
Value Added Course(VAC):									
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Seminar/Internship/Apprenticeship/Project/Community Outreach (S/I/A/P/C):									
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	Total				22				

Summary: II Semester (Vasant)			Credits
S.N.	Particulars		
1.	Discipline Specific Core(DSC):	16	
2.	Discipline Specific Elective (DSE):	04	
3.	Value Added Course (VAC):	02	
4.	Seminar/Internship/Apprenticeship/Project/Community Outreach (S/I/A/P/C):	00	
Total		22	
\$CW (Class work): It would include attendance, class test/quiz test/assignments, ppt, play, learn by fun activities etc.			

Note: VAC to be selected from the list of VAC courses for PG, given on University website.

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Curriculum Structure												
For Session 2024-2025 onwards												
Name of the Program: Master of Botany					Semester: III (Pawas)							
Year: Second												
Course Code	Course Title	Contact Hrs per Week	Credits			Weightage (%)			ETE			
			L	T	P	CW\$	MTE					
Discipline Specific Core (DSC):												
24MBO9301T	Taxonomy and Embryology of Angiosperms	3	0	0	3	10	20	70				
24MBO9302T	Plant Physiology and Metabolism	3	0	0	3	10	20	70				
24MBO9301P	Botany Laboratory	0	0	4	2	-	-	100				
Discipline Specific Elective (DSE): (Select any one group)												
Group A												
24MBO9303T	Tools and Techniques in Plant Sciences	4	0	0	4	10	20	70				
24MBO9304T	Advanced Plant Pathology	4	0	0	4	10	20	70				
24MBO9305T	Seed Pathology	4	0	0	4	10	20	70				
24MBO9302P	Plant Pathology Laboratory	0	0	8	4	-	-	100				
Group B												
24MBO9303T	Tools and Techniques in Plant Sciences	4	0	0	4	10	20	70				
24MBO9306T	Advanced Plant Physiology	4	0	0	4	10	20	70				
24MBO9307T	Stress Biology	4	0	0	4	10	20	70				
24MBO9303P	Plant Physiology Laboratory	0	0	8	4	-	-	100				
Group C												
24MBO9303T	Tools and Techniques in Plant Sciences	4	0	0	4	10	20	70				
24MBO9308T	Ecosystem Ecology	4	0	0	4	10	20	70				
24MBO9309T	Conservation Biology	4	0	0	4	10	20	70				
24MBO9304P	Plant Ecology Laboratory	0	0	8	4	-	-	100				
Group D												
24MBO9303T	Tools and Techniques in Plant Sciences	4	0	0	4	10	20	70				
24MBO9310T	Advanced Morphology and Morphogenesis	4	0	0	4	10	20	70				
24MBO9311T	Advanced Biosystematics of Angiosperms	4	0	0	4	10	20	70				
24MBO9305P	Biosystematics Laboratory	0	0	8	4	-	-	100				
Value Added Course (VAC):												
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Seminar/Internship/Apprenticeship/Project/Community Outreach (S/I/A/P/C):												
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				Total				26				

Summary: III Semester (Pawas)			Credits
S.N.	Particulars		
1.	Discipline Specific Core (DSC):		08
2.	Discipline Specific Elective (DSE):		16
3.	Value Added Course (VAC):		02
4.	Seminar/Internship/Apprenticeship/Project/Community Outreach (S/I/A/P/C):		00
Total			26
\$CW (Class work): It would include attendance, class test/quiz test/assignments, ppt, play, learn by fun activities etc.			


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Curriculum Structure											
For Session 2024-2025 onwards											
Name of the Program: Master of Botany						Semester: IV (Vasant)					
Year: Second											
Course Code	Course Title	Contact Hrs per Week			Credits		Weightage (%)			ETE	
					CWS	MTE					
		L	T	P							
Discipline Specific Core (DSC):											
24MBO9401T	Genetics	4	0	0	4	10	20	70			
Discipline Specific Elective (DSE): (Select any two)											
24MBO9402T	Plant Biochemistry and Metabolism	4	0	0	4	10	20	70			
24MBO9403T	Plant Biotechnology	4	0	0	4	10	20	70			
24MBO9404T	Morphogenesis & Experimental Biology	4	0	0	4	10	20	70			
24MBO9405T	Environmental Biology	4	0	0	4	10	20	70			
24MBO9406T	Plant Ecology and Resource Utilization	4	0	0	4	10	20	70			
24MBO9407T	Microbial Technology	4	0	0	4	10	20	70			
24MBO9408T	Bioinformatics and Biostatistics	4	0	0	4	10	20	70			
Value Added Course (VAC):											
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Seminar/Internship/Apprenticeship/Project/Community Outreach (S/I/A/P/C): (Select Any One)											
24MBO9401D	Dissertation	0	0	--	8	--	--	100			
24MBO9401V	Project	0	0	--	8	--	--	100			
24MBO9401S	Seminar	0	0	--	8	--	--	100			
	Total				20						

Vasant Semester IV

Summary: IV Semester (Vasant)			Credits
S.N.	Particulars		
1.	Discipline Specific Core (DSC):	04	
2.	Discipline Specific Elective (DSE):	08	
3.	Value Added Course (VAC):	00	
4.	Seminar/Internship/Apprenticeship/Project/Community Outreach (S/I/A/P/C):	08	
Total		20	
\$CW (Class work): It would include attendance, class test/quiz test/assignments, ppt, play, learn by fun activities etc.			


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Semester - I

Learning Objectives

To acquaint the students with the diversity, structural organization, reproduction and economic importance of Algae, Fungi and Bryophytes.

Learning Outcomes

Students will understand the morphology and organization of the thallus and their role in medicine, industry and food. Students will understand the interrelationship of algae and bryophytes.

Course Title:	Algae, Fungi and Bryophyta	Course Code: 24MBO9101T
Total Lecture hour	60	Hours
Unit I	Algae: Algae in diversified habitats (terrestrial, freshwater and marine), thallus organization, cell ultra-structure, reproduction (vegetative, asexual and sexual); Classification of algae: based on pigments, cell wall composition, reserved food material and flagellation. Salient features of cyanophyta, chlorophyta, bacillariophyta, xanthophyta, pyrophyta, phaeophyta and rhodophyta with special reference to <i>Spirulina</i> , <i>Anabaena</i> , <i>Oedogonium</i> , <i>Nitella</i> , <i>Pinnularia</i> , <i>Laminaria</i> and <i>Batrachospermum</i> .	15
Unit II	Economic importance of algae: specially in industries, food, fodder, Biofuels, biofertilizers and algal bloom, isolation and culture of algae.	
	Fungi: General characters, substrate relationship, cellstructure, thallus organization, cell wall composition, nutrition (saprobic, biotrophic and symbiotic), reproduction (asexual and sexual). Heterothallism, heterokaryosis, parasexuality, recent trends in classification of fungi.	15
Unit III	General account of mastigomycotina, zygomycotina, ascomycotina, basidiomycotina and deuteromycotina with special reference to <i>Rhizopus</i> , <i>Peronospora</i> , <i>Neurospora</i> , <i>Polyporus</i> , <i>Drechslera</i> and <i>Colletotrichum</i> . Economic importance of fungi in industries, medicines and as food, fungi as biocontrol agents, poisonous fungi, mycorrhizae.	15
Unit IV	Bryophyta: Distribution, classification, morphology, structure, and reproduction of bryophytes. General account of marchantiales, jungermanniales, anthocerotales, sphagnales, funariales and polytrichales with special reference to <i>Plagiochasma</i> , <i>Notothyas</i> , <i>Sphagnum</i> , and <i>Polytichum</i> . Economic importance of Bryophyta. Role of Bryophytes in plant succession. Fossil Bryophytes, evolutionary trends in Bryophytes.	15
Reference Books:		
1	Alexopoulos, C.J., Mims, C.W. and Blackwell, M. (1996). Introductory Mycology, John Wiley & Sons ind.	
2	Anderson, R.A. (2005) Algal Culturing Techniques. Physiological Society of America. Elsevier Academic Press, USA.	
3	Fritsch, F.E. (1993, 1945). The Structure and Reproduction of Algae Vol.I, II. Cambridge University Press, Cambridge, UK.	
4	Kashyap, S.R. (1932) Liverworts of Western Himalayas and Punjab Plains (VII. I & II) Research coPublications, New Delhi.	
5	Richardson, D.H.S. Biology of Mosses. (1981). Blackwell Scientific Publications, Oxford.	
6	Bold, H. C., Alexopoulos, C.J. and Delevoryas. T. (1980): Morphology of plant and fungi (4th Ed.) Harper & Foul Co., New Work.	
7	Ghenawat, M.S., Kapoor J.N., and Narayana, H.S. (1976): A text book of Algae. Ramesh Book Depot, Jaipur.	
8	Gilbert, M Smith. Cryptogamic Botany, Vol. I & II (2nd Ed.) (1985). Tata McGraw Hill. Publishing Co. Ltd., New Delhi. 11. Puri, V. Bryophytes. (1985). Atmaram & sons. Delhi, Lucknow.	

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9	Sharma, P.D.(1996). Introduction to Bryophytes. Ramesh Book Depot, Jaipur.
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Learning Objectives

The objective of this course is to familiarize students with the basic concepts and applications of modern techniques used in Cell and Molecular Biology.

Learning Outcomes

Upon completion of the course, students should be able to:

- Understand the fundamental principles of cell biology.
- Explain the structure and functions of cell organelles involved in diverse cellular processes.
- Understand the basic concept of cell cycle
- Understand cell signaling and processes of cell death and cellular aging.
- Know nuclear organization, DNA structure, replication and repair, transcription, translation, gene expression and gene regulation.

Course Title:	Cell and Molecular Biology	Course Code: 24MBO9102T
Total Lecture hour 60		Hours
Unit I	Cell structure and function: Cell structure in eukaryotes and prokaryotes, cell organelles and their ultra-structure, functions, cytoskeleton, cytoplasmic streaming, Cell membranes: membrane dynamics and solute transport across membranes. Nucleus: Structure, nuclear pores, nucleosome organization, DNA structure, A, B & Z forms. Structural organization of chromosomes: Organization of chromatin – nucleosome model, euchromatin and heterochromatin, constitutive and facultative heterochromatin, special type of chromosomes, karyotype analysis, repetitive and non-repetitive DNA, C-value paradox, structure and organization of telomere, centromere and kinetochore.	15
Unit II	Cell division and cell cycle: Mitosis and meiosis, their regulation, steps in cell cycle, regulation and control of cell cycle). Cell signaling: Cell signaling Hormones and their receptors, cell surface receptors, second messengers, signaling through G-protein coupled receptors, signal transduction pathways (Cyclic AMP, phospholipase C, Ca^{2+}/Calmodulin & Receptor Tyrosine Kinase pathway), regulation of signaling pathways, bacterial and plant two-component signaling systems, bacterial chemotaxis and quorum sensing. Cellular communication: general principles of cell communication, cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix, integrins. Apoptosis (Programmed cell death): Mechanism of apoptosis, Apoptosis triggered by internal & external pathways, Apoptosis-inducing factors, cancer, oncogenesis.	15
Unit III	Gene Structure: - Organization and Structure of prokaryotic and eukaryotic genes; structure and role of promoters, exons, introns, terminators and enhancers. DNA Replication: - Mechanism of prokaryotic and eukaryotic DNA replication, replication apparatus, Origins of replication, priming and DNA polymerases. Rolling circle. DNA damage and repair: - Types of DNA damage, enzymes involving in repairing of DNA, excision repair, mismatch repair systems. Transcription: - RNA polymerases and their role, Transcription apparatus, Transcription in prokaryotes and eukaryotes, Initiation, elongation and termination, RNA processing, reverse transcription and cDNA synthesis, Ribonucleoproteins, Structure of mRNA.	15
Unit IV	Regulation of gene expression in prokaryotes: Basic models: Lac, arabinose and Trp operons. Positive and negative controls. Regulation in viruses: Lytic and lysogenic cycle.	15

	Regulation of gene expression in Eukaryotes: Regulation at the chromatin level, Epigenetic changes at the chromosome level, genome imprinting, transcriptional gene regulation, epigenetic mechanisms of transcriptional gene regulation, regulation by cis-acting control elements, alternative promoters, trans-acting factors, transcriptional activator proteins, enhancers, silencers, post-transcriptional gene regulation including alternative splicing, RNA editing, RNA interference, Riboswitches, RNA stability, the role of RNA-decaying factors in gene regulation, translational regulation, posttranslational control, protein processing, proteasome complex and protein degradation.
Reference Books:	
1	Krishnamurthy, K.V. (2000). Methods in Cell Wall Cytochemistry. CRC Press, Boca Raton, Florida.
2	Reeve, ECR. (2001). Encyclopaedia of Genetics, F. D. Publication, Chicago, USA
3	De, DN. (2000). Plant Cell. Vacuoles: An Introduction. CSIRO Publication, Collingwood, Australia.
4	De Robertis, E.D.P. and De Robertis, E.M.F. (2006). Cell and Molecular Biology. (VIII Edition). Lippincott Williams and Wilkins, Philadelphia.
5	Cooper, G.M. and Hausman, R.E. (2009). The Cell: A Molecular Approach. (V Edition). ASM 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. (VI Edition). Pearson Benjamin Cummings Publishing, San Francisco.
7	Kleinsmith, L.J. and Kish, V.M. (1995). Principles of Cell and Molecular Biology (2 nd Edition). Harper Collins College Publishers, New York, USA.
8	Harris, N. and Oparka, K.J. (1994). Plant Cell Biology: A Practical Approach. IRL Press, at Oxford University Press, Oxford, U.K.
9	Gunning, B.E.S. and Steer, M. W. (1996). Plant Cell Biology: Structure and Function. Jones and Bartlett Publishers. Boston, Massachusetts.
10	Karp, G. (2010). Cell and Molecular Biology: Concepts and Experiments. VI Edition. John Wiley & Sons Inc.
11	Griffiths, A.J.P. et. al. (2000). An introduction to genetic analysis, W.H. Freeman and Company, New York, USA. Hall, J. L. and Moore, A.L. (1983), Isolation of Membranes and Organelles from Plant Cells Academic Press, London, UK.
12	Roy, S.C. and De, KK, (1999), Cell Biology, New Central Book Agency (P) Ltd., Calcutta.
13	Hartl, D. L. (1994). Genetics, Jones and Bartlett Publishers International, USA.
14	Power C.8., 1984, Cell Biology, Himalaya Publishing Co. Mumbai.
15	Sinnott, L.C. Dunn, Dobzhansky, Principles of Genetics McGraw-Hill.
16	Gupta, P. K. Genetics, Rastogi Publication, Meerut, India
17	James D. Watson, Tania A. Baker, Stephen P. Bell & Alexander Gann 2013. Molecular Biology of the Gene 7th Edition, Benjamin Cummings, San Francisco, California, USA.
18	Burton E. Tropp 2012. Molecular Biology: Genes to Proteins. 4th Edition, Jones & Bartlett, Burlington, USA.
19	Jocelyn E. Krebs, Elliott S. Goldstein & Stephen T. Kilpatrick 2012. Lewin's GENES XI. Jones & Bartlett, Burlington, USA.
20	Robert F. Weaver 2011. Molecular Biology 5th Edition, McGraw-Hill, NY, USA. Michael M. Cox, Jennifer Doudna & Michael O'Donnell 2011. Molecular Biology: Principles and Practice. W. H. Freeman, NY, USA.
21	Nancy Craig, Orna Cohen-Fix, Rachel Green and Carol Greider 2010. Molecular Biology: Principles of Genome Function. Oxford University Press, USA.

Learning Objectives
The paper aims to enhance the knowledge of students on the diversity of microorganisms and plant diseases.

Learning Outcomes

- Apply the knowledge on ecological and environmental significance of microbes for the benefit of the society.
- Identify and suggest measures for the prevention and control of diseases in crop plants.

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7	SubbaRao NS (1982) Advances in Agriculture Microbiology, Butterworth-Heinemann.
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Course Title:	Botany Practical	Course Code: 24MBO9104P
1	Algae & Fungi:- Morphological study of representative members of algae, fungi and bryophytes present in your locality in their natural habitat with special reference to: Algae: <i>Microcystis, Spirulina, Scytonema, Rivularia, Dunaliella, Aulosira, Spirogyra, Pediastrum, Hydrodictyon, Ulva, Pithophora, Stigeoclonium, Gelidium</i> and <i>Batrachospermum</i>: Isolation and culture of algae. Fungi: <i>Siemonites, Peronospora, Pythium, Albigo, Rhizopus, Pilobolus, Yeast, Chaetomium, Pleospora, Morchella, Melamsora, Phallus, Polyporus, Drechslera, Curvularia, Phoma, Penicillium, Aspergillus, Colletotrichum, Fusarium</i> and <i>Alternaria</i>: Isolation and culture of fungi using moistened blotters, PDA and Sabouraud's Dextrose Agar media.	
2		
3	1. Cytological techniques: Preparation of cytological stains, fixation of sample etc. 2. Study of size and shape of the cell 3. Study of cyclosis in Tradescantia staminal hairs. 4. Study of cell structure from onion leaf peels; demonstration of staining and mounting methods. 5. Comparative study of cell structure in onion cells, Hydrilla and spirogyra. 6. EM study of cell organelles 7. Fluorescence staining with FDA for cell viability. 8. Cell wall staining with calcofluor white 9. Study of stages in cell cycle 10. To study the mitosis by Squash technique of onion root tip 11. To study meiosis by smear technique 12. Demonstration of salivary gland chromosomes from Chironomus larva by Aceto orcein technique. 13. Isolation of chloroplast 14. Isolation of mitochondria 15. Histochemical localization of protein, carbohydrate, fats, starch, lignin 16. Demonstration of SEM and TEM. 17. Hardy-Weinberg numerical 18. Karyotype analysis: preparation of ideogram 19. Preparation of Reagents and Buffers for plant DNA isolation. 20. Gel electrophoresis to see the isolated plant DNA. 21. Plant RNA isolation 22. Gel electrophoresis to see the isolated plant RNA. 23. Quantification of DNA/RNA Any other practical based on the theory syllabus.	
4	Principles and use of different sterilization instruments like autoclave, oven, Laminar air flow system etc. Culture media for microorganisms Preparation of media (Potato Dextrose Agar). Isolation of fungi from soil. Identification of fungal isolates. Preparation of Nutrient Agar (NA) media.	

	Isolation of bacteria from water. Isolation of microbes from soil through serial dilution and streak plate method. Characterization of bacterial isolate by Gram's staining – curd, root nodule Counting of fungal spore by haemocytometer. Growth curve of bacteria Virus indexing Submit herbarium preparations of three plant diseases occurring in your area. Any other practical based on theory.
5	Study of the following diseases: • Wheat Karnal bunt. • Tikka disease of Groundnut • Crown gall of stone fruits • Black rot of Crucifer • Cadang-Cadang disease of Coconut • Sandle spike • Root Knot of Brinjal • Ear Cockle of Wheat
6	Visit to local area and study of observed lower plants.

Learning Objectives:

The course focuses on modern evolutionary theory in relation to the origins and dynamics of genetic diversity in time and space, reproductive isolation and evolutionary relationships among organismal groups. This also deals with phytogeography which includes principles of continental drift, theory of tolerance and endemism as well as local vegetations of different phytogeographical divisions of India.

Learning outcomes:

By the end of this course, students should be able to:

- Explain basic principles of Darwinian evolution.
- Understand the mechanisms of speciation and diversification.
- Understand the principles of population genetics, including selection, genetic drift, mutation, linkage, and gene flow.
- Know the processes that influence the distribution of plants across biomes, ecosystems, communities, and populations.
- Learn about phytogeographic realms, vegetation types of India and phytogeographical concepts.
- Develop an understanding of the factors that influence patterns of abundance and distribution in populations.

Course Title:	Evolutionary Biology and Phytogeography	Course Code: 24MBO9105T
Total Lecture hour 60		
Unit I	Evolution:Theories of origin of Universe, origin of Earth and origin of life; Development of Evolutionary Thoughts: Lamarckism Neolamarkism, Darwin's concepts of variation, adaptation, struggle, fitness and natural selection; evolution of prokaryotes, origin and evolution of eukaryotes, origin and development of major group of organisms in geological time scale, molecular evolution. Origin of cells and unicellular evolution: Origin of basic biological molecules; Abiotic synthesis of organic monomers and polymers, Concept of Oparin and Haldane; Experiment	Hours 15

Unit II	of Miller (1953); The first cell; Evolution of prokaryotes; Origin of eukaryotic cells; Evolution of unicellular eukaryotes.	
	Paleontology and Evolutionary History: The evolutionary time scale; Eras, periods and epoch; Major events in the evolutionary time scale; Origins of unicellular and multi-cellular organisms; Major groups of plants and animals. Population genetics – Populations, Gene pool, Gene frequency; Hardy-Weinberg Law; concepts and rate of change in gene frequency through natural selection, migration and random genetic drift; Adaptive radiation; Isolating mechanisms; Speciation; Allopatricity and Sympatricity; Convergent evolution; Sexual selection; Co-evolution.	15
Unit III	Phytogeography: Static and Dynamic, Principles of Plant Geography- Origin of Islands and Continents. Plant tectonics and Continental drifts. Plant distribution concept, Theory of tolerance, Theory of endemism; Patterns: Cosmopolitan, pantropical, continuous, discontinuous, endemic distribution; Factors affecting distribution, Age and Area hypothesis; Plant migration and barriers for plant migration. Center of origin of cultivated plants: Vavilov centers and Zhukoskycenters with plants in each region. Plant indicators. Cladistics: Introduction; advantages and problems. Cladistics (Phylogeny) concepts, parsimony, cladograms and trees; characters: apomorphic and plesiomorphic characters, homologous vs analogous; character states, binary and multistate characters.	15
Unit IV	Phytogeographical domains of World; Brief description of major terrestrial biomes. Phytogeographical division of India: Western Himalaya, Eastern Himalaya, Indus plane, Gangetic sub-mountain zone, Temperate zone, Alpine zone. Vegetation and floristics regions of India. Native taxa, naturalization of exotic taxa. Endemism; Concept of hotspots, hot spots of the world. Forest types of India. Climate, Vegetation and floristics of Rajasthan. Introduction to GPRS and Remote sensing (basics only).	15
Reference Books:		
1	Walter's Vegetation of the Earth: Ecological Systems of the Geo-Biosphere (4th Edition) by Heinrich Walter, Siegmund-Walter Breckle. Paperback - October 2002.	
2	Plant geography by George Simonds Boulger (Jan 1, 1912)	
3	Edible Wild Plants of the Prairie: An Ethnobotanical Guide by Kelly Kindscher (1987)	
4	Advanced Plant Geography Author: Shiv Manikant Dube. 2011 Swastik Publications.	
5	Textbook of the Plant Geography of India. by F.R. Bharucha	
6	Cain, S. A. (1944): Foundations of Plant Geography Harper & Brothers, N.Y.	
7	Mani, M.S (1974): Ecology & Biogeography of India Dr. W. Junk Publishers, The Hague	
8	Good, R. (1997): The Geography of flowering Plants (2nd Ed.) Longmans, Green & Co., Inc., London & Allied Science Publishers, New Delhi.	
9	Douglas, J. Futuyma. Evolutionary Biology. Sinauer Publications.	
10	Smith, J.M. Evolutionary Genetics. Oxford University Press. 1998. Print	
11	Minkoff, J.C. 1983. Evolutionary Biology. Addison Wesley Publishing Company. 1983. Print.	
12	Dobzhansky, T. Evolutionary Biology. Appleton – Century – Crofts, Educational Division/Meredith Corporation, New York.	
13	Ayala, F.J. & Valentine, J.W. Evolving the theory of organic evolution. The Benjamin Cumming Publishing Company, Menlo Park, California. Lull. 1979. Print.	
14	R.S. Organic Evolution. Light and Life Publishers, New Delhi. 1976. Print.	
15	Kathy Willis, Jennifer McElwain. The Evolution of Plants, Oxford University Press.2016. Print.	
16	Kenrick, Paul, and Peter R. Crane. "The origin and early evolution of plants on land." Nature 389.6646 (1997): 33-39.	

Learning Objectives

The course aims to provide instruction in the general principles of food microbiology, understand food spoilage microorganisms, the microbiology of food preservation and fermented foods. This course will enable students to apply the learning of microbiology concepts towards the exploitation of microbial populations for industrial, environmental and sustainable agriculture.

Learning Outcomes:

After completion of the course, students will be able to understand:

- Microbial enzymes of industrial interest, microbial metabolites, wine production, food spoilage and preservation, production of dairy products (fermented milk and cheese),
- Role of microbes in agriculture (biofertilizers, biocontrol agent) and waste water treatment.
- Role of microbes in environment and archaeology
- Mycorrhizal fungi in bioremediation and sustainable agriculture.

Course Title:	Applied Microbiology	Course Code: 24MBO9016T
Total Lecture hour 60		
Unit I	Food and Dairy Microbiology: Microbial spoilage of food products including cereals, fruits, vegetables, meat, fish, and dairy products, Factors influencing microbial growth in foods - extrinsic and intrinsic, Principles of food preservation, Food preservatives and their uses, Fermented food, wine, bakery products, cereals, and milk products, Bacteriocins and their application in food preservative (Nisin, Lactococcuslactis), food additives. Nutritional value of fermented foods. Microbiological examination of milk and milk products, source of their contamination and control.	15
Unit II	Applications of Microbes in Waste Treatment: Solid waste treatment (Landfills, incineration, composting, anaerobic digestion and pyrolysis). Waste water treatment: Pretreatment, primary, secondary (activated sludge, surface aerated basins, fluidized bed reactors, trickling filter, biotower, rotating biological contactors, membrane bioreactors and secondary sedimentation) and tertiary treatment, disinfection and odour control; Application of biofilm in waste water treatment. Microorganisms as indicators of water quality.	15
Unit III	Role of Microbes in Environment: Biodegradation of recalcitrant compounds - Pesticides, Petroleum, Polychlorinated biphenyls and other organopollutants; Lignin degradation: Lignocellulolytic microorganisms, enzymes and their applications in: Biopulping, Biobleaching, Textiles, Biofuels, Animal feed production. Bioremediation: In situ & <i>Ex situ</i> remediation, Concept of bioremediation technologies, Microbial consortium, Microbial remediation of oil spills, paper and pulp mill effluents and textile effluents; Biostimulation and Bioaugmentation. Bioaccumulation of metals and detoxification. Genetically Modified Organisms released and its environmental impact assessment.	15
Unit IV	Microbes in archaeology: Microorganisms deteriorating objects, glasses, ceramics, wood, paper, leather, textiles, metal surfaces and stone monuments. Methods of control of microbes for preservation of archaeological objects. Biobleaching of copper, gold and uranium from ore by microbes. Biofertilizers for sustainable agriculture: <i>Rhizobium</i> , <i>Azospirillum</i> , <i>Azotobacter</i> , <i>Azolla</i> , BGA - mass production methods, application methods of biofertilizers, significance of biofertilizers. Mycorrhizal fungi: Diversity of endo and ectomycorrhizal fungi, role in bioremediation of soil. Fungal endophytes as biocontrol agents.	15
Reference Books:		
1	Alexander, M. Microbial ecology. John Wiley and Sons, New York.	
2	Singh, B.D. Biotechnology, Kalyani Publishers, New Delhi	
3	Agrios, G.N. 1999. Plant Pathology. Academic Press	

4	Kale, V. and Bhusari, K. Applied Microbiology, Himalaya Publishing House.
5	Griffiths, A.J.F., J.H. Miller, Suzuki, D.T., Lewontin, R.C. and Gelbart, W.M. (2009). An Introduction to Genetic Analysis. IX Edition. Freeman and Co., N.Y., USA
6	Eldowney, S. and Waites, S. Pollution: Ecology and biotreatment. Longman, Harlow.
7	Madigan, M.T., Martinko, J.M. and Parker, J. Brock biology of microorganisms. Prentice Hall, New Jersey.
8	Mitchell, R. and Gu, J.D. Environmental microbiology. Wiley-Black well, New Jersey.
9	Evans, G.M. and John, J.C.F. Environmental biotechnology: Theory and applications. John Wiley and Sons, New York.
10	Waste Water Microbiology 2 nd Edition by Bitton.
11	Satyanarayana, T., Johri, B.N. and Prakash, A. Microorganisms in environmental management: Microbes and environment. Springer Verlag, New York.
12	Adams M.R. and Moss M.O: Food microbiology: Royal society of chemistry.
13	Dennis Allsopp and Seal, K.J. 1986. Introduction to Biodeterioration. E Edward Arnold Ltd
14	Cappucino, J. and Sherman, N. Microbiology: A laboratory manual. Benjamin Cummings Publishing Company, San Francisco.
15	Prescott, L.M. and Harley, J.P. Laboratory exercises in microbiology. McGraw-Hill, New York.
16	Singer, S. Experiments in applied microbiology. Academic Press, New York.
17	Pepper, I.L, Gerba, C.P. and Brendecke, J.W. Environmental microbiology: A laboratory manual. Academic Press, San Diego

Semester – II

Learning Objectives

- A basic understanding of how to pursue research.
- A basic understanding of how to learn mathematics.
- A basic understanding of set theory.
- A basic understanding of the software that supports the mathematical research.

Learning Outcomes

- After completion of this course, students will be able to
- Understand mathematics more efficiently and clearly.
 - Understand how to write a basic mathematics article.
 - Make students analyze a given fact or concept and how to reach a concept.
 - Make students curious enough to read the most recent trends in mathematics.
 - Understand the basic ideas of how to write an algorithm and related ideas.
 - Understand the effective use of open-source software to write mathematical articles.

Course Title:	Research Methodology	Course Code: 24MBO9201T
Total Lecture hour 60		Hours
Unit I	Nature of Scientific Inquiry- Scientific Methods- Induction- Deduction Hypothesis and Theory and their Interpretation-Nature and Scope of Social Research for Multi-Disciplinary Inter-Disciplinary Approach in Commerce. Planning of Research- Selection of a Problem for Research-Sample design-Census and Sample Surveys-	15

Unit II	Sampling Techniques- Sample size. Research Design- Important Aspects of Research Design. Methods of Data Collection- Sources of data Use of secondary data- Methods of collecting primary data- Observation- Interviews- Questionnaires and Schedules.	15
Unit III	Processing and Analysis of Data: Processing Operations-Types of Analysis- Presentation and Interpretation of Data-Editing, Classification and Tabulation- Interpretation. Preparation of a Report- Types of Report- Research Report- Format- Principles of Writing Reports- Documentation- Footnotes and Bibliography	15
Unit IV	Quantitative Tools- Measures of Central Tendency- Dispersion- Measures of Correlation- Simple and Multiple Correlation-testing of Hypothesis-Tests based on t-P, Z, and Chisquare-Time Series Analysis-Trend Measurement-Moving Averages	15
Reference Books:		
1	Shrivastava, S.C.: Foundation of Social Research and Economics Techniques, Himalaya Publishing House, 1990.	
2	Sharma H.D. and Mukherji S.P.: Research Methods in Economics and Business, New York: The Macmillan Company, 1992.	
3	Gerber R. and Verdoom, P.J. :Research Methods in Economics and Business, New York, The Macmillan Company, 1992.	
4	Krishna swami O.R.: Methodology of Research in Social Sciences, Himalaya Publishing House, 1993.	
5	Menden HYall and Varacity: Reinmuth J.E.: Statistics for Management and Economics (2 nd Edition), 1982.	
6	Courtis J.K. (ed.) Research and Methodology in Accounting & Financial Management, 1980.	

Learning Objectives

- This course will help the student understand the diversity of early land plants and the evolutionary process in plant kingdoms.

Learning Outcomes

Students will get in-depth knowledge of:

- The plant diversity (esp. In pteridophytes, and gymnosperms) and understanding the evolutionary trends through the study of palaeobotany.
- The evolutionary diversification of early land plants and morphological and reproductive innovations in pteridophytes and gymnosperms.

Course Title:	Pteridophytes, Gymnosperms and Palaeobotany	Course Code: 24MBO9202T
Total Lecture hour 60		Hours
Unit I	Pteridophytes: Classification of Pteridophytes, origin and evolution of stele, telome concept, apogamy and apospory, heterospory and seed habits in Pteridophytes. Economic importance of Pteridophytes. General account of fossil Pteridophytes, Psilopsida, Lycopsidea, Sphenopsida and Pteropsida classes.	15
Unit II	Morphology, anatomy, reproduction, classification, life history of: <i>Lycopodium</i> , <i>Gleichenia</i> , <i>Isoetes</i> , <i>Ophioglossum</i> and <i>Azolla</i> . Origin and evolution of stele, heterospory and seed habit.	15
Unit III	Gymnosperms: Distribution, morphology, anatomy, reproduction; classification, life history and evolution. Cycadales (<i>Zamia</i>), Ginkgoales (<i>Ginkgo</i>), Coniferales (<i>Pinus</i> , <i>Taxus</i> , <i>Araucaria</i>), Welwitschiales (<i>Welwitschia</i>), Gnetales (<i>Gnetum</i>).	15
Unit IV	Paleobotany: History of paleobotany, formation and types of fossils, techniques of study of fossils, Geological time scale. Brief account of Pteridospermales (<i>Lygenopteris</i> , <i>Caytonia</i> and <i>Glossopteris</i>). Brief account of Cycadeoidales (<i>Cycadeoidea</i>), Cordaitales (<i>Cordaites</i>). Palaeobotany and the evolution of vascular plants. Applied aspects of paleobotany, use in coal and petroleum exploration.	15

Reference Books:

1. Parihar, N.S. 1996. *Biology & Morphology of Pteridophytes*. Central Book Depot, Allahabad.
2. Sporne, K.K. 1991. *The Morphology of Pteridophytes*. B.I. Publishing Pvt. Ltd., Bombay.
3. Stewart, W.N. and Rathwell, G.W. 1993. *Paleobotany and the Evolution of Plants*. Cambridge University Press, UK.
4. Bhatnagar, S.P. and Mohitra, A. 1996. *Gymnosperms*. New Age International Pvt. Ltd., New Delhi.
5. Singh, H. 1978. *Embryology of Gymnosperms*. Encyclopaedia of Plant Anatomy X. Gebruder Borntraeger, Berlin, Germany.
6. Smith, G.M. 1955. *Cryptogamic Botany Vol II* Tata McGraw Hill Book Co, NY.
7. Pandey, B.P. 1993. *College Botany. Vol. II*. S. Chand and Company Ltd., New Delhi.
8. Arnold, Chester, A. 2000. *An Introduction to Paleobotany*. Agrobios, (India).
9. Rashid, A. 2001. *An introduction to Pteridophyta (II edition)*. Vikas Publishing House, Pvt. Ltd., New Delhi.
10. Sunderrajan S. 2007. *Introduction to Pteridophyta*, New Age International Publishers, New Delhi.

Learning Objectives:

Aim of the course is to educate students regarding differentiation of meristematic tissues, developmental biology, reproductive biology and economic botany of the flowering plants.

Learning Outcomes:

After studying of the course, students will be able to understand:

- Deals with naming and classification of plants their interrelationships and evolution.
- Highlights the strategies adopted by flowering plants for their reproduction.
- Deals with recent developments in plant systematics and phylogenetics.
- Know the techniques of herbaria preparation.
- Know the methods of morphological characterization of different families and field collection and documentation

Course Title:	Plant Morphology and Developmental Anatomy	Course Code: 24MBO9203T
Total Lecture hour 60		
Unit I	Introduction: Unique features of plant development, differences between animal and plant development. Seed germination and seedling growth: Metabolism of proteins and mobilization of food reserves, tropisms during seed germination and seedling growth, hormonal control of seedling growth, gene expression, use of mutants in understanding seedling development.	Hours 15
Unit II	Shoot development: Organization of the shoot apical meristem (SAM). cytological and molecular analysis of SAM, control of cell division and cell-to-cell communication, Stem cell in plants, Primary and Secondary tissue differentiation, control of tissue differentiation, especially xylem and phloem, secretory ducts and laticifers, wood development in relation to environmental factors.	15
Unit III	Leaf growth and differentiation: Inception, phyllotaxy, control of leaf form (leaf meristems and other factors), differentiation of epidermis (with special reference to stomata and trichomes) and mesophyll, Kranz anatomy, Leaf traces and leaf gaps, transfer cells.	15
Unit IV	Root development: Organization of root apical meristem (RAM), vascular tissue differentiation, lateral roots, root hairs, root-microbe interactions. Seed coat development: External and internal morphology of seed, seed appendages, ontogeny of seed coat in various families, mature structure, spermoderm patterns.	15
Reference Books:		
J. Atwell, B.J.Kriedermann, P.E. and Jumbull, C.G.N. (eds). 1999. <i>Plants in Action: Adaption in Nature Performance, in Cultivation</i> , MacMillan Education. Sydney, Australia		

2. Bewley, J.D. and Black, M. 1994. Seeds: Physiology of Development and Germination, Plenum Press, New York.
3. Burgess, J. 1985. An Introduction to Plant Cell Development. Cambridge University Press, Cambridge.
4. Fahn, A. 1982. Plant Anatomy. (3rd edition). Pergamon Press, Oxford. New York.
5. Raven, P.H., Evert, R.F. and Eichhorn, S. 1992. Biology of Plants (5th edition). Worth, New York.
6. Salisbury, P.B. and Ross, C. W. 1992. Plant Physiology (4th edition). Wadsworth Publishing, Belmont, California.
7. Steeves, T.A. and Sussex, I.M., 1989. Patterns in Plant Development (2nd edition) Cambridge University Press, Cambridge.
8. Waisel, Y., Eshel, A. and Kafkaki, U. (eds.). 1996. Plant Roots: The Hidden Hall (2nd edition). Marcel Dekker, New York.

Course Title:	Botany Laboratory	Course Code: 24MB09204P
1	Suggested Laboratory Exercises: Morphological and anatomical study of representative members of Pteridophytes in their natural habitat found in your locality with special reference to: <i>Lycopodium</i> , <i>Isoetes</i> , <i>Gleichenia</i> , <i>Ophioglossum</i> and <i>Azolla</i> in Pteridophytes.	
2	Morphological and anatomical study of representative members of Gymnosperms in their natural habitat found in your locality with special reference to: <i>Zamia</i> , <i>Ginkgo</i> , <i>Pinus</i> , <i>Taxus</i> , <i>Araucaria</i> and <i>Gnetum</i> in Gymnosperms. Collection and study of fossils.	
3	1. Study of living shoot apices by dissections using plants such as <i>Tabernaemontana</i> , <i>Albizia</i> . 2. Study of cytohistological zonation in the shoot apical meristem (SAM) in sectioned and double-stained permanent slides of a suitable plant. Examination of shoot apices in monocolytedon in both T.S. and L.S. to show the origin and arrangement of leaf primordia. 3. Study of alternate and distichous, alternate and superposed, opposite and superposed, opposite and decussate leaf arrangement. Examination of rosette plants (<i>Launaea</i> , <i>Mollugo</i> , <i>Raphanus</i> , <i>Hyoscyamus</i> etc.) and induction of bolting under natural conditions as well as by GA treatment. 4. Microscopic examination of vertical sections of leaves such as <i>Eucalyptus</i> , <i>Ficus</i> , <i>Mango</i> , <i>Nerium</i> , maize, grass and wheat to understand the internal structure of leaf tissues and trichomes, glands etc. Also study the leaf anatomy C3 and C4 of plants. 5. Study of epidermal peels of leaves such as <i>Coccinia</i> , <i>Tradescantia</i> etc. to study the development and final structure of stomata and prepare the stomatal index.	
4	6. Study of types of stomata in plants belonging to different families. 7. Study of whole roots in monocots and dicots. 8. Examination of L.S. of root from a permanent preparation to understand the organization of root apical meristem and its derivatives. (use maize, aerial roots of banyan etc.) 9. Study of lateral root development. 10. Study of leguminous roots with different types of nodules. 11. Study of primary and secondary tissue differentiation in roots and shoots. 12. Study of seed coat types- <i>Pisum</i> , <i>Cucurbita</i> , wheat. 13. Study of vascular tissues by clearing technique.	
5	Visit to local area and study of observed Higher plants.	

Learning Objectives

The main objectives of this course are

- To introduce basic concept and scope of ethnobotany
- To introduce students to complementary and alternative medicine
- To explore uses of plants as medicine ranging from traditional indigenous approaches for treating ailments to modern pharmaceuticals

- To inculcate awareness about rare and threatened taxa

Learning Outcomes

After studying this course, the students will:

1. Know concept of ethnobotany
2. Understand the lifestyle and traditional practices of plants by tribals
3. Investigate the various collection methods for ethnobotanical knowledge of tribals.
4. Understand the utility of plants as medicines
5. Build ideas to make digitization of ethnobotanical knowledge
6. Know about RET taxa

Course Title:		Ethnobotany	Course Code: 24MBO9205T
Total Lecture hour 60			Hours
Unit I	Ethnobotany: Introduction, concept, scope and objectives; Ethnobotany as an interdisciplinary science. Classification, International and National Contributions (J. W. Harshberger, R. E. Schultes, E. K. Janakiammal, S. K. Jain, K. S. Manilal, V. V. Sivarajan & P. Pushpangadan). Centres of Ethnobotanical Studies in India, AICRPE-All India Coordinated Research Project on Ethnobiology, FRLHT- Foundation for the Revitalisation of Local Health Traditions. Contributions of AICRPE and FRLHT to ethnobiology of India. Importance of ethnobotany in Indian systems of medicine (Siddha, Ayurveda and Unani), Role of AYUSH, NMPB, CIMAP. Impact of Ethnobotany in herbal-medicine industry, land-use development, agriculture, forestry, betterment of rural livelihoods and education.		15
Unit II	Methods and techniques in ethnobotany: Field work: Prior informed consent (PIC), PRA techniques, interviews and questionnaire methods, choice of resource persons, a few statistical tools for data analysis; documentation of the ethnobotanical knowledge. Collection of ethnobotanical data from other sources: a) Herbarium b) Ancient Literature c) Archaeological findings d) temples and sacred places. Ethnomedicinal plants: Medico-ethnobotanical sources in India; Significance of the following plants in ethno botanical practices (along with their general description, habitat and morphology of the parts used): <i>Azadirachta indica</i>, <i>Ocimum sanctum</i>, <i>Vitex negundo</i>, <i>Gloriosa superba</i>, <i>Tribulus terrestris</i>, <i>Cassia auriculata</i>, <i>Plantago ovata</i>, <i>Aegle marmelos</i> and <i>Tinospora cordifolia</i>.		15
Unit III	Ethnobotany and Bioprospecting: Role of ethnobotany in modern medicine with special examples <i>Rauvolfia serpentina</i>, <i>Artemisia annua</i>, <i>Withaniasomnifera</i>, <i>Commiphora wightii</i> and <i>Phyllanthus niruri</i>. Traditional Knowledge: Plants used by ethnic groups of Rajasthan as food, intoxicants, beverages, household materials, tattooing, musical instruments, magico-religious belief and for ethnoveterinary and ethnomedicinal purposes. NWFP (Non-Wood Forest Products), minerals, artefacts, and rituals, used by Tribal and Folk Communities of Rajasthan. Traditional indigenous knowledge and its importance. Ethnobotany and Ethnopharmacology as a tool to protect interests of ethnic groups and rural development.		15
Unit IV	Ethnobotany and legal aspects: Ethnobotany as a tool to protect interests of ethnic groups. Sharing of wealth concept with few examples from India, Biopiracy, Intellectual Property Rights, Issues pertaining to Traditional Knowledge Patent, Indian initiatives for Traditional Knowledge protection; Challenges in the promotion of alternative and complementary medicines. Ethno-conservation: Role of ethnic groups in conservation of plant genetic sources: rare, endangered and threatened (RET) taxa; Tribal people and forest management in Rajasthan (<i>Kesar chhanta</i>, Orans). <i>In situ</i> conservation: Biosphere reserves, National Parks, sacred groves; <i>Ex situ</i> conservation: Botanic Gardens, Ethnomedicinal plant Gardens. Role of Ethnobotany in conservation and sustainable development.		15

Reference Books:

1. Jain, S. K. (1981). Glimpses of Indian Ethnobotany. Oxford & IBH publishing Co. Pvt. Ltd., New Delhi
2. S.K. Jain, 1990. Contributions of Indian Ethnobotany. Scientific publishers, Jodhpur.
3. Jain, S. K. (1989). Methods and approaches in Ethnobotany. Society of Ethnobotanists, Lucknow.
4. Jain, S. K. (1995). A manual of Ethnobotany. Scientific Publishers, Jodhpur
5. Faulks, P.J. (1958). An introduction to Ethnobotany, Moredale Publ. London
6. Colton C.M. 1997. Ethnobotany – Principles and applications. John Wiley and sons –Chichester
7. Rama Rao, N and A.N. Henry (1996). The Ethnobotany of Eastern Ghats in A. P., India. Bot. Survey of India. Howrah.
8. Rajiv K. Sinha – Ethnobotany/The Renaissance of Traditional Herbal Medicine – INA –SHREE Publishers, Jaipur-1996
9. Herbal plants and Drugs Agnes Arber, 1999. Mangal Deep Publications.
10. Ayurvedic drugs and their plant source. V.V. Sivarajan and Balachandran Indra 1994. Oxford IBH pub. Co.
11. Ayurveda and Aromatherapy. Miller, Light and Miller, Bryan, 1998. Banarsidass, Delhi.
12. Principles of Ayurveda, Anne Green, 2000. Thomsons, London.
13. Pharmacognosy, Dr. C. K. Kokate et al. 1999. Nirali Prakashan.
14. Jose Boban K. (1998). Tribal Ethnomedicine: Continuity and change. APH publishing corporation 5, Ansari Road, Darya Ganj, New Delhi
15. Phytochemical Methods. Harborne JB. 1984. Chapman and Hall, London
16. P. C. Trivedi 7 N.K. Sharma, 2004. Ethnomedicinal Plants. Pointer Publishers

Learning Objective

This course is aimed to impart theoretical knowledge and practical skills about plant breeding objectives, modes of reproduction and genetic consequences, breeding methods for crop improvement.

Learning Outcomes

After completion of the course students will be able to understand:

- Objectives and scope of plant breeding.
- They will acquire knowledge of selection methods and other breeding practices.
- This course will help the students to understand a wholesome review on the fundamentals of plant breeding.

Course Title:	Principles of Plant Breeding		Course Code: 24MBO9206T
Total Lecture hour 60			
Unit I	Overview & Historical perspectives: History of Plant Breeding-the pioneers, their theories and plant breeding techniques. Reproductive systems: Importance of Mode of Reproduction, Types of Reproduction, Autogamy, Haploids and double haploids; their application in plant breeding, Allogamy, Inbreeding depression, hybrid vigour, Hybridization, wide crosses, clonal propagation and In vitro culture. Germplasm for Breeding: Variation-Types, origin and scale, Plant Domestication- Centres & Models, Plant Genetic resources -Importance & Sources of Germplasm, Concept of Gene pools, Crop vulnerability, Germplasm conservation: <i>In situ</i> & <i>Ex situ</i>, Types of Germplasm collection, Germplasm storage technologies, Plant explorations & Introductions & their impact on agriculture. Selection Methods: Breeding -self-pollinated species- Mass selection, pure line selection, Pedigree selection & Bulk population; cross-pollinated species -hybrid cultivars and clonally propagated species.	Hours	15
Unit II			15
Unit III	Breeding Objectives: Yield and morphological trait- Yield potential, Harvest Index, breeding for lodging resistance, shattering resistance, plant stature & early maturity; Quality traits- breeding for improved protein content, improved fatty acid content, seedlessness in fruits, delayed ripening & novel traits, Breeding for resistance to disease & insect pests - Resistance Breeding strategies;		15

Unit IV	Abiotic Stresses -Breeding for drought resistance, cold tolerance, salt tolerance, heat stress, aluminium toxicity, Oxidative stress, resistance to water logging.
	Molecular Breeding: Molecular markers- classification, Mapping of Genes- gene maps & QTL mapping, Marker assisted selection, Mutagenesis and Polyploidy in Plant Breeding. Marketing and Societal issues in Breeding: Performance and Evaluation for crop cultivar release, Seed certification and commercial seed release, Regulatory and Legal issues, Value driven concepts and social concerns, International Plant breeding Efforts. Plant cultivar protection, legislation, patenting and transgenics.
	15
Reference Books:	
1. George Acquaah.2012 Principles of Plant Genetics and Breeding. Wiley-Blackwell.	
2. B.D.singh and A.K.Singh.2015.Marker Assisted Plant Breeding Springer.	
3. B.D.singh .2015.Plant Breeding principles & Methods .Kalyani Publishers.	
4. Jack Brown, Peter Caligari and Hugo campos. 2014. An Introduction to Plant Breeding. Wiley.	
5. B rown and Caligari, 2008.An Introduction to Plant Breeding.Blackwell Publishing.	
6. Chopra VL. 2001. Breeding Field Crops. Oxford & IBH.	
7. Chopra VL. 2004. Plant Breeding. Oxford & IBH.	
8. Gupta SK. 2005. Practical Plant Breeding. Agribios. Jodhpur	
9. Roy D. 2003. Plant Breeding, Analysis and Exploitation of variation. Narosa Publ. House.	
10. Sharma JR. 2001. Principles and Practice of Plant Breeding. Tata McGraw-Hill.	
11. Simmonds NW. 1990. Principles of Crop Improvement. English Language Book Society.	
12. Dana, Sukumar. 2001. Plant Breeding. Naya Udyog, Calcutta. 700 006	
13. Kucku, Kobabe and Wenzel (1995). Fundamentals of Plant Breeding. Narosa Publishing House.	
14. Singh BD. 2006. Plant Breeding. Kalyani.	
15. Singh P. 2002. Objective Genetics and Plant Breeding. Kalyani.	
16. Singh P.2006.Essentials of Plant Breeding. Kalyani.	
17. Singh S & Pawar IS. 2006. Genetic Bases and Methods of Plant Breeding. CBS.	


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SEMESTER III

Taxonomy and Embryology of Angiosperms

Course Objectives:

- To impart basic knowledge of Taxonomy and Embryology of Angiosperms.
- To understand the students about the diversity of plants, Nomenclature and their classification including recent advances in the field.
- To acquire knowledge on development of male and female gametophytes in plants.
- To probe into embryogenesis in angiosperms.

Course Learning Outcomes: Students will be able to

- Understand origin of angiosperms, fossils angiosperms, plants diversity, description, identification, nomenclature and their classification including modern trends in the plant systematics.
- Gain knowledge about herbarium techniques.
- Familiarize about embryology, pollination, and Fertilization in plants development.
- Know about the Structure and development of dicot and monocot embryos.
- Compile the aspects of developmental and reproductive biology in plants.

Course Title:	Taxonomy and Embryology of Angiosperms	Course Code: 24MBO9301T
Total Lecture hours: 45		Hours
Unit I	Principle and Methods of Taxonomy: Taxonomic Hierarchy, Species, Genus, Family and other categories. Salient features of International Code of Botanical Nomenclature. Taxonomic Tools: Herbarium, Flora, Botanical Gardens, biochemical and molecular techniques, computers and GIS (Geo Information Systems). Cladistics in taxonomy. Numerical taxonomy and Sero taxonomy. Taxonomic evidences: Palynology, Embryology, Cytology, Phytochemistry and Genome analysis. Classification: Artificial system (Linnaeus), Natural system (Bentham and Hooker), and Phylogenetic (APG system) with merits and demerits of these systems.	11
Unit II	Taxonomic Studies: Ranunculaceae, Papaveraceae, Capparidaceae, Caryophyllaceae, Leguminosae, Cucurbitaceae, Apiaceae, Rubiaceae, Asteraceae, Asclepiadaceae, Apocynaceae, Convolvulaceae, Solanaceae, Acanthaceae, Bignoniaceae, Lamiaceae, Chenopodiaceae, Euphorbiaceae, Liliaceae, and Poaceae. Phylogeny of Angiosperm: Origin and evolution of Angiosperms. Fossil Angiosperms.	12
Unit III	Embryology: Introduction, History. Male gametophyte: Microsporogenesis, Tapetum; types and functions, Sporopollenin, Pollen structure, pollen Allergy. Female gametophyte: Brief Introduction to Embryo sac development (No type studies). Organization of Mature Embryo sac, Ultra Structure of Egg apparatus, Nutrition of Embryo sac.	11
Unit IV	Pollination: Brief account, Structure, Histo-chemical details of style and Stigma, Pollen germination, pollen embryo sac. Self incompatibility Fertilization: Path of entry of pollen tube, Site of pollen discharge. Double fertilization. Endosperm: Types of endosperm development, Endosperm haustoria, Endosperm culture & function. Embryogenesis: Monocot and dicot embryo development; Physiology and genetics of Embryo development, Somatic embryogenesis.	11
Reference and Reading Books:		
• Davis, P.H. and V.H. Heywood. 1991. Principles of Angiosperm Taxonomy. Today and Tomorrow Publications, New Delhi • Heywood - Plant taxonomy - Edward Arnold London. • Jeffrey, C. (1982). An Introduction to Plant Taxonomy. Cambridge University Press, Cambridge. • Judd, W.S, Christopher S. Campbell, Elizabeth A. Kellogg, Peter F. Stevens, and Michael J. Donoghue. 2016. Plant Systematics: A Phylogenetic Approach, 4rd ed. Sinauer. • Lawrence - Taxonomy of Vascular Plants - Oxford & I B H, New Delhi.		

• Datta S C, Systematic Botany, 4th Ed, Wiley Eastern Ltd., New Delhi, 1988. • Mondal AK. 2011. Advanced Plant Taxonomy. New Central Book Agency Pvt. Ltd., Kolkata. • Naik V.N., Taxonomy of Angiosperms, 1991. Tata McGraw-Hill Pub. Co. Ltd., New Delhi. • Pandey, B.P. 2007. Taxonomy of Angiosperms. S. Chand and Company Limited. New Delhi. • Pandey, S. N, and S.P. Misra (2008)-Taxonomy of Angiosperms- Ane Books India, New Delhi. • Radford, A.E. (1986). Fundamentals of Plant Systematics. Harper and Row, New York. • Sharma, O.P. 2009. Plant Taxonomy. Tata McGraw-Hill. Mumbai. • Simpson MG. 2006. Plant Systematics. Elsevier Academic Press, California, USA. • Singh, G. (2012). Plant Systematics: Theory and Practice (3 edition). Oxford & IBH Pvt. Ltd., New Delhi. • Singh V. & Jain - Taxonomy of Angiosperms - Rastogi Publications, Meerut. • APG III (2009) An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG III. Bot. J. Linnaean Soc. 161: 105-121. • Bhojwani S. S. and Bhavnagar S. P. (2000). The embryology of Angiosperms (4th revised and enlarged edition) Vikas Publishing house, New Delhi. • Johri, B.M. (2011) Embryology of Angiosperms. Springer-Verlag, Berlin. • Maheswari, P. (1971). An Introduction to Embryology of Angiosperms. McGraw Hill— Book Co., London. • Pandey, A. K. (2000) Introduction to Embryology of Angiosperms. CBS Publishers— & Distributors Pvt. Ltd., New Delhi • Any local/state/regional flora published by BSI or any other agency.
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Plant Physiology and Metabolism

Objectives:

The aim of the course is to illustrate the knowledge of concepts of transpiration, transport of water and solutes, photosynthesis, respiration, carbohydrate, lipid and nitrogen metabolism and plant growth regulators.

Course Title:	Plant Physiology and Metabolism	Course Code: 24MBO9302T
Total Lecture hours: 45		Hours
Unit I	Water relations to plants: Properties of water, Types of Solutions, Chemical potential, water potential, Soil-Plant-Atmosphere continuum, Transpiration, Stomatal regulation of transpiration, Antitranspirants. Translocation of water and solute, mechanism of water transport Cohesion- Tension theory, Pressure flow model. Membrane transport: Passive non-mediated transport, Nernst equation, passive mediated transport, ATP- drive active transport, ion channels. Mineral nutrition: macro and micro nutrients and their role in plants	11
Unit II	Biomolecules: General structure, classification, properties, distribution and functions of primary metabolites (carbohydrates, proteins, amino acids, lipids) and secondary metabolites (flavonoids, alkaloids, steroids) Enzymes: Discovery and nomenclature, characteristics of enzymes. Concept of holozymes, apozymes, coenzyme, ribozyme, abzyme and artificial enzyme. Regulation of enzyme activity, mechanism of action. Michaelis-Menten equation.	11
Unit III	Carbohydrate metabolism: Synthesis of carbohydrates: Photosynthetic pigments, absorption and transformation of radiant energy, (Light harvest complex LHC) photooxidation, Red drop effect, Emerson enhancement effect, Photosynthetic quantum yield, Photorespiration, CAM, impact of changing environment effect, Photosynthetic, Industrial Photosynthesis, Allocation, translocation and partitioning of photoassimilate. Degradation of Carbohydrate: Glycolysis, Krebs cycle, Electron Transport System (ETS) and its evolution, Pentose phosphate pathway, Hexose monophosphate shunt, glyoxylate pathway, Glycogenesis, gluconeogenesis, Respiratory inhibitors, High energy compounds, their synthesis and utilization.	12
Unit IV	Nitrogen metabolism: N ₂ fixation symbiotic and asymbiotic, Nodule development, Amino Acid Metabolism.	11

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	Fat metabolism: Synthesis of long chain fatty acids, lipid biosynthesis, & oxidation. Plant growth regulators: Chemical nature, bioassay, physiological effects and mode of action of Auxins, Gibberellins, Cytokinins, Abscissic acid and ethylene, Salicylic Acid Strigolactones, Jasmonic Acid.
Reference and Reading Books:	
1. Datta, S.C. (2007) Plant Physiology, New Age International (P) Ltd., Publishers, New Delhi 2. Devlin, R.M. and Witham, F.H. 1986. Plant Physiology, 4th Ed. CBS Pub. Delhi 3. Hopkins WG & Huner NPA. 2004. Introduction to Plant Physiology. John Wiley & sons 4. Lehnenger, A.L. 1982. Principles of biochemistry, CBS Publication 5. Hans Mohr & P. Schopfer (2006) Plant Physiology, Springer (India) Pvt. Ltd., New Delhi 6. Noggle Ray & J. Fritz (2013) Introductory Plant Physiology, Prentice Hall (India), New Delhi 7. Pandey, S.M. & B.K. Sinha (2006) Plant Physiology, Vikas Publishing House, New Delhi 8. Salisbury, F.B. and Ross, C.W. 1992. Plant Physiology. Asia Ltd. Singapore. 9. Sinha, R.K. (2014) Modern Plant Physiology, Narosa Publishing House, New Delhi 10. Taiz L and Zeiger E. (2006) Plant Physiology, 4th Edition, Sinauer Associates Inc. Publishers, Massachusetts, USA. 12. Verma, V. (2007) Text Book of Plant Physiology, Ane Books India, New Delhi 13. Voet, D and Voet J.G. 1995. Plant Biochemistry, John Wiley, New York.	

Botany Laboratory

Learning Outcomes:

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

- Comprehend the importance of water in plant life and mechanisms for transport of water and solutes in plants.
- Interpret the role of enzymes in plant metabolism.
- Critically understand the light reactions and carbon assimilation processes responsible for synthesis of food in plants.
- Analyze the biochemical reactions in relation to Nitrogen and lipid metabolisms.
- Evaluate the physiological factors that regulate growth and development in plants

Course Title:	Botany Laboratory	Course Code: 24MBO9301P
Suggested Laboratory/Field Exercises:		
1. Study of vegetative and floral characters of specimens from representative, locally available families (Description, V.S. flower, section of ovary, floral diagram/s, floral formula and systematic position according to Bentham & Hooker's system of classification): 1. Ranunculaceae - <i>Ranunculus, Delphinium</i> 2. Brassicaceae - <i>Brassica, Coronopus, Iberis</i> 3. Pappaveraceae: <i>Argemone</i> 4. Cappariaceae: <i>Capparis, Cleome</i> 5. Malvaceae: <i>Hibiscus, Abutilon, Sida, Malvastrum</i> 6. Pedaliaceae: <i>Pedaliium murex</i> 7. Leguminosae: <i>Acacia, Bauhinia, Cassia, Crotalaria, Pea</i> 8. Caryophyllaceae: <i>Dianthus, Spargula, Stellaria</i> 9. Cucurbitaceae: <i>Coccinia, Luffa, Momordica</i> 10. Rubiaceae: <i>Haemalia, Ixora</i> 11. Asclepiadaceae: <i>Calotropis, Cryptostegia</i> 12. Apocyanaceae: <i>Nerium, Catharanthus, Tabernaemontana</i> 13. Convolvulaceae: <i>Ipomoea, Convolvulus</i> 14. Solanaceae - <i>Datura, Withania, Petunia, Solanum</i> 15. Acanthaceae: <i>Adhatoda, Barleria</i> 16. Bignoniaceae: <i>Tecomella, Tecoma</i> 17. Labiatae – <i>Salvia, Ocimum, Majorana</i> 18. Nyctaginaceae: <i>Bauganvillea</i> 19. Chenopodiaceae: <i>Chenopodium</i> 20. Umbelliferae: <i>Coriandrum, Foeniculum</i>		


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21. Asteraceae: *Sonchus*, *Launaea*, *Vernonia*, *Ageratum*, *Eclipta*, *Tridax*
22. Euphorbiaceae – *Ricinus*, *Euphorbia*, *Jatropha*
23. Liliaceae – *Asphodelus*, *Lilium*, *Alium*
24. Poaceae – *Triticum*, *Hordeum*, *Avena*
2. Construction of taxonomic keys and Nomenclature exercise.
3. Training in using floras and herbarium for identification of specimens described in the class.
4. Study of anther and ovule using permanent slides/photographs.
5. Field study of several types of flowers with different pollination mechanisms.
6. Examination of modes of anther dehiscence and collection of pollen grains for microscopic examination (maize, grasses, *Cannabis sativa*, *Crotolaria*, *Tradescantia*, *Brassica*, *Petunia*, *Solanum melongena*, etc.)
7. Tests for pollen viability using stains and in vitro germination.
8. Emasculation, bagging and hand pollination to study pollen germination.
9. Study of nuclear and cellular endosperm through dissections and staining.
10. Dissection and observation of Embryo sac haustoria in *Santalum* or *Argemone*.
11. Structure of endosperm (nuclear and cellular) using permanent slides / Photographs.
12. Dissection and observation of Endosperm haustoria in *Crotolaria* or *Coccinia*.
13. Developmental stages of dicot and monocot embryos using permanent slides / photographs.
14. Field trips within and nearby areas in the university/college campus, compilation of field notes and preparation of herbarium sheets of such plants wild or cultivated that are abundant.
- Photography of the collected specimens and their habitat (if applicable).
15. Submission: Record book, Tour report and Herbarium specimens of at least 50 properly dried and pressed wild or cultivated plants from your locality.
16. Determination of osmotic potential of plant cell sap by plasmolytic method using *Rhoeo/Tradescantia* leaves.
17. Effect of temperature and different solvents on membrane permeability of beet root.
18. Calculation of stomatal index and stomatal frequency of a mesophyte and a xerophyte.
19. Separation of chloroplast pigments using paper chromatography technique.
20. Separation of amino acids by paper chromatography.
21. Separation of chlorophyll by liquid-liquid chromatography.
22. Test of phenols, steroids, alkaloids and terpenoids.
23. Anatomy of C3, C4 and CAM leaves
24. Demonstration of amylase enzyme activity and study the effect of substrate and Enzyme concentration.
25. Separation of aliphatic wax components by thin layer chromatography (TLC)
26. Isolation of root nodule bacteria from roots of legume plant.
27. Quantification of protein in given plant sample.
28. Demonstration of Physiological effects of growth regulator.
29. Quantification of carbohydrates in given sample.
30. Estimation of lipids
31. The effect of temperature on enzyme activity.
32. The effect of pH on enzyme action.
33. To determine total soluble carbohydrates in given plant material.
34. To determine proline in given plant material.
- Demonstration of Polyphenol oxidase enzyme activity (Potato tuber or Apple fruit)

Reference and Reading Books:

1. Raghavan V. (1997). Molecular embryology of flowering plants. Cambridge University press, Cambridge.
2. Raghavan V. (1986). Embryogenesis in angiosperms- A developmental and experimental studies. Cambridge University Press New York USA.
3. Shivanna K. R. and Sawhney V. K. (eds) 1997. Pollen Biotechnology for crop production and improvement. Cambridge University, Cambridge.
4. Hans Mohr & P. Schopfer (2006) Plant Physiology, Springer (India) Pvt. Ltd., New Delhi
5. Verma, S. K. A Textbook of Plant Physiology, Biochemistry & Biotechnology. S. Chand & Co.


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Tools and Techniques in Plant Sciences

Course Objectives:

This course would provide students with an understanding of principles, concepts and techniques of microscopy, chromatography, spectroscopy, microtomy and radiolabeling in plant sciences.

Course Outcomes:

- The course would equip students with practical skills and knowledge in various botanical techniques
- Students would be able to understand and utilize techniques like microscopy, chromatography, spectroscopy, and molecular biology tools to analyze plant tissues, identify compounds, and study genetic processes.

Course Title:	Tools and Techniques in Plant Sciences	Course Code: 24MBO9303T
Total Lecture hours: 60		Hours
Unit I	Instrumentation Microscopy: Principle, and applications of different types of microscopes Light, Phase Contrast, SEM and TEM. Centrifugation: Principle and applications of Centrifugation; differential and density gradient Centrifugation. Electrophoresis: Principle, structural components and applications of electrophoresis.	15
Unit II	Chromatography: Principle and applications of chromatography; Paper Chromatography, Ion exchange chromatography, Thin layer chromatography, Gas chromatography Spectrophotometer: Principle and applications of Spectrophotometer. UV and visible spectroscopy, NMR and ESR spectroscopy, Molecular structure determination using X-ray diffraction and NMR, mass spectrometry.	15
Unit III	Microtomes: Rocking, Rotary, Sledge and Ultra microtomes and their uses. Material preparation technique for microtome sectioning – fixatives, dehydrating agents, killing, fixing methods. Stains and their uses and staining of plant tissues – clearing, mounting and mountants. Microslide preparation: Whole mount, Smears, Squashes. Cryotechniques: History and applications of Cryotechniques, cryopreservation of cells, tissue, organisms.	15
Unit IV	Radiolabeling Techniques and Methods in Field Biology Radiolabeling techniques: Detection and measurement of different types of radioisotopes normally used in biology, incorporation of radioisotopes in biological tissues and cells, molecular imaging of radioactive material, safety guidelines.	15
Reference and Reading Books: 1. Principles and Techniques in biochemistry and molecular biology - Wilson and Walkes. 3. Sharma V.K. (1991), Techniques in microscopy and cell Virology. Tata McGraw Hill. 4. Robert Braun Introduction to instrumental analysis - Tata McGraw Hill. 5. Bisen and Mathw. Tools and Techniques in Life Sciences - CBS Publishers and distributors. 6. Keith Wilson and John Walker, (2005). Principles and Techniques of Biochemistry and Molecular Biology, 6 th edition, Cambridge University Press. 7. K.L.Ghatak (2011). Techniques and Methods in Biology, PHL learning Private Limited, New Delhi.		

Advanced Plant Pathology

Course Learning Objectives:

- To understand complex interactions between plants and their biotic stressors, including insects, nematodes, and pathogens.
- To gain advanced knowledge of nematology with a focus on economically important plant-parasitic nematodes and their management.
- To analyze and evaluate the role of modern biotechnological and information technology tools in plant disease diagnostics and management.

- To comprehend genetic principles underlying breeding for disease resistance in crops and explore classical and molecular approaches.
- To comprehend the formulation, mechanism, and application of nanopesticides in sustainable disease management.
- To evaluate disease management strategies under organic farming systems and compare them with conventional methods.

Course Learning Outcomes:

Upon successful completion of this course, students will be able to:

- Critically analyze plant-insect interactions and explain their role in disease epidemiology and vector-pathogen dynamics.
- Identify major plant-parasitic nematodes, their symptoms, and lifecycle, and devise appropriate integrated nematode management strategies.
- Evaluate the efficacy, environmental impact, and delivery mechanisms of nanopesticides in integrated plant disease management.
- Develop organic-compatible disease management plans using botanical pesticides, biological control, and cultural practices based on agroecological principles.
- Synthesize interdisciplinary knowledge from pathology, entomology, genomics, and agronomy to propose sustainable and innovative plant protection strategies.

Course Title:	Advanced Plant Pathology	Course Code: 24MBO9304T
Total Lecture hours: 60		Hours
Unit I	Insect-Plant Interactions: Important diseases caused by insects in crops, Plant galls: Classification, developmental anatomy, host-pathogen interaction: biochemistry and physiology of Insect induced plant diseases with special reference to Rajasthan. Economic significance of plant galls. Galls of <i>Pongamia</i> , <i>Alstonia</i> , <i>Prosopis</i> and <i>Salvadora</i> .	15
Unit II	Nematology: General account of nematode diseases, Symptoms caused by nematodes. Methods used in Nematology. Control of plant parasitic nematodes, Inter relationship between nematode and other Plant pathogens. Nematode Diseases: Molya disease of Wheat and Barley, Soybean Cyst. Root knot of vegetables.	15
Unit III	Application of Biotechnology and Information technology in disease management: Plant disease forecasting system, computer simulation of epidemics. Biotechnological advances for disease resistance in plants: Tissue culture techniques, transgenic plants, rDNA technology.	15
Unit IV	Breeding for disease resistance: Types of resistance, Mechanism of breeding for vertical and horizontal resistance. Biopesticides: Concept, significance, types and applications of biopesticides, Herbal, Fungal and bacterial examples. Nanopesticides: concept, historical aspects, importance. Plant disease management in Organic farming.	15
Reference and Reading Books:		
1. Agrios, G.N. 2005. Plant Pathology, 5th edition. Academic Press, New York, USA. 2. Alexopoulos, C.J., C.W. Mims and M. Blackwell. 1996. Introductory Mycology. 4th edition, John Wiley and Sons, Inc., New York, USA 3. Khan, J.A. and J. Dijkstra. 2002. Plant Virus as Molecular Pathogens. The Haworth Press Inc. USA. 4. Mehrotra, R.S. and A. Agarwal. 2003. Plant Pathology. 2nd Edition. TATA McGraw Hill. Pub. Company Ltd. New Delhi. 5. Jonathan, E. I. 2009. Nematology: Fundamentals and Applications. New India Publishing, 292 pages 6. Trigiano, R.N., M.T. Windham and A.S. Windham. 2008. Plant Pathology: Concepts and Laboratory Exercises. 2nd edition. CRC Press. 7. M. S. Mani, "Ecology of Plant Galls," Dr. W. Junk Publish, Hague, 1964.		

Seed Pathology

Course Objectives

- The course aims to provide students with a comprehensive understanding of seed-borne diseases


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- and their management in modern agriculture. Students will explore the history and importance of
- seed pathology, methods for testing seed-borne fungi, bacteria, and viruses, and mechanisms of
- seed infection. They will gain insights into seed-borne diseases affecting key crops in Rajasthan
- and India, as well as transmission mechanisms and disease forecasting. The course also covers
- management strategies, including seed treatments and their applications, along with practical lab
- exercises to develop hands-on skills in diagnosing and controlling seed-borne pathogens.

Course Learning Outcomes:

Upon completing the course, students will be able to:

- Learn the significance of Seed Pathology in modern agriculture and explore methods for testing seed-borne pathogens, including fungi, bacteria, and viruses.
- Comprehend seed infection mechanisms, environmental factors affecting seed infection, and pathogen localization within different seed parts.
- Gain knowledge of seed-borne diseases in key crops of Rajasthan, India, caused by fungal, bacterial, nematode, and viral pathogens.
- Explore aspects of seed-borne diseases such as inoculum density, disease forecasting, tolerance limits, and modes of disease transmission.

Course Title:	Seed Pathology	Course Code: 24MBO9305T
Total Lecture hours: 60		Hours
Unit I	Introduction and importance of Seed Pathology in modern agriculture. History of Seed Pathology. Various methods for testing seed borne fungi, bacteria and viruses (Dry seed examination, seed washing test, incubation methods, cultural, biochemical, serological, nucleic acid based methods). Mechanism of seed infection and its types, environment influencing seed infection, infected/contaminated part of seed.	15
Unit II	Morphology and anatomy of seeds in relation to invasion, location of inoculum of the pathogen in seed- seed coat and pericarp, endosperm and perisperm and embryo. Seed-borne diseases of some important crops with particular reference to the state of Rajasthan and India. Typical case of infection by: fungi (wheat-smuts and bunts, Sesamecharcoal rot; bacteria (Brassicac- black rot, cluster bean-bacterial blight); viruses (tomato mosaic virus, pea seed borne mosaic virus,) and nematodes (wheat- ear cockle, rice- white tip).	15
Unit III	Seed-borne inoculum, inoculum density and assessment of seed borne inoculum in relation to plant infection, epiphytotics due to seed borne inoculum, disease forecast based on infected seed samples, tolerance limits of seed borne pathogens. Transmission of seed borne disease: Systemic and non- systemic seed transmission, types of disease transmission.	15
Unit IV	Mode of establishment and course of disease from seed to seedling and plant, factors affecting seed transmission. Management of seed-borne disease, principles of control, seed treatments (physical, chemical and biological), mechanism of action of seed treatments, major seed treatments for important seed borne pathogens and their methods of application.	15
Reference and Reading Books:		
1. Agarwal, P. C., Mortensen, C. N. and Mathur, S. B. (1989). Seed-borne diseases and seed health testing of rice. Technical Bull. No.3, Danish government institute of seed Pathology for Developing Countries (DGISP), Copenhagen and CAB International Mycological Institute, (CMI) UK. 2. Agarwal, V.K. 2006. Seed Health. International Book Distributing Company. Charbagh, Lucknow, India. 3. Agarwal, V.K. and Sinclair, J.B. (1987). Principles of Seed-pathology, II edition CRC Lewis Publishers, Boca Raton, New York, London. 4. Agrawal, R.L. 1980. Seed Technology. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.		

5. Agrios, G.N. 2005. Plant Pathology. Academic Press, London., New York
6. Anonymous (1985, 2014). International rules for seed testing. International Seed Testing Association (<http://www.seedtest.org/en/home.html>; <http://www.seedtest.org/en/content--1--1083.html> (ISTA).
7. Clifton, A. 1958. Introduction to the Bacteria. McGraw Hill Book Co., New York.
8. Khare, D. and Bhale, M.S. (2014). Seed Technology. Scientific Publishers (India), Jodhpur. Revised 2nd Ed.
9. Mandahar, C.L. 1978. Introduction to plant viruses. S. Chand & Co. Ltd., Delhi.
10. Mathur, S.B. and Cunfer, B.M. 1993. Seed-borne diseases and Seed health Testing of Wheat. Danish Government Institute of Seed Pathology for Developing Countries. Hellerup, Denmark.
11. Neergaard, P. (1977). Seed Pathology. Vol. I & II. The Mac Millan Press Ltd., London.
12. Rangaswamy, G. & Mahadevan, A. 1999. Diseases of crop plants in India (4th edition). Prentice Hall of India, Pvt. New Delhi.
13. Richardson, M. J. (1990). An annotated list of seed borne diseases 4th edn. Proc. Int Seed Test Assoc. Zurich, Switzerland.
14. Schaad, N. W. (1980). Laboratory guide for identification of plant pathogenic bacteria (ed.). Bacteriology Committee of American Phytopathological Society, St. Paul, Minnesota.
15. Schaad, N. W. (1988). Laboratory guide for identification of plant pathogenic bacteria (2nd eds.). APS Press (The American Phytopathological Society), St. Paul, Minnesota.

Plant Pathology Laboratory

Course Title:	Plant Pathology Laboratory	Course Code: 24MBO9302P
Suggested Laboratory Exercises:		
1. Separation of cell organelles by differential centrifugation. 2. Separation of protein by electrophoresis (Native and SDS page). 3. Separation of amino acids etc. by paper and thin layer chromatography 4. Demonstration of column Chromatography. 5. Validation of Beer-lamberts law of a colored compound (CuSO₄). 6. Quantification of DNA by UV-Visible spectrophotometer. 7. Light microscope and its parts observation of unstained and stained cells. 8. Microscopy-SEM, TEM, Florescence, Staining & fixation procedures 9. Measurement of cell size using stage micrometer and ocular micrometer. 10. Galls of Pongamia, Cordia, Prosopis, Salvadora 11. Molya disease of wheat and Barley 12. Soyabean cyst nematodes 13. Histopathology of nematode infected roots 14. Virus detection through biological (indicator hosts and host range) and serological methods (ELISA, Immunodiffusion) 15. Virus Indexing 16. Methods of application of fungicides –seed and foliar application 17. Bio-control of plant pathogens –dual culture technique 18. Bioassay of fungicides – poisoned food technique, inhibition zone technique and slide germination technique 19. Biopesticides and nanopesticides: examples 20. Dry seed examination of seed lots. 21. Isolation and identification of seed-borne mycoflora by standard blotter method. 22. Preparation of culture media (PDA and NA). 23. Plating seeds on PDA/NA for identification of seed borne fungi and bacteria. 24. Other methods of plating e.g. deep freezing; 2,4D- blotter method. 25. Water agar test tube seedling symptom test. 26. Study of any seed borne nematode disease. 27. Detection of bacterial and viral pathogens in seeds. 28. LOPAT tests for detection of seed- borne bacteria. 29. Nucleic acid based detection of seed borne pathogens. 30. Histopathology of infected seed samples. 31. Physical control of seed-borne pathogens. 32. Antibiotic/fungicidal assay against seed-borne pathogens		

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5. William G.Hopkins and Norman P.Huner (2009), Introduction to Plant Physiology, John Wiley & Sons,Inc, USA.
- 6.Lincoln Taiz (2014). Plant Physiology and Development, Oxford University Press.
- 7.Bob. B Buchanan, W. Gruissem, and RL Jones. (2015). Biochemistry and Molecular Biology of Plants, 2nd Edition, Wiley-Blackwell

Stress Biology

Course Objectives

The Plant Stress Biology course aims to provide students with a thorough understanding of how plants respond to various stresses, including their adaptation strategies and signaling pathways. The course will illustrate knowledge of stress adaptations and management in plants, offer a molecular understanding of stress signaling, and demonstrate methods for analyzing key stress related parameters. Additionally, students will gain insights into current tools and strategies for enhancing plant stress tolerance.

Course Learning Outcomes

Upon completing the course, students will be able to:

- Learn about various stress factors, including flooding, drought, salt, cold, high temperatures, toxic materials, and biotic stresses from pathogens. Understand their classification and impact on plants.
- Grasp stress signaling mechanisms and plant responses at the tissue, cell, and organ levels.
- Explore strategies for stress escape and avoidance.
- Comprehend stress measurement methods, plant-environment interactions, and essential biomolecules, metabolites, and pathways required for stress tolerance.
- Develop critical thinking skills to devise solutions for enhancing plant stress resistance and minimizing yield loss.
- Utilize background information on stress measurement effectively.
- Design and conduct experiments to screen germplasm for stress-tolerant genotypes.
- Formulate hypotheses, collect and analyze data, and interpret results.

Course Title:	Stress Biology	Course Code: 24MBO9307T
Total Lecture hours: 60	Stress Biology	Hours
Unit I	Environmental stresses: Introduction, significance, types, Water deficit stress: Effects on physiological processes, Physiological responses to water deficit stress, Various strategies of drought resistance in plants, Mechanism of stomatal action, Antitranspirants, ABA as stress hormone, ABA dependent and ABA independent pathways, LEA proteins, Flooding stress (anoxia): Nature of waterlogging stress, Effects of flooding stress on physiological processes in plants, Wetland and non-wetland species, Mechanism of water logging tolerance.	15
Unit II	Salinity stress: Definition of saline soil, Causes of soil salinization, A brief outline of salt affected soils in India. Salinity stress- combination of osmotic stress and ionic stress, Physiological responses of plants to salinity stress, mechanism of salinity tolerance in higher plants, Signaling under salinity stress- Salt Overly Sensitive (SOS) Pathway, Compatible osmolytes- role in osmotic adjustment. Heavy metal stress: Effect of ion toxicity (iron, zinc), heavy metals toxicity and aluminum toxicity in plants, Mechanism of aluminum tolerance, Phytoremediation.	15
Unit III	Thermal stresses: Effects of high and low temperatures on plant, Physiological responses of plants to high and low temperatures, Mechanisms of high and low temperatures tolerance, Role of Heat Shock Proteins (HSPs), calcium, calmodulin and C-repeat binding factors (CBFs). Oxidative stress: Influence of high light intensity on photosynthesis, Generation of reactive oxygen species (ROS), Effects of ROS, Photoprotection and ROS detoxification mechanisms in plants.	15
Unit IV	Biotic stresses: Responses of plants towards biotic stresses, plant defense system, genetic basis, understanding of R genes, Systemic acquired resistance. Biotic stress signaling (plant defense): Elicitors and plant defense: Plant responses to elicitors and their role in crop improvement, Plant defense priming, Role of Jasmonic acid, salicylic acid, ethylene and nitric oxide signaling in plant defense.	15
Reference and Reading Books:		

1. Plant Physiology (3rd edition), Lincoln Taiz and Eduardo Zeiger (2002), Sinauer Associates
2. Biochemistry and molecular biology of plants: Buchanan et al 2000, American Society of Plant Biologists, USA.
3. Abiotic stress adaptation in plants: Pareek et al (2010), Springer
4. Plant Responses to Abiotic Stress: Hirt and Shinozaki: (Online) Springer
5. Plant Responses to environmental stress: Smallwood et al BIOS Scientific Publishers
6. Plant, Genes and Crop Biotechnology, Maarten J. Chrispeels & David E. Sadava, 2002, American Society of Plant Biologists, USA
7. Handbook of Plant and Crop Physiology: Pessarakli et al 2002, Marcel Dekker Inc. USA.
8. Plant Ecophysiology: Prasad MNV 1997, John Wiley & Sons, Inc, USA.
9. Introduction to Plant Physiology. Second Edition, Hopkins, William G. John Wiley & Sons, Inc.
10. Oxidative stress and the molecular biology of antioxidant defenses. Scandalios, J. 1997. New York: Cold Spring Harbor Laboratory Press.

Plant Physiology Laboratory

Course Title:	Plant Pathology Laboratory	Course Code: 24MBO9303P
1. Separation of cell organelles by differential centrifugation. 2. Separation of protein by electrophoresis (Native and SDS page). 3. Separation of amino acids etc. by paper and thin layer chromatography 4. Demonstration of column Chromatography. 5. Validation of Beer-lamberts law of a colored compound (CuSO₄). 6. Quantification of DNA by UV-Visible spectrophotometer. 7. Light microscope and its parts observation of unstained and stained cells. 8. Microscopy-SEM, TEM, Florescence, Staining & fixation procedures 9. Measurement of cell size using stage micrometer and ocular micrometer. 10. Study of effect of PEG induced water stress on seed germination. 11. Effect of various Plant growth regulators on Leaf discs (Normal & senescencing). 12. Effect of Red and Infrared light on seed germination and study of photo morphogenesis. 13. Hormonal regulation of leaves and petal senescence. 14. To study the rhythmic movements of plants. 15. Study of changes in starch and protein content during seed development. 16. Study of Tropic movements in Plants. 17. Estimation of Total Chlorophyll in Healthy leaves and senescencing leaves. 18. Estimation of Antioxidative enzyme activity in senescencing leaves. 19. Measurement of RWC under stress. 20. Leaf disc assays under various abiotic stresses. 21. Determination of chlorophyll content under stress. 22. Determination of electrolyte leakage under stress. 23. Estimation of sodium, potassium, chlorides in different plant leaves. 24. Estimation of free amino acids content in the given sample 25. Study of effect of fungal infection on peroxidase activity. 26. Study of phenolics in scales of onion varieties differing in disease resistance. 27. Study of free radicals scavenging enzymes, catalase and super oxide dismutase. 28. Estimation of proline content in given water stressed samples 29. Study of seed germination under stress condition. 30. Estimation of betaine content in salt stressed samples. 31. Determination of ascorbic content in temperature (low and high) and salt stressed samples. 32. Determination of the concentration of polyamines in the given stressed samples. 33. Effect of stress on the activity of following scavenging enzymes: a. superoxide dismutase, (b) catalase, (c) peroxidase, (d) ascorbate peroxidase. 34. Visualization of stress proteins by SDS-gel electrophoresis. 35. Effect of stress on membrane damage in relation to lipid peroxidation. 36. Effect of water stress and Hyperthermia on the activity of nitrate reductase.		

Reference and Reading Books:


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 Sheikhpur, Patna

Ecosystem Ecology

Course Objectives

The course aims to provide a thorough understanding of ecosystem structure and function, crucial for conservation and environmental remediation. Students will learn basic principles of ecosystem ecology, focusing on terrestrial and aquatic systems such as grasslands, forests, freshwater, and marine environments. The course covers ecosystem types, classifications, interactions, and productivity, along with urban and rural ecosystems, their challenges, and management strategies.

Course Learning Outcomes

Upon completing the course, students will be able to:

- Understand and outline the biotic and abiotic factors in both terrestrial and water ecosystems.
- Understand the basic flows of energy or nutrients, trophic interactions, and productivity within ecological systems and be able to describe them in a systems framework.
- Describe the factors that affect (and disrupt) the functioning of ecological systems.
- Understand the basic framework of urban and rural ecosystems, the limitation of urbanization and rural systems, and mitigation strategies.

Course Title:	Ecosystem Ecology	Course Code: 24MBO9308T
Total Lecture hours: 60		Hours
Unit I	Grassland Ecosystems - Characteristics of grasslands, stratification, grasslands and grazing, grasslands and drought, grassland and animal life, Grasslands types with special reference to Prairie and Savannah, Indian grasslands. Forest Ecosystems - Stratification of the forest, Forest types - Boreal, Temperate and Tropical forests, Forest animal life	15
Unit II	Freshwater Ecosystems- Classification of Freshwater Habitats, Lentic: Lakes & Ponds: Temperature and Oxygen stratification, Zonation based on light penetration, Flora and fauna, Productivity classes of lakes, Marshes and Swamps, Bogs Lotic: Springs, Streams and Rivers. Marine and Estuarine Ecosystems - Characteristics of marine environment: Salinity, Temperature and pressure, Zonation and Stratification, Tides, Estuarine ecosystem: Types of Estuaries, Flora and fauna, Estuarine productivity, Coral reef ecosystem, Mangrove ecosystem	15
Unit III	Urban Ecosystem- Urban environment and Climatic conditions, additional physical complexes (modified surfaces including parking lots, roofs, and landscaping, buildings, transportation networks, infrastructure and public amenities), flora and fauna (human beings as largest macro consumer), Implications of urbanization: problems of air pollutants, drinking water supply, floods, waste disposal. Rural ecosystems: Rural environment and climate, physical complexes (fields, agricultural implements and machines), Flora and fauna, Problems of discharge of chemical fertilizers, pesticides and drinking water. Management of waste, Principle; Social Forestry.	15
Unit IV	Desert Ecosystem: Desert: Definition, classification (hot and cold), physiography, desert features, flora, fauna and water, formation, topography, distribution and characteristics of world deserts; Thar desert: Sand dunes: types, origin and morphology of sand dunes; Vegetation types and plant communities, biological production, conservation of flora and fauna, wild life, Succession in vegetation of western Rajasthan and coastal sand dunes, economic importance of desert plants (general economic plants, medicinal, famine food plants and crops); Saline Arid zones: Saline tracts of Rajasthan and plants of saline arid zones (Halophytes), Economic and social considerations in the management of salt affected soils, afforestation in salt affected soils, Importance of halophytes.	15

Reference and Reading Books:

1. P. L. Jaiswal, A.M. Wadhwani and N.N. Chhabra (Eds.). 1983. Desertification and its Control. ICAR, New Delhi.
2. Smith, R.L. 1996. Ecology and Field Biology, Harper Collins, New York.
3. Subrahmanyam, N.S. and A.V.S.S. Sambamurthy 2000. Ecology. Narosa Publishing House, New Delhi.
4. G. M. Masters and W. P. Ela. 2008. Introduction to environmental engineering and sciences. PHI Learning Private Limited, New Delhi.
5. W. P. Cunningham and M. A. Cunningham. 2003. Principles of Environmental Science, Inquiry, Understanding (Pearson Education)


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Conservation Biology

Course Objectives:

The main objectives of this course are to understand the concept and components of biodiversity, its significance and values, various threats and strategies adopted for their conservation. The student will familiarize the IUCN Red list categories and national and international organization for conservation of biodiversity. The student will attain skill in process of red listing of plants based on the latest IUCN criteria.

Course Learning Outcomes:

Upon completing the course, students will be able to:

- Get a deep knowledge on biodiversity richness in global scale and biogeography of India.
- Assess the value of biodiversity wealth of our Nation.
- Analyze various threats to our biodiversity and able to suggest measures for conservation Strategies.
- Trained effectively and scientifically to convey the message of sustainable use of resources and conservation of biodiversity to the public and young generation.

Course Title:	Conservation Biology	Course Code: 24MBO9309T
Total Lecture hours: 60		Hours
Unit I	Introduction: Principles, characteristics and importance of conservation biology. Necessity of conservation, Economic value, balance of Nature, Genetic Resources, Aesthetic Enjoyment, Education. Conservation values and ethics, Role of species in conservation Global as well as Indian Prospective - Biodiversity of World, India and Rajasthan. Hotspots or Important Biodiversity Area of India and Rajasthan, Biodiversity Categorization. IUCN categorization of species (Extinct, Extinct in Wild, Critically Endangered, Endangered, Vulnerable, Near Threatened, Conservation Dependent and Least Concern), Earth summit 1992, Agenda 21.	15
Unit II	National and International organization for conservation of Biodiversity: IUCN, TRAFFIC, WWF, WII, BSI, NBPGR, National Biodiversity Authority India and National Medicinal Plant Board. Current issues in Biodiversity Loss: Community based conservation approach, Impact of climate change on species diversity, Human-wildlife conflict, Illegal trading (special reference to medicinal plants and timber), Habitat fragmentation and degradation. Synergic interactions. Biodiversity and ecosystem services	15
Unit III	Management and the conservation: Sustainable Development, ex-situ and in-situ conservation, World Heritage sites, Sacred groves, Bishnoi tradition, Chipko movement, Case studies of Tehri dam, SardarSarovar and Narmada dam. Action to save endangered species: Rehabilitation and reintroduction, gene banks, Captive breeding and propagation. Project Tiger and Elephant (role in protection of Indian forests), Project Rhino (role in protection of Tarai land) and Project GIB (Protection of Desert Grass land).	15
Unit IV	Conservation Policies: Importance of genetic resources and conservation of crop genetic resources. International and National efforts to conserve biodiversity: Convention on biological diversity, Wildlife Protection Act-1972 and Amendment Act, 2002, 2006, Environment Protection Act-1986, Forest Conservation Act-1980; Biodiversity Act-2002 and Forest Rights Act-2006, CITES, Ramsar convention; National Biodiversity strategy. Role of remote sensing and GIS and biodiversity conservation.	15
Reference and Reading Books:		
- Bookhout, T. A. (1996). Research and management techniques for wildlife and habitats (5th Ed.). The Wildlife Society, Allen Press, Kansas, USA. - Woodroffe R., Thirgood S. and Rabinowitz A. (2005). People and Wildlife, Conflict or Co-existence? (Conservation Biology) Cambridge University. - Caughley G. and Sinclair A.R.E. (Eds.) (1994) Wildlife Ecology and Management Blackwell Registrars		

Science, Cambridge.

4. Hunter M.L., Gibbs J.B. and E.J. Sterling (2008) Problem-Solving in Conservation Biology and Wildlife Management: Exercises for Class, Field, and Laboratory. Blackwell Publishing.
5. Rangarajan M. (2001) India's Wildlife History. Permanent Black, New Delhi, India.
6. Krebs, C. J. (1999). Ecological Methodology (2nd Ed.) Addison-Welsey Educational Publishers, Inc.
7. Sutherland, W. J. (2000). The conservation handbook; research, management and policy. Blackwell Sciences Ltd. London.
8. Fiedler P.L and Kareiva, P.M. (1997) Conservation biology Chapman and Hall International Thompson Publishing, USA
9. Krishnamoorthy, K. V (2004) An Advanced text book on Biodiversity- principles and Practice: Oxford and IBH publishing company Pvt. Ltd. New Delhi.
10. Negi, S.S. (1993) Biodiversity and its Conservation in India.
11. Sharma P.D. (2003). Ecology and Environmental Sciences, Rastogi Publications, Meerut, India
12. Swaminathan, M.N. & Jain, R.S. (1982) Biodiversity: Implications for global security, Macmillan.
13. Trivedi, P. C. (2007) Global Biodiversity status and conservation. Pointer publishers Jaipur India.

Plant Ecology Laboratory

Course Title:	Plant Ecology Laboratory	Course Code: 24MBO9304P
1. Separation of cell organelles by differential centrifugation.		
2. Separation of protein by electrophoresis (Native and SDS page).		
3. Separation of amino acids etc. by paper and thin layer chromatography		
4. Demonstration of column Chromatography.		
5. Validation of Beer-lamberts law of a colored compound (CuSO ₄).		
6. Quantification of DNA by UV-Visible spectrophotometer.		
7. Light microscope and its parts observation of unstained and stained cells.		
8. Microscopy-SEM, TEM, Florescence, Staining & fixation procedures		
9. Measurement of cell size using stage micrometer and ocular micrometer.		
10. Find out stomatal index of Xerophytes (<i>Nerium</i> , <i>Calotropis</i> , <i>Zizyphus</i> .) growing in your locality.		
11. Study of trichomes of xerophytes (<i>Zizyphus</i> , <i>Lantana</i> , <i>Calotropis</i> , <i>Aerua</i>) growing in your locality.		
12. Study spread of root system of a perennial species in the soil		
13. Study ecological adaptations of halophytes in your nearby area.		
14. Seed Viability by T.T.C. method		
15. Dormancy (seed coat & temperature) in seeds.		
16. Soil moisture and temperature at different depths		
17. Salinity of soil sample.		
18. Study of Canopy and Basal Cover of trees in your study area		
19. Estimate primary productivity of a water body by light and dark bottle method		
20. Mean leaf area of 2 plant Species growing in your area by graph method		
21. Relative humidity by hair hygrometer		
22. Light intensity by lux meter		
23. Visit any protected area (National Park/Sanctuary) and document red listed species.		
24. Biodiversity assessment in your area.		
25. Documentation of wildlife protection act for the plants species.		
26. Documentation of conservation major for Sandal wood, Red Sandal wood, Teak and Sal, Rohida wood.		
27. Documentation of IUCN and CITES species of Rajasthan plants.		
28. Visit any Sacred groves and documentation of their species.		
29. Visit any tribal community and describe their role for conservation.		
30. In situ conservation of germplasm /plant species		
31. Preparation of list of endangered plant species in your area		
32. Analysis and discussion of data of Project Tiger, Project Elephant, Project Rhino and GIB		
33. Scientific visits: The students should be taken to one of the following: A protected areas or Biosphere reserve or national park or sanctuary. A wetland. A mangrove. NBPGR (National Bureau of Plant Genetic Resources – New Delhi).		

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(Gwalior)
Dr. P. K. Singh
Dr. P. K. Singh

Advanced Morphology and Morphogenesis

Course Learning Objectives:

1. To understand advanced concepts in floral anatomy with specific emphasis on the morphological and taxonomic implications of reproductive structures such as stamens, carpels, seeds, and pericarps.
2. To analyze the cellular and molecular basis of morphogenesis, including factors influencing somatic embryogenesis and tissue differentiation.
3. To gain proficiency in modern plant tissue culture techniques such as micropropagation, suspension cultures, and synthetic seed technology.
4. To explore cellular techniques for isolation of mutant cell lines, including auxotrophic mutants and their underlying mechanisms.
5. To develop practical and theoretical understanding of imaging technologies like transmission and scanning electron microscopy for studying cultured plant cells and protoplasts.
6. To investigate embryogenesis in dicots and monocots, and the role of the endosperm and ovary culture in developmental biology and fertilization control.
7. To evaluate the application of plant morphogenetic techniques in crop improvement programs and biotechnology.

Course Learning Outcomes:

Upon successful completion of this course, students will be able to:

1. Describe the anatomical and developmental features of stamens, carpels, seeds, and pericarps, and interpret their significance in plant taxonomy and phylogeny.
2. Explain the role of morphogenetic factors in plant development and assess their regulatory mechanisms during organogenesis and embryogenesis.
3. Demonstrate competence in designing and executing plant tissue culture protocols including somatic embryogenesis, micropropagation, and synthetic seed production.
4. Apply cell culture techniques for isolation and characterization of mutant cell lines, and distinguish between different types of cell culture mutants based on their metabolic and growth responses.
5. Use microscopy techniques to investigate ultrastructural details of cultured cells, endosperm cytology, and protoplast development.
6. Differentiate between the developmental pathways of dicot and monocot embryos and explain the influence of endosperm and ovary cultures on embryo development and fertilization.
7. Critically evaluate how plant tissue culture contributes to the improvement of agronomic traits and aids in plant biotechnology applications.

Course Title:	Advanced Morphology and Morphogenesis	Course Code: 24MBO9310T
Total Lecture hours: 60		Hours
Unit I	Floral anatomy and its role in explaining the morphology of the Stamen and Carpel, Seed and Pericarp and their taxonomic significance. Morphogenetic factors: Physical, mechanical, chemical and genetic factors. Molecular basis of morphogenesis in plants with special reference to work done in Arabidopsis.	15
Unit II	Somatic embryogenesis: Survey of somatic embryogenesis in angiosperms, direct somatic embryogenesis and embryogenesis from callus and protoplasts; cytology, physiology and genetics of somatic embryogenesis, nutritional factors and embryo rescue in wide hybridization.	15
Unit III	Micropropagation advances and synthetic seeds. Cell plating technique and isolation of mutant cell lines, auxotrophic mutants. Mechanism involved in cell culture mutants. Suspension culture and growth studies. Transmission and scanning electron microscopy for plant protoplasts and cultured cells.	15
Unit IV	Cytology of endosperm, role in embryo development. Development of Dicot and Monocot embryos. Endosperm and ovary culture, control of fertilization and plant tissue culture in crop improvement.	

Reference and Reading Books:

1. Bhojwani, S.S. and Bhatnagar, S.P. 2000. The Embryology of Angiosperms (4th revised and enlarged edition). Vikas Publishing House, New Delhi.
2. Fahn, A. 1982. Plant Anatomy, (3rd edition). Pergamon Press, Oxford. New York.
3. Leins, P., TucKer, S.C. and Endress, P.K. 1988. Aspects of Floral Development, J. Cramer, Germany.
4. Proctor, M. and Yeo, P. 1973. The Pollination of Flowers. William Collins Sons, London
5. Raghavan, V. 1997. Molecular Embryology of Flowering Plants. Cambridge University Press, Cambridge.
6. Shivanna, K.R. and Sawhney, V. K. (eds.) 1997. Pollen Biotechnology for Crop Production and Improvement. Cambridge University Press, Cambridge.
7. Shivanna, K.R. and Rangaswamy, N.S. 1992. Pollen Biology: A Laboratory Manual, Springer-Verlag, Berlin-Heidelberg (and references therein).
8. Collin, H.A. and Edwards, S. 1998. Plant cell culture. Bios Scientific Publishers, Oxford, UK.
9. Glick, B.R. and Thompson, J.E. 1993. Methods in Plant Molecular Biology and Biotechnology, CRC Press, Boca Raton, florida.
10. Shaw, C.H. (Ed.) 1988. Plant Molecular Biology: A practical Approach. IRL Press, Oxford.
11. Smith, R.H. 2000. Plant Tissue Culture: Techniques and Experiments. Academic Press, New York.

Advanced Biosystematics of Angiosperms**COURSE LEARNING OBJECTIVES:**

1. To understand the foundational aims, components, and principles of plant taxonomy and biosystematics.
2. To analyze the types and importance of taxonomic characters and classifications in angiosperm systematics.
3. To critically evaluate the historical and modern taxonomic systems, including contributions by key taxonomists.
4. To apply knowledge of taxonomic tools, literature, and botanical nomenclature rules (ICBN) to classify and name angiosperms.
5. To integrate cytological, anatomical, chemical, embryological, and palynological data for biosystematic analysis.
6. To utilize numerical taxonomy and cladistics to study and interpret plant relationships and variations.

COURSE LEARNING OUTCOMES:

By the end of the course, students will be able to:

1. Describe and differentiate the key concepts such as alpha and omega taxonomy, and identify different types of characters used in taxonomy (qualitative, quantitative, analytic, synthetic).
2. Discuss the contributions of major historical figures in taxonomy and compare various evolutionary classification systems (Hutchinson, Takhtajan, Cronquist, Thorne, APG III).
3. Demonstrate proficiency in using taxonomic literature including flora, monographs, manuals, keys, and databases.
4. Apply the International Code of Botanical Nomenclature (ICBN) rules in assigning valid names and understanding typification, author citation, and hybrid naming.
5. Perform biosystematic analyses using cytological, anatomical, chemotaxonomic, palynological, and embryological characters.
6. Construct and interpret dendrograms and cladograms using numerical taxonomy techniques such as OTU analysis, cluster analysis, and coding methods.
7. Critically evaluate plant relationships and population variations using modern taximetric methods.

Course Title:	Advanced Biosystematics of Angiosperms	Course Code: 24MBO9311T
Total Lecture hours: 60		
Unit I	Aims, components, and principles of taxonomy; Alpha and omega taxonomy, documentation and scope. Concept of characters: analytic versus synthetic character, qualitative versus quantitative characters, good and bad characters. Major contributions of Theophrastus, Bauhin, Tournefort, Linnaeus, Adanson de Candolle and Bentham and Hooker. Evolutionary taxonomic classifications and their merits and demerits of Hutchinson, Takhtajan, Cronquist, Thorne. Brief	20

	reference of Angiosperm Phylogeny Group (APG III) classification.	
Unit II	Taxonomic literature: Flora & e-flora, monograph, icons, index, library, manuals, taxonomic keys for plant identification. Botanical nomenclature: ICBN Principles, rules and recommendation, typification, author citation, valid publication, rejection of names, principle of priority and its limitations, Nomenclature of hybrids and cultivars, concept of biocode.	16
Unit III	Biosystematic procedures: Serum diagnosis, Cytology- Chromosome morphology and number, anatomy, chemotaxonomy, palynology-pollen characters in detail related to taxonomy, Embryology- embryological characters of taxonomic importance.	18
Unit IV	Numerical Taxonomy- Principles, concepts, operational taxonomic units (OTU), data processing and taxonomic studies, taximetric methods for study of population variation and similarity - coding, cluster analysis, cladistics and cladogram.	06
Reference and Reading Books:		
1. Cole, A.J. Numerical Taxonomy, Academic Press, London. 2. Davis, P.H. and Heywood, V.H. 1973, Principles of Angiosperms Taxonomy, Robert E. Kreiger Pub. Co., New York. 3. Grant, V. 1971, Plant Specimen, Columbia University Press London. 4. Grant, W.E. 1984, Plant Biosystematics. Academic Press London. 5. Harrison, H.J. 1971. New Concepts in Flowering Plant Taxonomy. Rieman Educational Book Ltd. U.K. 6. Heslop- Harrison, J. 1967. Plant Taxonomy, English Language Book Soc. & Edward Arnold Pub. Ltd. U.K. 7. Heywood, V.H. And Moore, D.M. 1984. Current Concepts in Plant Taxonomy. Academic Press, London. 8. Jones, A.D. and Wilbins, A.D. 1971. Variations and Adaptations in Plant Species. Hiemand& Co., New York. 9. Jones, S.B. Jr. and Luchsinger, A.E. 1986. Plant Systematic (2nd Edition). Mc.GrawHill Book Co., New York. 10. Nordenstam, B., El Gazaly, G. and Kassas, M. 2000 Plant Systematic For 21st Century. Portland Press Ltd., London. 11. Porter C.L. Taxonomy of Flowering Plants, Radford, A.E. 1986. Fundamentals of Plant Systematics. Harper & Row Pub., USA. 12. Solbrig, O.T. And Solbrig, D.J. 1979. Population Biology and Evolution, Addison-Wesley Publishing Co. Ind USA. 13. Solbrig, O.T. 1970. Principles and Methods of Plant Biosystematics. The Macmillan Cocollier-Macmillan Ltd., London. 14. Stabbings, G.L. 1974. Flowering Plant- Evolution above Species Level. Edward Arnold Ltd. London. 15. Stace, C.A. 1989. Plant Taxonomy and Biosystematics (2nd Edition) Edward Arnold Ltd. London. 16. Takhtajan, A.L. 1997. Diversity and Classification of Flowering Plants. Columbia University Press, New York. 17. Woodland, D.W. 1991. Contemporary Plant Systematic. Prentice Hall. New Jersey. 18. Singh Gurcharan, 2014 Taxonomy of Angiosperms		

Biosystematics Laboratory

Course Title:	Biosystematics Laboratory	Course Code: 24MBO9305P
Suggested Laboratory Exercises: 1. Separation of cell organelles by differential centrifugation. 2. Separation of protein by electrophoresis (Native and SDS page). 3. Separation of amino acids etc. by paper and thin layer chromatography 4. Demonstration of column Chromatography. 5. Validation of Beer-lamberts law of a colored compound (CuSO₄). 6. Quantification of DNA by UV-Visible spectrophotometer. 7. Light microscope and its parts observation of unstained and stained cells. 8. Microscopy-SEM, TEM, Florescence, Staining & fixation procedures 9. Measurement of cell size using stage micrometer and ocular micrometer.		


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10. Study of floral anatomy by cutting serial transverse sections.
11. Transverse sections of different stages of developing anthers to see development of wall layers and sporogenesis.
12. Pollen viability tests using different salt and sugar concentrations.
13. Stages in embryo development in plants like *Raphanus* and Legumes etc.
14. Isolation of protoplasts from various plant tissues and testing their viability.
15. Effect of physical (e.g. Temperature) and chemical (e.g. osmoticum) factors on protoplast yield.
16. Organogenesis and somatic embryogenesis using appropriate explants and preparation of artificial seed.
17. Suspension culture
18. Description of a specimen from representative, locally available families:
(1) Ranunculaceae, (2) Capparidaceae, (3) Portulacaceae, (4) Caryophyllaceae, (5) Malvaceae, (6) Tiliaceae, (7) Sterculiaceae, (8) Zygophyllaceae, (9) Rhamnaceae, (10) Sapindaceae, (11) Fabaceae (12) Combretaceae, (13) Myrtaceae, (14) Cucurbitaceae, (15) Apiaceae, (16) Cyperaceae and (17) Poaceae
19. Description of a species based on various specimens to study intraspecific variation: a collective exercise.
20. Description of various species of a genus, location of key characters and preparation of keys at generic level.
21. Location of key characters and use of keys at family level.
22. Training in using floras and e-flora for identification of specimens described in the class.
23. Demonstration of the utility of secondary metabolites in the taxonomy of some appropriate genera.
24. Comparison of different species of a genus and different genera of a family to calculate similarity coefficients and preparation of dendrograms and cladograms.
25. Demonstration of the principle of priority.
26. Demonstration of the rejection of names according to ICBN. Developed NPC formula and identified different species.



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SEMESTER IV

Genetics

This course delves into the fundamental and advanced concepts of classical and molecular genetics. The course aims to equip students with a comprehensive understanding of genetic principles and their applications in biological research and biotechnology.

Course Learning Objectives:

1. To understand and interpret the principles of Mendelian and non-Mendelian inheritance, and the concept of allelism.
2. To analyze chromosomal structure and behavior using classical and molecular cytogenetic techniques.
3. To explore the fine structure of genes and the use of cis-trans complementation tests in functional genomics.
4. To examine different types of gene interactions and predict phenotypic outcomes in genetic crosses.
5. To describe the mechanisms, types, and significance of mutations and mutagenesis in biological systems.
6. To construct and interpret genetic linkage maps and apply cytogenetic techniques in gene mapping.
7. To integrate classical genetics with molecular tools for solving genetic problems and research applications.

Course Learning Outcomes:

Upon successful completion of the course, students will be able to:

1. Demonstrate proficiency in interpreting inheritance patterns and allelic interactions using real-world and theoretical problems.
2. Critically analyze chromosome structure, behavior during cell division, and abnormalities using cytogenetic tools.
3. Explain the functional architecture of genes, including regulatory and coding regions, and perform genetic analysis using cis-trans tests.
4. Identify and categorize various forms of gene interactions such as complementary, supplementary, epistasis, and duplicate genes.
5. Evaluate different types of mutations and assess the impact of chemical and physical mutagens on genetic material.
6. Develop genetic maps based on recombination frequencies and apply molecular cytogenetic techniques like FISH and CGH.
7. Solve complex genetic problems by integrating knowledge from classical inheritance, cytogenetics, and molecular biology.

Course Title:	Genetics	Course Code: 24MBO9401T
Total Lecture hours: 60		Hours
Unit I	Inheritance and allelism: Chromosome theory of inheritance; Mendelian laws; Organelle inheritance: mitochondrial, chloroplast genome: Evolution, structure and organization.	08
Unit II	Cytogenetics: Chromosome: Structure and nomenclature, centromere and telomere; Sex determination: mechanisms, sex chromosomes; Chromosomal aberrations: Duplications, deficiencies/deletions, inversions, interchanges/translocations; Role of chromosomal aberrations in crop evolution; Ploidy changes: Haploids, polyploids and aneuploids.	15
Unit III	Fine structure of gene, concept, cis-trans test. Gene interactions: complementary, supplementary, epistasis, duplicate genes. Mutation and mutagenesis: Spontaneous and induced mutations, physical and chemical mutagens, types of mutations; Molecular basis of mutations; Transposons and their use in mutagenesis and site directed mutagenesis; Behavioral genetics; Population genetics and Quantitative genetics.	20
Unit IV	Chromosome mapping: Linkage and crossing over: basic concepts, linkage maps, correlation of genetic and physical maps, molecular markers and construction of linkage maps; Molecular mechanism of recombination	17

	Molecular Cytogenetics: C value paradox, cot curve and its significance, multigene families and their evolution, in situ hybridization- concept and technique, flow cytometry.
Reference and Reading Books:	
Suggested Reading:	
1.	Benjamin Lewin (2000). Genes VII. Oxford university press.
2.	Gardner E J, Simmons M J, Snustad D P (1991). Principles of Genetics (III Edn). John Wiley and Sons Inc.
3.	Snustad D P, Simmons M J (2000). Principles of Genetics (III Edn). John Wiley and Sons.
4.	Strickberger (2005). Genetics (III Edn). Prentice Hall of India Pvt. Ltd.
5.	William S Klug, Michael R Cummings (1994). Concepts of Genetics. Prentice Hall.
6.	Robert J Brooker (2009). Genetics: Analysis and principles (III Edn). McGraw Hill.
7.	Daniel L Hartl, Elizabeth W Jones (2009). Genetics: Analysis of genes and genomes (VII Edn). Jones and Bartlett publishers.
8.	D Peter Snustad, Michael J Simmons (2010). Principles of genetics (V Edn). John Wiley and Sons.
9.	Acquaah G (2007). Principles of Plant Genetics and Breeding, Blackwell Publishing Ltd.USA.
10.	Hartl DL and Jones EW (2007). Genetics – Analysis of Genes and Genomes, 7th edition, Jones and Bartlett publishers.
11.	Hartwell LH, Hood L, Goldberg ML, Reynolds AE, Silver LM, Veres RC (2006). Genetics – From Genes to Genomes, 3rd edition, McGraw Hill.
12.	Lewin B (2008). Genes IX, Jones and Bartlett Publishers.
13.	Singh RJ (2002). Plant Cytogenetics, 2nd edition, CRC Press.
14.	Strickberger MW (2008). Genetics, 3rd Edition, Pearson (Prentice Hall).
15.	Weising K, Nybom H, Wolff K and Kahl G (2005) DNA Fingerprinting in Plants

Plant Biochemistry and Metabolism

Course Objectives

The course will provide students with a thorough understanding of plant bioenergetics, nucleotide metabolism, and related biosynthesis and degradation pathways. Students will analyze enzyme function and regulation, explore plant protein structure, function, and modifications, and study protein interactions. The course will cover secondary metabolites, including their classifications, biosynthesis, and roles in defense and signaling. Additionally, students will identify essential vitamins for plant growth, their biosynthesis, and functions within plant cells.

Course Learning Outcomes

Upon completing the course, students will be able to:

- Investigate how nucleotide metabolism affects plant responses to environmental stress and developmental processes. Investigate the ecological and economic significance of secondary metabolites in agriculture and medicine.
- Apply knowledge of enzymes to understand metabolic pathways and their regulation in plants.
- Synthesize information on bioenergetics, nucleotide metabolism, enzymes, proteins, secondary metabolites, and vitamins to understand their interconnected roles in plant physiology.
- Apply a holistic approach to analyze how these components contribute to plant growth, development, and adaptation to environmental changes.

Course Title:	Plant Biochemistry and Metabolism	Course Code: 24MBO9402T
Total Lecture hours: 60		Hours
Unit I	Energy: Principles of thermodynamics, free energy, Concept of energy rich compounds and intermediates, Structure and function of ATP, ATP synthesis and chemo-osmotic hypothesis of ATP generation, Redox reaction, Types and mechanisms of Phosphorylation. Nucleotides metabolism: Biosynthesis of Ribonucleotides and of Deoxy-ribonucleotide salvage and denovo pathways, nucleotide degradation.	15
Unit II	Enzymes: Enzyme kinetics, Michaelis- Menten equation and significance of Km value, negative and positive co- operativity, enzyme nomenclature and EC number, Catalytic mechanisms: Acid-Base catalysis, covalent catalysis, metal ion catalysis, electrostatic state bonding, Lysozyme as model enzyme for catalysis	15

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	mechanism, Regulation of enzyme activity: feedback and allosteric regulation , active sites, isozymes, activators and inhibitors.	
Unit III	Proteins: Structure, Ramchandran Plot, techniques of protein purification. Protein sequencing and proteomics, Dynamics of protein structure, Protein structure prediction tools, Protein Folding, protein stability, globular proteins and maintenance of specific confirmation, structural evolution. Molecular Chaperons, Protein Data Banks.	15
Unit IV	Secondary Metabolites: Detailed account of Coumarins, Lignins, Insecticides (pyrethrins and rotenoides), Tannins, Flavonoids, Alkaloids and Steroid and their role in plant defense. Vitamins: Water and fat soluble vitamins , biochemical functions of thiamine, riboflavin, nicotinic acid, pantothenic acid, pyridoxine, biotin, folic acid, vitamin B12, ascorbic acid, Vitamin A and Vitamin D.	15
Reference and Reading Books:		
1. Lehninger AL, Nelson DL, Cox MM : Principles of Biochemistry. 3 rd edition. Macmillan Publishers, Worth New York. 2000.		
2. Jain JL: Fundamental of Biochemistry. 2 nd ed., S. Chand & Co. Ltd., New Delhi. 1990.		
3. Voet D, Voet JG : Biochemistry. 2 nd edition. Wiley, New York. 1995.		
4. William G. Hopkins and Norman P. Huner. (2009), Introduction to Plant Physiology, Published by John Wiley & Sons, Inc, USA.		
5. Lincoln Taiz (2014). Plant Physiology and Development, Published by Oxford University Press.		
6. Bob. B Buchanan, W. Gruissem, and R. L. Jones. (2015). Biochemistry and Molecular Biology of Plants, 2 nd Edition, Published by Wiley-Blackwell.		

Plant Biotechnology

Course Title:	Plant Biotechnology	Course Code: 24MBO9403T
Total Lecture hours: 60		Hours
Unit I	The concept of totipotency and history of development of plant tissue culture from Haberlandt to the present development of different PTC media and their nutritional components. Plant tissue culture laboratory - facilities, operation and management, media preparation and handling; Sterile techniques.	08
Unit II	Pathways of plant regeneration - proliferation of axillary buds, adventitious shoot bud proliferation, organogenesis and somatic embryogenesis from callus and suspension cultures. Somatic embryogenesis- Survey of somatic embryogenesis in angiosperms. Zygotic versus somatic embryogenesis in monocots and dicots.	15
Unit III	Transgenic plants - The concept and history of development of transgenesis in plants. Agrobacterium - mediated transformation. Direct DNA transfer into intact plant cells - microprojectile bombardment and chemical uptake of DNA by plant protoplasts. Tools for genetic transformation - Transformation vectors, promoters, terminators, marker and reporter genes.	20
Unit IV	Manufacture of valuable products - antigens, antibodies, edible vaccines, enzymes, proteins. Benefits and risks of producing transgenic - plants IPR and regulatory requirements, field testing and regulations to release transgenic plants in India.	17
Reference and Reading Books:		
1. Bhojwani, S.S. and Razdan, M.K. 1996. Plant Tissue Culture: Theory and Practice (a revised edition). Elsevier Science Publishers, New York. USA.		
2. Bhojwani, S.S. 1990. Plant Tissue Culture: Applications and Limitations: Elsevier Science Publishers, New York, USA.		
3. Brown, T.A. 1999. Genomes. John Wiley & Sons (Asia) Pvt. Ltd. Singapore.		
4. Callow, J.A., Ford-Lloyd, B.V. and Newbury, H.J. 1997. Biotechnology and Plant Genetic Resources: Conservation and Use. CAB International, Oxon, UK.		
5. Chrispeels, M.J. and Sadava, D.E. 1994, Plants. Genes and Agriculture. Jones & Bartlett Publishers, Boston, USA.		
6. Collins, H.A. and Edwards, S. 1998. Plant Cell Culture. Bios Scientific Publishers, Oxford, UK.		
7. Glazer, A.N. and Nikaido, H. 1995. Microbial Biotechnology. W.H. Freeman & Company, New York, USA.		

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8. Gustafson, J.P. 2000. Genomes. Kluwer Academic Plenum Publishers, New York, USA.
9. Henry, R.J. 1997. Practical Applications of Plant Molecular Biology. Chapman & Hall, London, UK.
10. Jain, S.M., Sopory, S.K. and Veilleux, R.E. 1996. In vitro Haploid Production in Higher Plants, Vols. 1-5, Fundamental Aspects and Methods, Kluwer Academic Publishers, Dordrecht. The Netherlands.
11. Jolles, OÖ. and Jomvall, H. (eds.) 2000. Proteomics in Functional Genomics. Birkhauser Verlag, Basel, Switzerland.
12. Kartha, K.K. 1985. Cryopreservation of Plant Cells and Organs. CRC Press, Boca Raton, Florida, USA.
13. Old, R.W. and Primrose, S.B. 1989. Principles of gene Manipulation. Blackwell Scientific Publications, Oxford, UK.
14. Primrose, S.B. 1995. Principles of genome analysis. Blackwell Science Ltd., Oxford, UK.
15. Raghavan, V. 1986. Embryogenesis in Angiosperms: A Developmental and Experimental Study. Cambridge University Press, New York, USA.
16. Raghavan, V. 1997. Molecular Biology of Flowering Plants. Cambridge University Press, New York, USA.
17. Shantharam, S. and Montgomery, J.F. 1999. Biotechnology, Biosafety and Biodiversity. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
18. Vasil, I.K. and Thorpe, T.A. 1994. Plant Cell and Tissue Culture. Kluwer Academic Publishers. The Netherlands.

Morphogenesis and Experimental Biology

Course Objectives

The course aims to provide a comprehensive understanding of plant growth and development, focusing on the roles of genes, hormones, and environmental factors. Students will become proficient in experimental methods, including tissue culture and gene editing techniques. They will study plant growth patterns, analyzing how various factors influence plant structure. Practical applications will be emphasized, enabling students to use their knowledge to enhance crop improvement, develop disease-resistant plants, and cultivate varieties with desirable traits.

Course Learning Outcomes

Upon completing the course, students will be able to:

- Acquire a deep understanding of plant morphogenesis, including cellular and tissue differentiation.
- Learn about organogenesis and the roles of genetic and environmental factors in shaping plant form and structure.
- Gain proficiency in experimental methods for studying plant development, such as microscopy and molecular tools.
- Develop skills in designing and conducting experiments and analyzing data to investigate plant morphogenesis.
- Enhance the ability to integrate theoretical knowledge with practical research skills to address complex plant biology questions.
- Formulate research hypotheses, design experiments, and interpret results within the broader context of plant science.

Course Title:	Morphogenesis and Experimental Biology	Course Code: 24MBO9404T
Total Lecture hours: 60		
Unit I	Development and morphogenesis - Shoot apex the apical cell, meristem, the subcellular and biochemical structure of the meristem. the mechanism of primordium initiation, transition to flowering, growth and formation of organs. Experimental work on shoot apical meristem, meristem culture and virus free plants, histochemical studies on apical meristems.	08
Unit II	The phenomenon of morphogenesis - Correlation, polarity, symmetry, differentiation, regeneration. Morphogenetic factors - Physical, mechanical, chemical and genetic factors. molecular basis of morphogenesis in plants with special reference to work done in <i>Arabidopsis</i> .	15
Unit III	Somatic embryogenesis - Survey of somatic embryogenesis in angiosperms, direct somatic embryogenesis and embryogenesis from callus and protoplasts, cytology, physiology and genesis of somatic embryogenesis, nutritional factors, hormonal factors and embryo rescue in wide hybridization, endosperm and ovary.	


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	culture, Micropropagation advances and synthetic seeds. Cell plating technique and isolation of mutant cell lines, auxotrophic mutants. Mechanism involved in cell culture mutants. Suspension culture and growth studies.
Unit IV	Microtechniques. Collection, killing and fixation (FAA and glutaraldehyde) of plant material, dehydration and embedding in paraffin and GMA, microtomy, (equipments and method), conventional and histochemical staining procedures. Transmission and scanning electron microscopy for internal structure and morphological development of plant organs and tissues.
Reference and Reading Books:	
1. Bhojwani S.S. W, Y. Soh , Morphogenesis in plant tissue cultures Springer 1999. 2. Lyndon, R.F. 1990. Plant Development. The Cellular Basis, Unin Byman, London. 3. Rogar V. Jean 2009 A systematic study in palnt morphogenesis , Phylotaxis : Cambridge University Press 4. Sinnott E.W. 1960. Plant Morphogenesis., McGrawhill,Book Co. 6. Sinnott E.W. 1979 Plant Morphogenesis McGrawhillBook Co. 7. Steeves, T.A. and Sussex, I.M., 1989. Patterns in Plant Development (2 nd edition). Cambridge University Press, Cambridge 8. Wardlaw Wiley C.W. 1966. Trends in plant morphogenesis. 9. Zarsky V. and F. Curekova. Plant Cell Morphogenesis: Methods and Protocols: 2014Springer Protocols, Humana Press www.springer.com	
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Environmental Biology

Course Learning Objectives:

1. To analyze the causes, types, and consequences of air and water pollution, and examine current mitigation strategies.
2. To explore the scientific basis of climate change, global warming, and their ecological and societal impacts.
3. To evaluate major environmental concerns such as deforestation, biodiversity loss, waste management, and their relevance to sustainable development.
4. To critically assess national and international policies, laws, and regulatory frameworks addressing environmental issues.
5. To develop interdisciplinary thinking to propose viable solutions to contemporary environmental challenges.

Course Learning Outcomes:

Upon successful completion of this course, students will be able to:

1. Identify and explain the sources, impacts, and control measures of air and water pollution using scientific data and case studies.
2. Analyze climate data to interpret trends in climate change, and assess its impact on biodiversity, agriculture, and human health.
3. Evaluate environmental degradation scenarios and propose evidence-based strategies for pollution prevention and ecosystem restoration.
4. Interpret environmental legislation and critically analyze their implementation in national and global contexts.
5. Design and communicate research-informed environmental action plans, policies, or awareness programs using interdisciplinary approaches.

Course Title:	Environmental Biology	Course Code: 24MBO9405T
Total Lecture hours: 60		Hours
Unit I	Air Pollution: Important Primary (CO, CO ₂ , Oxides of Sulphur & Nitrogen, H ₂ S, Chlorine, Particulates, Odour Producing compounds) & Secondary Air Pollutants (Smog, Acid rain, Primary Photochemical reaction, Formation of ozone and peroxyacetyl nitrate in air), Effects of air pollutants on Buildings & Monuments, Plants, man and animals; Biomonitoring, Air pollution control (particulates and gaseous pollutants), Green belt, Ozone depletion, mechanism of depletion, control strategies	08
Unit II	Water Pollution: Eutrophication – Process and control; Oil Pollution, Thermal	15

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	Pollution, Heavy metal Pollution, Treatment, Disposal & Recycling of Wastewaters, drinking water standards, Minimum National Standards Solid & Hazardous waste management & Resource Recovery: Solid wastes, Types, collection, Shrinking waste streams: 3Rs (Reduction, Recycle & Reuse), composting, energy from waste, demanufacturing; Methods of disposal: Landfill, Open dumps, Exporting waste; Hazardous waste: Definition, disposal and management.	
Unit III	Climatic Issues: Greenhouse gases (CO ₂ , CH ₄ , N ₂ O, CFCs: sources, trends and roles and consequence of greenhouse effects (CO ₂ fertilization, global warming, sea level rise, Biodiversity erosion), Carbon sequestration, Applications of GIS and Remote Sensing technology in environmental studies, the future of planet earth. Policies, Regulations & related issues: Water (Prevention and Control of Pollution) Act 1981; Environment (Protection) Act 1986, Wild Life Protection Act 1972, Forest (Conservation) Act 1980, Biodiversity Act 2002.	20
Unit IV	Environmental Concerns: Environmental auditing, Ecological footprints, Environment Impact Assessment, Bioindicator and biomarkers of environmental health; Environmental economics, Ecopolitics and green policies; Ecolabel, Rain water harvesting, Orans, Indira Gandhi Canal and its ecological implications, water logging & salinity problems - The management alternatives.	17
Reference and Reading Books:		
1. Treshow, M. 1985. Air Pollution and Plant Life. Wiley Interscience. 2. Mason, C. I. 1991. Biology of Freshwater Pollution. Longman. 3. Hill, M. K. 1997. Understanding Environmental Pollution. Cambridge University Press. 4. Brij Gopal, P. S. Pathak and K. G. Saxena (Eds.). 1998. Ecology Today; An anthology of Contemporary Ecological Research. International Scientific Publications, New Delhi. 5. P. K. Goel. 1997. Water Pollution: Causes, Effects and Control. New Age international Ltd., Publishers, New Delhi. 6. R. K. Trivedy and P. K. Goel. 1998. An Introduction to Air Pollution. Technosience Publications, Jaipur 7. I. P. Abrol and V. V. Dhruva Narayana (Editors) 1990. Technologies for Wasteland Development. ICAR, New Delhi. 8. G. M. Masters and W. P. Ela. 2008. Introduction to Environmental Engineering and Sciences. PHI Learning Private Limited, New Delhi. 9. W. P. Cunningham and M. A. Cunningham. 2003. Principles of Environmental Science; Inquiry and Applications. Tata McGraw-Hill Publishing Company Limited, New Delhi 10. S. K. Maiti, 2004. Handbook of Methods in Environmental Studies Vol. 1 & 2. ABD Publisher, Jaipur		

Plant Ecology and Resources Utilization

Course Objectives

1. To introduce the concepts and principles of ecology, vegetative organization in community and changes take place during ecological succession.
2. To develop knowledge about structure and function of ecosystem and understand biogeochemical cycle in environment and its role.
3. To know about the domestication and introduction of plants.
4. To know about origin, cultivation and uses of various plant resources

Course Outcomes:

1. On completion of this course the students are able to analyze various types of ecosystems, correlate different ecosystems.
2. Evolve the relation between biotic and abiotic factors in an ecosystem.
3. They understand the pattern origin, diversification and cultivation of plants in nature.
4. The students would be able to enumerate the economically significant plants and their uses.

Course Title:	Plant Ecology and Resources Utilization	Course Code: 24MBO9406T
Total Lecture hours: 60		Hours
Unit I	Science of Ecology: principle and scope of ecology, ecological factors. Concept of habitat and niche.	17

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	Population: Characteristics of population; population growth curves; population regulation; life history strategies (r and K selection). Competition and coexistence, intra-specific interactions, inter specific interactions, scramble and contest competition model, mutualism, commensalism and allelopathy, prey-predator interactions. Vegetation organization: Community structure and attributes; levels of species diversity and its measurement; edges and ecotones. Methods of studying plant communities.	
Unit II	Vegetation development: Temporal changes (cyclic and noncyclic, mechanism of ecological succession (relay floristic and initial floristic composition), succession models (facilitation, tolerance and inhibition models), Changes involved in succession, concept of climax. Ecosystem: structure and function; food chain, food web, flow of energy; productivity of various ecosystems of the world; biogeochemical cycles (carbon, nitrogen, phosphorus) Ecosystem Stability: Concept (resistance and reilliance) ecological perturbations (Material and anthropogenic) and their impact on plants and ecosystems.	14
Unit III	World Centers of Primary Diversity of Domesticated Plants: Basic concepts, plant introduction and secondary centers. Origin; Evolution, Botany Cultivation and Uses of: (i) food, forage and fodder crop, (ii) fiber crops (iii) medicinal and aromatic plants (iv) vegetable and (v) oil yielding crops with special reference to local plants. General account of important spices.	15
Unit IV	Important Fire -Wood and timber Yielding Plants and Non-wood Forest Products (NWFPS) such as bamboos, rattans, raw materials for paper making, gums, tannin, dyes, resins and fruits. Green Revolution: Benefits and consequence, Innovation for meeting world food demands, plant used as avenue trees for shade, pollution control and aesthetics. Horticultural & floricultural plants.	14
Reference and Reading Books:		
1. Smith, R.L. 1996. Ecology and Field Biology, Harper Collins, New York. 2. Muller-Dombois, D. and Ellenberg, H. 1974. Aims and Methods of Vegetation Ecology, Wiley, New York. 3. Begon, M. Harper, J.L. and Townsend, C.R. 1996. Ecology, Blackwell Science, Cambridge, U.S.A. 4. Ludwig, J. and Reynolds, J.F. 1988. Statistical Ecology. John Wiley & Sons. 5. Odum, E.P. 1971. Fundamentals of Ecology, Saunders, Philadelphia. 6. Odum, E.P. 1983. Basic Ecology, Saunders, Philadelphia. 7. Barbour, M.G. Burk, J.H. and Pitts, W.D. 1987. Terrestrial Plant Ecology, Benjamin/Cummings Publication Company, California. 8. Kormondy, E.J., 1996. Concepts of ecology. Prentice-Hall of India Pvt. Ltd., New Delhi. 9. Chapman, J.L. and Reiss, M.J. 1988. Ecology; Principles and Applications. Cambridge University Press, Cambridge; U.K. 10. N.S. Subrahmanyam and A.V. S.S. Sambamurty. 2000. Ecology. Narosa Publishing House, Delhi. 11. Arora, R.K. and Nayyar, E.R. 1984. Wild Relatives of Crop Plants in India. NBPGR Science Monograph No. 7. 12. Baker, H.G. 1978. Plants and Civilization (3rd ed). C.A. Wadsworth, Belmont. 13. Bole, P.V. and Vaghani, Y. 1986. Field Guide to Common Indian Trees. Oxford University Press, Mumbai. 14. Chandel, K.P.S., Shukla, G. and Sharma, N. 1996. Biodiversity in Medicinal and Aromatic Plants in India: Conservation and Utilization: National Bureau of Plant Genetic Resources, New Delhi. 15. Chrispeels, M.J. and Sadava, D. 1977. Plants, Food and People. W.H. Freeman and Co., San Francisco. 16. Cristì, B. R. (ed.) 1999. CRC Handbook of Plant Sciences and Agriculture. Vol. I. In-situ conservation. CRC Press, Boca Raton, Florida, USA. 17. Conway, G. 1999. The Doubly Green Revolution: Food for All in the 21st Century. Penguin Books. 18. Kocchar, S.L. 1998. Economic Botany of the Tropics, 2nd edition. Macmillian India Ltd., Delhi. 19. Nair, M.N.B. et al. (Eds.) 1988. Sustainable Management of Nonwood Forest Products. Faculty of Forestry, University Putra Malaysia. 43004 PM Serdang, Selangor, Malaysia. 20. Plant Wealth of India 1997. Special Issue of Proceedings Indian National Science Academy B-63. 21. Sahni, K.C. 2000. The Book of Indian Trees. 2nd edition. Oxford University Press, Mumbai. 22. Schery, R.W. 1972. Plants for Man. 2nd ed. Englewood Cliffs, New Jersey. Prentice Hall.		

23. Sharma, O.P. 1996. Hill's Economic Botany(Late Dr. A.F. Hill, adapted by O.P. Sharma). Tata McGraw Hill Co. Ltd., New Delhi.
24. Simmonds, N. W. (1979), Evolution of Crop Plants. Longman, New York.
25. Swaminathan, M.S. and Kocchar, S.L. (Eds.) 1989. Plants and Society. Macmillan Publication Ltd., London.
26. Thakur, R.S. Puri, H.S. and Husain, A. 1989. Major Medicinal Plants of India. Central Institute of Medicinal and Anomantic Plants, CSIR, Lucknow.
27. Wanger, H., Hikino, H. and Farnsworth, N. 1989. Economic and Medicinal Plant Research. Vols. 1-3. Academic Press, London.

Microbial Technology

Course Objectives

The course aims to provide students with a comprehensive understanding of microorganisms, including bacteria, fungi, algae, and viruses, and their physiological and metabolic processes. Students will learn techniques for isolating, cultivating, and characterizing microorganisms and explore their applications in industries such as pharmaceuticals, food and beverage, agriculture, and environmental management. The course covers the production of microbial products like enzymes, antibiotics, biofuels, and biopolymers, as well as the role of microorganisms in ecosystems and their use in bioremediation and environmental sustainability. Ethical considerations, biosafety, and regulatory frameworks related to the use of microorganisms in technology will also be discussed.

Course Learning Outcomes

Upon completing the course, students will be able to:

- Apply various laboratory techniques for the isolation, cultivation, and identification of microorganisms.
- Understand of how to utilize microorganisms for the production of valuable products like antibiotics, enzymes, biofuels, and fermented foods.
- Apply microbial solutions for environmental challenges, such as bioremediation, waste treatment, and pollution control.
- Competence in using bioinformatics tools to analyze microbial genomes and interpret large datasets from microbial studies.
- Enhanced ability to design experiments, analyze results, and troubleshoot issues in microbial technology applications.
- Preparation for roles in biotechnology companies, research institutions, environmental agencies, pharmaceutical industries, and more.
- Foundation for entrepreneurship in microbial technology, particularly in developing new microbial products or processes.

Course Title:	Microbial Technology	Course Code: 24MBO9407T
Total Lecture hours: 60	Hours	
Unit I	Pre-requisite of industrial microorganisms; Strategies for screening, selection and improvement of industrial strains; Methods of preservation & maintenance of microbial strains & their stability; Formulation of fermentation media; methods of sterilization; culturing techniques of microbial strains; inoculum preparation and inoculum development. Overview of upstream and Downstream processing, In situ recovery of products. Industrial production of citric acid, lactic acid, enzymes (alpha-amylase, lipase, xylase, pectinases, proteases), acetone- butanol, Amino acid (lysine and glutamic acid).	08
Unit II	Vitamins (Riboflavin, cyanocobalamin). Microbial Production of Therapeutic and Pharmaceutical Compounds: Microbial production of therapeutic compounds (β lactam, aminoglycosides, Ansamycins (Rifamycin), peptide antibiotics Quinolones), biotransformation of steroids, Fermentative production of antibiotics (penicillins, erythromycins); Vaccines, recombinant vaccines.	15
Unit III	Biofuels: Useful features of bio-fuels, The substrate digester and the microorganisms in the process of biogas production (biomethanation), Production of bioethanol from sugar, molasses, starch and cellulosic materials. Ethanol recovery, Microbial production of hydrogen gas, biodiesel from hydrocarbons. Modern trends in Microbial Production: microbial production of bioplastics (PHB, PHA), bioinsecticides (thuricide), biopolymer (dextran, alginate, xanthan,	20


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Unit IV	pullulan). Biofertilizers (Rhizobia, BGA, Azotobacter, Phosphate solubilizing microorganisms), Single Cell Protein and production of biological weapons with reference to anthrax. Advances in Microbial Technology: Recombinant fermentations, strategies for fermentation with recombinant organisms and stability issues of recombinants; Applications of immobilized/co-immobilized cells/enzymes in fermentation industry; Overview of nanomaterials and biosynthesis of silver and gold nanomaterials from microbes.	17
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Reference and Reading Books:

1. Biotechnology: A Textbook of Industrial Microbiology by W. Cruieger, A. Cruieger and T.D. Brock, Sinauer Associates Inc., USA (1991). 24
2. Industrial Microbiology: An Introduction by M.M.J. Waite, N.L. Morgan, J.S. Rockey and G. Highton, John Wiley & Sons, USA (2010).
3. Manual of Industrial Microbiology and Biotechnology by R.H. Baltz, J.E. Davies and A.L. Demain, ASM Press, USA (2010).
4. Microbial Biotechnology, Fundamentals of Applied Microbiology by A.N. Glazer and H. Nikaïdo, Cambridge University Press, UK (2007).
5. Microbial Biotechnology: Principles and Applications by Y.K. Lee, World Scientific Pubs, Singapore (2006).
6. Microorganisms and Biotechnology by J. Taylor, N. Thorne, UK (2001). 1
7. Modern Industrial Microbiology and Biotechnology by N. Okafor, Science Publishers, USA (2007).
8. Prescott and Dunn's Industrial Microbiology by G. Reed, CBS Publishers and Distributors, India (2004).
9. Microbiology: A Laboratory Manual, J.G. Cappuccino and N. Sherman, 2002. Addison-Wesley.
10. Laboratory Manual of Experimental Microbiology, R.M. Atlas, A.E. Brown and L.C. Parks, 1995. Mosby, St. Louis.
11. Laboratory Manual in General Microbiology, N. Kannan, 2002. Panima Publishers.
12. Bergey's Manual of Determinative Bacteriology. Ninth edition J.G.Holt, N.R.Krieg, Lippincott Williams, 2000. Wilkin Publishers.
13. Pharmaceutical Microbiology SS Purohit, AK Saluja and HN Kakrani, 2012.

Bioinformatics and Biostatistics

Course Learning Objectives:

1. To understand the foundational concepts of bioinformatics, including the types and applications of biological databases and computational tools used in genomics and proteomics.
2. To gain practical experience with key bioinformatics tools for sequence analysis, gene annotation, protein structure prediction, and phylogenetic studies.
3. To develop competency in using various biological databases and online resources (e.g., GenBank, PDB, SWISS-PROT) for retrieval and analysis of molecular biology data.
4. To understand statistical methods used in analyzing biological data, including measures of central tendency, variability, correlation, regression, and hypothesis testing.
5. To apply biostatistical techniques in real-world biological data analysis, including determining sample sizes, conducting t-tests, ANOVA, Chi-square tests, and interpreting the results.
6. To integrate bioinformatics and statistical methods for problem-solving in molecular biology, genetics, and drug discovery.

Course Learning Objectives:

By the end of this course, students will be able to:

1. Understand the foundational concepts of bioinformatics, including the types and applications of biological databases and computational tools used in genomics and proteomics.
2. Gain practical experience with key bioinformatics tools for sequence analysis, gene annotation, protein structure prediction, and phylogenetic studies.
3. Develop competency in using various biological databases and online resources (e.g., GenBank, PDB, SWISS-PROT) for retrieval and analysis of molecular biology data.
4. Understand statistical methods used in analyzing biological data, including measures of central tendency, variability, correlation, regression, and hypothesis testing.

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5. Apply biostatistical techniques in real-world biological data analysis, including determining sample sizes, conducting t-tests, ANOVA, Chi-square tests, and interpreting the results.
6. Integrate bioinformatics and statistical methods for problem-solving in molecular biology, genetics, and drug discovery.

Course Title:	Bioinformatics and Biostatistics	Course Code: 24MBO9408T
Total Lecture hours: 60		Hours
Unit I	Concepts of Bioinformatics: Introduction and future prospects; Applications in genomics and proteomics; Public databases; Gene bank; Database searches: sequence retrieval systems; Similarity searching: BLAST, FASTA; Multiple sequence alignment: CLUSTALW; Detecting functional sites in DNA; Motif and domain prediction and analysis; Identification of open reading frames (ORF); Gene annotation technology. Databases and online tools: Biological Databases: - Types and applications;	15
Unit II	Applications of Bioinformatics: Computational methods for sequence analysis: Dot blot and dynamic programming methods; Phylogenetic analysis; Virtual and electronic cell; Internet tools for DNA sequence translation; Restriction enzyme mapping; Prediction of secondary structure of proteins; Application tools- primer designing, molecular mapping and concept and tools of computer aided drug designing	15
Unit III	Fundamentals of statistics: Arithmetic mean, median, mode: theory and simple numerical problem; Measures of variation: standard deviation, variance, coefficient of variation; Correlation, types and methods: simple, multiple, linear and nonlinear correlation, spearman's correlation, rank correlation; Regression: linear and curvilinear regression (for two variable X and Y only), Regression lines by least square method; regression equations of X on Y and Y on X only; Sample size; Power of study.	15
Unit IV	Tests of significance: Null hypothesis; Standard error; Level of significance; Degrees of freedom; Significance of mean for large samples; Significance in means for small samples (students t-test); Significance in ratio of two samples; F test (for difference between variance of two samples); Chi square test; Analysis of variance test (ANOVA) for one and two way classification; Calculation of an unknown variable using regression equation. Laws of probability, theorem of total probability	15
Reference and Reading Books:		
1. Introduction to Bioinformatics, Arthur M. Lesk, Oxford University Press. 2. Introduction to Bioinformatics, Attwood, Pearson Education. 3. A Textbook of Systems Biology, E. Klipp, W. Liebermeister, C. Wierling, Axel Kowald, H. Lehrach, R. Herwig (2009), Wiley-VCH Verlag GmbH & Co. 4. Bioinformatics: Sequence and Genome Analysis, David W. Mount (2001), Cold Spring Harbor (CSH) Laboratory Press. 5. Plant System Biology, Coruzzi, G.M. (2009), Wiley Publishing House. 6. Bioinformatics - A Practical Guide to the Analysis of Genes and Proteins. 2nd Edition by Baxevanis. 7. Bioinformatics: Sequence, structure and Data Bank: A Practical Approach by Higgs. 8. Bioinformatics - from Genomes to drug. 2 volumes by Lenganer. 9. Bioinformatic Methods and Protocols - Misener. 10. Bioinformatics: Sequence and Genome analysis. 11. Introduction to Bioinformatics by Altwood. 12. Proteome Research: New Frontiers in Functional Genomics: Principles and Practices. 13. Genomics: The Science and Technology behind the human project. 14. Protein Biotechnology. Edited by Felix Franks, Humana Press, Totowa, New Jarsey. 15. Practical Statistics for experimental biologist by Wardlaw, A.C. (1985). 16. Statistical Methods in Biology - 2000 by Bailey, N.T. J. English Univ. Press. 17. Biostatistics - 7th Edition by Daniel 8. Fundamental of Biostatistics by Khan 18. Statisticsfor Biologist by CampbellR.C. (1974) Cambridge University Press 19. Introduction to Biostatistics, Le and Chap (2009), Wilay and Sons. 20. Fundamentals of Biostatistics, B. Rosner (2005), Duxbury Press. 21. Medical Statistics from Scratch, Bowers (2008), Wiley and Sons.		

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