

DHANAMANJURI UNIVERSITY**Department of Botany****SYLLABUS - 2026****M. Sc. BOTANY (2 Year) under National Education Policy (NEP)****COURSE STRUCTURE****SEMESTER – I**

Paper Code	Paper Type	Paper Title	Marks			Hrs. per Week	No. of Credits
			Internal Assessment	End Semester	Total		
BOT-501	Core	CELL BIOLOGY, GENETICS AND EVOLUTION	20	80	100	4	4
BOT-502	Core	BIOCHEMISTRY AND PHYSIOLOGY	20	80	100	4	4
BOT-503	Core	Practical–I (Based on BOT-501 and BOT-502)		100	100	8	4
BOT-504	Core	CRYPTOGAMS, GYMNOSPERMS AND PALEOBOTANY	20	80	100	4	4
BOT-505	Core	MYCOLOGY, MICROBIOLOGY & PLANT PATHOLOGY	20	80	100	4	4
BOT-506	Core	Practical–II (Based on BOT-504 and BOT-505)		100	100	8	4
		Total		600		36	24

SEMESTER – II

Paper Code	Paper Type	Course Title	Marks			Hrs per week	No. of Credits
			Internal Assessment	End Semester	Total		
BOT-507	Core	ANGIOSPERM TAXONOMY, ADVANCED MORPHOLOGY, PLANT ECOLOGY AND ENVIRONMENT	20	80	100	4	4
BOT-508	Core	Practical–III (Based on BOT-507)		100	100	8	4
BOT-509	Core	MOLECULAR BIOLOGY, BIOTECHNOLOGY AND BIOINFORMATICS	20	80	100	4	4
BOT-510	Core	Practical–IV (Based on BOT-509)		100	100	8	4
BOT-511	VAC/AEC	To be prepared by University		50	50	2	2
		Total			450	22	18

SEMESTER – III

Course Code	Course Type	Course Title	Marks			Hrs. per Week	No. of Credits
			Internal Assessment	End Semester	Total		
BOT-612	Core	ETHNOBOTANY AND PLANT RESOURCE UTILIZATION	20	80	100	4	4
BOT-613	Core	Practical – V (Based on BOT-612)		100	100	8	4

SPECIALIZATION STREAM (ELECTIVE) Only One Stream							
Paper Code	Paper Type	Paper Title	Marks			Hrs. per Week	No. of Credits
			Internal Assessment	End Semester	Total		
BOT-621	Elective	GENETICS – I (Plant Breeding and Cytogenetics)	20	80	100	4	4
BOT-622	Elective	GENETICS – II (Molecular Genetics)	20	80	100	4	4
BOT-623	Elective	GENETICS - LAB (Based on BOT-621 and BOT-622)		100	100	8	4
BOT-631	Elective	ECOLOGY – I (Principles of Ecology)	20	80	100	4	4
BOT-632	Elective	ECOLOGY – II (Restoration Ecology and Environment Management)	20	80	100	4	4
BOT-633	Elective	ECOLOGY - LAB (Based on BOT-631 and BOT-632)		100	100	4	4
BOT-641	Elective	PLANT PATHOLOGY & MICROBIOLOGY – I (Principles of Pathology)	20	80	100	4	4
BOT-642	Elective	PLANT PATHOLOGY & MICROBIOLOGY – II (Microbiology)	20	80	100	4	4
BOT-643	Elective	PLANT PATHOLOGY & MICROBIOLOGY-LAB (Based on BOT-641 and BOT-642)		100	100	8	4
BOT-651	Elective	PLANT PHYSIOLOGY– I (Mineral Nutrition and Seed Physiology and Technology)	20	80	100	4	4
BOT-652	Elective	PLANT PHYSIOLOGY-II (Plant Metabolism and Translocation of Photoassimilates)	20	80	100	4	4
BOT-653	Elective	PLANT PHYSIOLOGY-LAB (Based on BOT-651 and BOT-652)		100	100	8	4
BOT-661	Elective	PLANT TAXONOMY – I (Basis Taxonomy)	20	80	100	4	4

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BOT-662	Elective	PLANT TAXONOMY – II (Recent Trends in Taxonomy)	20	80	100	4	4
BOT-663	Elective	PLANT TAXONOMY - LAB (Based on BOT-661 and BOT-662)		100	100	4	4
		Total			500	36	20

SEMESTER – IV

Paper Code	Paper Type	Paper Title	Marks			Hrs. per Week	No. of Credit
			Internal Assessment	End Semester	Total		
BOT-614	Core	PLANT ANATOMY AND EMBRYOLOGY	20	80	100	4	4
BOT-615	Core	Practical - VI (Based on BOT-614)		100	100	8	4
SPECIALIZATION STREAM (ELECTIVE) – Only One Stream							
BOT-624	Elective	GENETICS– III (Biotechnology, Microbial and Human Genetics)	20	80	100	4	4
BOT-634	Elective	ECOLOGY – III (Vegetation and Applied Ecology)	20	80	100	4	4
BOT-644	Elective	PLANT PATHOLOGY & MICROBIOLOGY - III (Plant Diseases and Management)	20	80	100	4	4
BOT-654	Elective	PLANT PHYSIOLOGY – III (Developmental and Stress Physiology and Secondary Metabolites)	20	80	100	4	4
BOT-664	Elective	PLANT TAXONOMY – III (Taxonomy and Evolution)	20	80	100	4	4
RESEARCH							
BOT-671	Research Methodology	BIOSTATISTICS AND METHODS IN PLANT SCIENCE	10	40	50	2	2

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BOT-672	Research (Thesis/ Project/ Field Work/Patent	(To be submitted at end of Semester)	-	150	150	18	6
		Total			500	36	20
Grand Total		For the Two years. M.Sc. course			2050 marks	130 hrs	82 credits

M.Sc. Botany Program Objectives (POs):

PO1: To introduce in-depth learning concepts in Plant Sciences with multidisciplinary approach at global status using various teaching tools (traditional and digital)

PO2: To acquire lifelong learning goals and become confident on basic and applied knowledge of plants science

PO3: To provide theoretical and practical knowledge of different plant science domains, inculcating critical thinking, scientific attitude, and true appreciation of nature

PO4: To expose the students to the applied aspects of various branches of botany, equip them with analytical and problem-solving skills, developing proficiency in recent techniques like Industrial Microbiology, applied Ethnobotany, molecular Systematics, Restoration ecology, genetic engineering, biotechnology and bioinformatics, promoting entrepreneurship and sustainable natural resource management

PO5: To arouse curiosity on environmental and societal challenges through a deeper understanding of functional traits of plants and biodiversity

PO6: To train students in research methodologies

PO7: To groom the programme a career oriented one

Program Learning Outcomes (PLOs):

PLO 1: The students will develop universally updated theoretical, practical and communication skills on plant world

PLO 2: After successfully completing M.Sc. Botany, students will develop deeper theoretical & Practical knowledge of different branches of Botany like Plant taxonomy, Advanced Morphology, Anatomy, Mycology, Microbiology, Physiology, Biochemistry, Cell biology, Genetics, Molecular biology, Pathology, Bioinformatics, Ethnobotany, Ecology and Related social issues, making them capable to deal the issues and demands of the society

PLO 3: Students will acquire the basic and progressive knowledge from entrepreneurship-based industry oriented thrust areas of plant sciences like Industrial Microbiology, applied Ethnobotany,

molecular Systematics, Restoration ecology, genetic engineering, biotechnology and bioinformatics in combination with mandatory core courses and multidisciplinary components of elective courses, research methodology as well as assignments/ seminars/ job trainings / Field works

PSO 4: This program has a strong theoretical basis that will help students to develop a sound knowledge on the evolutionary relationship of lower and higher plants by using the key characters, which is expected from a student of Botany to support the other branches of knowledge related to plants

PLO 5: This upgraded curriculum will develop outcome-oriented candidature, nurtured with discovery, learning, possessing experiences and skills to solve practical problems and friendly with recent pedagogical trends in education including e-learning, flipped class and hybrid learning, experiential learning to develop into responsible personality in the earth

PLO 6: Students will be able to exercise intelligence of scientific knowledge of plant science for investigation, innovation and sustenance of the world, and will be able to inculcate the knowledge in diverse contexts with global perspective

PLO 7: Students will learn Biodiversity value based ethical practices and principles and should be committed to professional ethics

PLO 8: The students will be able to establish skill oriented, independent and life-long learning

PLO 9: This programme will lay foundation for the students appearing to various competitive exams

PLO 10: The student completing the course will be capable of executing research projects

SEMESTER - I

Paper Type: Core (Theory)

Credit - 4

Paper Title: Cell Biology, Genetics and Evolution

Paper Code: BOT-501

100 marks

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

- Discuss the ultrastructure and function of cell organelles and cytoskeleton.
- Know the chemical composition of cell membrane and respective role of each compounds present in it.
- Comprehend the general principles of cell signalling and signal transduction in plant.
- Understand the causes and genetics of cancer and the process of apoptosis.
- Understand the roles of G-protein coupled receptors, receptor tyrosine kinase, and enzyme linked receptors.
- Know the concept of genetic variation and to analyze test crosses to identify linkage and calculation of recombination frequency.

- Understand the role of crossing over in evolution and biodiversity.
- Differentiate between Mendelian and Non-Mendelian inheritance and how traits controlled by Cytoplasmic genes are inherited.
- Understand aneuploidy, polyploidy, deletion, duplication, inversion and translocation.
- Evaluate the impact of chromosomal alterations on phenotype, genetic diversity, speciation etc.
- Have conceptual understanding of pedigree analysis, lod score for genetic testing, somatic Cell hybridization.
- Develop an understanding of Hardy - Weinberg Law and factors affecting it

Unit 1: Cell membrane and Cytoskeleton

15 Lectures

Structure of plasma membrane: membrane fluidity, lipid rafts, transport of substances across the plasma membrane, the extracellular matrix and cell-cell interactions. Endocytic pathway; post-translational uptake of proteins by mitochondria, chloroplasts, and peroxisomes.

Unit 2: Cell signalling and Signal transduction

15 Lectures

Cell-cycle and its control (regulation); cancer - causes, genetics, apoptosis - extrinsic and intrinsic pathways, cell signalling and signal transduction - principles of cell signalling, G-protein coupled receptors, enzyme-linked receptors, receptor tyrosine kinases; secondary messengers.

Unit 3: Gene interactions, Linkage and Crossing over

15 Lectures

Modern concept of gene allele, multiple alleles, pseudoalleles, lethal alleles, complementation test. Gene interactions and their molecular basis. Current concept of pleiotropy, penetrance, expressivity; phenocopy dosage compensation. Linkage and crossing over; Three-point test cross. Linkage mapping; Chi-square test in Mendelian and linkage analysis.

Unit 4: Epigenetics, Quantitative and Evolutionary Genetics

15 Lectures

Epigenetic alteration to genome; inheritance of epigenetic changes; genomic imprinting; epigenetic variation. Pedigree analysis, mapping by somatic cell hybrids, genetic disorders due to change in chromosome structure and number. Quantitative genetics: quantitative traits, multiple-factor hypothesis; heritability. Evolutionary Genetics: Hardy-Weinberg Law; Natural Selection-Level and types; Modern Synthesis of Evolution; Molecular evolution, speciation; co-evolution.

References:

1. Anthony J.F. Griffiths, Susan R. Wessler, Sean B. Carroll, John Doebley (2015): Introduction to Genetic Analysis, 11th Edition, W.H. Freeman and Company
2. Benjamin A. Pierce (2005): Genetics-a conceptual approach, 2nd edition, W.H. Freeman and Company.
3. D. Peter Snustad and Michael J. Simmons (2013): Principles of Genetics, 6th edition, John Wiley and Sons Incorporation
4. D.S. Falconer and Trudy F.C. Mackay (1996): Introduction to Quantitative Genetics, 4th edition, Longman Group Ltd.
5. David Hyde (2009): Introduction to Genetic Principles, Tata-McGraw Higher Education
6. Jocelyn e. Krebs, Elliott S. Golstein, Stephen T. Kilpatrick (2018): Lewin's Genes XII, Jones and Bartlett Learning
7. Lyle Armstrong (2014): Epigenetics, GS Garland Science
8. Mark Ridley (2004): Evolution, 3rd edition, Blackwell Science Limited

9. Michael R. Speicher, Arno G. Mokulsky and Stylianos E. Antonarakis (2010) ed: Vogel and Mokulsky's Human Genetics, Problems and approaches, 4th edition, SpringerVerlag
10. Peter J. Russell (2010): Genetics, a molecular approach, 3rd edition, Pearson Education Incorporation
11. Robert J. Brooker (2009): Genetics-analysis and principles, 3rd edition, Tata McGraw Higher Education
12. T.A. Brown (2007): Genomes 3, GS Garland Science
13. William S. Klug, Michael R. Cummings, Charlotte A. Spencer, Michael A. Palladion (2016): Concepts of Genetics, 11th Edition, Pearson Education Limited.

Paper Type: Core (Theory)

Credit - 4

Paper Title: Biochemistry and Plant Physiology

Paper Code: BOT-502

100 marks

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

- Understand chemical bonding in relation to the structure of biomolecules.
- Know the chemistry of carbohydrates, particularly Monosaccharides
- Visualize the Three-dimensional structure and folding of protein molecule.
- Learn the kinetics and regulation of enzyme activity.
- Understand the principles of thermodynamics and bioenergetics in living organisms.
- Learn the electron transport system in chloroplast and mitochondria
- Learn the process of biological oxidation leading to ATP synthesis.
- Understand Water relation of plants with respect to various physiological processes
- Explain chemical properties and deficiency symptoms of mineral nutrients in plants
- Explain the significance of Photosynthesis and respiration
- Learn how light energy is converted into chemical energy in the process of photosynthesis
- Know the different modes of carbon fixation and adding to the subsequent reactions leading the synthesis of carbohydrates.
- Assess the role of Phytohormones in growth, development and differentiation in plants.
- Comprehend the processes and physiology of flowering and fruiting

Unit 1. Biomolecules and Enzymology:

15 Lectures

Carbohydrates- Structure, classification, properties and function; Chemistry of monosaccharides, homo and hetero-polysaccharides; **Amino acids**-structure, classification and functions; Synthesis of peptides; **Proteins**- properties, covalent structure; secondary, tertiary and quaternary structure of proteins, Three-dimensional structure of proteins: Ramachandran plot, α -helix, β -pleated sheet, β -turn; **Lipids**-Classification, structure and function; **Porphyrins**- Importance of porphyrins in biology; chlorophyll porphyrins; **Vitamins**- structure and biological role; **Enzyme**- classification, coenzymes, active site of enzyme, allosteric enzymes, isoenzymes, ribozyme, multienzyme complexes; enzyme kinetics- Michaelis-Menten equation, determination of K_m , enzyme regulation.

Unit 2. Bioenergetics and Metabolism:

15 Lectures

Biochemical interactions of aqueous system; Principles of thermodynamics; Free energy transformations, Redox systems as biological energy transducers; Role of ATP in biological

energy transformations; Electron transport system and ATP synthesis in Mitochondria and Chloroplast; Role of Acetyl Co-A in metabolism, Basic concepts of intermediary metabolism. Carbohydrate metabolism: Glycolysis, Krebs's cycle, pentose phosphate pathway, Cyanide resistant pathway in plant mitochondria, Oxidation of fatty acids; Glyoxylate cycle, Gluconeogenesis

Unit -3: Nutrient Uptake and Growth and Development

15 Lectures

Concept and kinetics of Water Potential; Absorption and Transport processes of water; Recent concept in stomatal physiology; Signal transduction in guard cell; Functions and deficiency symptoms of essential elements; Nutrient uptake (transport) – Passive and Active; Physiological concept of plant growth; Roles of growth hormones - Auxin, Gibberellins, Cytokinins, Absciscic acid, Ethylene; Introduction of other natural and synthetic growth regulators in plant growth and development; Introduction of other natural and synthetic growth regulators in plant growth and development; Physiology of flowering by light, temperature and hormone; Senescence

Unit -4: Photosynthesis and Nitrogen fixation

15 Lectures

Photosynthetic pigments; Absorption and Dissipation of light energy; Red drop, Emerson effect and Two light reactions; Cyclic and Non-cyclic Photophosphorylation; Photosynthetic Electron Transport System in prokaryotic and eukaryotic organisms; Photosynthetic Carbon Reactions – Calvin cycle, Activity of RuBisCO and PEPcase, Photorespiration; CO₂ Concentrating mechanisms – C₄, CAM and C₁ mode; Synthesis of sucrose and starch, Bacterial Photosynthesis, Nitrogen fixation – Biological and non-biological, mechanism and genetics, Nitrate and ammonium assimilation;

Suggested Reading

1. Hopkins, W.G and Huner Norman, P.A. 1995. Introduction to Plant Physiology, John Wiley and Sons, Inc., New York, USA.
2. Noggle, G.R. and Fritz, G.F. 1997. Introductory Plant Physiology, Prentice Hall, New Delhi
3. Salisbury, F.B. and Ross, C.W. 1992. Plant Physiology (4th edition), Wadsworth Publishing Co., California, USA.
4. Taiz, L and Zieger, E. 2006. Plant Physiology (4th edition), Sinauer Associates Inc., Massachusetts, USA
5. Bidwell, R.G.S. 1987. Plant Physiology, MacMillan
6. Wilkins, M.B. 1989. Advanced Plant Physiology, ELBS Longman Scientific and Technical, England
7. Buchanan, B.B., Gruissem, W. and Jones, R.L. 2000. Biochemistry and Molecular Biology of Plants, American Society of Plant Physiologists, Maryland, USA
8. Hall, D.O. and Rao, K.K. 1996. Photosynthesis, University Press, Cambridge, England
9. Heldt, H.W. 2004. Plant Biochemistry, Academic Press, California, USA
10. Styrer, L. 2002. Biochemistry, Freeman and Co., New York, USA
11. Lehninger, A.L. 1987. Principles of Biochemistry, CBS Publishers and Distributors, New Delhi
12. Epstein, E. 1972. Mineral Nutrition in Plants: Principles and Perspective, Wiley, New York
13. Carl Leopold, A. and Kriedemann, P.E. 1983. Plant Growth and Development, Tata McGraw Hill Publishing Company Ltd, New Delhi
14. Mukherji, S and Ghosh, A.K. 2005. Plant Physiology, New Central Book Agency (P) Ltd, Kolkata

15. Nautiyal, B.P. 2005. Plant Growth and Development, Meditech Scientific International (Pvt) Ltd, New Delhi
16. Satish C Bhatla and Manju A Lal (2018): Plant Physiology, Development and Metabolism, Springer Nature Singapore Pte Ltd, Singapore

Paper Type: Core (Practical)

Credit - 4

Paper Title: Practical - I (Based on BOT-501 and BOT-502)

Paper Code: BOT-503

100 marks

A. Cell Biology, Genetics and Evolution: 50 Marks

i) Cell Biology:

1. Isolation of mitochondria and their visualization
2. Isolation and purification of nuclei and their staining with Feulgen stain
3. Isolation of chloroplasts and determination of number of chlorophyll molecules per chloroplast
4. C-banding in plant materials.
5. Isolation of RNA and quantification by spectrophotometric method
6. Study of interphase nuclei in buccal smear for barr body.
7. Study of mitotic cell division in plants
8. Study of mitotic index
9. Chromosome count and karyotyping in plant materials
10. Study of polytene chromosome in an appropriate material
11. Study of meiotic cell division in plant cells

ii) Genetics:

1. Solving Mendelian problems by probability method and analysis using Chi square test for Goodness of fit.
2. Solving problems related to gene interaction
3. Study of Linkage and Crossing over using chi square test of Independence of attributes.
4. Human Pedigree Analysis
5. Lod Score analysis
6. Biostatistical analysis of quantitative characters- Mean, standard deviation, Correlation and Regression analysis
7. Calculation of Broad sense, narrow sense and Realized heritability
8. Problem solving of evolutionary Genetics.

Submissions

1. Permanent slides of mitotic and meiotic cell division
2. a karyogram

B. Biochemistry and Physiology: 50 Marks

i) Biochemistry:

1. Preparation of different solutions – Normal, Molar, Percentage, ppm
2. Preparation of Buffer Solution – Phosphate and Acetate Buffer
3. Study of titration curve of a weak acid with a strong alkali and determination of pKa of weak acids
4. Determination of glucose concentration by Anthrone method
5. Detection of free amino acids with the help of paper chromatography
6. Colorimetric Estimation of amino acids
7. Estimation of protein content by Biuret method

8. Estimation of protein content by Lowry's method/Bradford's method)
9. TLC separation of amino acids
- 10 Assay of enzyme amylase activity on starch
11. Study on effect of temperature on the hydrolysis of starch by diastase
12. Qualitative and Quantitative Test for Ascorbic Acid
13. Calculation of Ramachandran (ϕ/ψ) Angles from PDB files using appropriate software.
14. Estimation of oil content in seeds by Soxhlet Extraction Method
15. solation and Estimation of free fatty acids

ii) Plant Physiology:

1. To study the effect of temperature upon permeability of the cytoplasmic membrane.
2. Determination of water potential by Gravimetric and Chardakov method
3. Determination of Permanent Wilting Point (PWP) of a soil.
4. To set up Wilmott's bubbler and study the effect of the following on the rate of photosynthesis:
 - i) Varying CO_2 concentration
 - ii) Different wavelengths of light
5. To study the effect of temperature on rate of photosynthesis.
6. To separate the four pigments i.e. Chl a, Chl b, Carotene & Xanthophyll from the green leaves by thin layer/column chromatography.
7. Comparison of chlorophyll content of two different leaves.
8. Determination of Respiratory Quotient in germinating seeds.
9. Determination of a) Stomatal index, b) Stomatal frequency and c) Transpiration index.
10. To study the effect of pH on stomatal opening and closing.
11. Comparison of rate of transpiration between two surfaces of dorsiventral leaves by Cobalt Chloride method or by conical flask-water-oil-leaf method.
12. Study of "Hill's Reaction" in isolated chloroplasts.
13. Estimation of Ascorbic acid by volumetric method.

Paper Type: Core Paper (Theory)

Paper Title: Cryptogams, Gymnosperms and Palaeobotany

Paper Code: BOT-504

Credit - 4

100 mark

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

- Learn various thallus structure of algae and different life cycle pattern found in diverse groups algae.
- Understand algalization technology and uses of algae for various purposes.
- Know the gametophytic and sporophytic structure of Liverworts, Hornworts and Mosses
- Visualize the economic and ecological importance of bryophytes.
- Conceive how early land plants had originated and later on evolved.
- Learn the general characteristics of Pteridophytes and Gymnosperms and their distribution in India.
- Know the Telome concept, Stele evolution and Heterospory in relation to seed habit.

- Learn the morphology and anatomy of Vegetative and Reproductive parts of different groups of Gymnosperms.
- Understand the characteristic features of fossil pteridophytes and gymnosperms.

Unit 1. Algae:

15 Lectures

General characters of Algae; Outline of Fritsch' classification; Modern approach in algal classification; Evolution and ranges of thallus structure- cell wall, Flagella, pigment systems; Mode of reproduction; Life cycle patterns in Cyanophyceae, Chlorophyceae, Xanthophyceae, Bacillariophyceae, Phaeophyceae and Rhodophyceae; Origin and evolution of sex in algae; Algal applications - algalization technology; biofuels from algae, Role of algae in soil fertility, algal bloom.

Unit 2. Bryophytes:

15 Lectures

General characters; Recent trends for classification in bryophytes; structure of gametophyte and sporophytes of Liverworts, hornworts and mosses; Evolutionary trends of gametophyte and sporophyte; Origin of bryophytes; Vegetative and perennation in bryophytes; Diversity and distribution of bryophytes in India; Economic and ecological importance- pollution indicators; Phytoremediation, Desiccation, Poikilohydry.

Unit 3. Pteridophytes:

15 Lectures

Origin and evolution of early vascular plants; classification of pteridophytes; Diversity of Life cycle with reference to haploid vegetative structure of Psilotopsida, Lycopsidea, Sphenopsida and Pteropsida; Evolution of stele; Telome concept, Apogamy, Apospory, Heterospory and seed habit; Soral and cytological evolution; Economic importance.

Fossil Pteridophytes - General characters of Psilotales, Lepidodendrales, Sphenophyllales and Calamitales

Unit 4. Gymnosperms:

15 Lectures

General characters; Principles of classification- popular and recent trends; Morphological and Anatomical features of vegetative and reproductive parts of Cycadales, Coniferales, Ginkgoales, Gnetales; Evolutionary trends in relation to Pteridophytes and angiosperms. Economic importance. Fossil gymnosperms-General characteristics; Pteridospermales, Bennittitales, Cordaitales; Applied aspects of Palaeobotany

Paper Type: Core Paper (Theory)

Credit - 4

Paper Title: Mycology, Microbiology & Plant Pathology

100 marks

Paper Code: BOT-505

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

- Understand characteristics, ultrastructure, diversity and nutrition of microbes
- Gain basic knowledge about plant viruses
- Skill the microbial culture techniques
- Understand the mechanism of gene transfer in Bacteria
- Understand the importance of microbiology in food Industries, agriculture, forestry and pharmaceutical Industries

- Apply information technology in plant disease management.
- Contribute to plant disease management

Unit 1. Microbiology I:

15 Lectures

Characteristics and ultrastructure of virus particles, Nomenclature and classification of plant viruses, viral replication strategies in RNA and DNA viruses, Reverse transcription, characteristic features of Bacteriophage T4, Viroids, prions, mycoplasma and L forms; Characteristics of Archaeobacteria and Eubacteria; ultrastructure, cell wall, nutrition and reproduction; mechanism of genetic transfer in bacteria-transformation, transduction and conjugation.

Unit 2. Microbiology II:

15 Lectures

Definition, nature and extent of microbial diversity; techniques of microbial culture and culture medium; Effect of environment in microbial growth; methods of studies of Rhizospheric, phyllospheric and phylloplane microflora, importance of microbes in food industries, biogeochemical cycle and agriculture, Forestry and pharmaceutical industries

Unit 3. Mycology:

15 Lectures

General account of fungi, Classification (Ainsworth, 1973), concept of molecular fungal taxonomy, phylogeny of fungi; morphology, reproduction and life cycle in different classes of fungi; parasexuality, Heterothallism, fungal endophytes. Lichens as best example of symbionts; characteristics and classification of Lichens; Role of Lichens in Plant succession, pollution monitoring and climate change; Lichen secondary metabolites.

Unit 4. Principles of plant pathology:

15 Lectures

History, concept, importance and components of plant diseases, Causes and classification of plant diseases; Dispersal of plant pathogens, mechanism of infection, Symptomology of fungal, bacterial, viral and mycoplasmal diseases, principles of plant disease management.

Paper Type: Core (Practical)

Credit - 4

Paper Title: Practical - II (Based on BOT-504 and BOT-505)

Paper Code: BOT-506

100 marks

A. Cryptogams, Gymnosperms and Palaeobotany: (50 Marks)

1. Vegetative and reproductive features of genera representing following algal classes:
 - a) Cyanophyceae: *Oscillatoria*, *Nostoc*, *Anabaena*, *Scytonema*
 - b) Chlorophyceae: *Chlamydomonas*, *Volvox*, *Pediastrum*, *Hydrodictyon*, *Cladophora*, *Ulothrix*, *Oedogonium*, *Chara*, *Nitella*
 - c) Phaeophyceae: *Laminaria*, *Ectocarpus*, *Fucus*
 - d) Rhodophyceae: *Batrachospermum*, *Gelidium*, *Polysiphonia*
 - e) Xanthophyceae: *Vaucheria*, *Botrydium*
2. Vegetative and reproductive features and anatomical details of the following:
 - a) Hepaticopsida : *Riccia*, *Marchantia*, *Plagiochasma*, *Porella*
 - b) Anthocerotopsida : *Anthoceros*, *Notothylus*
 - c) Bryopsida : *Sphagnum*, *Funaria*, *Polytrichum*
3. i) Vegetative and reproductive features and anatomical details of *Psilotum*, *Lycopodium*, *Selaginella*, *Equisetum*, *Marsilea*, *Isoetes*
 ii) To observe and study the arrangement of sori on a receptacle of the following members: *Dryopteris*, *Pteridium*, *Pteris*, *Adiantum*, *Lygodium*, *Blechnum*, *Gleichenia*

4. Morphological and anatomical features of the vegetative and reproductive parts of the following: *Cycas*, *Pinus*, *Ginkgo*, *Taxus*, *Araucaria*, *Podocarpus*, *Gnetum*, *Ephedra*
5. Studies on permanent slides of fossil Pteridophytes, fossil Gymnosperms and fossil angiosperms.

B. (Mycology, Microbiology and Pathology): (50 Marks)

1. Vegetative and reproductive features of the following fungal genera: *Saprolegnia*, *Mucor*, *Rhizopus*, *Neurospora*, *Ustilago*, *Puccinia*, *Penicillium*, *Aspergillus*
2. Pathological and micrometric studies of following diseases with reference to symptoms, etiology, causal agent and measurement of fungal spores: Stem Gall of Coriander, Rust of Pea, Rust of broad bean, Black stem Rust of wheat, False Smut of rice
3. Methods of sterilization and media preparation; Isolation of pathogenic fungi from diseased materials.
4. Differential staining of bacteria using Gram's stain;
5. Isolation of microbes from soil and air by serial dilution, pour plate and spread plate method; Purification of microbes.
6. Study of vegetative & reproductive structures of lichens belonging to Foliose, Crustose and Fruticose
7. Photomicrography and digital image analysis of representative pure cultures and interpretation of results
8. Submission of 10 dried herbarium specimens of infected plant materials (fungal 4, bacterial 3, viral 3)
9. Field study of a suitable place/site in Manipur for survey of Cryptogams in their natural habitat.

SEMESTER – II

Paper Type: Core Paper (Theory)

Credit - 4

Paper Title: Angiosperm Taxonomy, Advanced Morphology, Ecology and Environment

Paper Code: BOT-507

100 marks

Learning Outcomes: After completion of this course, students will be able to:

- Know the components of taxonomic fundamentals and level of Taxonomic study.
- Know the Principles and Recommendations of ICN and concept of Draft Biocode and Phylocode.
- Learn about the National and Regional Herbaria and its utilities and maintenance
- Understand the bases of different system of classification and their critical assessment.
- Learn the basis of APG classification and concept of palaeoherbs, Eudicots, paraphyly, parallelism, convergence etc.
- Understand the modern approach of taxonomic study through Phenetics, Cladistics, Numerical and Molecular basis.

- Learn the origin and evolution of flower and as well of Angiosperms.
- Explain ecological principles, ecosystem structure and function, energy flow, nutrient cycling, and global ecological patterns.
- Analyze community dynamics, including diversity, succession, species interactions, biomes, and ecological niches.
- Evaluate population ecology concepts such as growth patterns, regulation, life history strategies, metapopulations, and landscape processes.
- Assess environmental issues, including types and impacts of pollution, toxicology, e-waste, and global challenges like climate change and ozone depletion.
- Apply principles of conservation biology, biodiversity management, environmental management, and impact assessment for sustainable ecosystem functioning.

Unit 1: Principles, Nomenclature, Classification system and Modern Trends in Taxonomy

15 Lectures

Concepts and components – Description, Identification, Nomenclature, Phylogeny and Classification; Taxonomic Hierarchy; Species concept; ICN – Principles, Rule -Scientific names, Ranks, Author citation, Type method, Valid and Priority of publication, Conservation of names, Name changes, Synonyms; Herbarium- Utility of National and Regional Herbaria. Development of Plant Classification – Artificial, Natural and Phylogenetic; Critical assessment of classification systems of Bentham and Hooker, Hutchinson, Takhtajan and Cronquist; Basis of APG classification, Outline of APG-IV (short version), Merits and Demerits; Concepts of Palaeoherbs and Eudicots, Primitive and Advanced characters; Parallelism and Convergence; Monophyly, Paraphyly and Polyphyly; Modern trends in Taxonomy–Roles of Micro morphology, Embryology, Palynology, Phytochemistry in Taxonomy; Phenetics and Cladistics in Taxonomy, Molecular taxonomy-DNA bar coding; Applications of Taxonomic Databases.

Unit 2: Advanced Morphology of Angiosperms and Taxonomic Study of Selected Families

15 Lectures

Diagnostic features, Range of Floral structure, Phylogeny, Relationship, Some Important Species and treatment (Taxonomic position) in Bentham and Hooker system and APG-IV of the following selected families–Nymphaeaceae, Malvaceae, Caryophyllaceae, Rosaceae, Asteraceae, Acanthaceae, Lamiaceae, Euphorbiaceae, Orchidaceae, Musaceae, Zingiberaceae, Cannaceae, Amaryllidaceae, Cyperaceae, Poaceae; Origin and evolution of Angiosperms; Phyllode Theory; Origin and Evolution of Inflorescence; Concept of angiosperm primitive flower; Origin and Evolution of flower; Carpel Polymorphism; Role of Morphology in Plant Classification; Types of Placentation, Fruit.

Unit-3: Ecosystem Concept, Community Ecology and Niche

15 Lectures

Ecosystem components, Structure and Function of Ecosystem, Primary Productivity; Methods of measurement, Biogeochemical cycles –basic types; Energy flow, models of energy flow; Concepts of Community and Continuum, Methods of studying communities – quadrat, line and belt methods; Analysis of communities – Analytical and synthetic characteristics; Measures of species diversity – richness, evenness; Ecological Succession, concept of climax; Edges and Ecotones; Species Interactions – types; Concepts of Habitat and Niche, niche width and overlap; Fundamental & realized niche, Resource partitioning, Character displacement.

Unit-4: Population and Landscape Ecology Environmental and Conservation Biology

15 Lectures

Population characteristics; Life tables – diagrammatic and conventional (cohort and static); Demography; Population growth (density dependent and density independent); Population regulation, Life history strategies (r and k selection); concept of metapopulation – demes and dispersals; Age Structured Population, Island Biogeography; Source, Nature, Residence and Persistence periods of Pollutants; Types of Pollution; Impact of Air, Water, Bio-monitoring, Bioremediation, Biofuel, Biofilm and Bioconversion; Introduction to Environmental Toxicology; E-Waste; Occupational health Hazards; Global Environmental Issues – Climate Change; Principles of Conservation; Biodiversity Management Approaches; Environmental Management; Environmental Impact Assessment

References (Taxonomy):

1. Singh, G. 2012. Plant Systematics: Theory and Practice, Third Edition, Oxford & IBH, New Delhi
2. Simpson, M.G. 2006. Plant Systematics. Elsevier Academic Press, Amsterdam
3. Sivarajan, V.V. and Robson, N.K.P. 1991. Introduction to the Principles of Plant Taxonomy, Cambridge University Press, Cambridge
4. Stace, C.A. 1989. Plant Taxonomy and Biosystematics. Edward Arnold, London
5. Stuessy, T.F. 1990. Plant Taxonomy: The Systematic Evaluation of Comparative Data. Columbia University Press, New York
6. Judd, W.S., Campbell, C.S., Kellogg, E.A., Stevens, P.F., Donoghue, M.J. Plant Systematics: A Phylogenetic Approach, Third Edition, Sinauer Associates, Massachusetts
7. Kaplan, D.R. 2001. The science of plant morphology: definition, history, and role in modern biology, American Journal of Botany, 88(10):1711-41.
8. Craene, L.P.R.D. 2010. Floral Diagrams: An Aid to Understanding Flower Morphology and Evolution. Cambridge University Press, Cambridge

References (Ecology and Environment):

1. Odum, E.P. & Barrett, G.W. (2005). Fundamentals of Ecology. 5th Edition. Thomson Brooks/Cole.
2. Chapin, F.S., Matson, P.A., & Vitousek, P.M. (2011). Principles of Terrestrial Ecosystem Ecology. Springer.
3. P.J. (2011). Community Ecology. Wiley-Blackwell. (for macroecology concepts).
4. Whittaker, R.H. (1975). Communities and Ecosystems. Macmillan.
5. Morin, P.J. (2011). Community Ecology. Wiley-Blackwell.
6. Molles, M.C. (2019). Ecology: Concepts and Applications. 9th Edition. McGraw Hill.
7. Turner, M.G., Gardner, R.H., & O'Neill, R.V. (2001). Landscape Ecology in Theory and Practice. Springer.
8. MacArthur, R.H. & Wilson, E.O. (2001 reprint). The Theory of Island Biogeography. Princeton University Press.
9. Primack, R.B. (2022). Essentials of Conservation Biology. 7th Edition. Sinauer Associates.
10. Sharma, P.D. (2020). Ecology and Environment. Rastogi Publications.
11. Cunningham, W.P. & Cunningham, M.A. (2017). Principles of Environmental Science. McGraw Hill.

Paper Type: Core (Practical)**Credit - 4****Paper Title: Practical - III (Based on BOT-507)****Paper Code: BOT-508****100 marks****A Angiosperm Taxonomy and Advanced Morphology: (50 Marks)**

1. Taxonomic study of 20 seasonal, local flowering plants (Monocot & Dicot).
 2. Advanced morphological character analysis of representative species of Orchidaceae, Scrophulariaceae, Lamiaceae, Verbenaceae.
3. Artificial key construction based on diagnosis.
4. Construction of Phylogenetic tree from a data provided for the purpose –
 - a) By using Distance Matrix Method (UPGMA). (Gene sequence data is to be provided)
 - b) By Using Parsimony Method (Character Taxon Matrix data is to be supplied to each student)
5. Taxonomic field study tour in a local forest area to collect different angiosperm species and Preparation herbarium specimens and field report submission

B Ecology: (50 Marks)

1. Study of the biomass and primary productivity of the grassland/ cropland/ forest by the harvest method.
2. Determination of the relative frequency/ relative dominance/ relative abundance by the quadrat method in the grassland community.
3. Determination of the Leaf Area Index (LAI) by using constant factors/ graph paper methods.
4. Estimation of soil organic carbon and organic matter percentage of the different ecosystems by Walkley & Black's titration method.
5. Determination of soil moisture content and water holding capacity of soil of different ecosystems.
6. Determination of pH, free CO₂ of the polluted and unpolluted water samples collected from DMU campus ponds.
7. Study of Dissolved Oxygen Content of the polluted and unpolluted water samples.
8. Determination of the Biological Oxygen Demand of two different ponds located within DMU campus

Paper Type: Core Paper (Theory)**Credit - 4****Paper Title: Molecular Biology, Biotechnology and Bioinformatics****100 marks****Paper Code: BOT-509****Learning Outcomes:** On completion of this course, students will be able to:

- Understand the recombinant DNA technology and role of Vectors.
- Learn Gene expression pattern, functional gene analysis and gene cloning and mechanism of gene delivery to plants by *Agrobacterium tumefaciens*
- Describe the macromolecule structures and sequence information using bioinformatics tools and their principles.
- Grasp the application of various bioinformatics tools and databases in analyzing and interpreting macromolecules (genes, genetic elements and genomes)
- Make students learning about the principles of *in silico* drug design and molecular modelling using bioinformatics tools.

- Learn about the statistical concepts and principles relevant to analyze biological data and their applications.
- Work on computational tools and databases to generate and interpret biological information
- Inculcate interdisciplinary research in the fields of computer science, biosciences, mathematics, chemistry and physical sciences
- Analyze genomic, proteomic and metabolic data to have introduction to personalised medicine
- Evaluate the experimental raw data to infer molecular models.

Unit 1. Molecular Biology I:

15 Lectures

Structure of nucleic acids, different forms of DNA, triple and quadruple stranded DNA sequences, DNA supercoiling, Genome organization in viruses, prokaryotes and eukaryotes; C-value paradox; DNA replication in prokaryotes and eukaryotes; Displacement and rolling circle method of DNA replication, Molecular basis of mutation and DNA repair, DNA recombination-Homologous and non-homologous recombination.

Unit 2. Molecular Biology II:

15 Lectures

DNA sequencing: Chain termination method, Thermal cycling method, chemical degradation method, Pyrosequencing, shotgun method, RNA synthesis: DNA dependent RNA synthesis in prokaryotes and eukaryotes, DNA binding proteins and their interactions with DNA, RNA dependent RNA and DNA synthesis. Processing of RNA, Gene expression: Genetic code, Protein synthesis in prokaryotes and eukaryotes. Gene regulation: overview, transcriptional control in bacteria (araBAD and Tryptophan operons), transcriptional control in phage; transcriptional control in eukaryotes.

Unit 3: Biotechnology

15 lectures

Principles and techniques of rDNA technology; Purification of DNA from living cells. Vectors for gene cloning, structure and properties of pBR322, pUC8; Ti plasmid- octopine and nopaline; Structure and properties of phage genome - M13 phage, Cosmid and yeast genome; Cosmids and yeast episomal plasmids; Construction of recombinant vectors, genomic and cDNA libraries; PCR, Real-time PCR, inverse PCR. Studying PCR products - gel electrophoresis, Role of PCR in gene cloning; Technique of gene transfer to plants, agro-infection, in-planta transformation.

Unit 4: Introduction and Overview of Bioinformatics

15 lectures

Bioinformatics and common software and applications; biological databases and types; modes of data storage; flat-file formats of GenBank, EMBL, DDBJ, and PDB; sequence alignment; dynamic programming—concept of local and global sequence alignment; multiple sequence alignment (MSA); FASTA; BLAST—search statistics and E-value; sequence submission methods and tools;

sequence retrieval systems; introduction to phylogenetic tree construction and analysis (Neighbour joining methods, UPGMA, maximum parsimony, maximum-likelihood method, and Bayes method); phenetic and cladistic molecular clock theory; species tree versus gene tree. Bioinformatics in drug discovery, quantitative structure-activity relationship (QSAR) techniques in drug design, introduction to clustered regularly interspaced short palindromic repeats (CRISPR).

References:

1. Introduction to System Biology, Big Data; Data Mining, Artificial Neural Network and SVM
2. Christopher Howe (2007): Gene Cloning and Manipulation, 2nd edition, Cambridge University Press.
3. S.B. Primrose and R.M. Twyman (2006): Principles of Gene Manipulation and Genomics, 7th Edition, Blackwell Publishing.
4. T.A. Brown (2016): Gene Cloning and DNA analysis, An Introduction, 7th edition, Wiley Blackwell
5. B.D. Singh (2012): Biotechnology, Expanding Horizons, 4th edition, Kalyani Publishers.
6. P.K. Gupta (2016): Biotechnology and Genomics, 1st edition, Rastogi Publishers.
7. S. Chawla (2009): Introduction to Plant biotechnology, Taylor and Francis
8. Bishun Deo Prasad, Sangita Sahni, Prasant Kumar, Mohammed Wasim Siddiqui (2018): Plant Biotechnology, Vol 1, Apple Academic Press
9. Lesk, A.M. 2008. Introduction to Bioinformatics, Oxford University Press
10. Lesk, A., 2016. Introduction to Protein Science: Architecture, Function and Genomics, Oxford University Press, New York
11. Dale, J.W., Schantz, M.V. 2012. From Genes to Genomes - Concepts and Applications of DNA Technology, John Wiley and Sons, US
12. Xiong, J. 2006. Essential Bioinformatics, Cambridge University Press
13. Choudhuri, S. 2014. Bioinformatics for Beginners: Genes, Genomes, Molecular Evolution, Databases and Analytical Tools, Academic Press, Elsevier, Amsterdam.
14. Sharma, V., Munjal, A., Shanker, A., 2008. A Text Book of Bioinformatics, Rastogi Publications, Meerut
15. Pevsner, J. 2009. Bioinformatics and Functional Genomics, John Wiley, US
16. Cavasotto, C.N. 2017. In Silico Drug Discovery and Design: Theory, Methods, Challenges and Applications, Taylor & Francis Group, US

Paper Type: Core (Practical)

Credit - 4

Paper Title: Practical - IV (Based on BOT-509)

Paper Code: BOT-510

100 marks

Molecular Biology (practical): (50 Marks)

1. Preparation of LB medium and raising *E. coli*
2. DNA isolation - from Plant cell (leaf of cabbage / Cauliflower head/mustard)
- 3 DNA estimation by diphenylamine/UV Spectrophotometer.
4. Study of DNA replication mechanisms through photographs (Rolling circle, Theta replication and semi discontinuous replication)
5. Study the structures of prokaryotic RNA polymerase and Eukaryotic RNA polymerase II through photographs.

6. Photographs establishing nucleic acid as genetic material (Messelson and Stahl's, Avery et al, Griffith's and Hershey and Chase experiments)
7. Study of the following through photographs: Assembly of Spliceosome machinery, Polymerase Chain Reaction, Gel electrophoresis.etc

Biotechnology and Bioinformatics): (50 Marks)

1. Preparation of different tissue culture media
2. To perform of Callus induction from an explant.
3. To study Protoplast culture.
4. Any other biotechnological experiments deemed to be suited for the course.
5. Phylogenetic Analysis using appropriate software (MEGA, PHYLIP, PAUP etc.)
6. Retrieval of gene Sequence from Protein ID
7. Retrieve the gene sequence similar to given mRNA.
8. Sequence Analysis using BLAST and FASTA
9. To obtain the global alignment between two given sequences using BLAST
10. Multiple sequence alignment and development of phylogenetic tree of the organism from given sequence.
11. Analysis of the protein structure of selected protein in PDB

SEMESTER - III

Paper Type: Core Paper (Theory)

Paper Title: Ethnobotany and Plant Resource Utilization

Paper Code: BOT-612

Credit - 4

100 marks

Learning Outcomes: After studying this course, the students would be able to:

- Understand basics of ethnobotany and major Hypothesis driven theories of ethnobotany.
- Know scientific validation methods for ethnobotanical knowledge through experimental method (pharmacological and biochemical knowledge) and non-experimental approach.
- Make link between folk taxonomy and scientific knowledge
- recognise different approaches for ethnobotanical data collection methods
- Apply free listing and questionnaire (open, structured and semi-structured) in ethnobotanical data collection.
- Demonstrate use of common qualitative and quantitative research methods
- 8. Calculate ethnobotanical indices such as FIC, FL, RCI and Use Value Indices.
- understand important interactions between cultural practices, ecosystem conservation and modern science
- distinguish between monoherbal and polyherbal formulations
- know characteristics of plant taxa used by the people of the North East India
- Have ideas about the national and international initiatives to safeguard ethnobotanical knowledge.
- Understand concept of primary and secondary centres of crop origin.
- Have some idea about Hawkes' nuclear centres and regions of diversity of domesticated plants and harlan's centres and non-centres

Unit 1: Ethnobotanical Knowledge

15 Lectures

Introduction, history, scope of Ethnobotany and significance; current trends; Types of ethnobotany (paleoethnobotany, historical ethnobotany, urban ethnobotany, diaspora ethnobotany, ethnophycology, ethnomycology, gastronomic ethnobotany, ethnoecology, evolutionary ethnobotany); Hypothesis-driven theories in ethnobotany – Doctrine of Signature, Optimal Defense Theory, Theory of Non-Random Plant Selection, Plant Use Value Hypothesis. Scientific validation of folk claims; Folk classification of Brent Berlin; Correspondence between folk and scientific classifications; Traditional Conservation practices - sacred groves, community forest; sustainable harvest; Traditional Environmental Knowledge; Traditional uses of plants as in food, medicine, construction and socio-cultural purposes in North East India and Manipur.

Unit 2: Ethnobotanical Analysis and Bioprospecting

15 Lectures

Ethnobotanical data - sources, qualitative and quantitative data, cautions; Data collection methods – free listing, questionnaires, participatory method, Rapid Ethnobotanical Appraisal; Data Collection Standards (Economic Botany Data Collection Standards and others); Traditional Concepts in Data Collection; Data Analysis - Ethnobotanical indices (Factor for Informant Consensus, fidelity level, relative citation index and use value indices); Concept of inferential statistics in Ethnobotany; Commercial use of Traditional Knowledge – Bioprospecting: Ethnopharmacology; Phytomedicines (monoherbal and polyherbals); Reverse pharmacology; Toxicity of Herbal Therapy; Herb-drug interaction; NTFP; Traditional Knowledge in relation to Intellectual property Rights and Biopiracy; Ethics in Ethnobotany - Prior Informed Consent; International law and policy for safeguarding traditional knowledge; Traditional Knowledge Digital Library

Unit 3: Origin of Agriculture and Plant Germplasm

15 Lectures

Origin of Agriculture – history, theories (Oasis Theory, Feasting Model, Hilly Flanks Hypothesis, Demographic Theory, Evolutionary/Intentionality Theory, Innovation and Specialisation Model, Levantine Primacy Model, Domestication Hypothesis); World Centres of primary diversity of domesticated plants –Vavilov's Centre of Origin; The Indo-Burmese Centre; Primary Centres and Secondary Centres; Plant Introductions – process and types. Germplasm collection; Concept, importance and ecogeographical considerations of introduction and exchange of plant germplasm; conventions and achievements of PGR exchange; Germplasm conservation - farm conservation; Gene banks (short, medium and long-term conservation), gene bank standards for various crops; Concept of genetic integrity; Post-harvest handling of germplasm.

Unit 4: Economically Important Plants

15 Lectures

Origin, evolution, botany, cultivation and uses as Food, Fodders, Forage and green manure crops - Wheat, Rice, Maize, Sorghum and Alfalfa ; Pulses - pigeon pea, chickpea, green gram, cowpea, soyabean pea; Vegetable - tomato, brinjal, cole crops; Vegetable oil-yielding crops - Mustard, sesame; Tuber crops - potato, aroids; Sugars - sugarcane, sugar beet; Fruits - citrus, grapes, walnut; Spices – Ginger, Turmeric, Cinnamon, Chillies; Fumigatories and masticatories - tobacco, betel vine, arecanut; Medicinal and Aromatic Plants – *Andrographis*, *Phlogacanthus*, *Acrorus*, *Vitex*, *Withania*, *Mentha*; Important fire-wood and timber-yielding plants and non-wood forest products (NWFPs) - bamboos, rattans; Fibre Crops – Silk cotton, Jute, Coconut; Narcotics - *Cannabis*, *Datura*, and Opium; Plants of agro-forestry importance, Multipurpose Trees/Shrubs; Avenue Trees; Plants used in paper-making, gums, tannins, dyes, resins; Beverages – Coffee, tea; Energy

Crops - *Jatropha* ; Transgenic crops – objectives, achievements and concerns; Innovations for meeting world food demands; Green revolution - benefits and adverse consequences

References:

1. Alburquerque, U.P., Ramos, M.A., Ferreira, W.S.J., de Medeiros, P.M. 2017. Ethnobotany for Beginners, Springer International Publishing
2. Albuquerque, U.P., da Cunha, L.V.F.C., de Lucena, R.F.P., Alves, R.R.N. 2014. Methods and Techniques in Ethnobiology and Ethnoecology, Humana Press, New York
3. Anderson, E.N. Pearsall, D.M., Hunn, E.S., Turner, N.J. 2011. Ethnobiology, WileyBlackwell, New Jersey
4. Baker, H.G. 1978. Plants and Civilization, 3rd Edition, C.a. Wadsworth, Belmont
5. Heinrich, M., Barnes, J., Gibbons, S., Williamson, E.M. 2012. Fundamentals of Pharmacognosy and Phytotherapy, Elsevier
6. Martin, G.J. 1995. Ethnobotany: A methods manual, Springer Science
7. Sharma, O.P. 1996. Hill's Economic Botany (Late Dr. AF Hill, Adopted by O. P Sharma)' Tata Mc Graw Hill Co. Ltd., New Delhi.
8. Kochhar, S.L. 2009. Economic Botany in the Tropics, 3rd Edition, Macmillan India, Delhi
9. Wickens, G.E. 2001. Economic botany - Principles and Practice, Springer Science.
10. Jain, S.K. (1995) 2nd Edition. Manual of Ethnobotany, Scientific Publishers (India)
11. Ajit Kr. Tamuli, Singh M.K and Ron Kemprai, (2025) A Text Book of Ethnobotany, ARB Publications, Guwahati, Assam
12. Pullaiah T, Krishnamurthy, K.V. and Bir Bahadur (2021) Ethnobotany of India, 5-Volumes, Apple Academic Press, Florida, USA.
13. Das, A.K., Ranjana, R.K., Reshma Kh. And Singh P.K (2017) Glimpses of Ethnobotany and Medicinal Plants of Manipur, N.E. India, Deep Publications, New Delhi

Paper Type: Core Paper (Practical)

Paper Title: Practical – V (Based on BOT-612)

Paper Code: BOT-613

Credit - 4

100 marks

Ethnobotany and Plant Resource Utilization (Practical): (100 Marks)

1. Calculation of Fidelity Level of an ethnobotanical dataset.
2. Preparation of Free List of preferential vegetables from the selected students, teachers or villagers and calculation of salience index by manual method
3. Study of some ethnobotanical plants used by different tribes in Manipur.
4. Demonstration of Non-Random Plant Selection by Linear Regression Method by using medicinal plant data.
5. Organoleptic Analysis of selected plant part (For example - Seed of Leipungkhanga, Petiole of Nongmangkha leaf, Rhizome of Yaimu, Stem or petiole of Bhubati, Rhizome of Ginger etc or any other plant. This portion belongs to Qualitative Ethnobotanical Data. Criteria for analysis may be texture, appearance, aroma, taste, mouthfeel, and form along with other relevant morphological and anatomical characters)
6. Field Survey in an urban, suburban or rural area in the state and preparation of a Field Report with the following conditions: (a) Community Mapping, (b) Objective – Documentation of Wild Edible Plant, Medicinal Plant, Fodder, Ethnoveterinary Plant, or NTFP, (c) Tools – Structured or Semi-Structured Questionnaire (d) Indices – FIC, FL, RCI or UV with evidence of Prior Informed Consent.

7. Morphological and histochemical features of cereals, oil seed, legumes and forest trees.
8. Morphology, Anatomy and Microscopic Study of Whole Fibers such as cotton, Jute, Coir etc
9. Determine the amount of unsaturation in fatty acids in a given oil sample by iodine number method
10. Identification of some common timber species of Manipur (by using parameters such as colour, specific gravity, texture, strength group, durability, treatability, etc.)
11. Submission of important timber species of common occurrence for architectural patterns of habit, bole, buttress, leaf, flower, fruit and seeds.

GENETICS SPECIALIZATION

Paper Type: Elective Paper (Theory)

Credit - 4

Paper Title: Genetics-I (Plant breeding and Cytogenetics)

Paper Code: BOT-621

100 marks

Learning Outcomes: After learning this course, students will be able to:

- Assess and visualize genetic diversity among germplines by Metroglyph analysis; understand how genetic traits are associated through phenotypic and genotypic correlation.
- Understand heritability measures and genetic advance, predict potential gain from selection.
- Estimate genetic variances and understand gene action from diallel, triallel and quadriallel analysis.
- grasp the fundamental concept of Analysis of variance (ANOVA)
- Understand molecular markers and their importance in plant breeding.
- Know the different breeding methods and their mechanisms.
- Understand the underlying principles and protocols of FISH and GISH.
- Analyze and interpret DNA profiles
- Understand how CGH can detect smaller, sub microscopic rearrangements beyond the resolution of conventional methods.

Unit-1:

15 Lectures

Biometrical Techniques in plant breeding experiments - Principles and applications, Genetic diversity analysis, Metroglyphs Association analysis - phenotypic and genotypic correlations, Concepts of selection - heritability and genetic advance; Mating designs - Diallel, Partial diallel, Triallel and Quadriallel analysis. Analysis of genotype and environment interaction, adaptability and stability; Analysis of variance (ANOVA): one-way and two-way ANOVA.

Unit-2:

15 Lectures

Breeding for abiotic; Drought resistance, Salinity resistance, minimisation of crop loss, biotic, disease resistance, insect resistance; parasitic, weed resistance; Main features, breeding methods, mechanisms, -achievements, merits and demerits of biotic and abiotic systems. Applications of molecular markers; RAPD, CAP, AFLP, STS, ITS, SSR, RFLP.

Unit 3:**15 Lectures**

The handling of chromosomes; Fluorescence in situ Hybridization (FISH); Genomic in situ Hybridization (GISH); Primed in situ DNA labelling (PRINS), Determination of nuclear DNA content by Flow Cytometry Comparative Genomic Hybridization (CGH). Human genome mapping; DNA fingerprinting.

Unit 4:**15 Lectures**

Introduction to techniques of karyotyping Chromosome bonding and painting, genetic control of recombination; Genes responsible for chromosome disjunction Role of heterochromatin in chromosome pairing; Genetics of chromosome elimination in haploids: Genome analysis: Genomic relationship among diploid species"; Chromosome aberrations in Cell and Tissue Culture, Organelle genes and genomes, Mitochondrial DNA in Evolutionary studies.

Suggested Reading:

1. B.D. Singh (2012): Plant breeding- Principles and methods, 9th edition, Kalyani publishers.
2. B.D. Singh and A.K. Singh (2015): Marker Assisted Plant Breeding, Springer
3. George Aquaah (2012): Principles of Genetics and Plant breeding, John Wiley and sons Ltd.
4. Izak Bos and Peter Caligari (2008): Selection methods in plant breeding, 2nd edition, springer
5. Jack Brown, Peter D.S. Caligari, Hugo a. Campos (2014): Introduction to Plant breeding, 2nd edition; John Willey and Sons Ltd.
6. Jawahar R. Sharma (2001): Statistical and Binomial Techniques in Plant breeding, New Age publishers, India
7. Nadarajan N. and Gunasekaran M. (2005): Quantitative Genetics and Biometrical Techniques in Plant breeding, Kalyani publishers
8. Roberto Fritsche-Neto Aluizio Borem (2012) (ed): Plant Breeding for biotic stress Resistance, Springer-Verlag
9. Roberto Fritsche-Neto Aluizio Borem (2012) (ed): Plant Breeding for abiotic stress Tolerance, Springer-Verlag
10. Sir kenneth Mather and John L. Jinks (1982): Biometrical Genetics-The study of continuous variation, 3rd edition, Springer Science
11. Yunbi Xu (2010): Molecular Plant breeding, CAB International Cytogenetics:
12. Hank W. Bass and james A. birchler (2012) (ed): Plant Cytogenetics-Genome structure and chromosome function, springer
13. Ram J. Singh (2003): Plant Cytogenetics, 2nd edition, CRC Press
14. Ram J. Singh (2018): Practical Manual on Plant cytogenetics, 2nd edition, CRC Press

Paper Type: Elective (Theory)**Credit - 4****Paper Title: Genetics II (Molecular Genetics)****Paper Code: BOT-622****100 marks**

Learning Outcomes: After learning this course, students will be able to:

- understand the molecular concepts and mechanisms of transcription, RNA processing, translation and post-translational modifications.
- detect abnormalities in chromosomes and associated genetic diseases by Karyotype study
- identify chromosomal abnormalities and genetic disorders and can also trace the phylogenetic relationship of different species by chromosome banding study.

- understand core principles and molecular mechanisms like CRISPR-Cas9 and RNAi
- Analyzing and evaluating experimental results and recognizing the applications in human disease treatment.
- understand the different markers; their applications in different fields.
- understand the concept of analytical techniques in Northern, Southern and Western blotting.
- know the role of transcription factors in gene expression, in recognition of specific DNA sequences i.e. promoters, enhancers, activators and repressors.

Unit 1:

15 Lectures

An overview of gene regulation in eukaryotes: Structure and functions of transcription factors, transcription activators - domains and motifs, transcription repressors, regulation of transcription factors; chromatin remodelling.

Unit 2:

15 Lectures

RNA processing: Splicing, alternate and trans-splicing and protein isoforms; Capping and poly-adenylation; rRNA and tRNA processing; their role in decoding the codons; translating genetic information, mRNA stability and localization, Evolutionary importance of split genes; Post - translational modifications.

Unit 3:

15 Lectures

Gene editing and silencing creating random mutations; in vitro mutagenesis deletion and insertional techniques; Gene knock out in bacterial and eukaryotic organisms; Gene silencing by non-coding RNAs: RNAi, miRNA and other Non-coding RNAs; CRISPR system. Encoding genetic information; codon identification.

Unit 4:

15 Lectures

Micro- array analysis of large-scale gene expression and genetic screening; RNA sequencing, Ribosome profiling; Molecular markers: CAPS, STS, ITS, RELP, RAPD, AFLP, SSR Techniques used in the identifications of DNA and RNA.

Suggested Reading:

1. Bruce Alberts (2015): Molecular biology of the cell 6th edition; Garland Science
2. Gerald Karp (2016): Cell and Molecular biology-concepts and experiments, 8th Edition, John Wiley and sons
3. Geoffrey M. Cooper and Robert E. Hausman (2018): The cell: A molecular approach; Sinauer Associates Inc., U.S.; 8th ed. Edition
4. Harvey Lodish, (2016): Molecular cell biology: 8th Edition W.H. Freeman, Macmillan Learning
5. Jocelyn e. Krebs, Elliott S. Golstein, Stephen T. Kilpatrick, 2018: Lewin's GENES XII; Jones and Bartlett Learning
6. Robert F. Weaver (2012): Molecular biology, 5th edition, Mc Graw Hill

Paper Type: Elective (Practical)

Credit - 4

Paper Title: Genetics Lab (Based on BOT-621 and BOT-622)

Paper Code: BOT-623

100 marks

Plant breeding:

1. Metroglyph analysis

2. D2 analysis
3. Cluster analysis and construction of cluster diagrams and dendrograms Path analysis
4. Diallel analysis: Griffing's Numerical approach and Hayman's Graphical approach
5. Triallel and Quadriallel analysis
6. Line X Tester analysis
7. Use of softwares in analysis and result interpretation

Cytogenetics:

8. Chromosome banding
9. Karyotype preparation and analysis

PLANT ECOLOGY SPECIALIZATION

Paper Type: Elective (Theory)

Credit - 4

Paper Title: Ecology-I (Principles of Ecology)

Paper Code: BOT-631

100 marks

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

- Explain ecosystem structure, functions, nutrient dynamics, trophic organization, and concepts of stability.
- Analyze vegetation organization through community coefficients, metabolism, and competition models.
- Evaluate mechanisms of ecological succession, models of community development, species adaptations.
- Assess plant physiological ecology, including responses to temperature, light, water, tolerance laws, limiting factors, and allelopathic interactions.
- Apply molecular and phylogenetic ecological approaches, including metagenomics, conservation applications.

Unit 1: Ecosystem and Ecosystem Stability

15 Lectures

Ecosystem Structure, Functions, and their controls; Controlling factors of primary production; litter and nutrient dynamics; Trophic coherence and food web; Concept of Ecosystem Stability (resistance and resilience); Structural and functional stability; Ecological perturbations (natural and anthropogenic) and their impact on plants and ecosystems.

Unit 2: Vegetation Organization

15 Lectures

Community coefficients; Community Metabolism and Community Periodism; Intraspecific competition, Competition Exclusion Principle
Interspecific Competition; Scramble and Contest Competition Model; Symbiosis; Predator-prey interaction, Co-evolution of predator-prey interaction, Plant-Herbivore interactions

Unit 3: Vegetation Development

15 Lectures

Mechanism of ecological succession - relay floristic and initial floristic composition; facilitation, tolerance and inhibition models; changes in ecosystem properties during succession;
Plant adaptations, ecological equivalents, Ecological Guild, Introduction to meta-population and meta-communities; fugitive species

Unit 4: Molecular and Physiological Ecology**15 Lectures**

Introduction to Physiological Ecology, Role of temperature, light and water in plant physiology; Law of Tolerance and Limiting Factors; Allelopathic interference; Molecular Ecology (Introduction, meta-genomics, application in Conservation); Concept of Phylogenetic Ecology; Landscape Genetics

References:

1. Cronk, Q.C.B., Whitton, J., Ree, R.H., Taylor, I.E.P. 2004. Plant Adaptation: Molecular Genetics and Ecology, NRC Research Press, Ottawa
2. Freeland, J.R. Peterson, S.D., Kirk, H. 2011. Molecular Ecology, Second Edition, WileyBlackwell
3. Kumar U., Asija, M.J. 2000. Biodiversity Principles and Conservation, Agrobios (India), Jodhpur
4. Moore, P.D. & Chapman, S.B. 2007. Methods in Plant Ecology, Blackwell, Oxford
5. Odum, E.P., Barrett, G.W. 2004. Fundamentals of Ecology, Brooks/Cole
6. Rockwood, L.L. 2006. Introduction to Population Ecology, Blackwell Publishing
7. Russell K.M. 2014. Ecology and the Environment, Springer, Dordrecht, Heidelberg, New York
8. Smith, T.M., Smith, R.L. Elements of Ecology, 9th Edition, 2015. Pearson
9. Singh J.S., Singh, S.P., Gupta. S.R. 2014. Ecology, Environmental Science and Conservation, 4th Edition, S. Chand & Company, New Delhi
10. Townsend, C.R., Begon M., Harper, J.L. 2003. Essentials of Ecology, 2nd Edition, Blackwell Publishing, Oxford
11. Weathers, K.C., Strayer, D.L., Likens, G.E. 2012. Fundamentals of Ecosystem Science, Academic Press

Paper Type: Elective (Theory)**Credit - 4****Paper Title: Ecology-II (Restoration Ecology and Environment Management)****Paper Code: BOT-632****100 marks****Learning Outcomes:** By the end of this course, students will be able to:

- Explain and apply concepts, aims, and strategies of restoration ecology
- Evaluate Environmental and Social Impact Assessment (ESIA) processes, environmental audits.
- Analyse the principles of sustainable development, global challenges sustainability indicators, and national strategies, along with applied and computational sustainability approaches.
- Critically assess the genesis, ideologies, and impacts of international and Indian environmental movements.
- Apply system ecology and ecosystem modeling approaches, including conceptual and working models.

Unit 1: Restoration Ecology**15 Lectures**

Restoration Ecology - Concept, aim and strategies; Restoration Plan and rehabilitation measures; Major tools of Restoration; Restoration of forest and grassland ecosystem; Restoration of aquatic resources (wetlands and lakes);

Adaptive restoration of wetlands; Waste water recycling, Prevention of habitat fragmentation; Climate change mitigation; Bioremediation, Phytoremediation.

Unit 2: Environmental Audit and ESIA**15 Lectures**

Environmental and Social Impact Assessment – Concept, Components, Process, Evaluation Methodology; Environmental Audit – Concept, Scope and Types; Energy audit; Environmental Management Plan, ISO 14000 family of standards and Certifications; International Environmental Agreements (Convention on Biodiversity, UN Convention on Climate Change, Convention on International Trade in Endangered Species of Wild Fauna and Flora, Ramsar)

Unit 3: Sustainable Development and Environmental Movements**15 Lectures**

Sustainable Development – history, definition, sustainable development goal; global environmental issues (population, livelihoods, energy); indicators (sustainable community indicators, global indicators); applied sustainability, computational sustainability, national sustainable development strategies; Environmental Education and value based education; environmental ethics-types and principles; Role of Woman and NGO in Environmental protection and awareness. Environmental Movements-Major environmental movements in India.

Unit 4: System Ecology and Modelling**15 Lectures**

Introduction and elements of System Ecology; Ecosystem Modelling - Conceptual Model, working Model, auxiliary variables and Foresters diagram (FD), Types, Steps in Modelling approaches, Applications, Limitations of model application; Remote Sensing – Principles, Types, System Overview, Applications; Application of Geographic Information System in Ecological Studies.

References:

1. Bradshaw, A.D., Chadwick, M.J. 1980. The Restoration of Land Ecology and Reclamation of Derelict and Degraded Land Blackwell Scientific Publication, Oxford
2. Falk, D.A., Palmer, M.A., Zedler, J.B. (eds). 2006. Foundations of Restoration Ecology, Island Press, Washington
3. Howell, E.A., Harrington, J.A., Glass, S.B. 2011. Introduction to Restoration Ecology, Island Press, Washington
4. Jorgensen, S.E. 2011. Fundamentals of Ecological Modelling: Applications in Environmental Management and Research, Elsevier
5. Jorgensen, S.E. 2012. Introduction to Systems Ecology, CRC Press
6. Santra, S.C. 2016. Environmental Science, NCBA, Kolkata
7. Singh, J.S. 1993. Restoration of degraded land: concepts and strategies, Rastogi Publications, Meerut.
8. Urbanska, K.M. Webb, N.R. Edwards, P.J. 1998. Restoration Ecology and Sustainable Development, Cambridge University Press, Cambridge

Paper Type: Elective (Practical)**Credit - 4****Paper Title: Ecology Lab (Based on BOT-631 and BOT-632)****Paper Code: BOT-633****100 marks****Experiments/Demonstrations/Activities/Field:**

1. Determination (or Demonstration) of the percentage of litter compositions in the litter mass of the different ecosystems. (Forest or Grassland)
2. Determination of the community coefficient (Jaccard Coefficient) of two study sites by the quadrat method.
3. Comparison of stomatal frequency in the upper and lower surfaces of the leaves in the selected hydrophytes and mesophytes. (Nail Polish and Microscopy Method)

4. Comparison of morphological, anatomical, and physiological characteristics of Cactus and Euphorbia. (To demonstrate Ecological Equivalence)
5. Study of allelopathic interference of residues by seed germination/seedling growth bioassay. (Allelopathic potential plants - *Ageratum conyzoides*, *Lantana camara*, *Parthenium hysterophorus*, *Mikania micrantha*, *Argemone mexicana*, *Ageratina adenophora*; testing plants - rice, maize)
6. Estimation of biomass and primary productivity of a grassland ecosystem by the Harvest method or by the Chlorophyll estimation method using a Spectrophotometer.
7. Studies on the Life Form Classification and Biological Spectrum of the two grassland study sites. Compare the data with Raunkiaer's life form classification.
8. Determination of the IVI (Important Value Index) of the grassland community.
9. Conduct an Energy Audit of the Botany Department or the Office of the University.
10. Relationship between plant distributions and their own environment control by using Spearman's Rank correlation coefficient and semi-averaged regression. (Parameters- Ferns or any plant species: Environmental variables- soil moisture or soil temperature).
11. Field survey in the selected site and study any of the following objectives. (Elaborated from an ecological field trip to study a particular ecosystem and submission of field report" proposed by the DM College of Science)
 - i) Transects to study zonation in relation to environmental gradients and examination of the gradual transition from one zone to another. (Succession)
 - ii). Isonome studies to consider mosaics or examine transition zones in Succession.
 - iii) Mapping the Site, survey, and inventory of biotic and abiotic components of a degraded site (related to Restoration Ecology)
 - iv) Listing the Community Sustainability Indicators of the site

References:

1. Berg, B. McClaugherty C., 2014. Plant Litter: Decomposition, Humus Formation, Carbon Sequestration, Third Edition, Springer, Heidelberg
2. Gilbertson, D.D., Kent, M., Pyatt, F.B. 1995. Practical Ecology for Geography and Biology: Survey, mapping and data analysis, Chapman & Hall, London
3. Hendry, G.A.F., Grime, J.P. 1993. Methods in Comparative Plant Ecology: A laboratory manual, Springer Science + Business Media, B.V.
4. Jackson, M.L. 1958. Soil Chemical Analysis. Prentice-Hall, Inc., U.S.A. (2nd reprint 1973. Prentice Hall of India, New Delhi). pp. 498
5. Krebs, C.J. 1998. Ecological Methodology, Second Edition, Benjamin Cummins, California
6. Misra, R. 1968. Ecology Workbook, Oxford and IBH Publ. Co., New Delhi
7. Rew, J.L., Pokorny, M.L. 2006. Inventory and Survey Methods for Nonindigenous Plant Species, Montana State University Extension, Idaho, US
8. Slingsby, D., Cook, C. 1986. Practical Ecology, Macmillan, Hampshire

PLANT PATHOLOGY SPECIALIZATION

Paper Type: Elective (Theory)

Paper Title: Plant Pathology and Microbiology-I (Principles of Pathology)

Paper Code: BOT-641

Credit - 4

100 marks

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

- Understand the concepts of plant development of plant diseases
- Critically analyze the plant disease defense mechanisms
- Understand the plant disease epidemics and forecasting mechanisms.
- Predict local disease epidemics
- Apply information technology in plant disease management.
- Contribute on Plant disease prediction and forecasting services in India

Unit 1: Disease development

15 Lectures

Pre-penetration (spore germination, growth, attachment on host surface and recognition); Penetration (direct, through natural openings and wounds); Post penetration changes, Roles of enzymes, toxins and growth hormones in pathogenesis. Factors affecting infection.

Unit 2: Defense mechanism

15 Lectures

Pre-existing structural defense and chemicals, induced structural and biochemical defense, hypersensitive response, phenolic compounds and phytoalexins, pathogen related proteins, plants elicitors.

Unit 3: Epidemiology

15 Lectures

Concept and elements of epidemic (host, pathogen and environment), epidemics of past and present, epidemic growth analysis and decline assessment of plant disease and yield lost and disease intensity measurement and loss, modelling and computer simulation of epidemics information technology in plant disease management.

Unit 4: Disease forecasting

15 Lectures

Introduction and importance, methods and devices used In forecasting, forecasting based on amount of initial inoculum; weather condition favouring development of secondary inoculum; Plant disease prediction and forecasting services in India; Examples of plant disease forecasting.

Recommended Books:

1. Agrios, G N: Plant Pathology. Elsevier Academic Press, USA
2. Ananthanarayan, R. and Paniker, C.K J. 2012: Text book of Microbiology. Universities Press.
3. Atlas. R M. 1987: Principles of Microbiology (2nd Edition). Dubugue, Wn C-Brown.
4. Baker, K.F, and Cook R.J. 1979 Biological Control Plant Diseases S. Chand and Company Ltd. New Delhi.
5. Bitgrami, KS and Dubey, H.C. 1970: A Test Book of Modern Plant Pathology, Vikas Publishing House Pvt. Ltd. New Delhi.
6. Biswas, P.K. : Agricultural Microbiology, Dominant Publishers New Delhi.
7. Chaube, H.S. and V.S. Pundhir 2010, Crop diseases and their management* Prentice Hall of India, New Delhi.
8. Nair, M. 1994. Advances in Mushrooms Biotechnology. Scientific Publishers Jodhpur.
9. Pelczar, M.J. Reid, R.D. and Chandl E.C.S. 1986: Microbiology (5th Edition), Tata McGraw Hill Publishing Company Ltd. New Delhi.
10. Rai, R.D. Singh, S.K. et al. 2007: Mushroom Biology and Biotechnology. NRCM. Solan. 17.
11. Rajendran, P and Gunasekaran, P. 2006: Microbial Bioremediation. MJP. Publishers, Chennai.
12. Sharma P.D. 2010: Microbiology, Rastogi Publications Meerut - New Delhi.
13. Singh R.S. 2007: Plant Diseases, Oxford and IBH publishing Co. Pvt. Ltd. New Delhi.
14. Singh R.S. 1995: Introduction to Principles of Plant pathology Oxford and IBH publishing Co. Pvt. Ltd. New Delhi.

Paper Type: Elective (Theory)**Credit - 4****Paper Title: Plant Pathology and Microbiology-II (Microbiology)****100 marks****Paper Code: BOT-642****Learning Outcomes:** On completion of this course the students will be able to

- Gain acquaintance with the various microbiological techniques.
- Understand soil microbial diversity, their role in plant disease management and agricultural sustainability.
- Have a sound knowledge about edible mushrooms: the nutritional and medicinal values and mushroom poisoning.
- Achieve familiarity with the cultivation techniques of Mushrooms.
- Gain knowledge about fermented food, role of microbes in food spoilage and preservation.

Unit 1: Microbiological techniques**15 Lectures**

Methods of sterilization (heat, chemical, physical agents, and filtration), staining methods (Gram staining, acid fast staining, capsule and spore staining; Isolation of microbes (serial dilution, direct impregnation and pure culture techniques; Isolation of bacteria by direct count method and turbidometric method.

Unit 2: Soil Microbiology**15 Lectures**

Diversity of soil microbes, Rhizophore and rhizoplane microbes and their role in plant disease management and organic matter decomposition; Biodegradation of polysaccharides, pesticides & xenobiotics; Bioremediation of heavy metals and hydrocarbons.

Unit 3: Agricultural microbiology**15 Lectures**

Microbial sources of plant nutrients and nutrient cycling; Mycorrhiza – types and their roles in plant nutrition and disease management; Microbes as biodeteriorators of agricultural products; Mycotoxin – types and production.

Unit 4: Food Microbiology**15 Lectures**

Edible fungi, nutritional and medicinal values of mushrooms. Cultivation of oyster, Button mushroom, paddy straw mushroom, Shiitake and *Auricularia*; Mushroom poisoning, food borne diseases and toxins; Fermented foods of Manipur; Microbial spoilage of meat and dairy products; Food preservation.

Recommended Books:

1. Agrios, G N: Plant Pathology. Elsevier Academic Press, USA
2. Ananthanarayan, R. and Paniker, C.K J. 2012: Text book of Microbiology. Universities Press.
3. Atlas. R M. 1987: Principles of Microbiology (2nd Edition). Dubugue, Wn C-Brown.
4. Baker, K.F, and Cook R.J. 1979 Biological Control Plant Diseases S. Chand and Company Ltd. New Delhi.
5. Bitgrami, KS and Dubey, H.C. 1970: A Test Book of Modern Plant Pathology, Vikas Publishing House Pvt. Ltd. New Delhi.
6. Biswas, P.K. : Agricultural Microbiology, Dominant Publishers New Delhi.
7. Chaube, H.S. and V.S. Pundhir 2010, Crop diseases and their management* Prentice Hall of India, New Delhi.
8. Nair, M. 1994. Advances in Mushrooms Biotechnology. Scientific Publishers Jodhpur.
9. Pelczar, M.J. Reid, R.D. and Chandl E.C.S. 1986: Microbiology (5th Edition), Tata McGraw Hill Publishing Company Ltd. New Delhi.

10. Rai, R.D. Singh, S.K. et al. 2007: Mushroom Biology and Biotechnology. NRCM. Solan.
11. Rajendran, P and Gunesekaran, P. 2006: Microbial Bioremediation. MJP. Publishers, Chennai.
12. Sharma P.D. 2010: Microbiology, Rastogi Publications Meerut - New Delhi.
13. Singh R.S. 2007: Plant Diseases, Oxford and IBH publishing Co. Pvt. Ltd. New Delhi.
14. Singh R.S. 1995: Introduction to Principles of Plant pathology Oxford and IBH publishing Co. Pvt. Ltd. New Delhi.

Paper Type: Elective (Practical)

Credit - 4

Paper Title: Plant Pathology and Microbiology Lab

100 marks

(Based on BOT-641 and BOT-642)

Paper Code: BOT-643

Experiments / Activities:

1. Methods of sterilisation (demonstration of heat, chemical and filtration)
2. Preparation of culture media for fungi. Bacteria.
3. Isolation and identification of microorganisms (fungi. bacteria) from soil, rhizosphere, rhizoplane, aerial plant parts.
4. Pure culture techniques and staining of microorganism.
5. Estimation of bacterial population by standard plate count method
6. Monitoring of fungal airspora with rotorod air sampler
7. Mushroom spawn preparation and demonstration of mushroom cultivation.
8. Isolation & Identification of mycorrhizal fungi from soils & roots

PLANT PHYSIOLOGY SPECIALIZATION

Paper Type: Elective (Theory)

Credit - 4

Paper Title: Plant Physiology – I (Mineral Nutrition and Seed Physiology & Technology)

Paper Code: BOT-651

100 marks

Learning Outcomes: After learning this course, students will be able to:

- Understand plant-soil-water relations and soil as the reservoir of plant nutrients.
- Design the Methods and Techniques of studying plant mineral nutrition
- Correlate the functional roles of essential elements with their deficiency symptoms
- Analyze the general mode of action of herbicides in plants.
- Differentiate between passive and active solute or ion transport in plants
- Explore more on ion channels as a new area of electrophysiology.
- Know developmental and metabolic changes taking place during seed germination.
- Understand the underlying principles of seed testing, seed certification and seed legislation

Unit 1: Soil and Mineral Nutrition:

15 Lectures

History and scope of plant mineral nutrition; Soil – Components and Types, soil as nutrient reservoir; Methods and Techniques of studying plant mineral nutrition, Analysis of plant tissue, Nutrient solution; Root-microbe and soil interaction in nutrient absorption and availability; Treating soil acidity and alkalinity; Soil fertility enrichment - Fertilizers, manure, compost; Fertilizer production and consumption in India.

Unit 2: Inorganic Nutrients:

15 Lectures

Essential mineral nutrients, Criteria of essentiality, Classification of essential mineral nutrient according to biochemical function, Functional roles, Deficiencies and disorders of essential nutrients, beneficial elements; Nutrient availability: Toxicity of micronutrients; Herbicides and its chemical diversity, selective and non-selective, general mode of action, Absorption and translocation of herbicides in plants.

Unit 3: Nutrient Uptake:

15 Lectures

Short distance transport, Solute transport across a member barrier, Nernst equation in predicting solute transport; Membrane transport proteins – carriers, pumps and channels; Structure and function of ATPase/pump, Regulation of nutrient homeostasis by target mimicry; Electrophysiology – exploring ion channel.

Unit 4: Seed Physiology and Technology:

15 Lectures

Development, maturation and germination of Seed, Hormonal regulation of seed development, Events associated with seed maturation, mobilization of food reserves during seed germination; Seed viability and vigour, orthodox and recalcitrant seeds, biochemical changes during seed deterioration, Seed invigoration, viability test, Seed testing, seed certification and seed legislation.

Paper Type: Elective (Theory)

Credit - 4

Paper Title: Plant Physiology – II (Plant Metabolism & Translocation of Photoassimilates)

Paper Code: BOT-652

100 marks

Learning Outcomes: After learning this course, students will be able to:

- Understand various components of thylakoid complexes and lateral heterogeneity.
- Grasp the process of photo-oxidation of water for uninterrupted Photosynthetic ETS.
- Know ROS formation and removal in order to regulate and protect photosynthetic apparatus
- Comprehend various modes of carbon fixation and assimilation by green plants and its significances
- Understand allocation and partitioning of Photoassimilates for various subsequent mobilization processes.
- Visualize the Carbon oxidation processes viz. glycolysis, TCA cycle and its regulation.
- Know the role of Acetyl CoA in biological oxidation and its synthesis.
- Understand nitrogen metabolism viz. fixation and assimilation.
- Explore more on the genetics and molecular aspects of Biological Nitrogen Fixation (BNF)

Unit 1. Photochemistry in photosynthesis:

15 Lectures

Genes and polypeptide components of photosynthetic complexes, Lateral heterogeneity of Thylakoid complexes, Photo-oxidation of water, Q-Cycle, Water to water cycle, Inhibitors of chloroplast ETC, Bioenergetics of light reactions, ROS formation and Scavenging in Photosynthesis, Biosynthesis of chlorophylls, Photo-inhibition, Regulation and Repair of photosynthetic apparatus.

Unit 2. Carbon assimilation and translocation of photo assimilates:

15 Lectures

Review of carbon fixation and assimilation reactions, Regulations of RuBisCO activity, Regulation of Calvin cycle, Variations in C₄ cycle, Biosynthesis of starch and sucrose, Translocation of photo assimilates – source- sink relationship, Phloem loading and unloading, Mechanism of phloem translocation, Allocation and partitioning of photo assimilates.

Unit 3. Respiratory and Lipid metabolism:

15 Lectures

Plant specific Glycolysis and alternative pathways; TCA cycle in plant mitochondria; Synthesis of Acetyl CoA; Mitochondrial electron transport and oxidative stress in plants; Oxidation of cytosolic NADH and alternative dehydrogenases; Interactions between mitochondria and other cellular compartments; Biosynthesis of fatty acid; Regulation of FAS, phospholipid synthesis; Introduction to mitochondrial genome.

Unit 4. Nitrogen and sulfur metabolism:

15 Lectures

Enzymology of nitrogen fixation (nitrate and nitrite reductase activity), Biochemistry of BNF, Molecular aspects of BNF – organization, function and regulation of Nif and Nod genes; Carbon – Nitrogen balance, Ammonia assimilation – GDH, GS/GOGAT pathways, Nitrogen metabolism in relation with photosynthesis and respiration, Application of BNF for crop improvement, Reduction of sulfate, significance of ATP – sulfurylase.

Suggested Reading (BOT-651 and BOT-652):

1. Hopkins, W.G and Huner Norman, P.A. 1995. Introduction to Plant Physiology, John Wiley and Sons, Inc., New York, USA.
2. Noggle, G.R. and Fritz, G.F. 1997. Introductory Plant Physiology, Prentice Hall, New Delhi
3. Salisbury, F.B. and Ross, C.W. 1992. Plant Physiology (4th edition), Wadsworth Publishing Co., California, USA.
4. Taiz, L and Zieger, E. 2006. Plant Physiology (4th edition), Sinauer Associates Inc., Massachusetts, USA
5. Bidwell, R.G.S. 1987. Plant Physiology, MacMillan
6. Wilkins, M.B. 1989. Advanced Plant Physiology, ELBS Longman Scientific and Technical, England
7. Buchanan, B.B., Gruissem, W. and Jones, R.L. 2000. Biochemistry and Molecular Biology of Plants, American Society of Plant Physiologists, Maryland, USA
8. Hall, D.O. and Rao, K.K. 1996. Photosynthesis, University Press, Cambridge, England
9. Heldt, H.W. 2004. Plant Biochemistry, Academic Press, California, USA
10. Styrer, L. 2002. Biochemistry, Freeman and Co., New York, USA
11. Lehninger, A.L. 1987. Principles of Biochemistry, CBS Publishers and Distributors, New Delhi
12. Epstein, E. 1972. Mineral Nutrition in Plants: Principles and Perspective, Wiley, New York
13. Carl Leopold, A. and Kriedemann, P.E. 1983. Plant Growth and Development, Tata McGraw Hill Publishing Company Ltd, New Delhi
14. Mukherji, S and Ghosh, A.K. 2005. Plant Physiology, New Central Book Agency (P) Ltd, Kolkata
15. Nautiyal, B.P. 2005. Plant Growth and Development, Meditech Scientific International (Pvt) Ltd, New Delhi
16. Satish C Bhatla and Manju A Lal (2018): Plant Physiology, Development and Metabolism, Springer Nature Singapore Pte Ltd, Singapore.
17. Malcom B. Wilkins (Ed) (1984). Advanced Plant Physiology, Longman Group UK Ltd.

Paper Type: Elective (Practical)**Credit - 4****Paper Title: Plant Physiology Lab (Based on BOT-651 and BOT-652) 100 marks****Paper Code: BOT-653****Experiments/ Activity:**

1. Preparation of suspensions, emulsions & colloids.
2. Preparation of lyophilic and lyophobic sols and their precipitation.
3. Study on Brownian movement and flocculation of lyophilic and lyophobic sols.
4. Determination of porosity, water holding capacity and adsorptivity of soil.
5. Determination of capillary flow in soil.
6. Determination of permanent wilting percentage (PWP) or wilting coefficient of soil.
7. Ash analysis for the determination of mineral nutrients available in plants.
8. Study of deficiency symptoms of different essential nutrients in field and lab.
9. Study on the essentiality of different nutrients in hydroponic cultures.
10. Estimation of cellulose by spectrophotometer.
11. Estimation of total free amino acids by spectrophotometer
12. Effect of temperature on the activity of diastase.
13. Effect of temperature and pH on the activity of Nitrate reductase.
14. Effect of light intensity on chlorophyll content.
15. Absorption spectrum of Chlorophyll.
16. Absorption spectrum of Carotene.

PLANT TAXONOMY SPECIALIZATION**Paper Type: Elective (Theory)****Credit - 4****Paper Title: Plant Taxonomy– I (Basic Taxonomy)****100 marks****Paper Code: BOT-661****Learning Outcomes:** After learning this course, students will be able to:

- Inculcate the knowledge of different types of classification-artificial to recent most APG system.
- Update all plant names with the correct scientific names.
- Furnish reliable information on all types of plant names.
- Understand the need of taxonomist in the world context.
- Describe and delimit species of families of Angiosperms.
- Rules and regulation of Nomenclature (latest ICN).
- Expertise in plant identification techniques using different types of structured keys.

Unit 1: Components and classification of Plant Taxonomy**15 Lectures**

Introduction to Plant Taxonomy; Components of taxonomy, Classification (Artificial, Natural and Phylogenetic classifications); Bentham and Hooker System of Classifications; APG system of Classification, principles, Merits and Demerits.

Unit 2: International Code of Nomenclature of Algae, Fungi and Plants**15 Lectures**

History and development of ICN, Principles, illegitimate names; legitimate names; validly published names; principle of Priority; Rejection of Names, Typification, effective publication; Correct names, synonyms, basionyms; Tautonym, Nomen Nudum; Conservation of Names-species conservada, genus conservada.

Unit 3: Tools of Taxonomy

15 Lectures

Herbarium-Concept of modern herbarium, Herbarium methodology, e-Herbarium, Botanical Garden, Taxonomic Keys, AI applications.

Unit 4: Morphology of Flowering Plants

15 Lectures

Morphology of leaves, inflorescence, fruits; Micromorphology; Basal angiosperms (ANA Grade); Taxonomic study of dicotyledon families (Lamiaceae, Solanaceae, Asteraceae, Euphorbiaceae, Moraceae); Taxonomic Study of Monocot Apomorphies; Zingiberales (Musaceae, Zingiberaceae, Cannaceae); Poales (Poaceae, Cyperaceae).

Paper Type: Elective (Theory)

Credit - 4

Paper Title: Plant Taxonomy–II (Recent Trends in Taxonomy)

100 marks

Paper Code: BOT- 662

Learning Outcomes: After learning this course, students will be able to:

- Explain the recent trends in plant taxonomy (new plant systematic approach)
- Understand floristic diversity of world, India, Northeast India and Manipur
- Understand role of IUCN, RET, in conservation biology.
- Have ideas about the economically significant plants.

Unit 1: Numerical taxonomy

15 Lectures

Numerical Taxonomy, OTUs, Unit Taxonomic Characters or Attributes, Types of Basic Characters or Attributes, coding of characters, Estimation of Resemblance (Coefficients of association, coefficients of correlation), cluster analysis, phenons and ranks, advantages of numerical taxonomy.

Unit 2: Systematic Botany (Molecular taxonomy)

15 Lectures

Molecular Taxonomy and phylogenetics, techniques (Non-PCR based, PCR based), molecular markers (protein-based, DNA based), basis and uses, initiating DNA molecular systematic studies in a developing Country.

Unit 3: Biodiversity, Conservation and RET Plants

15 Lectures

Diversity of Plants: Biological diversity region of the world; India as a mega-hotspot region; Floristic works in India, Northeast India and Manipur; Hotspots and categories of Hotspots; International efforts and Indian Initiative for conservation; RET plants and their conservation strategies; IUCN categories, Role of taxonomy in conserving Biodiversity.

Unit 4: Economically Significant Plants

15 Lectures

Medicinal Plants – *Alpinia galanga*, *Azadirachta* (Neem), *Clerodendrum colebrookianum*, *Eupatorium birmanicum*, *Terminalia arjuna*; Major Forest Products (Important fire-wood and timber-yielding plants), Minor forest Products- bamboos, rattans; Fibre Crops – Silk, cotton, Jute; Narcotics – *Areca catechu*, *Cannabis sativa*; Plants of agro-forestry importance; Avenue Trees; Beverages – Coffee, tea; Edible wild plants – *Alpinia nigra*, *Curcuma angustifolia*, *Ficus palmata* (Heiba mana); Transgenic crops – objectives and achievements.

Suggested books

2. Baruah, A. 2013. Plant Taxonomy. EBH Publisher, Guwahati.
3. Hooker, J.D. 1872-1897. The Flora of British India. Vol. I-VII. Bishen Singh Mahendra Pal Singh, Dehra Dun. (Reprint 1997-2006).
4. Ingrouille, M. and Eddie, B. 2006. Plants: Evolution and Diversity. Cambridge University Press.
5. Kanjilal, U.N., Kanjilal, P.C. & Das, A. 1936. Flora of Assam. Vol. II. Government of Assam, Shillong.
6. Kanjilal, U.N., Kanjilal, P.C., Das, A. and De, R.N. 1938. Flora of Assam. Vol. III. Government of Assam, Shillong.
7. Kanjilal, U.N., Kanjilal, P.C., Das, A. & Purkayastha, C. 1934. Flora of Assam. Government of Assam, Shillong.
8. Kanjilal, U.N., Kanjilal, P.C., De, R.N. & Das, A. 1940. Flora of Assam. Vol. IV. Government of Assam, Shillong.
9. Lawrence, G.H.M. 1967. Taxonomy of Vascular Plants. Oxford & IBH Publishing Co. Pvt. Ltd. New Delhi.
10. Mondal, A.K. 2016. Advanced Plant Taxonomy. New Central Book Agency (P) Ltd.
11. Naik, V.N. 1995. Taxonomy of Angiosperms. Tata McGraw-Hill Publishing Company Ltd. New Delhi.
12. Ray, S. & Ray, A.K. 2012. Biodiversity & Biotechnology. New Central Book Agency (P) Ltd.
13. Sharma, O.P., 2016. Plant Taxonomy. McGraw Hill Education (India) Private Limited.
14. Singh, G. 2012. Plant Systematic: Theory and Practice. Oxford & IBH Publishing Co. Pvt. Ltd. New Delhi.
15. Singh. N.P., Chauhan, A.S. & Mondal, M.S. 2000. Flora of Manipur. Vol. I. Botanical Survey of India, Kolkata.
16. Singh, V. and Jain, D.K. 1995-96. Taxonomy of Angiosperms. Rastogi Publication, Meerut.
17. Sinha, S.K. 2013. A Textbook of Plant Taxonomy. Centrum Press, New Delhi.
18. Sivarajan, V.V. 1990. Introduction to Principle of Plant Taxonomy. Oxford & IBH Publishing Co. Pvt. Ltd. New Delhi.
19. Subrahmanyam, N.S. 2016. Modern Plant Taxonomy. Vikas Publishing House Pvt. Ltd.
20. Takhtajan, A.L. 1986. Floristic Regions of the world. Berkeley.
21. Takhtajan, A.L. 2009. Flowering Plants, 2nd Edition, 918pp. Springer.
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23. Stace, C.A. 1989. Plant Taxonomy and Biosystematics. (2nd ed.) Edward Arnold, London.
24. Simpson, M.G. 2010. Plant Systematics. Elsevier Academic Press, San Diego, CA.
25. Sneath, P.H.A. and R.R. Sokal 1973. Numerical Taxonomy. W. H. Freeman and company, San Francisco.
26. Singh, G. 2012. E-flora: the future of floristic documentation. In (eds. P. Festschrift & R. Gupta) Plant Taxonomy, Past Present and Future. TERI, New Delhi.
27. Singh HB and Subramaniam B. 2008. Field Manual on Herbarium Techniques. New Delhi: National Institute of Science Communication and Information Resources (NISCAIR).
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Paper Type: Elective (Practical)

Credit - 4

Paper Title: Plant Taxonomy Lab (Based on BOT-661 and BOT-662)

100 marks

Paper Code: BOT-663

Activities / Experiments:

1. Study of family, genus, species character delimitation of 3 common local taxa.
2. Study of special inflorescence types (Cyathium, Verticillaster, Hypanthodium).
3. Detail taxonomic description of a wild Angiospermic specimen.
4. Preparation of taxonomic keys (indented and bracketed) for species not less than 10 under Asteraceae, Poaceae, Solanaceae.
5. To describe and illustrate primitive characters of Nymphaeaceae.
6. Classification and Identification of fruit types.
7. Study of flower types.
8. Identification of 50 angiospermic plants with their correct names giving basionyms and synonyms.
9. Assessment of RET category of 20 species available in the state.
10. Preparation of dendrogram and cluster analysis based on resemblance among taxa (OTU's) of Numerical Taxonomy.
11. DNA extraction methods in angiosperms and the working of a PCR, DNA sequencer, BLAST.
12. Fasta Format alignment of DNA sequences and phylogenetic tree construction using Mega Software.
13. Field study tour to any one of floristic regions of India and submit well processed Herbarium specimens (not less than 50 sheets) along with field note book and Field report.
14. Documentation of wild edible plants and medicinal plants found in Manipur (not less than 50).

SEMESTER - IV

Paper Type: Core Paper (Theory)

Credit - 4

Paper Title: Plant Anatomy and Embryology

Paper Code: BOT-614

100 marks

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

- Understand the structural and cytological organization of SAM and RAM
- Learn the development and differentiation of xylem and phloem.
- Know the development and differentiation of epidermal tissue system.
- Differentiate primary growth and secondary growth and role of vascular cambium in sencondary growth.
- Visualize the anatomical adaptations of hydrophytes and xerophytes.
- Learn the process of microspogenesis and megasporogenesis and subsequent microgametogenesis (development of male gametophyte) and megametogenesis (development of female gametophyte/embryo sac)
- Understand the genetic basis of self-incompatibility and methods to overcome incompatibility
- Learn the process of Apomoxis, Polyembryony and technique of embryo culture technique

Unit 1: Development of Primary plant body

15 Lectures

Organization of shoot apical meristem (SAM), Cytological and molecular analysis of SAM; Control of tissue differentiation especially Xylem and Phloem; Development of cell wall of sieve elements; nature and function of p – protein; Differentiation of epidermis with special reference to stomata and Trichome; Secretory ducts and laticifers Leaf Development and Differentiation; Differentiation of Mesophyll; Organization of root apical meristem (RAM) Nodal anatomy; Root-stem transition

Unit 2: Secondary growth and Wood anatomy

15 Lectures

Vascular cambium – types – Ontogeny; Cambium and seasonal activities; Secondary xylem Basic structure, sap wood and heartwood, reaction wood, growth rings; Cambium in monocotyledons; Periderm development; Anomalous secondary growth in dicot (*Aristolochia*, *Boerhaavia*, *Bignonia*, *Achyranthes*, *Nyctanthes*) and monocot stems (*Dracaena* and *Yucca*); Mechanical tissues and its distribution; Ecological anatomy – Hydrophytes and xerophytes; Application in Taxonomy, archaeology, climatic studies and crime detection.

Unit 3: Developmental Embryology

15 Lectures

Microsporangium - Structure of anther, Microsporogenesis, pollen wall development, pollenkit, Tapetum, development of male gametophyte, male sterility; Megasporangium: Types of ovules, Megasporeogenesis, Development of female gametophyte; Types of embryo sac; Pollen germination, Pollen tube growth and guidance, Pollen storage, Pollen allergy, Pollen stigma interaction, Fertilization, double fertilization, Barriers to fertilization; Self-incompatibility (Genetics, physiology and biochemistry); Methods to overcome Sexual Incompatibility.

Unit 4: Embryogeny and Applied/Experimental Embryology

15 Lectures

Endosperm – types, development and function, Embryogeny in Dicot and Monocot; Polyembryony: Classification, causes, and practical importance; Apomixis – definition and types, consequences and significances of apomixis; Techniques for embryo, anther, ovary culture and their applications; Seed – seed coat development, Endospermic and non-endospermic seeds, dispersal of seeds; Effect of seed on fruit development, Parthenocap; Embryology relation to taxonomy; Pollen morphology and scope of Palynology.

Suggested Reading:

1. Carlquist, S. (1961). Comparative Plant Anatomy, Springer-Verlag, Berlin Heidelberg.
2. Eames, A.J and MacDaniels, L.H. (1947). An Introduction to Plant Anatomy, McGraw Hill, New York.
3. Esau, K. (1977). Anatomy of Seed Plants, Wiley, New York.
4. Fahn, A. (1990). Plant Anatomy. 4th edition, Pergamon Press, New York.
5. Dickison, W.C. (2000). Integrative Plant Anatomy, Harcourt, Inc., Orlando
6. Mauseth, J.D. (1988). Plant Anatomy, Benjamin/Cummings, Menlo Park.
7. Metcalfe CR, Chalk L. (1979) Anatomy of Dicotyledons: Vol-1, 2nd edn. Oxford University Press, New York.
8. Metcalfe CR, Chalk L. (1983) Anatomy of Dicotyledons: Vol-2, 2nd edn. Oxford University Press, New York.
9. Cutter, E.G. (1978) Plant Anatomy (part I and II), Edward Arnold, London.
10. Cutler DF, Botha T, Stevenson D. (2008) Plant Anatomy: an applied approach, Blackwell Publishing, Malden.

11. Pijush Roy, (2010). Plant Anatomy, New central Book Agency, Pvt. Lit, New Delhi.
12. Charles B. Beck. 2010. An Introduction to plant structure and development. 2010, Cambridge University Press. New York.
13. Pandey, S.N. and Chadha, A. 1996. Plant anatomy and Embryology. Vikas Publications, New Delhi.
14. Pandey, B.P. (1978). Plant Anatomy, S. Chand & Co., New Delhi
15. Marimuthu, R. 2008. Microscopy and Microtechnique. MJP Publisher, Chennai.
16. Johansen, D.A. 1940. Plant Microtechnique. MC Graw Hill, New York.
17. Lersten, N.R. 2004. Flowering Plant Embryology. Blackwell Publishing, Australia.
18. Pullaiah, T., Lakshminarayanan, K. and Hanumantha Rao, B. 2001. Text book of embryology of angiosperms, Regency Publications, New Delhi.
19. Davis, G.L. (1966). Systematic Embryology of the Angiosperms.
20. Dwivedi, J.N. (1988). Embryology of Angiosperms. Rastogi & Co., Meerut.
21. Bhojwani, S.S. and Soh, W.Y. 2001. Current Trends in the embryology of angiosperms. Kluwer Academic Publishers, Netherlands
22. S.S. and Bhatnagar S.P. (1999). The Embryology of Angiosperms, Vikas Publishing House, New Delhi.
23. Maheshwari, P. (1950). An introduction to the Embryology of Angiosperms, McGraw-Hill.

Paper Type: Core (Practical)

Credit - 4

Paper Title: Practical – VI (Based on BOT-614)

100 – marks

Paper Code: BOT-615

A. Experiments / Activities (Plant Anatomy):

1. Study of cell types – trichomes, sclereids, tracheids, vessels and sieve tube elements using maceration, staining, light and electron micrographs.
2. Study of secretory structures and cell inclusions – nectaries, glandular hairs, oil glands, laticifers, resin canals, cystoliths and raphides.
3. Study of different types of stomata (Monocot and Dicot).
4. Study of shoot apical meristems with the help of dissection, whole mount preparation, sections and permanent slides.
5. Study of nodal anatomy – unilacunar, trilacunar and multilacunar.
6. Anatomy of bark and lenticels.
7. Wood anatomy from TS, TLS, and RLS of woody plants with the help of models, visual charts and permanent slides
8. Study of secondary growth (normal and abnormal) of selected plants by section cutting/microtome and preparation of permanent slides using double stain.
9. Study of ecological leaf anatomy: Sun and Shade leaves, xeromorphic, succulents, halophytic and hydrophytic leaves.

B. Experiments / Activities (Plant Embryology):

1. Study of the stages of pollen and ovule development through permanent slides.
2. In vitro Pollen germination method – sitting drop culture, suspension culture and surface culture and calculation of percentage pollen germination of some selected species.
3. Excision of embryo from some selected seeds and preparation of slides of different stages of embryo development.
4. Study of mature embryo/embryonal axis by dissecting some selected dicot and monocot seeds.
5. Study of permanent slides of different developmental stages of micro and megagametogenesis

GENETICS SPECIALIZATION

Paper Type: Elective (Theory)

Credit - 4

Paper Title: Genetics – III (Biotechnology, Microbial and Human Genetics)

Paper Code: BOT-624

100 marks

Learning Outcomes: After learning this course, students will be able to:

- Develop the concept of tissue culture; principles of totipotency, explant culture, micropropagation essential components of Culture media.
- Know the production of disease-free plants, knowledge of different conservation strategies
- Understand the concept of synthetic seeds, somatic embryogenesis and Somaclonal variation.
- Know the basic structure of a plasmids, bacteriophages, cosmids as cloning vectors.
- Comprehend complementation and functional allelism.
- Comprehend the parasexual cycle, mitotic crossing over, tetrad analysis and gene conversion.
- Develop critical understanding of epigenetic gene silencing in filamentous fungi..
- Develop the concept of Mu transposition, as a genetic tool in gene disruption and insertional mutagenesis
- Understand the disorders of carbohydrates, lipids and amino acid metabolism
- Conceive the idea different patterns of inheritance and the analysis of the pedigree patterns of various genetic disorders
- Describe role of transposons in both prokaryotic and eukaryotic systems
- Understand the fundamental role of antioxidants in neutralizing free radicals
- Know how proper functioning of a tumour suppressor gene prevent uncontrolled cell growth and development of cancer.
- Understand the overlapping genetic and environmental risk factors and cognitive profiles of bipolar disorder, schizophrenia, and autism.

Unit I:

15 Lectures

Fungi as model systems: Mutants and wild types: Isolation of various kinds of mutants, functional mutants (auxotrophs, conditional lethals, resistance mutants, reverse mutants). Characterisation of mutants; complementation and functional allelism. Parasexual analysis: Parasexual cycle, heterokaryosis and protoplast fusion. Epigenetic gene silencing in filamentous fungi. Important aspects of lytic cycle, Phage Mu as a genetic tool.

Unit II:

15 Lectures

Cell culture: Isolation of single cells, suspension culture types, assessment of growth and viability; single-cell culture. Somatic embryogenesis and production of synthetic seeds, immature embryo culture and embryo rescue, production of virus-free plants.

Production of protein from cloned genes – Special vectors for the expression of foreign genes in E. coli, general problems with the production of recombinant protein in E. coli, production of recombinant protein by eukaryotic cells. Identification of genes responsible for human diseases, gene therapy.

Unit III:**15 Lectures**

Biochemical Genetics: disorders of metabolism, Carbohydrate metabolism, amino-acid metabolism. Genetic testing and treatment: Genetic counselling, testing, treating genetic diseases by using genetically engineered and RNA therapeutics, Augmentation therapy. Molecular genetics of mitochondrial disorders, Mitochondria and oxidative phosphorylation, Mitochondrial disorders.

Unit IV:**15 Lectures**

Antioxidants in human health and diseases. Cancer genetics: oncogenes, Tumor Suppressor genes; Genetics of immunity: overview of Immune system, importance of cell surfaces in the human immune system, abnormal immunity. Genetics of Behaviour: Genes and behaviour, sleep, intelligence and intellectual disability. Bipolar disorders, Schizophrenia, Autism.

References:

1. B.D. Singh (2012): Biotechnology, Expanding Horizons, 4th edition, Kalyani Publishers.
2. Barry Halliwell and John M.C. Gutteridge (2015): Free Radicals in Biology & Medicine, 5th Edition, Oxford University Press
3. Bishun Deo Prasad, Sangita Sahni, Prasant Kumar, Mohammed Wasim Siddiqui (2018): Plant Biotechnology, Vol 1, Apple Academic Press
4. P.K. Gupta (2016): Biotechnology and Genomics, 1st edition, Rastogi Publishers.
5. S.M. Paul Khurana, Rajarshi Kumar Gaur (ed) (2019): Plant Biotechnology: Progress in Genomic Era, Springer
6. S.S. Bhojwani and M.K. Razdan (1996): Plant Tissue Culture: theory and Practice, a Revised Edition, Elsevier
7. Ceese J. Bos (ed) (1996): Fungal Genetics- Principles and Practice, Mercel Dekker, Inc
8. David Moore and Lily Ann Novak Frazer (2002): Essential Fungal Genetics, Springer 3.
9. Edward A. Brige (2006): Bacterial and Bacteriophage Genetics, 5th edition, Springer.
10. Jeremy W. Dale and Simon F. Park (2010): Molecular Genetics of Bacteria, 5th edition, Wiley-Blackwell
11. Joanne M. Willey, Linda M. Sherwood, Christopher J. Woolverton (2017): Prescott's Microbiology, 10th edition, McGraw Hill Education.
12. Lansing M. Prescott (2002): Microbiology, 5th edition, McGraw Hill
13. Larry Snyder, Joseph E. Peters, Tina M. Henkin, and Wendy Champness (2013): Molecular Genetics of Bateria, 5th edition, ASM Press
14. Sheela Srivastava (2013): Genetics of Bacteria, Springer
15. D.J. Pritchard and B.R. Kori (2013): Medical Genetics at a Glance, 3rd edition, Wiley Blackwell
16. Barry Halliwell and John M.C. Gutteridge (2015): Free radicals in Biology and Medicine, 5th Edition, Oxford University Press.
17. E.S. Tobias, M. Connor, M. Ferguson-Smith (2011): Essential Medical Genetics, 6th Edition, Wiley Blackwell
18. Jack J. Pastermak (2005): An Introduction to Human Molecular Genetics-Mechanisms of Inherited Diseases, 2nd edition, John Wiley and Sons Inc.
19. Judith A. Owen, Patricia P. Jones, Jenni Punt, Sharon A. Stranford (2019): Kuby Immunology, 8th edition, W.H. Freeman and Company.
20. L.B. Jorde, J.C. Carey, M.J. Bamshad (2010): Medical Genetics, 4th Edition, Mosby Elsevier
21. Maurice Tubiana, Jean Dutreix, Andre Wambersie, Taylor and Francis (1990): Introduction to Radiobiology, Taylor and Francis

22. M.R. Speicher, S.R. Antonarakis, A.G. Motulsky (ed) (2010): Vogel and Motulsky's Human Genetics- Problems and Approaches, 4th edition, Springer-Verlag.
23. Ricki Lewis (2018): Human Genetics: Concepts and Applications, 12th edition, McGrawHill Education, New York.
24. Tom Strachan and Andrew P Read (2019): Human Molecular Genetics, 5th Edition, CRC Press, London

PLANT ECOLOGY SPECIALIZATION

Paper Type: Elective (Theory)

Credit - 4

Paper Title: Ecology-III (Vegetation and Applied Ecology)

Paper Code: BOT-634

100 marks

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

- Explain the influence of climate, soil, and vegetation dynamics on plant distribution and phytogeography.
- Analyse the structure, function, and management of terrestrial ecosystems including forests, drylands, grasslands, and rangelands.
- Evaluate ecological processes and conservation strategies in freshwater, wetland.
- Assess landscape ecology concepts such as patterns, processes, disturbances and metrics.
- Analyze extinction causes and global biodiversity conservation strategies.
- Evaluate the structure and function of urban and assess the ecological and societal impacts of climate change with mitigation and adaptation approaches.
- Assess ecological economics principles, ecosystem services, their valuation, and global initiatives for sustainable management.

Unit 1: Vegetation Ecology

15 Lectures

Vegetation Ecology: Concepts of "flora" and "vegetation"; vegetation description - Raunkiaer's life-form scheme (evolutionary and ecological meaning); classifications of Braun Blanquet, USNVC, NVC, UNESCO, numerical; components of vegetation classification; Habitat Classification of Elton & Miller, International Code of Phytosociological Nomenclature.

Plant Formations – overview; Life Zone; vegetation zone of the world, factors affecting vegetation distribution; Phytogeography - Origins and modern; Phytogeographical Classifications of Hansen, Ronald Good and Takhtajan.

Unit 2: Terrestrial and Aquatic Ecology

15 Lectures

Forest – definition, general aspects, structure of forest ecosystem; canopy structure; Forest ecosystem function - primary productivity; nutrient cycling in forest ecosystem; Forest ecosystem management.

Watershed - definition, management; Grassland – characteristics; classifications, grassland management; rangeland management. Aquatic Ecosystem: Aquatic plants – microphytes; Macrophytes – Characteristics; Aquatic Weeds.

Freshwater Ecosystems: types & distribution; origin of lake, lake classification; Stratifications – (thermal); Eutrophication; Wetland – definition, classification, conservation & management.

Unit 3: Climate Change, Urban and Landscape ecology

15 Lectures

Climate Change, plants response to CO₂ variation in air; impact of CO₂ on biomes, agriculture, water resource and health; mitigation efforts; carbon sequestration.

Urban ecology – introduction, urban ecosystems, ecological role of urban tree; urban forestry; Ecological cities, techniques in conservation of urban biodiversity; Landscape - Classification and Nomenclature; Disturbance – meaning, measurement and implications; Landscape dynamics, Equilibrium and Non-equilibrium landscape.

Unit 4: Ecological Economics, Ecosystem Services and Conservation Biology 15 Lectures

Ecological economics – introduction, principles & objectives; natural resources accounting - procedure and techniques; Ecosystem Services – definition, concept, Ecosystem Services cascade (ESC), Ecosystem Service Management.

Biodiversity conservation – ex-situ and in-situ, conservation strategies, Global approaches to biodiversity conservation; Threatened Species, IUCN Red Data Book; Biodiversity Hotspots; Keystone species

References:

1. Dodds, W.K. 2002. Freshwater Ecology: Concepts and Environmental Applications, Academic Press, California
2. Foth, H.D. 1951. Fundamentals of Soil Science, 8th Edition, John Wiley, New York
3. Gibson, D.J. 2009. Grasses and Grassland Ecology, Oxford University Press
4. Keddy, P.A. 2010. Wetland Ecology: Principles and Conservation, Cambridge University Press, New York
5. Kent, M., 2012. Vegetation Description and Data Analysis, Second Edition, WileyBlackwell
6. Kraus, GJ and Nies, D.H. 2015. Ecological Biochemistry: Environmental and Interspecies Interactions, Wiley-VCH, Weinheim
7. Kuchler, A.W. 1988. Vegetation Mapping, Springer Netherlands
8. Lambers, H., Chapin, F.S., Pons, Thijs, L. 2008. Plant Physiological Ecology, Second Edition, Springer, New York
9. Mitchell, D.S. 1974. Aquatic vegetation and its use and control, UNESCO, Paris
10. Mitra, A., Zaman, S. 2016. Basics of Marine and Estuarine Ecology, Springer India, New Delhi
11. Wetzel, R.G. 2001. Limnology: Lake and River Ecosystems, Elsevier
12. Wickens, G.E. 1998. Ecophysiology of Economic Plants in Arid and Semi-Arid Lands, Springer-Verlag, Berlin
13. Young, R.A., Giese, R.L. 2003. Introduction to Forest Ecosystem Science and Management, Third Edition, John Wiley, NJ
14. Barton, L.L., Northup, D.E. 2011. Microbial Ecology, Wiley-Blackwell, NJ
15. Connor, D.J., Loomis R.S., Cassman, K.G. 2011. Crop Ecology: Productivity and Management in Agricultural Systems, Cambridge University Press, Cambridge
16. Sodhi, N.S., Ehrlich, P.R., 2010. Conservation Biology for All, Oxford University Press, Oxford
17. Everard, M., 2017. Ecosystem Services: Key Issues, Routledge, Abingdon
18. Forman, R.T.T. 2014. Urban Ecology: Science of Cities, Cambridge University Press
19. Grunewald, K., Bastian, O. 2015. Ecosystem Services: Concept, Methods and Case Studies, Springer-Verlag, Berlin
20. Ayres, R.U., Ayres, L.W. 2002. A Handbook of Industrial Ecology, Edward Elgar Publishing Ltd, Cheltenham
21. Costanza, R., Cumberland, J.H., Daly, H., Goodland, R., Norgaard, R.B., Kubiszewski, I., Franco, C. 2015. An Introduction to Ecological Economics, 2nd Edition, CRC Press

PLANT PATHOLOGY SPECIALIZATION

Paper Type: Elective (Theory)

Credit - 4

Paper Title: Plant Pathology & Microbiology-III (Plant Diseases and Management)

Paper Code: BOT-644

100 marks

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

- Understand the basic concepts of plant pathology and its related terminologies.
- Develop critical understanding of plant diseases due to biotic and abiotic agents.
- Identify important crop diseases, causal organisms and the various management techniques.
- Identify diseases caused by mycoplasma, virus, flowering plants and plant parasitic nematodes.
- Understand and compare the different disease control methods-chemical, physical and biological.
- Learn the recent approaches to disease management including genetic engineering, tissue culture and nanotechnology.
- Understand the various international conventions related to plant quarantine.

Unit 1: Symptoms, epidemiology and management of diseases

15 Lectures

Rice diseases (blast, brown leaf spot, sheath blight, false smut), Rust of wheat, red rot of Sugarcane, powdery mildew of pea, Apple scab, club root of crucifers. Damping off of seedlings, Late blight of potato, white rust of crucifers; leaf blight of rice, citrus cankers, Angular leaf spot of cotton, Brown rot of potato, common abiotic diseases – causes and control.

Unit 2: Diseases caused by Mycoplasma, virus & plant parasitic nematodes:

15 Lectures

Sandal spike, little leaf of egg plant, citrus greening. yellow vein mosaic of Bhindi; papaya leaf curl, Bunchy top of banana; Dodder (*Cuscuta*), Mistletoes, Broomrapes, Potato cyst nematode, Root knot of vegetables.

Unit 3: Exclusion, Eradication and control of plant diseases

15 Lectures

Plant Quarantine, types and importance, seed health and seed health testing; Fungicide - formulation and application, fungicide resistance- factors and management, antibiotics; Physical control of Diseases; biological control of diseases; Biopesticides.

Unit 4: Recent approaches to disease management

15 Lectures

Role of biotechnology: Genetic engineering, Tissue culture, transgenic plants, Nanotechnology and remote sensing in plant disease management, breeding for resistant varieties.

Recommended Books:

1. Agrios, GN.: Plant Pathology, Academic Press.
2. Aneja, K.R. Experiments in Microbiology, Plant pathology and Tissue Culture, Wishera Publications, New Delhi.
3. Chet, Ilan : Innovative Approaches to Plant Disease Control, Wiley.
4. Dehne, Wo Adam, q Dielcman, M, Franhm, J. Mauler, A.t Machnik and Hatteren, P. Van, 1997, Diagnosis and identification of Plant Pathogens, KluwerAcademic Pub.
5. Glazer, A.N, and Nikaidot H, Microbial Biotechnology : Fundamentals of Applied

- Microbiology, W.H. Freeman,
6. Manners, J.G, Principles of Plant Pathology, Cambridge University Press.
 7. Mahadevan, A and Sridhar, R, : Methods in Physiological Plant Pathology, Sivakashi Publication, Madras.
 8. Nene Y.L. and Thapaliyan. Fungicides. Oxford and IBH Publication New Delhi.
 9. Paul Neergaard 2011 Seed Pathology (Vol. 1 & 2) Amazon.
 10. Schaad, N.W. Plant Pathogenic Bacteria: Laboratory Guide for identification of Plant Pathogenic bacteria. Academic Presse.
 11. Sigeo, D.C. Bacterial Plant Pathology, Cambridge University Press.
 12. Sharma RD, Plant Pathology second edition 2010-17. Rastogi publications.
 13. Surya Narayan, D. 1978. Seed Pathology. Vikas Publishing house Pvt. Ltd, New Delhi.
 14. Vyas S.C. 1984. Systemic fungicides. Tata McGraw Hill Publishing Company Ltd. New

PLANT PHYSIOLOGY SPECIALIZATION

Paper Type: Elective (Theory)

Credit - 4

Paper Title: Plant Physiology – III (Developmental and Stress Physiology and Secondary Metabolites)

Paper Code: BOT-654

100 marks

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

- Know the role of Phytohormones either in inducing or retarding growth in plant.
- Understand physiological effects of some elicitor molecules.
- Understand the developmental changes that takes in the shoot apex during floral initiation (evocation).
- Grasp the biochemical and genetic control of flower development.
- Know the process of fruit setting and metabolic changes that occurs during fruit ripening.
- Describe the structure and function and as well the biochemical and photochemical properties of Phytochrome and Cryptochrome
- Know the types of Senescence and Programmed Cell Death (PCD) and their roles in the growth and development of plant..
- Know the mechanisms of tolerance and avoidance to drought and salinity.
- Understand the injuries and metabolic damages on plants due to flooding, freezing, chilling, heat and oxidative stresses and tolerance mechanisms.
- Know an array of diverse groups of secondary metabolites present in plants and their biological roles and biosynthetic pathways.
- Understand the idea of metabolic engineering of secondary metabolites for a good harvest.

Unit 1: Growth, Development and Senescence and PCD

15 Lectures

Analysis and measurement of plant growth, General review of Phytohormones – Auxin induced growth and gene expression, GA in hyper elongation of stem and mobilization of reserve foods in germinating seed, Physiological Role of Cytokinins, ABA and Ethylene, Elicitor molecules - Brassinosteroids, Salicylic acid, Jasmonic acid and Polyamines. Senescence and Programmed Cell Death (PCD) - Senescence and its type, senescence associated genes, Protein and pigment metabolism during senescence; PCD and its role in the life cycle of plants,

Unit 2: Flowering, Fruiting and Potomorphogenesis (Phytochrome) 15 Lectures

Floral evocation – autonomous and environmental signals, Circadian Rhythms, Photoperiodic control of flowering, Vernalization, Biochemical signalling in flowering, Genetic control – ABC model: Fruit set and development, Climacteric and non-climacteric fruits, Biochemical changes during fruit ripening, Phytochrome –Discovery, Photochemical and biochemical properties, structure and function of phytochrome; Phytochrome induced responses, Photophysiology of blue and uv light – Cryptochrome, blue light responses – inhibition of stem elongation, osmotic regulation of guard cell.

Unit 3: Plant Stress Physiology 15 Lectures

Introduction to abiotic stresses on plant, Stresses involving water deficit, Stomatal response to water deficit, Role of ABA; Effects of salinity on plants, salinity and drought avoidance and tolerance mechanisms, Flooding - Injury, metabolic damage and hormonal imbalance and tolerance mechanisms; Chilling and Freezing stress injury on plants, freezing tolerance mechanisms; Effects of High temperature on plants, Heat shock proteins and acclimation to heat stress; Oxidative stress and antioxidants in tolerating oxidative stress.

Unit 4: Plants Secondary Metabolites 15 Lectures

Secondary vs Primary metabolites; Diversity, structure, occurrence and Biological roles of plant secondary metabolites - Phenolic compounds, Terpenes and Terpenoids, Alkaloids, Cyanogenic glycosides and steroids; Volatile organic compounds – a means of molecular communication; Metabolic engineering of plant secondary metabolites; Biosynthesis of basic 5-C unit in isoprenes and modification of Terpenoid skeleton; Shikimic Acid Pathway and biosynthesis Phenolic compounds; and alkaloids biosynthesis in plants.

Suggested Reading:

1. Taiz, L and Zieger, E. 2006. Plant Physiology (4th edition), Sinauer Associates Inc., Massachusetts, USA
2. Carl Leopold, A. and Kriedemann, P.E. 1983. Plant Growth and Development, Tata McGraw Hill Publishing Company Ltd, New Delhi
3. Salisbury, F.B and Ross, C. (1992) Plant Physiology, 4th ed. Wadsworth, Belmont, CA.
4. Nautiyal, B.P. 2005. Plant Growth and Development, Meditech Scientific International (Pvt) Ltd, New Delhi
5. Satish C Bhatla and Manju A Lal (2018): Plant Physiology, Development and Metabolism, Springer Nature Singapore Pte Ltd, Singapore
6. Giri, B., & Sharma, M. P. (Eds.) (2021). Plant Stress Biology: Strategies and Trends .Springer Nature.
7. Hopkins, W.G and Huner Norman, P.A. 1995. Introduction to Plant Physiology, John Wiley and Sons, Inc., New York, USA.
8. Shropshire W and Mohr H. (1983). Photomorphogenesis, Springer Nature
9. Levitt J. (1980). Responses of Plants to Environmental Stresses. Academic Press, New York
10. Dwivedi and Dwivedi (2012). Physiology of Abiotic Stress in Plants, Agrobios (India), Jodhpur (India).
11. Smith H. (1974). Phytochrome and Photomorphogenesis, McGraw Hill Inc, US
12. Kendrick, R.E. and Kornberg, G.H.M eds (1994) Photomorphogenesis in Plants, 2nd ed. Kluwer, Dordrecht, Netherlands.
13. Kendrick, R.E and Frankland, B. (1983) Phytochrome and Plant Growth, 2nd ed. Edward Arnold,

London

14. Turner, N.C. and Kramer, P.J. (1980) Adaptation of Plants in Water and High Temperature Stress. Wiley, New York.
15. Malcom B. Wilkins (Ed) (1984). Advanced Plant Physiology, Longman Group UK Ltd.

PLANT TAXONOMY SPECIALIZATION

Paper Type: Elective (Theory)

Credit - 4

Paper Title: Plant Taxonomy-III (Taxonomy and Evolution)

Paper Code: BOT-664

100 marks

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

- Possess clear knowledge on origin, evolution and distribution of Angiosperms
- Understand recent advances in the study of structural evolution of Angiosperms
- Understand the concept of species
- Describe and document new species, new records, floras, monographs
- Establish publication knowledge of new species, new records, flora, monograph and taxonomic research papers.

Unit 1: Origin and Evolution of Flowering Plants

15 Lectures

What makes an Angiosperm plant, First traces of Angiosperm, Cretaceous angiosperms, theories of probable ancestors of Angiosperms, monophyletic and polyphyletic Origin of Angiosperms, Origin of Monocotyledons; Cradle of Angiosperms, hypothetical construction of the first form Angiosperms, primitive characters of angiosperms; Centre of Origin.

Unit 2: Origin and Evolution of Vascular Tissue

15 Lectures

Structural Evolution, Tracheary Element evolution, Floral evolution, stamen evolution, carpel evolution, inferior ovary evolution, pollen grain evolution.

Unit 3: Species Concept and Speciation

15 Lectures

Concepts of Species – Typological Species Concept, Taxonomic Species Concept, Biological Species Concept, Cladistic Species Concept, Evolutionary Species Concept; Ideal Species; Speciation, isolating mechanisms, Mode of Speciation; Variation in plants.

Unit 4: Publication of New Species

15 Lectures

Taxonomic Publication Methods: How to describe a new Species; writing a flora, a Monograph; Publication of New Records; How to write a Journal paper; Correcting Symbols; Review of Literature.

Suggested books

2. Baruah, A. 2013. Plant Taxonomy. EBH Publisher, Guwahati.
3. Hooker, J.D. 1872-1897. The Flora of British India. Vol. I-VII. Bishen Singh Mahendra Pal Singh, Dehra Dun. (Reprint 1997-2006).
4. Ingrouille, M. and Eddie, B. 2006. Plants: Evolution and Diversity. Cambridge University Press.
5. Kanjilal, U.N., Kanjilal, P.C. & Das, A. 1936. Flora of Assam. Vol. II. Government of Assam, Shillong.
6. Kanjilal, U.N., Kanjilal, P.C., Das, A. and De, R.N. 1938. Flora of Assam. Vol. III. Government

- of Assam, Shillong.
7. Kanjilal, U.N., Kanjilal, P.C., Das, A. & Purkayastha, C. 1934. Flora of Assam. Government of Assam, Shillong.
 8. Kanjilal, U.N., Kanjilal, P.C., De, R.N. & Das, A. 1940. Flora of Assam. Vol. IV. Government of Assam, Shillong.
 9. Lawrence, G.H.M. 1967. Taxonomy of Vascular Plants. Oxford & IBH Publishing Co. Pvt. Ltd. New Delhi.
 10. Mondal, A.K. 2016. Advanced Plant Taxonomy. New Central Book Agency (P) Ltd.
 11. Naik, V.N. 1995. Taxonomy of Angiosperms. Tata McGraw-Hill Publishing Company Ltd. New Delhi.
 12. Ray, S. & Ray, A.K. 2012. Biodiversity & Biotechnology. New Central Book Agency (P) Ltd.
 13. Santra, S.C., Chatterjee, T.P. and Das, A.P. 1993. College Botany. Practical VOLUME II. New Central Book Agency (P) Ltd. Calcutta.
 14. Sharma, O.P., 2016. Plant Taxonomy. McGraw Hill Education (India) Private Limited.
 15. Singh, G. 2012. Plant Systematic: Theory and Practice. Oxford & IBH Publishing Co. Pvt. Ltd. New Delhi.
 15. Singh. N.P., Chauhan, A.S. & Mondal, M.S. 2000. Flora of Manipur. Vol. I. Botanical Survey of India, Kolkata.
 16. Singh, V., Pande, P.C. and Jain, D.K. 2006. A Text Book of Botany Angiosperms. Rastogi Publication, Meerut.
 17. Sinha, S.K. 2013. A Textbook of Plant Taxonomy. Centrum Press, New Delhi.
 18. Sivarajan, V.V. 1990. Introduction to Principle of Plant Taxonomy. Oxford & IBH Publishing Co. Pvt. Ltd. New Delhi.
 19. Subrahmanyam, N.S. 2016. Modern Plant Taxonomy. Vikas Publishing House Pvt. Ltd.
 20. Takhtajan, A.L. 1986. Floristic Regions of the world. Berkeley.
 21. Takhtajan, A.L. 2009. Flowering Plants, 2nd Edition, 918pp. Springer.
 22. Stevens, P.F. (2001 onwards). Angiosperm Phylogeny Website. Version 9, June 2008 (updated continuously since) <http://www.mobot.org/MOBOT/research/APweb>.
 23. Stuessy, T.F. 1990. Plant Taxonomy. Columbia Univ. Press, New York.
 24. Stace, C.A. 1989. Plant Taxonomy and Biosystematics. (2nd ed.) Edward Arnold, London.
 25. Simpson, M.G. 2010. Plant Systematics. Elsevier Academic Press, San Diego, CA.
 26. Sneath, P.H.A. and R.R. Sokal 1973. Numerical Taxonomy. W. H. Freeman and company, San Francisco.
 27. Singh, G. 2012. Eflora: the future of floristic documentation. In (eds. P. Festschrift & R. Gupta) Plant Taxonomy, Past Present and Future. TERI, New Delhi.
 28. Singh HB and Subramaniam B. 2008. Field Manual on Herbarium Techniques. New Delhi: National Institute of Science Communication and Information Resources (NISCAIR).
 29. Holmgren PK, Holmgren NH, and Barnett LC (eds.). 1990. Index Herbariorum: the herbaria of the world. New York: New York Botanical Garden.

RESEARCH

Paper Type: Research Methodology (Theory)

Credit - 2

Paper Title: Biostatistics and Methods in Plant Science

Paper Code: BOT-671

50 marks

Learning Outcomes: On completion of this course, students will be able:

- Learn the need of statistical science in biology
- Work out the measures of central tendency (Mean, Median and Mode).

- Calculate the measures of dispersion (Standard Deviation, Standard Error, Coefficient of Variation etc.
- Understand the application of probability laws in biology.
- Learn Population sampling methods and testing of hypotheses in biology.
- Work out important statistical test (Chi square test, F-test, t-test)
- Understand the Basic Principles of Experimental Design – Randomization, Replication; Completely Randomised Design, Randomised Block Design, Split Plot Design etc.
- Learn the principles and methods of various bio-analytical techniques.
- Understand important instruments used in the analysis biological specimens and its content.

Unit 1: Introduction to Biostatistics

8 Lectures

Concepts in Statistics: Data Types –Variables and Attributes; Frequency – Relative, Cumulative; Data Presentation; Data Normalization; Measure of central tendency (Mean, median, mode), measure of dispersion (Standard Deviation, Coefficient of Variation), coefficient of variation, skewness and kurtosis; Introduction to probability and application of probability laws in biology; Population and sample; Sampling methods in biology, sampling distribution and standard error; testing of statistical hypotheses; Confidence intervals, confidence limits, hypothesis tests, type of errors, p-values.

Unit 2: Statistical Procedures and Experimental Design

8 Lectures

Concept of Parametric and Non-parametric test; t-Statistic - Roles of t – statistic; Independent t – statistic, Paired t – statistic, Two-samples t – statistic, One sample t – statistic; F-test; Chi-square test – Goodness of fit, Correlation – partial and multiple; Linear Regression, R and R² in regression; common errors in regression; Basic Principles of Experimental Design – Randomization, Replication; Completely Randomised Design, Randomised Block Design, Latin Square Design, Split Plot Design; Comparing two or more means - analysis of variance-one and two-way (ANOVA)

Unit 3: Spectroscopy, Chromatography and Electrophoresis

7 Lectures

Chromatography: Principles and applications (Paper and thin-layer chromatography, Column chromatography, High Performance Liquid Chromatography (HPLC). Gas Chromatography and Mass Spectrometry (GCMS); Principles of electrophoresis and types - Agarose and polyacrylamide gel, Isoelectric focussing; Northern and Southern Blotting; Spectrophotometry. Beer-Lambert's law. Principles and instrumentation of UV-visible spectrophotometer, Flame photometer; Introduction to atomic absorption and nuclear magnetic resonance spectrophotometry;

Unit 4: Radiolabeling, Microscopy and Centrifugation

7 Lectures

Radiolabelling Techniques - Detection and measurement of different types of radioisotopes used in biology; Radio-tracer techniques – Autoradiography; Radioimmunoassay; safety guidelines Microscopy - Basic principles and types of microscopes (Bright field, dark field, phase contrast, fluorescence, transmission and scanning electron microscopy) Centrifugation – Types of centrifuge; sedimentation coefficient

Suggested Books :

1. Khan and Khanum Shiba Khan (1994) : Fundamentals of Biostatistics (5e); Ukaaz Publications
2. Madan Kumar Patra((2024) : Fundamentals of Biostatistics; Taurean Publications
3. Bernard Rosner (2016) : Fundamentals of Biostatistics (8e); Cengage Learning
4. Marcello Pagano, Kimberlee Gauvreau(2018) : Principles of Biostatistics (2e); CRC Press
5. Chap T. Le, Lynn E. Eberly(2016) : Introductory Biostatistics (2e); John Wiley & Sons
6. Keith Wilson and John Walker (2010) : Principles and Techniques of Biochemistry and Molecular Biology (7e); Cambridge University Press
7. M H Gordon, R. Macrae (1987) : Instrumental Analysis in the Biological Sciences; Blackie & Sons Limited.
8. Suzanne Bell, Keith Morris (2010) : An Introduction to Microscopy; CRC Press
9. J. Michael Hollas (2004) : Modern Spectroscopy (4e); John Wiley & Sons Ltd.
10. Rajan Katoch (2011) : Analytical Techniques in Biochemistry & Molecular Biology; Springer
11. L. Veerakumari (2006) : Bioinstrumentation; MJP Publishers
12. S.V.S. Rana (2022) : Biotechniques Theory & Practice(2e); Rastogi Publications

Paper Type: Research

Credit - 6

Paper Title: Dissertation/Thesis/ Project/Field work/Patent

Paper Code: BOT-672

150 Marks

(Students are required to take up a project work in a topic which is to be decided in consultation with teachers of Botany Department during this semester (4th semester) and a thesis/dissertation/ Report of the project work has to be submitted at the end of Semester Exam).
