DEPARTMENT OF BOTANY

TELANGANA UNIVERSITY

Dichpally, Nizamabad-503322

(A State University Established under the Act No.28 of 2006, A.P.
Recognized by UGC under 2(f) and 12 (B) of UGC Act 1956)
Accredited by NAAC 'B' grade, CGPA: 2.61
w.e.f. 2026-2027

M.Sc. BOTANY
COURSE STRUCTURE AND SYLLABUS

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DEPARTMENT OF BOTANY

TELANGANA UNIVERSITY

Dichpally, Nizamabad-503322

M.Sc. Botany (Previous)

Course Structure as per National Education Policy (**NEP**)

w.e.f. 2026-2027

SEMESTER – I (20 Credits)

S. No.	Type	Title of the Paper	Credits	HPW	CA	ESE	Marks
1	DSC	Systematics of Non-Vascular Plants	4	4	40	60	100
2	DSC	Plant Anatomy & Embryology	4	4	40	60	100
3	DSC	Plant Biochemistry	4	4	40	60	100
4	PR-1	Practical – I	2	4	20	30	50
5	PR-2	Practical – II	2	4	20	30	50
6	VAC	Green Technology and Sustainable Development	2	2	-	50	50
7	IDC	Artificial Intelligence (AI) in Plant Sciences	2	2	20	30	50
		Total	**20**	**24**	**180**	**320**	**500**

DSC: Discipline Specific Course
VAC: Value-Added Course
AI: Artificial Intelligence
CA: Continuous Assessment
ESE: End Semester Examination
IDC: Inter Disciplinary Course
PR: Practical

SEMESTER – II (22 Credits)

S. No.	Type	Title of the Paper	Credits	HPW	CA	ESE	Marks
1	DSC	Systematics of Vascular Plants	4	4	40	60	100
2	DSC	Plant Physiology	4	4	40	60	100
3	DSC	Principles of Plant Pathology	4	4	40	60	100
4	PR-1	Practical – III	2	4	20	30	50
5	PR-2	Practical – IV	2	4	20	30	50
6	SEC	Hydroponics Farming	4	4	40	60	100
7	VAC	Quantum Technology	2	2	20	30	50
		Total	**22**	**26**	**220**	**330**	**550**

DSC: Discipline Specific Course
VAC: Value Added Course
DSE: Discipline Specific Elective
SEC: Skill Enhancement Course
PR=Practical
QT : Quantum Techniques

M.Sc. Botany (Previous)

SEMESTER – I

DSC 1: Systematics of Non-Vascular Plants

Course Objectives

- **CO-1:** To examine the classification frameworks, ultrastructural characteristics, thallus organization, and reproductive cycles across major algal lineages (Cyanophyta through Rhodophyta).
- **CO-2:** To analyze fungal phylogenetic systems, nutritional paradigms, parasexual phenomena, and life cycle dynamics from basal chytrids to higher dikaryotic phyla and fungus-like organisms.
- **CO-3:** To evaluate the evolutionary trajectories, comparative morphology, anatomical adaptations, and fossil record of Bryophytes across liverworts, hornworts, and mosses.
- **CO-4:** To synthesize key evolutionary concepts in lower plants, including thallus organization trends, sporophytic reduction/elaboration, and the physiological drivers of sexuality.

Course Outcomes (COs)

- **CO-1 (Understand):** Classify algae, fungi, and bryophytes according to modern taxonomic systems (e.g., AlgaeBase/Ruggiero classification, modern mycological phyla, and modern bryophyte classification).
- **CO-2 (Analyze):** Trace thallus evolution, reproductive adaptations, and life cycle variations (haplontic, diplontic, diplohaplontic, triphasic) across lower plant groups.
- **CO-3 (Apply):** Differentiate fungal fruiting bodies (ascocarps and basidiocarps) and centrum development types for diagnostic mycological identification.
- **CO-4 (Evaluate):** Compare gametophytic and sporophytic architectures among Hepaticopsida, Anthocerotopsida, and Bryopsida to infer evolutionary relationships.
- **CO-5 (Synthesize):** Assess the industrial, agricultural, and ecological value of algal products, fungal biofertilizers/biotechnologies, and bryophyte ecological functions.

Unit – I

Introduction to Algae - An outline of general classification of algae by Fritsch

Diversity of Algae

Cyanophyta: Cell ultrastructure; cell division; thallus organization, Life cycle (*Microcystis, Lyngbya*)

Brief introduction, structural and reproductive features of Xanthophyta (*Botrydium*), Bacillariophyta (*Cyclotella, Pinnularia*).
Chlorophyta: structure and evolution of thallus, reproduction, life cycle, (*Eudorina*, *Hydrodictyon, Cladophora, Draparnaldiopsis, Closterium*)
Charophyta: structure and reproduction (*Nitella*)
Phaeophyta: general account of external and internal morphology, reproduction and life cycle (*Laminaria, Sargassum*)
Rhodophyta: general account of external and internal morphology, reproduction and life cycle (*Gracillaria*)
Beneficial and Harmful Aspects of Algae – Algal blooms, Toxic algae, Algal biofertilizers and Industrial products from algae

Unit – II
Introduction to Fungi
Recent trends in the classification of fungi; Evolution and Phylogeny of the fungi; Substrates of fungi, Nutrition (saprophytic, parasitic and symbiotic); Reproduction in fungi (sexual and asexual), Heterothallism: Heterokaryosis, Parasexuality. Fungi as food (Mushrooms), Fungi as bio-fertilizers (Mycorrhizae), Fungi in industry (Production of alcohol, organic acids and antibiotics)
Diversity of Fungi
Structure, kinds of mycelia, life cycle patterns, reproductive structures of the forms belonging to:
Phylum: Chytridiomycota (*Synchytrium*), Neocallimastigomycota (general account), Blastocladiomycota (*Pilobolus*), Microsporidia (general account).
Ascomycota: thallus organization, centrum development, different types of ascocarps (*Erysiphe, Morchella*)
Basidiomycota: tissue differentiation, development of basidia and basidiospore (*Melampsora, Polyporus*)
Oomycota (*Peronospora*), Fungi like organism (*Stemonitis*)

Unit – III
Introduction to Bryophytes
Morphological characters used for classification; Systems of classification of Bryophytes; Ecology of Bryophytes; Fossil history of Bryophytes; Economic importance of Bryophytes

Diversity of Bryophytes

Distribution, morphological, anatomical, reproductive characters and comparative account of sporophytes and gametophytes and interrelationships along with their fossil relatives of the following orders: Calobryales (*Calobryum* and *Haplomitrium*), Sphaerocarpales (*Sphaerocarpos*), Marchantiales (*Targionia*), Jungermanniales (*Porella*), General account - Anthoceratales, Notothyladales, Takakiales (*Takakia*), Sphagnales (*Sphagnum*), Andraeales (*Andreaea*), General account - Polytrichales, Buxbaumiales, Funariales.

Unit – IV

Origin and evolution of Marchantiaceous and Anthocerotales thallus; resemblances and differences between Hepaticopsida (Liverworts) and Bryopsida (Mosses), External form of mature gametophyte, Thalloid Forms, Leafy forms, Appendages and Internal form of mature gametophyte, Bryophytic Sporophyte, Development and differentiation of different organs of sporophyte, Spore germination and formation of gametophyte; Major factors affecting sexuality in Bryophytes

References

1. Fritsch, F.E. The structure and reproduction of algae volume I and II
2. Robin South, G and Alan Whittick: Introduction to Phycology
3. Morris, I: An Introduction to Algae
4. Round, F.E.: The Biology of Algae
5. Bold, H.C. and Wynne, M.D.: Introduction to the Algae structure and reproduction
6. H. D. Kumar: Introductory Phycology
7. Peter Pay: The Blue greens
8. M.G. Carr and S.A. Whitton: The biology of the Cyanobacteria
9. Trainer, F.R.: Introductory Phycology
10. Smith, G.M.: Manual of Phycology
11. Dawaon, Y.: Marine Botany
12. Dickson: Biology of the Rhodophyta
13. Cole, K.M. and Robert G. Sheet: Biology of the Red Algae
14. Change. S.T. & P.G. Miles, Edible mushrooms and their cultivation
15. Mosses, B.V.A. Mycorrhizae
16. Powel, C&D. J. Bagyaraj, V.A. Mycorrhizae
17. Smith, J.E. The Filamentous Fungi
18. Berry, R, Industrial mycology (Vol. I)
19. Bio-synthesis and metabolism (Vol II)
20. Dubey, S.C. Biotechnology.
21. Ainsworth, G.C. and Sussmann, A.S. The Fungi
22. Bernett, J.H. Fundamentals of Mycology
23. Ram Udar: Bryology in India, 1976.
24. Smith, G.M. Cryptogamic Botany. Vol. II
25. Watson: The structure and life history of Bryophytes
26. Parihar, N.S.: Bryophyta
27. Beirhorst, D.W. 1971. Morphology of Vascular Plants

M.Sc. Botany (Previous)

SEMESTER – I

DSC 2: Plant Anatomy & Embryology

Course Objectives

- **CO-1:** To examine the cellular organization and tissue differentiation dynamics within root and shoot apical meristems, leaf blade adaptations, and vascular ultrastructure.
- **CO-2:** To analyze normal cambial activity, anomalous secondary growth patterns, 3-dimensional wood architecture, and diagnostic anatomical markers of commercial timbers.
- **CO-3:** To elucidate the developmental pathways of microsporangia and megasporangia, gametogenesis, embryo sac variations, and gametophytic nutrition.
- **CO-4:** To evaluate palynological diversity, fertilization mechanics, physiological self-incompatibility systems, endosperm development, and the applications of embryology in taxonomy.

Course Outcomes (COs)

- **CO-1 (Understand):** Compare root apex zonation and shoot apical meristem theories alongside stomatal ontogeny pathways (paracytic, diacytic, anisocytic).
- **CO-2 (Analyze):** Differentiate C_3, C_4 (Kranz anatomy), and CAM leaf structural adaptations, as well as wood cell arrangements used in timber identification.
- **CO-3 (Apply):** Trace microsporogenesis and megasporogenesis stages, pollen germination dynamics, and double fertilization events.
- **CO-4 (Evaluate):** Assess the biochemical and physiological basis of sporophytic vs. gametophytic self-incompatibility and techniques to overcome reproductive barriers.
- **CO-5 (Synthesize):** Integrate palynological and embryological data into plant taxonomic frameworks and experimental breeding programs.

Unit – I

Root Development: Organization of root apex and significance of Quiescent center; Recent experimental studies on differentiation of tissues.

Shoot Development: Recent views on organization of shoot Apical Meristem and types of vegetative shoot apex.

Leaf: Structure with reference to C3 and C4 plants – Kranz and CAM Syndrome

Structural composition of Epidermal cells, orientation and arrangement; Basic structure with reference to subsidiaries and ultra-structure of guard cells; Ontogeny of Paracyctic, diacytic, and anisocytic stomata.

Ultrastructure of xylem and phloem

UNIT-II

Nature of cambium - Cambial activity-normal and abnormal (anomalous secondary growth)

Secondary growth with reference to stem:

a) Wood: Significance of study of 3-dimensional structure of wood

b) Morphology and arrangement of vessels, Axial parenchyma fibres and Ray parenchyma and their value in wood identification

Salient features of the following woods: a) *Tectona grandis,* b) *Shorea robusta* c) *Azadirachta indica*

Unit- III

Introduction to embryology of angiosperms

Microsporangium – anther wall, sporogenous tissue; Development of male gametophyte; Formation of vegetative and generative cells; Formation of sperms, pollen wall and abnormal features

Megasporangium - Types of ovules, integuments and nucellus; Special features of megasporogenesis; Development of female gametophyte; Types of female gametophyte

Mature embryo sac - Haustorial behavior of embryo sac; Nutrition of embryo sac

Unit- IV

Morphology of pollen – Polarity, Symmetry, Apertural pattern, Exine stratification, Ornamentation of pollen wall; Pollination; Anther dehiscence; Pollen dehiscence

Fertilization - Pollen germination, Pollen tube growth; Double fertilization

Sexual incompatibility - Physiology and biochemistry of self-incompatibility; Biological significance of incompatibility; Methods to overcome incompatibility

Development of endosperm and function of endosperm

Role of Palynology in Taxonomy; Embryology in relation to taxonomy and an account of experimental and applied embryology.

References

1. Fahn, A. Plant Anatomy (4th Ed.), 1990.
2. Easu, K. Anatomy of Seed Plants.
3. Easu, K. Plant Anatomy, 2nd Ed. Wiley N.Y. 1965.
4. Cutter, E.G. Plant Anatomy, Part I and II Edward Arnold; London, 1971 and 1978
5. Metcalf and Chalk. Anatomy of dicots (2nd Edition) (1983). Clarendon Press, Oxford.
6. Metcalf (1982-87) Anatomy of Dicots Vol. I to III
7. meureth, J.D. 1988. Plant Anatomy. The Benjamin/Cummings Pub1. Inc., Menlo Park California.
8. Carliquist. S. (1988). Comparative wood anatomy, Springer – Berlag, Berlin.
9. Jeffrey, E.C. The Anatomy of woody plants.
10. Rao, K.R. & K.B.S. Juneja (1971) A Hand book for identification of fifty important Timbers of India.
11. Pearspm & Brown – Commercial Timbers
12. Lyndon R.F. 1990. Plant development – The cellular basis. Unnin. Hyman, London.
13. Steeves T.A. & Sussex 1. M, 1989, Pattersacin plant development 92nd Edition) Cambridge UNIT y
Press, Cambridge.
14. P.K.K. Nair. Pollen Morphology of angiosperms.
15. P.K.K. Nair: Essentials of Palynology
16. Moor & Moor: Pollen analysis
17. R.B. Knox, Pollen allergy
18. M.R. Suxena: Palynology
19. Bhojwani S. S. and Bhatnagar S. P. (1999). The embryology of angiosperms. Vikas Pub. House

M.Sc. Botany (Previous)

SEMESTER – I

DSC 3: Plant Biochemistry

Course Objectives

- **CO-1:** To examine the structural organization, classification, and biochemical roles of fundamental biomolecules: carbohydrates, lipids, enzymes, amino acids, proteins, and nucleic acids.
- **CO-2:** To elucidate key metabolic pathways including lipid oxidation, gluconeogenesis, nitrogen assimilation via GS-GOGAT, cellular respiration, and the pentose phosphate pathway.
- **CO-3:** To evaluate the thermodynamic principles governing biological energy transformations, ATP coupling mechanisms, and mitochondrial electron transport networks.
- **CO-4:** To analyze plant cell wall architecture, biomembrane structural dynamics, and the biosynthetic/functional diversity of plant secondary metabolites.

Course Outcomes (COs)

- **CO-1 (Understand):** Compare the structural hierarchies and functions of primary biomolecules, including structural/storage polysaccharides, complex lipids, protein levels, and nucleic acid topologies (A, B, and Z DNA).
- **CO-2 (Analyze):** Calculate enzyme kinetic parameters ($V_{\max}$, K_m) using the Michaelis–Menten framework and determine mechanisms of enzyme inhibition and catalytic activation.
- **CO-3 (Apply):** Trace central metabolic networks—Glycolysis, TCA cycle, ETC/Oxidative Phosphorylation, Glyoxylate cycle, HMP shunt, and Cyanide-resistant respiration—to derive net ATP yields.
- **CO-4 (Evaluate):** Interpret Ramachandran plots to predict sterically allowed peptide backbone conformations and protein folding constraints.
- **CO-5 (Synthesize):** Correlate membrane lipid/protein organization with transport functions, cell wall biopolymer deposition, and secondary metabolite defensive signaling.

Unit-I

Carbohydrates: Classification, structure and functions of a. Monosaccharides b. Oligosaccharides c. Polysaccharides; Storage polysaccharides, structural polysaccharides, glycoproteins.

Lipids: Classification of lipids: a. Simple lipids, b. Compound lipids, c. Sterols d. Terpenoids, e. lipoproteins; Fatty acids structure and functions, Triacyl glycerols structure, functions and properties.

Biosynthesis of fatty acids, polyunsaturated fatty acids, lipoproteins; Oxidation of fats - α-oxidation, β-oxidation; glyoxylate cycle, gluconeogenesis

Enzymes: Properties of enzymes, Structure of enzyme: holoenzyme, apoenzyme, cofactors, coenzymes and prosthetic group; Classification of enzymes; Features of active site, substrate specificity, mechanism of action (activation energy, lock and key hypothesis, induced - fit theory), Michaelis – Menten equation, enzyme inhibition and factors affecting enzyme activity.

Unit-II

Amino acids - a) General properties b) Classification and characteristics c) non protein amino acids d) peptide bonds; Biosynthesis with reference to GOGAT and GS.

Proteins - Peptide bonds; Levels of protein structure-primary, secondary, tertiary and quaternary; Isoelectric point; Protein denaturation and biological roles of proteins. Classification of proteins, Structure of proteins and Ramachandran plot

Nucleic acids: Structure of nitrogenous bases; Structure and function of nucleotides; a) Structure of DNA and types – B, A and Z forms and DNA

Structure of RNA – m-RNA, t-RNA, r-RNA

Unit-III

Bioenergetics: Metabolic pathways and oxidation–reduction process; Energy Currency –ATP structure and reactions; other energy rich compounds

Thermodynamic Principles applicable to bioenergetics: Conservation of Energy, Entropy, Disorder, Gibb's free Energy and energy coupled reactions.

Respiration: Glycolysis, fermentation, tricarboxylic acid cycle and its regulation, Electron transport chain, and oxidative phosphorylation, chemiosmotic hypothesis, hexose monophosphate shunt and its significance, Cyanide – resistant respiration.

Unit-IV

Structure and function of membranes: a) Chemical composition, b) Membrane models, c) Functions of Membranes d) Membrane proteins e) Membrane lipids

Biochemistry of plant cell wall: cellulose, hemicelluloses, lignin, pectin, suberin and cutin**.**

Secondary metabolites: introduction, classification, distribution and functions

References:

1. Plant Physiology, biochemistry and molecular biology. David, T: Dennis and Davis Turnip. Longman. Scientific and technical U.K. 1990.
2. Plant Biochemistry Voet, D and Voet J.G. International
3. Outlines of biochemistry. 5th edition Conn E.E. and Stump P.K. 1995. Wiley
4. Principles of biochemistry, Lehninger, A.L. 1982 CBS Publication
5. Biochemistry, Stryer W.H. 1976. Foreman Company.
6. Introduction to Plant Physiology. Willium G. Hopkins and Norman P. A. Huner
7. Plant Physiology. Lincoln Taiz and Eduardo Zeiger. International Edition
8. Plant Biochemistry. P.M. Dey and J.B. Harborne
9. Plant Biochemistry. Hans-Walter Heldt
10. Physicochemical and Environmental Plant Physiology. Park S. Nobel

M.Sc. Botany (Previous)

SEMESTER – I

VAC: Green Technology and Sustainable Development

Course Objectives

- **CO-1:** To examine the foundational concepts of Green Technology, including the 5 R's framework, Green Planning, Green Chemistry principles, and Life Cycle Assessment (LCA).
- **CO-2:** To evaluate commercial green technologies such as biofuel blending, energy-efficient lighting, eco-friendly refrigerants, and biodegradable polymers.
- **CO-3:** To analyze decentralized renewable energy systems, waste management practices, urban water harvesting, and sustainable mobility solutions.
- **CO-4:** To execute campus environmental auditing protocols covering land use, energy, waste, air quality, ecological footprint estimation, and mitigation frameworks.

Course Outcomes (COs)

- **CO-1 (Understand):** Explain the core pillars of green technology (Green Energy, Infrastructure, Economy, and Chemistry) and the operational framework of the 5 R's.
- **CO-2 (Analyze):** Perform Life Cycle Assessment (LCA) evaluations across product life stages to determine net environmental impacts.
- **CO-3 (Apply):** Design functional models for rainwater harvesting, vermicomposting, biogas generation, and solid waste management.
- **CO-4 (Evaluate):** Conduct comprehensive energy, waste, and campus green audits adhering to standard environmental monitoring parameters.
- **CO-5 (Synthesize):** Calculate individual ecological footprints and formulate institutional mitigation plans to reduce carbon emissions and resource depletion.

Unit - I

Scope And Significance of Green Technology- Past and Present Perspective; Green Energy, Green Infrastructure, Green Economy and Green Chemistry and principles; Green Planning- Concept of green cities.

Successful Green Technologies- blending of fossil fuels with bioethanol, LED, green refrigerant, biodegradable plastic. Life Cycle Assessment (LCA).

5 R's of green technology: Recycle, Reuse, Reduce, Recover, Refuse.

Unit – II

Solar panels, Rainwater harvesting, Biogas plant, Vermicomposting, Well recharging, Solid waste management, Electric vehicles.

Waste auditing of the institution, Energy auditing, estimation of the ecological footprint of an individual, steps to do green audit on campus- Land Use System - Biodiversity Status-Climatic Conditions- Air Quality- Noise Pollution- Water Resources and Management- Waste disposal and management- Environmental Awareness-Mitigation and Management practices.

Suggested Readings

1. Jairam Ramesh Green Signals: Ecology, Growth, and Democracy in India"

2. Sivasankar. B "Green Chemistry: Environmentally Benign Approaches"

3. Rajeev. B. R. Green Cities of India: Pioneering Approaches to Urban Sustainability"

4. "Renewable Energy Sources and Emerging Technologies: Solar Energy, Wind Energy, Biomass, and Geothermal Energy" by H. P. Garg and J. Prakash "Green Chemistry and Engineering: A Practical Design Approach" by S. S. Bhagat

5. "Carbon Capture and Storage Technologies: Advances in CO2 Capture, Sequestration, and Conversion" by Rajesh Kumar

M.Sc. Botany (Previous)

SEMESTER – I

IDC: Artificial Intelligence in Plant Sciences

Course Objectives

- **CO-1:** To examine the historical evolution, current paradigms, and emerging technological frontiers of Artificial Intelligence (AI) and Data Science in plant biology.
- **CO-2:** To build foundational knowledge in AI architectures, knowledge representation, supervised/unsupervised Machine Learning (ML), and Deep Learning (DL) models applicable to biological data.
- **CO-3:** To apply machine learning algorithms across structural biology, genomics, transcriptomics, and multi-omics data for trait prediction and stress-resistance analysis.
- **CO-4:** To evaluate computer vision and sensor-based AI models in plant disease diagnosis, species identification, growth trajectory modeling, and environmental monitoring.

Course Outcomes (COs)

- **CO-1 (Understand):** Classify core AI frameworks—ranging from reactive systems and limited memory models to deep neural networks—and their structural utility in botanical research.
- **CO-2 (Analyze):** Evaluate regression models, decision trees, random forests, and deep neural networks for processing diverse plant biological datasets (sequences, images, tabular sensor data).
- **CO-3 (Apply):** Utilize AI tools for protein structure prediction, genomic sequence analysis, meiotic recombination site mapping, and stress-associated gene identification.
- **CO-4 (Synthesize):** Design automated computer vision pipelines for high-throughput plant phenotyping, disease detection, taxonomic classification, and environmental monitoring.

Unit – I

Introduction

Introduction to AI and its importance in plant sciences. Historical overview of AI-based work in plant sciences**.** Current developments in AI based research work in plant sciences**.** Emerging trends in AI-based techniques in plant sciences**.**

AI in plant sciences

Limited memory AI. Relative machines-based AI. Knowledge representation. Machine Learning. Regression. Tree-based methods. Deep learning. Neural networks

Unit – II

Application of AI approaches in plant sciences

Protein-structure based machine learning; Machine learning for the prediction of meiotic recombination in plants; Study of ecology and evolution with modern advances in statistics and computation; Potential of omics data in predicting gene association with abiotic and biotic stress-resistant traits using machine learning; AI in plant growth prediction and environmental monitoring; AI in plant disease detection and management; Machine learning techniques for plant identification and classification; Genomic data analysis in botany using AI.

Suggested Readings

1. Publishing, A. (2020). Python Machine Learning for Beginners: Learning from Scratch NumPy, Pandas, Matplotlib, Seaborn, Scikitlearn, and TensorFlow for Machine Learning and Data Science. Estonia: AI Publishing LLC.
2. Tensor, O. (2020). Machine Learning for Beginners: The Beginner's Guide to Understand Artificial Intelligence, Business Applications, and Machine Learning for Business: Includes Deep Learning and Data Science for Business. (n.p.): Francesca Bandu.
3. Chatterjee, I. (2021). Machine Learning and Its Application: A Quick Guide for Beginners. (n.p.): Bentham Science Publishers.
4. Zhang, A., Lipton, Z. C., Li, M., Smola, A. J. (2023). Dive Into Deep Learning. India: Cambridge University Press.
5. Russell, S. J., Norvig, P., Davis, E. (2009). Artificial Intelligence: A Modern Approach. United Kingdom: Prentice Hall.
6. Kelleher, J. D., Mac Namee, B., D'Arcy, A. (2020). Fundamentals of Machine Learning for Predictive Data Analytics, Second Edition: Algorithms, Worked Examples, and Case Studies. United Kingdom: MIT Press.

M.Sc. Botany (Previous)

Semester - I

Practical Syllabus

Practical - I

1. Collection and identification of algae occurring in and around University Colleges / Campuses.

2. Identification of genera mentioned in Chlorophyceae, Cyanophyceae, Xanthophyceae, Phaeophyceae, Rhodophyceae and Bacillariophyceae

3. Introduction to Mycological techniques: i) Methods of Sterilization ii) Preparation of Media (PDA) iii) Culturing methods

4. Study of Symptomology of fungal diseases like Downy mildews, Tikka disease, Green bajra, sunflower rust, *Melampsora* rust, wheat and sorghum rusts and powdery mildews.

5. Section cutting and slide preparation of diseases mentioned above

6. Screening of Mycorrhizal fungal spores from the soil

7. Bryology: Morphological and structural study using whole mount of the following - a. *Plagiochasma / Fimbraria b. Targionia* c. *Notothylas* d. *Sphagnum / Funaria*

Practical - II

1. Study of angiosperm leaf epidermis in the following taxa: *Crotalaria, Portulaca* or *Talinium, Tridax, Petunia* or Datura, *Barleria, Rhoeo discolor* or *Commelina, Brassica, Cyperus* and Grass.

2. Estimation of stomatal frequency and stomatal index in the materials studied.

3. Maceration of wood and identification of various elements in *Michelia, Bombax, Tectona, Terminalia* and *Azadirachta*

4. Study of wood structure with the help of T.S., R.L.S. in the following: *Tectona, Bombax, Michelia, Pongamia* and *Azadirachta*

5. Histochemical tests for identification of the following: a) Callose b) Lignin c) Pectin d) Starch e) Suberin f) Silica bodies in the leaf of grasses and sledges.

6. Study of shoot apex in suitable locally available materials to understand cyto histological zonation (*Coleus, Kalanchoe*)

7. Study of roots in Monocots and Dicots. Examination of L.S. of root from a permanent preparation to understand the organization of root apical meristem and its derivatives (maize, aerial roots of banyan, *Pistia, Jussiaea*)

8. Study of the pollen grains of *Hibiscus, Tribulus, Ocimum* and Grass.

9. Acetolysis

10. Studies on section of ovules and identification of their ovaries

11. Pollen germination studies in different locally available plants and estimation of pollen fertility.

12. Study of embryos and Haustoria in locally available plants by dissection of young seeds

13. Determination of catalase activity

14. Determination of amylase activity

15. Estimation of fructose by resorcinol method

16. Estimation of protein by Biuret method/Lowry et.al. method

17. Estimation of phenols

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Semester - II

DSC 1: Systematics of Vascular Plants

Course Objectives

- **CO-1:** To examine the classification, structural diversity, evolutionary milestones (stelar theory, telome theory, heterospory), and economic value of Pteridophytes and Gymnosperms.
- **CO-2:** To build foundational skills in taxonomic methodologies, herbarium management, plant nomenclature rules (ICN / Shenzhen Code), and modern cladistic frameworks.
- **CO-3:** To critically evaluate classical and modern systems of angiosperm classification (Bentham & Hooker, Takhtajan, Cronquist, APG IV).
- **CO-4:** To master the comparative morphology, floral biology, evolutionary trends, and economic applications of major dicot and monocot families.

Course Outcomes (COs)

- **CO-1 (Understand):** Compare the life cycles, reproductive structures, and evolutionary affinities linking Bryophytes, Pteridophytes, Gymnosperms, and Angiosperms.
- **CO-2 (Analyze):** Trace evolutionary modifications in vascular plants, including stelar evolution, soral development, apogamy/apospory, and the origin of the seed habit.
- **CO-3 (Apply):** Apply the rules of the International Code of Nomenclature (ICN) regarding typification, priority, author citations, and valid publication in plant taxonomy.
- **CO-4 (Evaluate):** Compare phenetic and phylogenetic classification systems, highlighting the relative merits and demerits of traditional vs. molecular APG systems.
- **CO-5 (Synthesize):** Identify unknown flowering plants to their respective families using diagnostic vegetative/floral traits, floral formulas, and floral diagrams.

Unit – I

Introduction to Pteridophytes - Characteristic features and diversity of Pteridophytes, affinities with Bryophytes and Algae; Recent systems of classification- PPG I, (2016); Economic importance of pteridophytes

Diversity of Pteridophytes - Comparative account of distribution, morphology, anatomy, gametophyte, sporophyte and interrelationships of following orders – Lycopodiales, Isoetales, Selaginallales, Equisetales, Psilotales, Ophioglossales, Marattiales, Osmundales, Salviniales, Pteridinae

Evolution in Pteridophytes - Apogamy, apospory; Telome theory, stelar and soral evolution, gametophyte evolution; Heterospory and seed habit.

Unit – II

Introduction to Gymnosperms - Classification system of Gymnosperms (Christenhusz, 2011); Geographical distribution, characteristic features; Affinities with pteridophytes and angiosperms; Economic importance of gymnosperms.

Diversity of Gymnosperms

Comparative account of morphology, anatomy, sporogenesis, gametogenesis, embryology, and interrelationships of - Cycadales**,** Ginkgoales, Welwitschiales, Ephedrales, Gnetales, Pinales, Aurocariales, Cupressales

Unit – III

Taxonomic tools: Herbarium, floras, Botanical gardens, Arboretum; Plant nomenclature: Salient features of International Code of Nomenclature for algae, fungi, and plants (ICN), brief account of The Shenzhen Code 2018; ICN Articles and Recommendations about Ranks and Nomenclature, Typification, Author citation, Effective and valid publication; Classification of angiosperms: Natural, Artificial, Phylogenetic system of classification; Systems of angiosperm classification : Phenetic verses Phylogenetic system; cladistics in taxonomy; Relative merits and demerits of major systems of classifications- Bentham & Hooker; Takhtajan and Cronquist; Introduction to APG system of classification.

Unit – IV

Study of following families with particular reference to systematic position, phylogeny, evolutionary trends and economic importance.

Polypetalae - Ranunculaceae, Sapindaceae, Myrtaceae, Crassulaceae

Gamopetalae – Rubiaceae, Sapotaceae, Verbanaceae, Oleaceae

Monochlamydeae–Nyctaginaceae, Aristolochiaceae, Piperaceae, Euphorbiaceae

Monocotyledonae – Orchidaceae, Zingiberaceae, Cyperaceae, Poaceae

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Sporne, K.R. Pteridophytes

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Cavers, F. Inter-relations of Bryophytes

Campbell. D.H.: Mosses and ferns

Foster & Gifford: Comparative morphology of vascular plants

Chamberlain, C.J. Gymnosperms: Structure and evolution

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19. Dunn, C. and B.S. Veritt. An introduction to Numerical Taxonomy

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Semester - II

DSC 2: Plant Physiology

Course Objectives

- **CO-1:** To examine the physical and biochemical mechanisms governing plant-water relations, root-soil interactions, mineral nutrition transport systems, and nutrient assimilation pathways.
- **CO-2:** To elucidate the biophysics and biochemistry of light-harvesting mechanisms, photosynthetic pathways (C_3, C_4, CAM), photorespiration, and hormonal/photoperiodic control of growth and flowering.
- **CO-3:** To evaluate the physiological and metabolic impact of abiotic stress factors, including drought, flooding, heavy metals, and allelochemical interactions.
- **CO-4:** To analyze cellular and molecular defense responses under temperature extremes, salinity, and Ultraviolet-B (UV-B) radiation.

Course Outcomes (COs)

- **CO-1 (Understand):** Explain the Soil-Plant-Atmosphere Continuum (SPAC), stomatal regulation models, and the function of ion channels, ATPases, and aquaporins in solute transport.
- **CO-2 (Analyze):** Compare the energy efficiency, carbon fixation mechanisms, and regulatory enzymes of C_3, C_4, and CAM pathways alongside photorespiratory carbon recovery.
- **CO-3 (Apply):** Demonstrate how plant hormones (ABA, ethylene, auxins) mediate acclimation responses during drought, flooding, seed dormancy, and flowering.
- **CO-4 (Evaluate):** Assess physiological damage caused by heavy metals (Al, Mn, Fe, Zn) and allelochemicals on membrane stability and metabolic integrity.
- **CO-5 (Synthesize):** Formulate models of stress tolerance mechanisms involving heat shock proteins (HSPs), osmolytes, antioxidant systems, and UV-B screening compounds.

Unit-I

Water relations: Transpiration - stomatal regulation of transpiration, SPAC concept; Root – soil water relations; Mineral nutrition: Role of micronutrients in plant nutrition; Theories of mineral salt absorption, ion channels, ATPase carrier, aquaporins.

Assimilation of nutrients: Physiology and biochemistry of nitrogen fixation; Sulphur reduction and assimilation; Protein phosphorylation; Structure and functions of Calmodulin.

Unit-II

Photosynthesis: Photosynthetic apparatus; Properties of light and absorption of light by photosynthetic pigments; Composition and characterization of photo systems I and II; Photophosphorylation; C3 cycle, C4 cycle, CAM pathway; Regulation of C3, C4 and CAM pathway; Photorespiration and its regulation.

Hormonal Regulation of growth and development: General role of Auxins, Gibberellins, Cytokinins, Ethylene, Abscisic acid, Salicylic acid and Brassinosteroids; Physiology of flowering - Photoperiodism, Phytochrome; Physiology and biochemistry of seed germination; Physiology and biochemistry of seed dormancy (Causes and methods of breaking dormancy).

Unit-III

Drought Stress - Membranes and water stress, Stomatal response to water stress- Role of ABA, Photosynthesis and water stress, Mechanisms of drought tolerance; Flooding stress - Flooding injury, Metabolic damage, Hormonal imbalance, Soil toxins.

Metal stress - Metal toxicity and tolerance with special reference to i) Aluminum ii) Manganese iii) Iron iv) Zinc; Allelochemicals - Chemical nature of allelochemicals, Mode of release and production of allelochemicals, Mode of action of allelochemicals on plant physiological processes

Unit-IV

Temperature stress - Effect of low temperature and frost injury on plant productivity, Stress effects on productivity and yield susceptibility of plants, Chilling and freezing effects on carbon dioxide exchange; Heat stress - Cellular responses to high temperature: enzyme activities, photosynthesis, ultra-structural effects, Molecular responses to high temperature. Heat shock proteins. High temperature tolerance mechanisms in plants

Salt stress - Effect of high salt concentration of plants – water stress, nutrient ion deficiency, ion toxicity; Regulation of salt content – Salt elimination, salt succulency; Mechanisms of salt resistance and tolerance.

Ultraviolet – B radiation - Plant response to UV - B radiation, Effect of UV-B on chemical composition, Effect of UV-B radiation on photosynthesis, UV-B defense and gene expression

References

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3. Plant Physiology by F.B. Salisbury and C.W. Ross. Wordsworth biology series.

4. Growth and differentiation in plants by Wareing and Phillips, Pergamon press.

5. Plants Cell structure and metabolism. J.L. Hall, Flower and Roberts, ELBS, Longman.

6. Advanced Plant Physiology by M.B. Wilkinson, ELBS, Longman

7. Introduction to Plant Physiology by G.R. Noggle and G.J. Fritz, Printice Hall Press

8. Plant Physiology by R.N. Devlin and F.H. Witham, CBS 1986

9. Introduction to plant physiology W.G. Hopkins. 1999. John Wiley and sons.

10. Plant Physiology. Lincoln Taiz and Eduardo Zeiger

11. Plant ecophysiology Ed. M.N.V. Prasad. John Wiley and Sons Inc. NY (1997)

12. Encyclopedia Plant Physiology. New Series.

13. ABCD Plant Physiology Ecology 1983. Springer Verlag Berlin

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Semester - II

DSC 3: Principles of Plant Pathology

Course Objectives

- **CO-1:** To introduce fundamental concepts of plant pathology, including pathogenicity, host-pathogen interactions, chemical weapons of pathogens, and Koch's postulates.
- **CO-2:** To examine pathogen nutrition, spore physiology, alterations in host physiology, and structural and biochemical host defense mechanisms.
- **CO-3:** To analyze the influence of environmental factors on disease development, epidemic patterns, computer simulations, forecasting models, and IDM practices.
- **CO-4:** To classify plant disease control measures and understand the chemical nature, mode of action, and application strategies of various fungicide classes.

Course Outcomes (COs)

- **CO-1 (Understand):** Explain the stages of disease development, modes of penetration (physical and chemical), and the role of pathogen enzymes, toxins, and growth regulators.
- **CO-2 (Analyze):** Evaluate host physiological disruptions (photosynthesis, respiration, translocation) and classify structural and biochemical defense responses (phytoalexins, hypersensitivity, phenolic compounds).
- **CO-3 (Apply):** Calculate disease incidence and severity using visual scales or digital image analysis to model disease progress curves and forecasting systems.
- **CO-4 (Synthesize):** Design an Integrated Disease Management (IDM) framework combining quarantine, cultural, biological, physical, and chemical strategies.
- **CO-5 (Evaluate):** Select appropriate fungicide formulations based on their chemical composition, target site mode of action, and application methods.

UNIT- I

Introduction: Terminology, Disease concept. Pathogenicity and Koch's postulates; disease quantification, Traditional and image analysis. Parasitism and Disease Development: Host range of pathogens, disease development, disease cycle, penetration (chemical and physical), colonization and dissemination of pathogens. Host pathogen interaction: Chemical Weapons of pathogens (Enzymes, Toxins and Growth regulators).

UNIT- II

Changes in Host physiological functions due to pathogenesis: Nutrition and Physiology of plant pathogenic fungi: Carbon, Nitrogen, phosphorous and trace elements. Physiology of spore dormancy and spore germination. Host defense mechanisms: Structural defense, Hypersensitivity, Physical barriers, Metabolic or Biochemical defense, Phenols, Phytoalexins and induced enzymes.

UNIT- III

Effect of Environment on Disease Development: Effect of Moisture, Temperature, Wind, Soil, pH and Host-plant nutrition. Plant disease Epidemiology: Elements of epidemics, Measurement of Plant diseases, Patterns of epidemics and pathogens factors. Computer simulation of epidemics, Disease Forecasting.

Quarantine; Cultural practices; Biological Methods; Physical Methods; Chemical Methods; Integrated Disease management- General account (importance and basic principles). Photosynthesis, Translocation of water and nutrients, Respiration and Permeability of membrane.

UNIT- IV

Principles of Plant Disease Management: a. Classification of fungicides, b. Chemical nature, mode of action and methods of application of the following: Sulphur fungicides, Copper fungicides, Mercurial compounds, Quinones, Heterocyclic compounds, Oxanthins. & Benzimidazoles and Miscellaneous fungicides.

References

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Semester - II

SEC: Hydroponics Farming

Course Objectives

- CO-1: To introduce the principles of soil-less culture, contrasting hydroponics with traditional soil agriculture in resource efficiency and crop yield.
- CO-2: To examine plant mineral nutrition, identifying functions and deficiency symptoms of macronutrients and micronutrients in controlled environments.
- CO-3: To master environmental factor management (light quality, photoperiod, temperature, humidity, CO_2, pH, and EC/TDS) to optimize crop growth.
- CO-4: To evaluate active and passive hydroponic techniques, including setup protocols for specialized commercial crops (Tomato, Chilly, Spinach, Fodder).
- CO-5: To understand hydroponic entrepreneurship, navigating operational challenges, government schemes, commercial production, and market channels.

Course Outcomes (COs)

- CO-1 (Understand): Explain the historical evolution and physiological advantages of soil-less farming systems over traditional soil cultivation.
- CO-2 (Analyze): Diagnose nutrient deficiency symptoms across essential macro- and micronutrients (N, P, Ca, Mg, K, S, Fe, Mn, Cu, Zn, B, Mo) to adjust nutrient solution formulations.
- CO-3 (Apply): Regulate greenhouse environmental parameters (DLI, photoperiod, VPD, pH, TDS/PPM) for specific crop cycles.
- CO-4 (Design): Construct operational hydroponic systems (NFT, DWC, Aeroponics, Dutch Bucket, Raft) tailored to targeted crop protocols.
- CO-5 (Synthesize): Formulate a small-scale commercial hydroponics business plan covering production stages, risk mitigation, grading, packaging, and supply-chain marketing.

Unit I

Introduction to hydroponics technology

Definition and Concept, History and origin of Soil-less culture, Present status of Hydroponics - Contrasts with soil-based culture, Types of hydroponics, applications and future developments.

Unit II

Plant Nutrition: Essential, mineral elements

Functions and effects on plants, Deficiency Symptoms of the following Essential Minerals- N, P, Ca, Mg, K, S, Fe, Mn, Cu, Zn, B, Mo. Environmental and Chemical Factors: Light (Quality, Photoperiodism and systems), Temperature (heating and cooling), Humidity and CO2, pH, PPM / TDS.

Unit III

Hydroponics entrepreneurship

Definition; Significance of entrepreneurship; Challenges - family, social, technological, financial and policy; Role of government in promoting entrepreneurship; Stages in starting a small-scale industry.

Nutrient Solutions and Media Inorganic salts (fertilizers) - Macronutrients, Micronutrients, Formulating, monitoring, and analyzing, pH adjustment, selecting fertilizers and nutrient monitoring; Media used for Hydroponics: Ex-clay, Rock wool, Coir, Perlite, Pumice, Vermiculite, Sand, Gravel, Brick shards, Polystyrene packing peanuts, wood fiber; Weed management, diseases and pest control, Pollination, making clones of plants.

Unit IV: Techniques in Hydroponics and Cultivation of crop plants

Techniques in Hydroponics – Static solution culture, Continuous – flow Solution culture, Aeroponics, Passive sub-irrigation, Ebb and flow or flood and drain irrigation, Deep water culture; Protocols for – Tomato cultivation through Dutch bucket method, Chilly cultivation through NFT system, Spinach through Raft system, Fodder system.

Marketing of hydroponics products - Harvesting, grading, storage and marketing process of crops grown under hydroponics system global hydroponic market and commercial hydroponic production.

References

1. Keith Roberto. How to Hydroponics. The future garden press New York. 4th Edition.

2. Howard M. Resh. Hobby Hydroponics. CRC Press USA.

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Semester – II

VAC: Quantum Technology

Course Objectives

- CO-1: To introduce the historical evolution, foundational concepts, and current scientific debates in the emerging field of quantum biology.
- CO-2: To build a rigorous understanding of core quantum mechanical phenomena—including wave-particle duality, superposition, coherence, entanglement, and quantum tunnelling—as they apply to biological environments.
- CO-3: To analyze the structural and physical mechanisms of light-harvesting complexes (LHCs), contrasting quantum coherent energy transfer with classical incoherent hopping models.
- CO-4: To evaluate chemical reaction dynamics in biological systems by comparing classical transition state theory (TST) with quantum corrections in enzyme catalysis.
- CO-5: To investigate quantum phenomena in nucleic acids, focusing on proton tunnelling in DNA base pairs, tautomeric shifts, charge transport along π-stacks, and quantum-assisted repair mechanisms.

Course Outcomes (COs)

- CO-1 (Understand): Explain how quantum mechanics operates within warm, wet, and complex biological systems despite decoherence.
- CO-2 (Analyze): Differentiate between wave-like quantum coherent exciton transport and classical Förster resonance energy transfer (FRET) in photosynthetic light-harvesting complexes.
- CO-3 (Evaluate): Quantify energy barrier crossing using classical Arrhenius kinetics alongside quantum corrections (such as zero-point energy and tunnelling factors) in enzymatic reactions.
- CO-4 (Apply): Demonstrate how proton tunnelling via the Löwdin hypothesis leads to rare tautomeric forms in DNA and contributes to spontaneous point mutations.
- CO-5 (Synthesize): Model charge transfer mechanisms (π-stack conduction vs. hopping vs. tunnelling) across DNA structures and describe the quantum mechanics underlying photolyase-mediated DNA repair.

Unit – I

Foundations of Quantum Physics & Biology - Introduction to quantum biology: History, scope, and key debates, Quantum mechanics essentials: Wave-particle duality, superposition, quantum coherence, entanglement, and tunnelling, Statistical mechanics and biological thermodynamics

Quantum Effects in Photosynthesis & Energy Transfer - Light-harvesting complexes (LHCs) and chromophore architecture, Exciton dynamics: Coherent wave-like energy transfer vs. classical incoherent hopping

Unit – II

Fundamentals of Enzyme Catalysis & Quantum Mechanics - Transition state theory (TST) vs. quantum corrections, Energy barrier crossing: Activation energy, Arrhenius equation, and classical kinetics

Quantum Effects in DNA Stability and Mutation - Proton tunnelling in GC and AT base pairs (The Lowdin Hypothesis), Tautomeric shifts (rare enol/imino forms) and point mutations, Charge transfer through the DNA π-stack: Conduction, hopping, and tunnelling, Quantum mechanics of DNA repair mechanisms (e.g., DNA photolyase)

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Semester – II

Practical Syllabus

Practical – III

1. Pteridology: Morphology and anatomy of vegetative as reproductive organs using cleared whole mount, sections, macerations and permanent preparations of - a. *Psilotum*, b. *Isoetes*, c. *Ophioglossum*, d. *Adiantum*, e. *Salvinia*, f. *Azolla*

2. Comparative study of the vegetative, reproductive parts and Anatomy of the following: *Zamia, Ephedra, Thuja, Ginkgo, Taxus.*

3. Studies on section of ovules and identification of their ovaries

4. Pollen germination studies in different locally available plants and estimation of pollen fertility.

5. Study of embryos and Haustoria in locally available plants by dissection of young seeds

6. Study of the locally available plants and recording of the intraspecific variation

7. Description and identification at family, genus and species levels using Floras.

8. Identification of key characters in a group of species of a genus and construction of keys.

9. Construction of indented keys for the given material

10. Identification of families studied based on flowers or essential parts of the flowers

11. Knowledge of Herbarium techniques

Practical – IV

1. Determination of water potential by Shardolo's methods.
2. Determination of total and titrable acidity.
3. Separation of chloroplast pigments by solvent method
4. Determination of chlorophyll a, chlorophyll b and total chlorophylls in C3 and C4 plants.
5. Estimation of reducing sugars in fruits.
6. Determination of iodine number.
7. Estimation of proline
8. Extraction and estimation of total phenols
9. Estimation of catalase activity
10. Estimation of peroxidase activity
11. Estimation of polyphenol oxidase activity
12. Estimation of ascorbic acid oxidase activity
13. Techniques of isolation of fungi: Dilution method, soil plate method, agar plate method and single spore isolation.
14. Collection, isolation and identification and of fungi from soil, water, air, leaf, root and seeds.
15. Calculation of spore count using Haemocytometer.
16. Isolation and identification of AM Fungi and estimation of root colonization.
17. Mushroom cultivation.
18. Demonstration of antagonistic fungi a) Antibiosis b) Competition c) Mycoparasitism.