UNIVERSITY OF PATANJALI, HARIDWAR

Syllabus of M. Sc. in Applied Artificial Intelligence in Plant Science

UNDER NATIONAL EDUCATION POLICY-2020
W.E.F. Academic Session 2026-27

DEPARTMENT OF ALLIED AND APPLIED SCIENCE

Faculty of Science

Sem	Core/Major	Minor	ID	AEC	SEC	VA	Total Credits
1	**1.** Microbiology, Mycology and Plant Pathology (3+1) **2.** Algae, Bryophytes and Pteridophytes (3+1) **3.** Gymnosperms and Plant Anatomy (3+1) **4.** Reproductive Biology and Embryology (3+1) **5.** Plant Resources in Human Life (4)						
2	**1.** Angiospermic Taxonomy And Biosystematics (AI-assisted classification, digital herbaria) (3+1) **2.** Plant Physiology (3+1) **3.** Cell Biology and Plant Biochemistry (3+1) **4.** Bioprocess Development (3+1) **5.** Research Methodologies and Proposal Writing in Plant Sciences (3+1) **6.** Methods in Plant Sciences (3+1)						
3	**1.** Crop modeling & nutraceutical validation (3+1) **2.** Plant Ecology and Ecosystem Analysis (3+1) **3.** Plant Biotechnology (3+1) **4.** AI-driven solutions for biodiversity monitoring (4) **5.** Climate Change and Plant Adaptations Modeling (4) **6.** AI in Plant Genetics & Genomics (4)						
4	**Dissertation** **1.** Problem identification, review of literature, proposal writing and Presentation (5) **2.** Dissertation: Experiments, data collection, analysis, interpretation and discussion (10) **3.** Dissertation presentation and *Viva-Voce (5)*						
Total Credits	**85**						

University of Patanjali, Haridwar
Allied and Applied Science Department

In Accordance with New Education Policy-2020
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	M.Sc. in Applied Artificial Intelligence in Plant Science **Teaching and Evaluation Scheme** **Semester-I**													
S. No	**Sub Code**	**Subject**	**Learning Mode**	**Periods**			**Internal Evaluation (Marks)**				**External Evaluation (Marks)**		**Total Marks**	**Total Credits**
				L	T	P	CT	Viva	AS	Total	TE	PE		
1	MSBTMJ-101	Microbiology, Mycology and Plant Pathology	offline	6			10	10	5	25	75		100	3
2	MSBTMJ-101-P	Microbiology, Mycology and Plant Pathology-P	offline			2	5	5	5	15		35	50	1
3	MSBTMJ-102	Algae, Bryophytes and Pteridophytes	offline	6			10	10	5	25	75		100	3
4	MSBTMJ-102-P	Algae, Bryophytes and Pteridophytes-P	offline			2	5	5	5	15		35	50	1
5	MSBTMJ-103	Gymnosperms and Plant Anatomy	offline	6			10	10	5	25	75		100	3
	MSBTMJ-103-P	Gymnosperms and Plant Anatomy-P				2	5	5	5	15		35	50	1
6	MSBTMJ-104	Reproductive Biology and Embryology	offline	6			10	10	5	25	75		100	3
7	MSBTMJ-104-P	Reproductive Biology and Embryology-P	offline			2	5	5	5	15		35	50	1
8	MSBTMJ-105	Plant Resources in Human Life		6			10	10	5	25	75		100	4

	M.Sc. in Applied Artificial Intelligence in Plant Science													
	Semester-II													
1	MSBTMJ-201	Angiospermic Taxonomy and Biosystematics	offline	6			10	10	5	25	75		100	3
2	MSBTMJ-201-P	Angiospermic Taxonomy and Biosystematics-P	offline			2	5	5	5	15		35	50	1
3	MSBTMJ-202	Plant Physiology	offline	6			10	10	5	25	75		100	3
4	MSBTMJ-202-P	Plant Physiology-P	offline			2	5	5	5	15		35	50	1
5	MSBTMJ-203	Cell Biology and Biochemistry	offline	6			10	10	5	25	75		100	3
6	MSBTMJ-203-P	Cell Biology and Biochemistry-P	offline			2	5	5	5	15		35	50	1
7	MSBTMJ-204	Bioprocess Development	offline	6			10	10	5	25	75		100	3
8	MSBTMJ-204-P	Bioprocess Development-P	offline			2	5	5	5	15		35	50	1
9	MSBTMJ-205	Methods in Plant Sciences	offline	6			10	10	5	25	75		100	3
10	MSBTMJ-205-P	Methods in Plant Sciences-P	offline			2	5	5	5	15		35	50	1
11	MSBTMJ-206	Research Methodologies and Proposal Writing in Plant Sciences	offline	6			10	10	5	25	75		100	4

M.Sc. in Applied Artificial Intelligence in Plant Science **Semester-III**														
1	MSBTMJ-301	Crop Modeling & Nutraceutical Validation	offline	6			10	10	5	25	75		100	3
2	MSBTMJ-301-P	Crop Modeling & Nutraceutical Validation -P	offline			2	5	5	5	15		35	50	1
3	MSBTMJ-302	Plant Ecology and Ecosystem Analysis	offline	6			10	10	5	25	75		100	3
4	MSBTMJ-302-P	Plant Ecology and Ecosystem Analysis-P	offline			2	5	5	5	15		35	50	1
5	MSBTMJ-303	Plant Biotechnology	offline	6			10	10	5	25	75		100	3
6	MSBTMJ-303-P	Plant Biotechnology-P	offline			2	5	5	5	15		35	50	1
7	MSBTMJ-304	AI-driven solutions for biodiversity monitoring	offline	6			10	10	5	25	75		100	4
8	MSBTMJ-305	Climate Change and Plant Adaptations	offline	6			10	10	5	25	75		100	4
9	MSBTMMJ-306	AI in Plant Genetics & Genomics	offline	6			10	10	5	25	75		100	4

M.Sc. in Applied Artificial Intelligence in Plant Science **Semester-IV**			
Paper Code	**Name of the**	**Marks**	**Credits**
MSBTMJ-401	**Dissertation**		
	Problem identification, review of literature, proposal writing and presentation	125	5
	Dissertation: Experiments, data collection, analysis, interpretation and discussion	250	10
	Dissertation presentation and *Viva-Voce*	125	5

Programme Objectives (POs):

M. Sc. in Applied Artificial Intelligence in Plant Science programme offers a comprehensive curriculum covering wide topics essential for understanding plant biology and its interdisciplinary applications.

- Students would be acquainted with scientific knowledge and skills to study plants in a holistic manner and trained in all areas of plant biology using a unique combination of core and discipline-specific papers with significant interdisciplinary components.
- Students would be exposed to advanced technologies like Artificial Intelligence that are currently in use in the study of plant science.
- Students would also become aware of the significance of plants and their relevance to the economy of the nation.
- Through hands-on laboratory experiments and project work, students will gain understanding into the practical aspects of Plant Biology such as ecology, taxonomy, genetics, development and biotechnology.
- With a carefully modulated blend of theoretical learning and hands-on practical exposure, graduates of the M.Sc. programme would be equipped to emerge as skilled plant biologists prepared to address the diverse challenges of plant ecology, agriculture, environmental sustainability, and biotechnological innovations.

Programme Specific Outcomes (PSOs):

PSO1. The student completing the course will be able to understand different areas of Plant Sciences such as systematics, morphology, anatomy, developmental biology, biochemistry and physiology, reproduction, plant interactions with microbes, evolution, ecology, genetics and biotechnology.

PSO2. The student completing the course will be trained in various analytical techniques of plant biology, use of plants as industrial resources for human livelihood and the use of transgenic technologies for research in plants.

PSO3. The student completing the course will be able to identify plants, design and execute experiments related to evolution, ecology, developmental biology, physiology, biochemistry, plant interactions with microbes and insects, morphology, anatomy, reproduction, genetics, microbiology, molecular biology, recombinant DNA technology, proteomics and transgenic technology. Students will be also familiarized with the use of bioinformatics tools and application of statistics to biological data.

PSO4. The programme aims to integrate classical botany with modern artificial intelligence, fostering interdisciplinary competence that bridges plant sciences, computing, and policy, while simultaneously encouraging research and innovation to address contemporary challenges. It is designed to empower societal impact and outreach through farmer training, and biodiversity conservation, ensuring that students gain practical skills for employability and professional development. Finally, the curriculum emphasizes global and national policy integration, aligning with NEP 2020 and sustainability frameworks to prepare graduates for leadership in science, technology, and community engagement.

First Semester

Sub Code	*Name of subject*	*L*	*T*	*P*	*Max Marks (T)*	*Max Marks (P)*	*Total Credit*
MSBTMJ-101	Microbiology, Mycology and Plant Pathology	6	-	1	100 (75+25)	50 (35+15)	4

Course Objectives:

1. To develop an understanding of the diversity, classification, and characteristics of microorganisms.
2. To provide knowledge about the structure, growth, reproduction, and identification of microorganisms.
3. To familiarize students with plant diseases, their causal organisms, symptoms, and control measures.
4. To enhance understanding of plant–microbe interactions and their ecological significance.
5. To introduce the applications of microorganisms in agriculture, biotechnology, and environmental management.

Course Outcomes:

1. Increasing the understanding of the students about the diversity of microorganisms, their classification, structure and growth.
2. Recognize functional ubiquity and diversity observed among different microbes.
3. Developing functional knowledge on differentiating disease caused by virus, fungi, and bacteria
4. Knowing about the various plant diseases and their control measures.
5. Interpreting the various ecological and evolutionary principles that impact microbes.

Unit I Microbial growth; batch culture: synchronous and continuous culture; microbial cultures: methods of isolation and maintenance of pure cultures. Various measurement of microbial growth; Effect of environmental factors on microbial growth; Microbes in extreme environments; Microbes in nanotechnology, biosensors. Microbiology of foods: Vegetables, fruits, milk, fermented and non- fermented milk products, fresh meats, poultry and non-dairy fermented foods; Microbial spoilage of food and poisoning; Food preservation: Chemical, physical and biological methods. Fermentation: batch, continuous and fed-batch. Microbes in recovery of metal (bioleaching) and oil, Cell and enzyme immobilization, microbial enzymes of industrial interest; Novel medicines from microbes.

Unit II Criteria used in the classification of fungi with reference to vegetative and reproductive structures; parasexuality; wood decay fungi and their importance; interaction between microbes and roots of higher plants: rhizosphere microorganisms and its significance; mycorrhizal fungi: types and applications; endophytic fungi and their importance.

Unit III Symptomology and identification of local plant diseases with reference to fungi, bacteria and viruses viz. late blight of potato, citrus canker, tobacco mosaic disease, wilt of tomato crown gall disease, role of enzymes and toxins in pathogenesis; effect of temperature, pH and moisture on the development of plant diseases; mechanisms of plant pathogenicity; chemical and biological control of plant diseases; bioremediation of
contaminated soils.

Practicals MSBTMJ-101-P

1. Collection and identification of causal organisms from diseased plant materials.
2. Isolation, identification and enumeration of bacteria and fungi from soil, litter and air.
3. Preparation and maintenance of pure cultures.
4. Gram and acid fast staining of bacterial cultures and acid fast stain.

Suggested Readings:

1. Barnett, H.L. and Hunter, B.B. (1972). Illustrated Genera of Imperfect Fungi. Burges Publishing. Co. USA.
2. Johnson, L.F. and Curl, E.A. (1972). Methods for Research on the Ecology of Soil Borne Plant Pathogens. Burgess Publishing Co. USA.
3. Domsch, K.H., Gams, W. and Anderson, T.H. (1980). Compendium of Soil Fungi. Academic Press. New Delhi, India.
4. Harley, H.L and Smith, S.E. (1983). Mycorrhizal Symbiosis. Academic Press, USA.
5. Benson, H.J. (1990). Microbiological Applications-A Laboratory Manual in General Microbiology. Wm. C. Brown Publishers. USA.

Sub Code	*Name of subject*	*L*	*T*	*P*	*Max Marks (T)*	*Max Marks (P)*	*Total Credit*
MSBTMJ-102	Algae, Bryophytes and Pteridophytes	6	-	1	100 (75+25)	50 (35+15)	4

Course Objectives:

1. To develop an understanding of the evolutionary diversification of early land plants.
2. To study the morphology, anatomy, reproduction, and developmental patterns of algae, bryophytes, and pteridophytes.
3. To understand the morphological and reproductive innovations in lower plant groups.
4. To provide knowledge of plant taxonomy and evolutionary relationships among primitive plant forms.
5. To highlight the ecological and economic importance of algae, bryophytes, and pteridophytes.

Course Outcomes:

1. Understanding the taxonomic position, occurrence, thallus structure, plant morphology and reproduction of the plants
2. Knowing the vegetative and reproductive characteristics of the plants.
3. Ecological and economic importance of algae, bryophytes, pteridophytes which will help to understand their role in ecosystem functioning.
4. Understand the origin, classifications and theories of evolutions among algae, bryophytes and pteridophytes.
5. To understand the stelar evolution and seed formation habit in pteridophytes.

Unit I Algal ecology: Distribution in diverse habitats; diversity of light harvesting pigments, food reserves, economic importance, algae as biological monitor of water pollution; cyanobacteria, symbiotic algal associations-Nitrogen fixation; mass cultivation methods of algae; algal blooms, eutrophication, Economic importance of algae

Unit II Origin and classification of bryophytes; vegetative and sexual reproduction; mechanism of dehiscence of capsules and dispersal of spores in bryophytes; evolution of gametophytes and sporophytes; association of bryophytes with microorganisms; anisospory and sexual dimorphism; biologically active compounds in bryophytes; ecological and economic importance of bryophytes.

Unit III Origin of pteridophytes: theories of algal and bryophytean origins; classification; morphological, anatomical and reproductive diversity; telome theory; enation theory; stelar evolution; heterospory and seed habit; apogamy and apospory; ecological and economic importance of pteridophytes.

Practicals MSBTMJ-102-P **1 Credit**

1. Study of morphological features of some common freshwater, terrestrial and marine representatives of algae.
2. Study of morphology, anatomy and reproductive structures of some representatives of bryophytes and pteridophytes.

Suggested Readings:

1. Bold, H.C. and Wyne, M.J. (1978). Introduction to the Algae. Prentice Hall of India Private Ltd., New-Delhi.
2. Geissler, P and Greene, S.W. (1982). Bryophyte Taxonomy, Methods, Practices and Floristic Exploration. J Cramer, Germany.
3. Hoek, Van den, Mann, D.G. and Janes, H.M. (1995). Algae-An Introduction to Phycology, Cambridge University Press, New Delhi.
4. Parihar, N.S. (1996). The Biology and Morphology of Pteridophytes. Central Book Depot, Allahabad.
5. Stevenson, R.J., Bothwell, M.L. and Lowe, R.L. (1996). Algal Ecology-Fresh Water Benthic Ecosystems. Academic Press.

Sub Code	*Name of subject*	*L*	*T*	*P*	*Max Marks (T)*	*Max Marks (P)*	*Total Credit*
MSBTMJ-103	Gymnosperms and Plant Anatomy	6	-	1	100 (75+25)	50 (35+15)	4

Course Objectives

1. To develop an understanding of the distribution, morphology, anatomy, and reproduction of gymnosperms.
2. To study the structural features, affinities, and evolutionary significance of fossil gymnosperms.
3. To provide knowledge of shoot, leaf, and wood development in plants.
4. To understand the principles and current trends in plant anatomy.
5. To highlight the ecological and economic importance of gymnosperms.

Course Outcomes:

1. The importance of fossil and living gymnosperms.
2. To gain knowledge on the distribution of gymnosperms.
3. The development of the different organs of the plant whichwill help in their understanding of the ecosystems.
4. To understand the importance characteristics, morphology,anatomy, reproduction and affinities of living gymnosperms.
5. To explain about the affinities of fossils gymnosperms.

Unit I Distribution of gymnosperms in India; economic importance of gymnosperms; salient structural features and affinities of fossil gymnosperms; pro-gymnosperms; Pteridospermales; Cycadeoidales (Bennettitales); Pentoxylales; Cordaitales; Diversity, morphology, anatomy, reproduction and affinities of living gymnosperms: Cycadales, Ginkgoales, Taxales, Coniferales, Ephedrales, Gnetales,
and Welwitschiales.

Unit II Shoot development: Shoot apical meristem; organization, ultrastructure and histochemistry of lateral and intercalary meristems; differentiation of xylem; procambium vs. vascular cambium; factors influencing the activity of vascular cambium; wood development in relation to environmental factors; current trends
and prospects in plant anatomy.

Unit III Leaf development: Leaf meristem, and histogenesis; stomatal ontogeny and classification; ultrastructure of guard cells; secretary glands and laticifers; transfer cells; fine structure of plasmalemma, microtubules and microfibrils; origin and development of primary and lateral roots; phloem: sieve tubes, sieve cells, differentiation and ultrastructure of cellular organelles; phloem protein and its
function.

Practicals MSBTMJ-103-P **1 Credit**

1. Comparative study on the external morphology and anatomy of vegetative and reproductive parts of *Pinus*, *Gingko*, *Cedrus*, *Cupressus*, *Cryptomeria*, *Taxus andGnetum* etc
2. Study of the reproductive stages of genera listed above through permanentslides.
3. Use of paraffin method of microtechnique.
4. Acquaintance with ultratomy, uses of wood microtomy and other commonanatomical and histochemical methods.
2. Study of shoot and root apical meristems and lateral meristem, development of leaf and axillary bud, anomalous secondary growth, maceration and micro dissection.

Suggested Readings:

1. Sporne, K.R. (1965). The Morphology of Gymnosperms. Hutchinson & Co.
2. Trivedi, B.S and Singh, D.K. (1965). Structure and Reproduction of Gymnosperms. Shashidhar Malaviya Prakashan.
3. Cutter, E.G. (1971). Plant Anatomy: Experiment and Interpretation. Vols. 1 & 2. Edward Arnol.
4. Esau, K. (1972). Plant Anatomy. John Wiley.
5. Beck, B. (1988). Origin and Evolution of Gymnosperms. Columbia University Press.
6. Mauseth, J.D. (1988). Plant Anatomy. The Benjamin Cummings Publishers.
7. Fahn, A. (1990). Plant Anatomy. Pergmon Press.
8. Iqbal, M. (1990). The Vascular Cambium, John Wiley.
9. Shivanna, K.R. and Rangaswamy, N.S. (1992). Pollen Biology: A laboratory Manual. Springer- Verlag
10. Bhatnagar, A.K. and Moitra, A. (1996). Gymnosperms. New Age International Press.

Sub Code	*Name of subject*	*L*	*T*	*P*	*Max Marks (T)*	*Max Marks (P)*	*Total Credit*
MSBTMJ-104	Reproductive Biology and Embryology	6	-	1	100 (75+25)	50 (35+15)	4

Course Objectives:

1. To develop an understanding of the fundamentals of plant growth, development, and differentiation in angiosperms.
2. To study the mechanisms involved in the development of various plant organs.
3. To provide knowledge of plant reproduction and its role in growth and development.
4. To understand the influence of developmental and ecological factors on plant fitness and adaptation.
5. To familiarize students with the coordination of physiological, developmental, and environmental processes in plants.

Course Outcomes:

1. To gain knowledge of plant cells, tissues and their functions.
2. To identify and compare structural differences among different taxa of vascular plants.
3. To know the structure and development of monocot and dicot embryos.
4. To compare the function and morphology of pollen grains.
5. To describe and illustrate modern and fossil spores and pollen grains.

Unit I Development of flower (e.g. *Arabidopsis*); development of anther, ultra structure of tapetum and its role in pollen development; microsporogenesis, male sterility,
male gametophyte development, heterogeneity in sperm cells; pistil and stigmatypes; megasporogenesis; polarity and ultrastructure of embryo sac.

Unit II Pollen–pistil interaction; pollen tube attraction by synergids endosperm: types, endosperm haustoria and their functions; ultrastructure and polarity of zygote, formation of tetrad, quadrant and octant proembryos; difference between monocot and dicot embryos, structure and function of suspensor; polyembryony and
apomixes; parthenocarpy.

Unit III Microsporangium-Structure (T.S. of typical anther), Microsporogenesis, Structure of Pollen grain, Pollination (self and cross pollination), Development of male gametophyte, Megasporangium- Structure (L.S. of typical ovule), types of ovule. Megasporogenesis, Development of Monosporic (Polygonum type), Bisporic (Allium type) and Tetrasporic (Adoxa type) female gametophytes, Fertilization- Double fertilization and Significance, Endospermand types (Nuclear, Cellular and Helobial endosperm) , Embryo- Development of Monocot and Dicot (Crucifer type) embryo, Development of seed and Fruit (Post fertilization changes)

Practicals MSBTMJ-104-P **1 Credit**

1. Study of microsporogenesis and gametogenesis in anthers
2. Study of pollen viability using stains and *in vitro* pollen germination
3. Preparation of dissected whole mounts of endothecium, tapetum and ovule
4. Study of nuclear and cellular endosperm and suspensor through dissections and staining
5. Isolation of globular, heart shaped and torpedo stages of embryos from suitable seeds

Suggested Readings:

1. Maheswari, P. (1950). An Introduction to the embryology of Angiosperms. McGraw Hill Book Co.
2. Meeuse, A. D. (1966). Fundamentals of phytomorphology. Ronald Press Co.
3. Raghavan, V. (1966). Embryogenesis in angiosperms. Cambridge Univ. Press.
4. Shivanna, K .R. and Johri, B. M. (1985). The angiosperm pollen structure and function. Wiley eastern.
5. Sattler, R. (1978). Theoretical Plant morphology. Leiden University Press.
6. Swamy, B. G. L. and Krishnamurthy, K.V. (1980). From flower to fruit Tata McGraw Hill Book Co.
7. Real, L. (1983). Pollination Biology. Academic Press.
8. Johri, B. M. (1984). Embryology of angiosperms. Springer-Verlag.

Sub Code	*Name of subject*	*L*	*T*	*P*	*Max Marks (T)*	*Max Marks (P)*	*Total Credit*
MSBTMJ-105	Plant Resources in Human Life	6	-	-	100 (75+25)	00	4

Course Objectives:

1. To develop an understanding of plant resources and their importance for human welfare.
2. To provide knowledge about medicinal plants and their therapeutic applications.
3. To study bioactive compounds obtained from plants and their significance.
4. To familiarize students with the industrial applications of algae and other plant products.
5. To introduce sustainable farming practices and the utilization of plant resources in agriculture and industry.

Course Outcomes:

1. To develop an understanding of the importance of plant resources in daily life and human welfare.
2. To provide knowledge about useful plants and plant products utilized by society.
3. To familiarize students with the identification features of economically important plant resources.
4. To study medicinal plants and plant-derived products used for therapeutic purposes.
5. To understand the applications of algae as food, nutraceuticals, and biofuel sources.

Unit I Economic Botany: Uses, active principles, and value addition of the following medicinal and aromatic plants: *Aquilaria, Taxus, Mentha, Ocimum* and *Stivia.* Ethnobotany: Use of plants by the tribal societies in north-eastern India and Uttarakhand for subsistence, medicine and cultural purposes.

Unit II Algal lipids, biodiesel and biofuel production; biohydrogen and bioethanol production; genetic engineering in algae, mutagenesis for strain improvement, engineering efforts for advancement in culturing techniques; integrated multi-trophic aquaculture.

Unit III Plant resource utilization-Centres of primary diversity and secondary centres of cultivated plants; crop domestication genes; introduction to current research paradigms in major cereals, oilseeds, legumes, medicinal plants, forest trees, non-alcoholic beverages; in vitro extraction isolation of bioactive compounds from plants used as drugs in pharma industries such as antimalarials e.g. artemisinin, anticancerous, taxol, psoralen, spilanthol, connessine, antidabeticssteviosides, rebaudiosides etc.

Unit IV Interactions between farming systems and biodiversity-biodiversity in farming systems, landscape fragmentation, relationships and interdependencies of biodiversity within farming systems with outside farming systems. Case studies of farming systems of India.

Unit V Basics of Artificial Intelligence & Machine Learning
Bioinformatics and AI in Plant Research, Bridging Traditional Knowledge with AI

Suggested Readings:

1. Jain, S.K. (1981). Glimpses of Indian ethnobotany. Oxford.
2. Frankel, O.H., Anthony, H.D. and Burdo, J.J. (1995). Conservation of Plant Biodiversity. Cambridge University Press, Cambridge. pp 299.
3. Reaka-Kulda, L.M., Wilson, D.E. and Wilson, E.O. (1997). Biodiversity II. Understanding and protecting our biological resources. Joseph Henry Press, Washington.
4. Barthlott, W. and Winiger, W. (2001). Biodiversity. Springer-Verlag, New York.
5. Brookfield, H., Padoch, C., Parsons, H., and Stocking, M. (2002). Cultivating biodiversity: understanding, analysing and using agricultural diversity. ITDG Publishing.
6. Andersen, R. A. (Ed.). (2005). Algal culturing techniques. Elsevier.
7. Rai, M., and Carpinella, M. C. (2006). Naturally occurring bioactive compounds. Elsevier.
8. Richmond, A. (Ed.). (2008). Handbook of microalgal culture: biotechnology and applied phycology. John Wiley & Sons.

M.Sc. in Applied Artificial Intelligence in Plant Science

Second Semester

Sub Code	*Name of subject*	*L*	*T*	*P*	*Max Marks (T)*	*Max Marks (P)*	*Total Credit*
MSBTMJ-201	Angiospermic Taxonomy and Biosystematics	6	-	1	100 (75+25)	50 (35+15)	4

Course Objectives:

1. To develop an understanding of advanced concepts and principles of plant taxonomy.
2. To study the evolutionary significance of important morphological characters in flowering plants.
3. To provide knowledge of the classification and distinguishing features of major angiosperm families.
4. To understand the role of taxonomic characters in identification and classification of plants.
5. To familiarize students with the application of standard DNA barcode markers in species identification and delineation.

Course Outcomes:

1. Theories of evolution of angiosperms.
2. Systems of classification of plants.
3. Plant bar coding and the role of standard barcode markers used in delineating species.

Unit I

Taxonomic hierarchy; species concept and speciation; theories pertaining to the evolution of angiosperms; important Indian and world herbaria; taxonomic literature (floras, taxonomic accounts, revisionary studies); computer-aided taxonomic studies.

Unit II

Systems of classification: artificial, natural and phylogenetic systems (Linnaeus, Bentham and Hooker, Engler and Prantl, Takhtajan, APG), merits and demerits of major systems of classification; biosystematics; direct and indirect methods of plant identification; practice of taxonomic key; study of selected families (Solanaceae, Brassicaceae, Cucurbitaceae, Poaceae, Liliaceae, Chenopodiaceae, Apiaceae, Orchidaceae, Fabaceae, Malvaceae, Rosaceae, Asteraceae, Euphorbiaceae, Rutaceae, Myrtaceae, Anacardiaceae, Musaceae, Zingiberaceae), International Code of Botanical Nomenclature (ICN); principles of the code; ranks of taxa. Interactive keys and DELTA, MESQUITE.

Unit III

Plant Molecular Systematics: DNA sequence data, Types of sequence data, Sequence alignment, Phylogenetic analysis (parsimony, Maximum Likelihood, Bayesian approaches, Neighbor-Joining), DNA barcoding and its practical implications, AI-assisted classification, digital herbaria)

Practicals MSBTMJ-201-P **1 Credit**

1. Use of floras and manuals for identification of locally available monocot and dicot taxa up to species level.
2. Field and herbarium methods and preparation of herbarium specimens/museum specimens. (Students are required to submit at least twenty herbarium/museum specimens).
3. Familiarity with taxonomic softwares.

Suggested Readings:

1. Hutchinson, J. (1967). Key to the families of the flowering plants of the World. E. Arnold.
2. Cronquist (1968). The Evolution and Classification of Flowering Plants.
3. Heywood, V. H. (1968). Modern methods in plant taxonomy. Acad. Press.
4. Takhtajan, A. (1969). Flowering Plants Origin and Dispersal. Oliver & Boyd.
5. Jain, S.K. and Rao, R.R. (1977). A handbook of field and herbarium methods. Today & Tomorrow.
6. Sivarajan, V. V. (1990). Introduction to Principles of Plant Taxonomy. Oxford & IBH
7. Taylor, D. W. and Hickey, L. (1996). Flowering Plant Origin, Evolution and Phylogeny. Chapman & Hall. Angiosperm Phylogeny Group (2016). An update of the Angiosperm Phylogeny Group Classification for the orders and families of flowering plants: APG IV. Botanical Journal of the Linnaean Society 181: 1-20.
8. Crawford, D. J. (2003). Plant Molecular Systematics. Cambridge University Press, Cambridge,UK.
9. Stuessy, T. F. (2009). Plant Taxonomy: The systematic Evaluation of Comparative Data. Columbia University Press, New York.

Sub Code	*Name of subject*	*L*	*T*	*P*	*Max Marks (T)*	*Max Marks (P)*	*Total Credit*
MSBTMJ-202	Plant Physiology	6	-	1	100 (75+25)	50 (35+15)	4

Course Objectives:

1. To develop an understanding of water relations, mineral nutrition, and nutrient uptake mechanisms in plants.
2. To provide knowledge of plant bioenergetics, including photosynthesis, respiration, and energy transformation in biological systems.
3. To study the mechanisms of carbon fixation, nitrogen metabolism, and oxidative phosphorylation in plants.
4. To understand the role and mechanism of action of plant growth regulators in growth and development.
5. To familiarize students with the physiological and biochemical basis of dormancy, flowering, photoperiodism, vernalization, and assimilate partitioning in plants.

Course Outcomes:

1. Water relations in plants - its movement and uptake of nutrientsby the plants.
2. The important physiological processes which lead to the growthand development of plants.
3. The importance of plant growth regulators and their mechanismof action.
4. The understanding of perception mechanism of different signals would be imparted to students.

Unit I Water relations in plants: Chemical potential of water, water potential in plants, soil-plant-atmosphere continuum; movement of water in plants.
Essential nutrients; chelates; heavy-metal stress and homeostasis; molecular mechanism of mineral nutrition in plants.

Unit II Bioenergetics: laws of thermodynamics and their significance in free energy changes in biological systems; organization of the light absorbing pigment systems; mechanisms of photoexcitation of chlorophyll and electron transport chain; carbon fixations in photosyntheis; regulation of CO_2 fixation activity in plant cells; glycolysis and its regulation; fatty acid oxidation, mechanisms of oxidative decarboxylation of pyruvic acid; mitochondrial electron transport and oxidative
phosphorylation; biological nitrogen fixation and assimilation of ammonia.

Unit III Plant growth regulators: auxins, gibberellins, cytokinins, abscisic acid, ethylene- physiological effects and mechanism of action; brassinosteroids- types, physiological effects and mechanism of action.
Dormancy: types and mechanism of regulation; physiology of flowering: photoperiodism and vernalization; biochemical mechanisms involved in flowering; partitioning of assimilates during different phases of plant growth.

Practical MSBTMJ-202-P **1 Credit**

1. Study of the effect of organic compounds on membrane permeability.
2. Determination of water potential in plant tissues.
3. Isolation of plant pigments and determination of their absorption spectra.
4. Estimation of chlorophyll a, b and total chlorophyll content of plant tissues.
5. Measurement of Hill reaction activity by Winkler's method: effect of light wavelength and light intensity.
6. Assay of amylase induction by GA in plant tissues.
7. Assay of effect of cytokinin on chlorophyll degradation by leaf disc method.

Suggested Readings:

1. Salisbury, F.B and Ross, C. W. (1969). Plant Physiology. Wadsworth Publishing Company.
2. Noggle, G.R. and Fritz, C.J (1989). Introductory Plant Physiology. Prentice Hall.
3. Bernle, J.D. and Black, M. (1992). Seed Physiology and Biochemistry. Springer-Verlag.
4. Seigler, D.S. (1994). Plant Secondary Metabolism. Narosa.
5. Srivastava, H.S. (1994). Plant Physiology. Rastogi and Co.
6. Mattoo, A.K. and Shuttle, J.C. (1995). The Plant hormone Ethylene. CRC. Press.
7. Mukherji, S. and Ghosh, A.K. (1996). Plant Physiology. Tata- McGraw Hill.
8. Aducci, P. (1997). Signal Transduction in Plants. BirkhauserVerlag.
9. Dennis, D. (1997). Plant Metabolism. John Wiley.
10. Thomas, B. and Vince-Prue, D. (1997). Photoperiodism in plants. Academic Press.
11. Lender, D.W. (2001). Photosynthesis. Mercel Deker.

Sub Code	*Name of subject*	*L*	*T*	*P*	*Max Marks (T)*	*Max Marks (P)*	*Total Credit*
MSBTMJ-203	Cell Biology and Biochemistry	6	-	1	100 (75+25)	50 (35+15)	4

Course Objectives:

1. To develop a foundational understanding of plant cellular organization and cellular entities.
2. To study the structure and functions of plant cells and their organelles.
3. To understand the relationship between cellular structure and physiological functions in plants.
4. To provide knowledge of cellular processes and mechanisms operating within plant cells.
5. To familiarize students with the regulatory mechanisms controlling cellular activities and functions.

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Course Outcomes:

1. The components of endo-membrane systems and mechanisms governing intracellular trafficking in plant cells.
2. The role of plant cytoskeleton and accessory proteins in major cellular processes of plants.
3. Detailed knowledge of the enzymes and the application of immobilized enzyme technology.

Unit I Plasma membrane: structure and functions; Membrane transport: ion channels and pumps; Mitochondria: structure, and organization of respiratory chain complexes; Chloroplast: organization of photosynthetic complexes; Cell cycle: phases and their regulation.

Unit II Carbohydrates and their derivatives: synthesis and inter-conversions; lipids: biosynthesis of fatty acids and their regulation; phospholipids and their role in signal transduction in cells; amino acids: structure and function, properties of amino acids; proteins: structure and function, folding and sub-unit assembly, post translational processing.

Unit III Enzymes: structure of active site, mechanisms of action, kinetics of enzymes catalysed reactions, regulation of enzyme activity; industrial enzymology: principles of immobilized enzyme technology; applications of immobilized enzymes.

Practical MSBTMJ-203-P **1 Credit**

1. Estimation of starch from plant tissues by iodine reaction.
2. Estimation of sugars from plant tissues by dinitrosalycilic acid.
3. Estimation of amino acids from plant tissues by ninhydrin reaction.
4. Estimation of soluble protein content from plant tissues by Lowry's method.
5. Separation of soluble proteins by (a) gel filteration (b) gel electrophreis.
6. Assay of phosphatase activity in plant cells.

Suggested Readings:

1. Stryer, L. (1993). Biochemistry. W.H. Freeman.
2. Plumer, D. T. (1993). An Introduction to Practicals in Biochemistry. Tata McGraw Hill.
3. Conn, E.E. and Stumpf, P.K. (1994). Outlines of Biochemistry. Wiley Eastern.
4. Dey, P.M. and Harborne, J.B. (1997). Plant Biochemistry. Acad. Press.
5. Boyer, R. (1999). Concept in Biochemistry. Brooks/Cole Publ.
6. Lea, P.J. and Leagood, R.C. (1999). Plant Biochemistry and Molecular Biology. Wiley.
7. Boyer, R.F. (2012). Biochemistry Laboratory: Modern Theory and Techniques, Pearson Prentice Hall, New Jersey

Sub Code	*Name of subject*	*L*	*T*	*P*	*Max Marks (T)*	*Max Marks (P)*	*Total Credit*
MSBTMJ-204	Bioprocess Development	6	-	1	100 (75+25)	50 (35+15)	4

Course Objectives:

1. To develop a comprehensive understanding of the applications of living organisms for human welfare and environmental sustainability.
2. To provide knowledge of biological principles and techniques used in applied life sciences.
3. To enhance practical and analytical skills required for the utilization of biological resources.
4. To familiarize students with the role of microorganisms, plants, and other living organisms in sustainable development.
5. To promote the application of biological knowledge for improving human life and conserving nature.

Course Outcomes:

1. The various processes that use complete living cells or their components (e.g., bacteria, enzymes, chloroplasts) to obtain desired products.
2. The entire process from early cell isolation and cultivation, to product development; purification of product for desiredquality.
3. Finally, the harvest of the desired density (for batch and fed-batch cultures).

Unit I Raw materials for bioprocessing, identification of raw drug, comparison of chemical and biochemical processing based on energetics and environmental issues. Development of inocula, kinetics of enzymatic and microbial processes, optimisation studies, sterilization of media, air and equipment, modes of cell cultivation.
Principle of bioreactor design and their operation, types of bioreactors; microbial fermentation.

Unit II Media formulation, sterilization of equipments, gas compressor types and principles of compression, air filtration, solid and liquid handling. Industrially fermented broth (filtration and ultrafiltration), centrifugation, solvent extraction, chromatographic separation, liquid extraction of biopolymers and antibiotics ion exchange recovery of antibiotics and proteins.

Unit III Microbial biomass, single cell proteins and its nutritional values, baker's yeast, brewer's yeast, food and fodder yeast. SCP production technology bacterial protein ICI process yeast protein actinomyceatous protein, mycoproteins, algal proteins (Spirulina cultivations).
Bioconversion of waste products by microbes with special reference to biogas and organic compost; steroid bio- transformations.

Practicals MSBTMJ-204-P **1 Credit**

1. Isolation, identification, preparation and maintenance of pure cultures.
2. To study the growth patterns and specific growth rate of bacteria.
3. To study the effect of peptone concentration on bacterial growth
4. To study the effects of temperature on fungal and bacterial growth.
5. To study the carbohydrate fermentation tests.
6. To study about the bioreactor design.

Suggested Readings

1. Stanbury, P. F., Whitaker, A. and Hall, S. J. (1997). Principles of Fermentation Technology, Pergamon Press, Oxford.
2. Alexander, N.G. and Hiroshi, N. (1998). Microbial Biotechnology. W.H.Freeman& Co., USA.
3. Edward, A.B. (1992). Modern Microbiology – principles and application, WMC Brown Publishers, USA.
4. Flickinger, M.C. and Drew, S.W. (1999). Encyclopedia of bioprocess technology. Vol 1-5. John Wiley & Sons, Inc.
5. Crueger, W. and Crueger, A. (2000). Biotechnology: A textbook of industrial microbiology. Panima Publishing Corporation, India.
6. Mansi, E.M.T.E.L. and Bryle, C.F.A. (2002). Fermentation Microbiology and Biotechnology Taylor & Francis Ltd, UK.

Sub Code	*Name of subject*	*L*	*T*	*P*	*Max Marks (T)*	*Max Marks (P)*	*Total Credit*
MSBTMJ-205	Methods in Plant Sciences	6	-	1	100 (75+25)	50 (35+15)	4

Course Objectives:

1. To develop an understanding of various techniques used in plant sciences.
2. To provide knowledge of laboratory and analytical methods applied in plant research.
3. To familiarize students with modern tools and instrumentation used in plant science studies.
4. To enhance practical skills in experimental design, data collection, and analysis.
5. To prepare students for research and applications in different areas of plant sciences.

.**Course Outcomes**:

1. Various techniques in microbiology
2. Plant tissue culture techniques for *in vitro* culture.
3. Techniques in molecular biology.
4. Statistical methods to be used for data analysis.

Unit I Techniques in Microbiology: Culture techniques of fungi and bacteria, microbe handling, preparation and maintenance of cultures; different Types of culture media; study the microbiological quality of water samples; isolation and identification of mycorrhizal associations; biofertilizers production, microbial fermentation; mushroom cultivation; molecular techniques to assess microbial community structure, function, and dynamics in the environment; culturable and unculturable bacterial analysis.

Unit II Plant Tissue Culture: Introduction to plant tissue culture, methods of sterilization; various media preparations; MS, B_5, etc.; explants selection; sterilization and inoculation; callus and cell suspension culture; micropropagation through various explants (induction of callus and somatic embryogenesis); preparation of artificial seeds; isolation of protoplasts.
Techniques in Molecular Biology: Microscopy: fluorescence, confocal, and atomic-force microscopy (AFM/SFM); spectrophotometry; Chromatography: gel filtration, adsorption, ion exchange and affinity; electrophoresis; blotting: southern, western, northern, south-western, nucleotide sequencing and analysis.

Unit III Biostatistics: Measures of variation - Standard deviation, coefficient of variation, standard error; sampling distribution; probability distributions (normal, binomial, poisson and normal); difference between non-parametric and parametric statistics; chi-square test; tests of significance: Students' 't' test, 'z' test, analysis of variance and 'F' test: one-way ANOVA; correlation and regression; introduction to statistical software.

Practical MSBTMJ-205-P **1 Credit**

1. Isolation, identification and enumeration of bacteria and fungi.
2. Preparation and maintenance of pure cultures.
3. Study of different mycorrhizal associations.
4. Induction of callus and somatic embryogenesis
5. Micro propagation of plants using different explants.
6. Isolation of protoplasts
7. Observation of specimens using fluorescence microscopy.
8. Demonstration of confocal microscopy images.
9. Estimation of DNA/RNA concentration using spectrophotometry.
10. Separation of proteins by SDS-PAGE electrophoresis.
11. Agarose gel electrophoresis of DNA samples.
12. Gel filtration chromatography for protein separation.
13. Ion exchange chromatography demonstration.

Suggested Readings

1. Alberts, B., Dennis, B., Lewis, J., Martin, R., Roberts, K., Watson, J. D. (2002). Molecular Biology of the Cell. Gerland.
2. Brown, C.M., Campbell, I. and Priest, F.G. (1990). Introduction to Biotechnology. Blackwell Scientific Publications, Oxford, London.
3. Chawla, H. S. (2000). Introduction to Plant Biotechnology. Oxford & IBH Publishing Co. Pvt. Ltd.New Delhi.
4. Dixon, R.A. and Gonzales, R. A. (Eds.) 1994. Plant Cell Culture - A Practical Approach. Oxford University Press, New York.
5. Dubey, R.C. (2015). A Textbook of Biotechnology. 5th Edition. S. Chand Publishing.
6. Gamborg, O.L and Phillips, G.C (1998). Plant Cell, Tissue Organ Culture. 1998. Narosa PublishingHouse, New Delhi.
7. Hoshmand, A.R. (1998). Statistical methods for environmental and agricultural sciences. CRCpress, New York.
8. Lodish, H. et al. (1996). Molecular cell biology. Sc. American Books.

Sub Code	*Name of subject*	*L*	*T*	*P*	*Max Marks (T)*	*Max Marks (P)*	*Total Credit*
MSBTMJ-206	Research Methodologies and Proposal Writing in Plant Sciences	6	-	-	100 (75+25)	00	4

Course Objectives

1. To develop an understanding of the fundamentals and principles of research methodology.
2. To familiarize students with various research processes, methods, and experimental designs.
3. To provide knowledge of data collection, analysis, interpretation, and presentation techniques.
4. To enhance critical thinking and problem-solving skills required for scientific research.
5. To prepare students for conducting independent and ethical research in their respective fields.

Course Outcomes:

1. Collection and analyzing of the data.
2. Survey of literature for the identified problem.
3. Scientific research process and the various steps involved.
4. Research proposals, publications and ethics
5. Presentation of the results and writing of manuscripts.

Unit I Basic concepts of research: Research-definition and types of research (Descriptive *vs.* analytical; applied *vs.* fundamental; quantitative *vs.* qualitative; conceptual *vs.* empirical); Research methods *vs.* methodology; literature-reviewand its consolidation; library research; field research; laboratory research.

Unit II General laboratory practices; common calculations in botany laboratories; understanding the details on the label of reagent bottles; molarity and normality of common acids and bases; preparation of solutions; dilutions; percentage solutions; molar, molal and normal solutions; technique of handling micropipettes; common toxic laboratory chemicals and their safety measures.

Unit III Data collection and documentation of observations; maintaining a laboratory record; tabulation and generation of graphs; imaging of tissue specimens and application of scale bars; art of field photography; key biology research areas (A brief overview): Genetics, physiology, biochemistry, molecular biology, cell biology, genomics, proteomics – transcriptional regulatory network, Programming for Biologists (Python/R)

Unit IV Methodology and scientific writing: Numbers, units, abbreviations and nomenclature used in scientific writing; writing references; power point presentation; poster presentation; scientific writing and ethics; introduction to bioethics, copyright- academic misconduct and plagiarism.

Suggested Readings

1. Ruzin, S.E. (1999). Plant Microtechnique and Microscopy. Oxford University Press, New York, U.S.A.
2. Stapleton, P., Yondeowei, A., Mukanyange, J. and Houten, H. (1995). Scientific Writing for Agricultural Research Scientists – a Training Reference Manual. West Africa Rice Development Association, Hong Kong.
3. Dawson, C. (2002). Practical Research Methods. UBS Publishers, New Delhi.
4. Goodfellow, I., Bengio, Y., & Courville, A. (2016). *Deep Learning*. MIT Press.

M.Sc. in Applied Artificial Intelligence in Plant Science

Third Semester

Sub Code	*Name of subject*	*L*	*T*	*P*	*Max Marks (T)*	*Max Marks (P)*	*Total Credit*
MSBTMJ-301	Crop Modeling & Nutraceutical Validation	6	-	1	100 (75+25)	50 (35+15)	4

Course Objectives:

1. To develop an understanding of the fundamental concepts of classical and molecular genetics.
2. To enhance analytical, quantitative, and problem-solving skills in genetic studies.
3. To provide knowledge of chromosomal structure, numerical aberrations, linkage, and chromosome mapping.
4. To understand chromosome behavior and its applications in crop improvement and plant breeding.
5. To familiarize students with the principles, objectives, and methods of plant breeding.

Course Outcomes:

1. The students will learn about the eukaryotic gene and chromosome organization, mapping of eukaryotic chromosomes through linkages and recombinants both theoretically and practically by solving various related numerical problems.
2. They will learn about the fundamentals of mutation, origin and breeding behaviour at different ploidy levels, various techniques used in crop improvement
3. Students will acquaint with the fundamentals of population genetics learning phenotypic and genetic variations, understanding the mechanism of speciation through Hardy Weinberg and gene flow mechanism
4. Understand the exploitation of heterosis, male sterility for crop improvement as well as control of plant development through epigenetics

Unit I Modern gene concept: eukaryotic gene organization; organization of eukaryotic chromosomes; mutations (induced and spontaneous); physical and chemical mutagens and their mode of action; molecular mechanism of mutation and recombination; Chromosomal aberrations in plants: origin, meiotic and breeding behaviors of structural aberrations; breeding behavior of interchange heterozygotes and permanent hybrids; interchange tester sets; euploidy and aneuploidy; alien chromosome additions and substitutions; Giemsa banding of chromosomes.

Unit II Crop Genetics: introduction to crop genetics; Domestication: domestication syndrome, molecular basis of domestication, archaeological and molecular evidences of domestication (e.g. wheat, maize, cotton, tobacco, coffee, brassica spp.).

Genetic Maps and comparative genomics: Construction of linkage maps; high density maps; QTL maps; integration of genetic and physical maps; association mapping, molecular markers; High Throughput markers: SNP methods: NGS, GBS; Comparative Genomics: Gene families and their evolution.

Unit III Phenotypic variance and its components; heritability of traits and its estimation; gene frequency in a population, genetic equilibrium and Hardy-Weinberg law, barriers to gene flow and mechanism of speciation; heterosis, male sterility and its application in hybrid seed production; fluorescence *in situ* hybridization (FISH) vs. genomic *in situ* hybridization (GISH); Breeding Methods: Recombinant Inbred lines (RILS), Near Isogenic Lines (NILS), Multi Parent Populations (MPP); Epigenetics: Genomic imprinting, epigenetic control of plant development, transposable elements, RdDM, role of sRNA.

Practicals MSBTMJ-301-P **1 Credit**

1. Preparation of materials and study of somatic chromosomes of some common plants.
2. Karyotype preparation of somatic cells.
3. Collection of flower buds and study of meiosis and aberrant meiosis of some common plants (e.g., *Tradescantia*, *Datura*, *Phlox*, etc.).
4. Numerical exercises on linkages, crossing over and χ 2 for independence of attributes and goodness of fit.

Suggested Readings:

1. Acquaah, G. (2020). Principles of Plant Genetics and Breeding (3rd edition), WILEY Blackwell, UK
2. Allard, R. W. (1999). Principles of Plant Breeding. John Wiley and Sons.
3. Brown, T.A. (1989). Genetics- a Molecular Approach. Chapman & Hall.
4. Fukui, K. and Nakayam, S. (1996). Plant Chromosomes: Laboratory Methods. CRC Press.
5. Gardner, E. J., Simmons, M. J., Snustad, D. P. (2015). Principles of Genetics. 7th Edition. John Wiley & Sons.
6. Gupta, P.K. (1998). Genetics and Biotechnology in Crop Improvement. Rastogi & Co.
7. Hartl, D., Jones, E.W. and Lozovsky, E.R. (2006). Essential Genetics, 4th Edition, Jones and Bartlett, London.
8. Hartwell, L. H., Hood L., Goldberg, M. L., Reynolds, A. E., Silver, L. M., Veres, R. C. (2006). Genetics- From Genes to Genomes. McGraw Hill.
9. Misra, A.K. (2011). Fundamentals of Cell and Molecular Genetics. Panima Publ., New Delhi.
10. Sharma, A.K. and Sharma, A. (1999). Plant Chromosomes: Analysis, Manipulation and Engineering.Harwood Academic Publishers.

Sub Code	*Name of subject*	*L*	*T*	*P*	*Max Marks (T)*	*Max Marks (P)*	*Total Credit*
MSBTMJ-302	Plant Ecology and Ecosystem Analysis	6	-	1	100 (75+25)	50 (35+15)	4

Course Objectives:

1. To develop an understanding of the fundamental principles and concepts of ecology.
2. To study the structure and functioning of ecosystems and their components.
3. To understand ecological interactions and environmental processes affecting living organisms.
4. To provide knowledge about conservation and sustainable management of ecosystems.
5. To apply ecological principles in environmental management and biodiversity conservation.

Course Outcomes:

1. Develop an understanding of the principles of population, community, ecosystem and landscape ecology.
2. Develop an understanding of how the ecological principles can be applied to the management of ecosystem.

Unit I Population ecology: characteristics of a population; population growth curves and models; survivorship curves, life-table analysis and age structured populations; life history strategies (r and K selection); concept of metapopulation; demes and dispersal; interdemic extinctions; types of population interactions; inter- and intra-specific competition; population regulation; symbiosis, allelopathy, red data book (IUCN)

Unit II Community ecology: concept of community; Raunkiaer's Life-forms and biological spectrum; Edge effect and ecotones; Ecological niche: concept of habitat and niche, Grillenian niche, Eltonian niche, niche breadth and overlap, fundamental and realized niche, resource partitioning; Analysis of community structure: qualitative and quantitative attributes, quantitative methods of studying plant communities: importance value index; Species diversity and indices; AI in ecosystem modeling, biodiversity monitoring, Remote Sensing & GIS for Plant Studies

Unit III Ecosystem ecology: Ecosystem concept: ecosystem structure, function and services; Ecoenergetics: flow of energy, primary productivity and its measurement; primary productivity of terrestrial and aquatic ecosystems of the world; Biogeochemical cycles: carbon, nitrogen, phosphorus, and sulphur cycles; Ecosystem development: Clements' view and Gleason's view of ecological succession, models of succession; Ecosystem stability: resistance and resilience; Concept of landscape; Plant invasion hypotheses; Strategies for ecorestoration.

Practicals MSBTMJ-302-P **1 Credit**

1. Study of interactions between plants and environment
    a) Study of microclimatic conditions in open and closed communities
    b) Study of plastic response of plant species under contrasting environmental conditions
2. Study of physico-chemical properties of soil: (a) texture, (b) porosity, (c) water holding capacity and (d) TKN
3. Study of analytical characters of plant community using plot methods
4. Determination of frequency, density, relative frequency and relative density of component species of a forest vegetation.
5. To estimate population by point-centered quarter method (PCQM)
6. Study of cohort survivorship in plant populations and life-table analysis
7. Estimation of phytomass and its distribution in different compartments in grassland communities
8. Determination of leaf-area index in the grassland community
9. Estimation of primary productivity of a terrestrial ecosystem following harvest method
10. Estimation of primary productivity of an aquatic ecosystem using light and dark bottle method.

Suggested readings

1. Andel, J.V. and Aronson, J. (2012). Restoration Ecology. Wiley-Blackwell.
2. Ambasht, R.S. and Ambasht, N.K. (2022). A Textbook of Plant Ecology. 16th Edition. CBS Publishers and Distributors, New Delhi.
3. Anderson, J.M. and Ingram, J.S.I. (1993). Tropical Soil Biology and Fertility: A Handbook of Methods. CAB International.
4. Begon, M., Townsend, C.R. and Harper, J.L. (2006). Ecology: From individuals to ecosystems. Blackwell Sciences Ltd., U.K.
5. Boucher, J. (2019). The Ecology of Plants. Callisto Reference.
6. Cain, M.L., Bowman, W. D. and Hacker, S.D. (2014). Ecology. Third Edition. Companion Website.
7. Elton, C.S. (1977). The Ecology of Invasions by Animals and Plants. Springer.
8. Ismay, M. (2016). Plant Ecology: Principles and Practices. Callisto.
9. Johnson, E.A. and Miyanishi, K. (2007). Plant Disturbance Ecology: the process and the response.
10. Jong, T. and Klinkhamer, P. (2005). Evolutionary Ecology of Plant Reproductive Strategies. Cambridge University Press.

Sub Code	*Name of subject*	*L*	*T*	*P*	*Max Marks (T)*	*Max Marks (P)*	*Total Credit*
MSBTMJ-303	Plant Biotechnology	6	-	1	100 (75+25)	50 (35+15)	4

Course Objectives:

1. To develop a comprehensive understanding of classical and modern biotechnology processes.
2. To provide knowledge of fundamental principles and applications of biotechnology in plant sciences.
3. To train students in plant tissue culture techniques and their applications.
4. To familiarize students with methods of plant transformation and genetic manipulation.
5. To enhance practical and analytical skills in biotechnology for research and agricultural applications.

Course Outcomes:

1. Distinguish plant culture techniques and culture types.
2. Role of tissue culture in plant biotechnology.
3. Evaluate several methods for improvement of crop plants using plant transformation.

Unit I Tissue culture: role of *in vitro* tissue culture in plant biotechnology, anther culture, ovary culture, somatic hybridization and production of cybrids, embryo culture and rescue, clonal propagation, cryopreservation and germplasm storage, somatic embryogenesis, artificial seeds, somaclonal variations and gametoclonal variation; virus free plants; secondary metabolite production from cell cultures.

Unit II DNA modifying enzymes; Cloning vectors – Plasmids, Bacteriophage - Lambda and M13 vectors, Transgenesis: methods and applications; Direct gene transfer, Agrobacterium– mediated, electroporation, particle bombardment; screenable and selectable markers; adapters & linkers. useful gene transfers; genetic engineering of plants for insect control, herbicide resistance, resistance against viruses, quality improvement, and increased shelf-life; safety regulations for transgenic plants.

Unit III PCR-basic process, types and applications. DNA sequencing - Principle of chemical and enzymatic methods; automated DNA sequencing and high throughput sequencing; site-directed mutagenesis and protein engineering; DNA foot printing, chromosome walking.

Practical MSBTMJ-303-P **1 Credit**

Unit IV

1. Clonal propagation of forest plants.
2. Embryo culture and rescue
3. Preparation of artificial seeds for germplasm storage
4. PCR amplication of genomic DNA from plants
5. Agro-bacterium-mediated genetic transformation of plants through co-culture.

Suggested Readings:

1. Bhojwani, S.S. and Razdan, M.K. (2004). Plant Tissue Culture: Theory and Practice, Revised Edition - (Studies in Plant Science), Elsevier Publications, Netherlands.
2. Brown, T. A. (2006). Gene Cloning and DNA Analysis-An Introduction. Blackwell University Press.
3. Chawla, H.S. (2020). Introduction to Plant Biotechnology, 3rd Edition (Pb 2020), Oxford & IBH Publishing.
4. Desmond, S.T. N. (2004). An Introduction to Genetic Engineering. Cambridge.
5. Dixon, R.A. (1995). Plant Cell Culture-A Practical Approach. IRL Press, Oxford.
6. Gamborg, O.L. and Phillips, C. (1998). Plant Cell Tissue and Organ Culture: Fundamental Methods. Narosa Publishing House, New Delhi.

Sub Code	*Name of subject*	*L*	*T*	*P*	*Max Marks (T)*	*Max Marks (P)*	*Total Credit*
MSBTMJ-304	AI-driven solutions for biodiversity monitoring	6	-	-	100 (75+25)	00	4

Course Objectives:

1. To develop an understanding of the concepts and significance of biodiversity.
2. To study the principles and current practices of biodiversity conservation.
3. To provide knowledge of threats to biodiversity and strategies for its sustainable management.
4. To understand the concept and applications of bioprospection in biological resource utilization.
5. To familiarize students with the role of biodiversity conservation in environmental sustainability and human welfare.

Course Outcomes:

1. Understand the basic concepts of bioprospecting
2. Understand the methods of bioprospection for plants and microbes
3. Understand the basics of product development from plant and microbial bioprospection

Unit I Biodiversity: concept of biodiversity and its levels, global biodiversity, biodiversity hot spots, biodiversity of India and its *ex situ* and *in situ* conservation measures, threat to biodiversity and conservation of threatened plants; endemism; convention on biological diversity, India biodiversity act and rules; island biogeography, phytogeographic regions of India, and forest types of India, AI-driven solutions for biodiversity monitoring.

Unit II: Bioprospection: current practices in bioprospectionon for biomolecules, genes and species; methods and instruments for isolation, identification and characterization of biomolecules: chromatographic techniques- TLC, HPLC, UPLC, HPTLC, LC-MS, GC-MS; spectroscopy-UV spectroscopy, FTIR, NMR, HRMS.

Unit III Plant bioprospectionon for drugs: preparation of extracts and standardized extracts; bioactive-guided fractionation, bio-efficacy and product development: isolation, identification and characterization of bioactive compounds, *in vitro* assays, antioxidant assay, free radical scavenging assay, cell-line assays, *in vivo* models; safety and toxicity assays; pharmacokinetics; clinical trials; regulatory framework for drug discovery.

Unit IV Microbial bioprospection for agriculture and environment: isolation, identification and characterization of microbes and microbial metabolites for agriculture and environmental uses; steps involved in product development using regulatory guidelines - biofertilizer and municipal waste degradation.

Suggested Readings:

1. Arora, R.K. and Nayar, E.R. (1984). Wild relatives of crop plants in India, NBPGR Science Monograph No.7.
2. Baker, H.G. (1978). Plants and civilization. Ill Ed. (A. Wadsworth, Belmount).
3. Barnes, R.S.K. (1998). Diversity of Living Organisms. Blackwell Sciences Ltd., U.K.
4. Bole, P.V. and Vaghani, Y. (T986). Field guide to common Indian trees, Oxford University Press, Mumbai.
5. Champion, H. G. and Seth, S. K. (1968). A Revised Survey of Forest Types of India, Govt. of India Press, New Delhi, p. 404
6. CSIR (1986). The useful plants of India. Publication and Information directorate, CSIR, New Delhi.
7. CSIR (1948 - 1976) The wealth of India, Publication and Information directorate, CSIR, New Delhi.
8. Dwivedi, A.P. (1993). Forestry in India.Surya Publications.
9. Eldredge, N. (1992). Systematics, Ecology and Biodiversity Crisis. Cambridge University Press, New York.
10. Kocchar, S.L. (1998). Economic Botany of the tropics, II Edn. MacMillan India Ltd.,

Sub Code	*Name of subject*	*L*	*T*	*P*	*Max Marks (T)*	*Max Marks (P)*	*Total Credit*
MSBTMJ-305	Climate Change and Plant Adaptations	6	-	-	100 (75+25)	00	4

Course Objectives:

1. To familiarize students with causes and consequences of climate change, and future scenarios of climate change.
2. To acquaint the students with various adaptation and mitigation measures against climate change
3. To understand plant adaptations against climate change.

Course Outcomes:

1. Students would be able to understand the causes, trends, and consequences of climate change.
2. Develop an understanding of mitigation and adaptation strategies available to tackle adverse effects of climate change.
3. Understand plant adaptation strategies to climate change

Unit I Introduction to Environmental Pollution - Causes of Climate change: changing composition of the atmosphere due to various anthropogenic activities, greenhouse gases; trend: climate variability in the last millennium and the recent climate records, future emissions and future climate scenarios, climate models.

Unit II Assessing impacts and vulnerabilities: climate change consequences-impacts on forestry, agriculture, human health, biodiversity, soil and land, water resources; methods of vulnerability assessment; indicators of vulnerability and livelihood; climate sensitivity analysis; climate change mitigation and adaptation measures.

Unit III Plant adaptation to climate change related drought: eco-physiological mechanisms of drought tolerance in plants, molecular mechanisms of drought tolerance, screening microbes and plants/crop varieties for drought tolerance, approaches for developing drought tolerant plants/crops.

Unit IV Plant adaptation to climate change related enhanced temperature: eco-physiological mechanisms of temperature tolerance in plants, molecular mechanisms of temperature tolerance, screening microbes (metagenomics) including endophytes and plants/crop varieties for temperature tolerance (FACE), approaches for developing high temperature tolerant plants/crops.

Suggested Readings:

1. Bazzaz, F.A. (1996). Plants in changing environments. Cambridge University Press.
2. Daubenmire, R.F. (1959). Plant and Environment. 2nd Edition. John Wiley & Sons Inc.
3. Gribbin, J. 1979. Climate Change. Cambridge University Press. New York, 280p
4. Gunderson, LH, Allen CR and Holling (2012). Foundations of Ecological Resilience, Island Press.
5. John Houghton, 2009. (4th edition) Global Warming - A complete briefing. Cambridge University Press.
6. Lambers, H. and Oliveira, R.S. (2021). Plant Physiological Ecology. Springer.
7. Larcher, W. (2009). Physiological Plant Ecology: Ecophysiology and Stress Physiology of Functional Groups With contributions by numerous experts. Springer.
8. Lovejoy, Thomas E. and Hannah, Lee Jay (2006). Climate Change and Biodiversity. Yale University Press.
9. Malhotra, K.C., Barik, S. K. and Tiwari, B. K. (2009). People's perception on climate change. Astral Publications, New Delhi.
10. National Research Council (1999). Global Environmental Change: Research Pathways for the Next Decade. The National Academies Press, USA.

Sub Code	*Name of subject*	*L*	*T*	*P*	*Max Marks (T)*	*Max Marks (P)*	*Total Credit*
MSBTMJ-306	AI in Plant Genetics & Genomics	6	-	-	100 (75+25)	00	4

Course Objectives:

1. To develop an understanding of advanced concepts and applications of genetic engineering in plant improvement.
2. To provide knowledge of modern tools and techniques used in genetic engineering.
3. To study advanced methods of genome editing and their applications in crop enhancement.
4. To familiarize students with recent developments and innovations in genetic engineering.
5. To enhance analytical and practical skills related to molecular manipulation and plant biotechnology.

Course Outcomes:

1. The students will learn the cloning and transformation techniques of the plants.
2. Students will be acquainted with the fundamentals of genome editing techniques, starting with the basic concepts till the screening of the transformants.
3. Students will be learning about the prospects of genome edited crops with regards to sustainable food security and the ethical issues

Unit I Genetic Manipulation: Introduction, Historical perspective, Cutting and joining DNA Molecular Cloning, Constructing DNA libraries, Probes, Library screening, Expression libraries Restriction mapping, RFLP, DNA sequencing, Transposons

Unit II Gene Expression: Introduction, Transient and stable transfection assays, *in vitro* mutagenesis, Analysis at the level of gene transcriptions: RNA expression and localization; Analysis at the Level of translation: protein expression and localization; Antisense technology, Analysis of DNA-Protein, Structural analysis of proteins.

Unit III Genome editing for crop improvement: Introduction to genome engineering, basic concepts of Meganucleases, Zinc-Finger Nucleases, TALENs, CRISPR/Cas9 immune response of bacteria; Genome editing in plants using CRISPR/Cas: principle (Single guide RNA, Protospacer adjacent motives (PAM), Cas9 recruitment and cleavage of target DNA sequence), DNA repair mechanisms in plants (NHEJ and HR repair).

Unit IV Production of Plant made pharmaceuticals (PMPs): Biopharmaceuticals derived from transgenic plants; Production of recombinant Proteins, Antibodies, Vaccines and other therapeutic agents in plants; ExpressTec: High-level expression of biopharmaceuticals in cereal grains;

Biopharmaceutical production in cultured plant cells; Ethical and Environmental concerns on Genetic Engineering of plants; 'Pharm' Factories of the future, AI in Plant Genetics & Genomics.

Suggested Readings:

1. Alan G. Atherly, Jack R. Girton, John F. McDonald (1998). The Science of Genetics, Published by Saunders College Pub.
2. Arencibia, A.D. (2000). Plant Genetic Engineering- Towards the Third Millennium, Publisher Elsevier Science
3. Benjamin Pierce (2017). Genetics: A Conceptual Approach (6th edn), Publishers WH Freeman
4. Daniel L. Hartl and Elizabeth W. Jones (2000) Genetics: Analysis of Genes and Genomes, Jones and Bartlett Publishers, Inc
5. Daniel L. Hartl and Bruce Cochrane (2017). Genetics: Analysis of Genes and Genomes Jones and Bartlett Publishers, Inc
6. Desmond, S.T. N. (2004). An Introduction to Genetic Engineering. Cambridge.
7. Govil C.M., Ashok Aggarwal and Jitender Sharma (2017). Plant Biotechnology and Genetic Engineering PHI Learning Pvt. Ltd.,
8. Grierson D. (2011). Plant Genetic Engineering (Plant Biotechnology Series) Publisher Springer
9. McCoy Herbert (Ed.) (2019). Plant Genetic Engineering Publisher Callisto Reference

10. Slater Adrian,Nigel Scott, and Mark Fowler (2008). Plant Biotechnology - The genetic manipulation of plants, Second Edition, Oxford University Press

M.Sc. in Applied Artificial Intelligence in Plant Science

Fourth Semester

Paper Code	Name of the	Credits	Total Credits	Max. Marks
MSBTMJ-401	**Dissertation**		20	500
	Problem identification, review of literature, proposal writing and presentation	5		
	Dissertation: Experiments, data collection, analysis, interpretation and discussion	10		
	Dissertation presentation and *Viva-Voce*	5		
	Total	**20**	**20**	**500**

Course objectives

1. Independent research on AI applications in Plant Science (e.g., river ecology, medicinal plant cultivation, eco-management)
2. To prepare the students to adapt to the research environment and understand how projects are executed in a research laboratory.
3. To enable students to learn practical aspects of research and train them in the art of analysis and thesis writing.

Course outcomes:

1. Students should be able to learn how to select and defend a topic of their research.
2. Students should learn how to effectively plan, execute, evaluate and discuss their experimental works.
3. Students should be able to demonstrate considerable improvement in the following areas:
4. In-depth knowledge of the chosen area of research.
5. Capability to critically and systematically integrate knowledge to identify issues that must be addresses within the framework of thesis.