M.Sc. BOTANY
SYLLABUS BASED ON THE SEMESTER SYSTEM

Candidates who have passed **B.Sc. (Hons.) in Botany** with **10+2+3 examination** pattern of the Banaras Hindu University, or an equivalent examination of other Universities having studied **Chemistry** as a third science subject, shall be considered eligible for admission to **M.Sc. Course in Botany.**

1. There shall be four semesters, two in each year, and each semester will have 22.5 credits.
2. There shall be twelve core courses; each core course will have 4.5 credits (3 credits for theory and 1.5 credits for practical).
3. Candidates will select three major elective courses. **Major elective courses 1 and 2** will have **three options** each and **Major elective Course 3** will have **four options**. Credits for each elective course will be at par with that of the core course.
4. Candidates will select two minor elective courses which will be based only on theory; each course will have 3 credits.
5. The project work will be carried out by the students in the 3rd and 4th semester; however, evaluation of dissertation will be done in the 4th semester.
6. Dissertation shall be examined by the internal and external examiners. Assessment of seminar shall be done by a board of internal examiners.
7. Candidates will have to carry out a botanical excursion in the 3rd semester, and will be required to submit a report thereof. It will carry 3 credits.

The distribution of credits will be as follows:

Course	Total Credits
Theory paper of each core course (CC No. 1-12) @ 3 credits each	36
Practical paper of each of the core course (CC No. 1-12) @ 1.5 credits each	18
Theory paper of each Major Elective course (MJE No. 1-3) @ 3 credits each	9
Practical paper of each of Major Elective course (MJE No. 1-3) @ 1.5 credits each	4.5
Theory paper of each Minor elective course (MIE No. 1-2) @ 3 credits each	6
Botanical excursion, and report thereof	3
Seminar	2
Dissertation	9
Viva-voce examination (based on dissertation)	2.5
Total credits	**90**

COURSES

First Semester:

Core Course 1:	Phycology
Core Course 2:	Mycology
Core Course 3:	Microbiology
Core Course 4:	Plant Ecology
Core Course 5:	Cytogenetics

Second Semester:

Core Course 6:	Bryophytes, Pteridophytes and Gymnosperms
Core Course 7:	Angiosperms
Core Course 8:	Plant Physiology
Core Course 9:	Plant Biochemistry and Biotechnology
Core Course 10:	Cell and Molecular Biology

Third Semester:

Core Course 11:	Environmental Management, Computer Application, and Biostatistics
Major Elective Course 1:	To be selected from MJE1A, MJE 1B or MJE 1C
Major Elective Course 2:	To be selected from MJE2A, MJE 2B or MJE 2C
Minor Elective Course 1:	To be selected from MIE-1A and MIE-1B
Minor Elective Course 2:	To be selected from MIE-2A and MIE-2B

Botanical Excursion, and presentation of seminar by students.

Fourth Semester:

Core Course 12:	Biochemical and Molecular Techniques and Bioinformatics
Major Elective Course 3:	To be selected from MJE 3A, MJE 3B, MJE 3C or MJE 3D
Dissertation	Topic to be decided in consultation with the supervisor
Viva-voce examination	**Based on dissertation**

Major Electives

MJE- 1A.Air Pollution and Climate Change	**MJE- 2A.Conservation and Restoration Ecology**	**MJE- 3A.Applied Phycology**
MJE- 1B.Photochemistry, Photobiology and Molecular Biology of Cyanobacteria	**MJE- 2B.Stress Biology and Molecular Genetics of Cyanobacteria**	**MJE- 3B.Applied Mycology**
MJE- 1 C.Plant Pathology and Plant Protection	MJE- 2C.Plant Cell and Tissue Culture	MJE- 3C.Water Pollution Management
		MJE- 3D.Microbial Genetics and Biotechnology

Minor Electives

MIE-1A Herbal Medicine	MIE-2A Biodiversity and its Conservation
MIE-1B Microbial Biogeochemistry	MIE-2B Biofertilizer Technology

CORE COURSES

CC-1 : Phycology

- Principles and systems of classification.
- Comparative account of algal pigments, food reserves, fllagellation, chloroplasts and eye spots; their taxonomic importance and molecular phylogeny.
- Cyanophyta: Cell structure and thallus organisation, heterocyst and akinete development and their role, chromatic adaptation and reproduction.
- Chlorophyta : Range of thalli, methods of reproduction and perennation, life cycles and alternation of generation.
- Phaeophyta : Range of thallus structure, reproduction, life histories and alternation of generation.
- Rhodophyta : Range of thallus structure, reproduction, life histories and alternation of generation, post-fertilization development and sites of meiosis.
- A brief account of Xanthophyta, Chrysophyta, Bacillariophyta, Pyrrophyta, Euglenophyta, Eustigmatophyta, Prasinophyta, Prochlorophyta and Phycoviruses.
- Algae and human affairs : Edible algae, algal biofertilizers, phycocolloids, algal blooms and phycotoxins.

CC-2 : Mycology

- Introduction, scope and general principles of classification of fungi.
- Myxomycotina: Plasmodiophorales.
- Mastigomycotina: Chytridiales, Blastocladiales, Saprolegniales and Peronosporales.
- Zygomycotina:Mucorales and Entomophthorales.
- Ascomycotina: Endomycetales, Protomycetales, Taphrinales, Erysiphales, Eurotiales, Sphaeriales, Helotiales, Phacidiales and Pezizales.
- Basidiomycotina: Uredinales, Ustilaginales, Lycoperdales, Nidulariales, Sclerodermatales, Phallales, Agaricales, Aphyllophorales, Tremellales and Auriculariales.
- Dueteromycotina: Sphaeropsidales, Melanconiales, Moniliales and Mycelia sterilia.
- Lichens: Thallus structure, reproduction and economic importance.

CC-3 : Microbiology

- Introduction: A brief idea of microbial diversity; scope of microbiology; a general account of Archaea.
- Nutritional types of microorganisms, Rhizobium-legume symbiosis and mycorrhiza.
- Anoxygenic photosynthesis with special reference to light reaction in purple bacteria; methanogenesis.

- Genetics of bacteria: Genetic recombination - an overview; mechanisms of transformation, conjugation and transduction in bacteria; role of microorganisms in genetic engineering.
- Lytic cycle in T even phages and its regulation; lysogeny and its regulation in lambda phage; a brief account of viroids and prions.
- Water-borne pathogenic microbes; role of microbes in wastewater treatment with special reference to activated sludge.
- Basic design of a fermentor; biosensors; bioremediation of hydrocarbon and metal polluted waters.

CC-4 : Plant Ecology

- Vegetation patterns of the world: Life zones; major biomes and major vegetation types of the world.
- Population concepts: Population growth; carrying capacity, population regulation, r and k selection; population interactions; population differentiation.
- Vegetation organization and characteristics: Concepts of community and continuum; community coefficients, interspecific associations, ordination; ecological niche; species diversity (α, β, γ).
- Ecological succession: Mechanism of ecological succession (relay floristics and initial floristic composition; facilitation, tolerance and inhibition models); changes in ecosystem properties during succession.
- Ecosystem organization: Structure and functions; primary production (methods of measurement, global pattern, controlling factors); energy dynamics (trophic organization, energy flow pathways, ecological efficiencies); litter fall and decomposition (mechanism, controlling factors); global biogeochemical cycling and ecosystem nutrient cycles.
- Ecosystem stability: Concept (resistance and resilience); ecological perturbations (natural and anthropogenic) and their impact on plants and ecosystems; ecology of plant invasion.
- Biological diversity: Concept and levels; distribution and global patterns; terrestrial biodiversity hot spots; role of biodiversity in ecosystem functions; IUCN categories of threat; inventory and conservation, protected area network.
- Environmental pollution: Kinds, sources, effects on plants and ecosystems.
- Climate change, greenhouse gases, ozone layer depletion, consequences of climate change.

CC-5 : Cytogenetics

- Chromatin organization and replication: Chromosome structure and packaging of DNA, nucleosome assembly and deassembly, histones, euchromatin and heterochromatin.
- Cytogenetics of haploids: Haploidy/monoploidy, meiosis and breeding behaviour of haploids, uses of haploids in plant breeding, genetic and cytogenetic studies.
- Aneu-and euploids: Induction and characterization of monosomics, trisomics and nullisomics, inheritance pattern in autopolyploids, status of allopolyploids in plant evolution.

- Chromosome banding patterns: Linear differentiation of chromosome segments, types of chromosome banding, uses of chromosome banding in cytogenetics.
- Alien gene transfer through chromosome manipulations: Transfer of whole genome, transfer of individual chromosomes, characterization and utility of alien addition and substitution lines.
- Organization and function of eukaryotic genetic material: Nuclear DNA and C-value paradox, DNA content and adaptability, repetitive DNA, split genes, overlapping genes.
- Inbreeding and heterosis: Genetic basis of inbreeding depression and heterosis, manifestations and exploitation of hybrid vigour, non-conventional methods of crop improvement.
- Chromosome mapping: Cytological and genetic maps, deletion and aneuploid mapping, Fluorescent in situ hybridization (FISH) and Genomic in situ hybridization (GISH).

CC- 6 : Bryophytes, Pteridophytes and Gymnosperms

Bryophytes:

- Classification of Bryophytes.
- Thallus organization in Hepaticopsida, Anthocerotopsida and Bryopsida
- Sporophyte evolution in bryophytes; peristome structure and its significance in classification of mosses.
- Importance of Bryophytes.

Pteridophytes:

- Classification of Pteridophytes
- A brief account of the range of structure and reproduction in Ferns.
- Telome theory, apogamy and apospory, heterospory and seed habit.
- A brief account of the following fossils: *Psilophyton, Lepidodendron* and *Calamites*.
- Economic importance of Pteridophytes.

Gymnosperms:

- Classification of Gymnosperms.
- Kinds of fossils and environmental conditions favouring the process of fossilization.
- A brief account of Glossopteridaceae; Comparative study of various families of Coniferales (Cupressaceae, Araucariaceae, Podocarpaceae, Cephalotaxaceae and Taxodiaceae) and Gnetales (Gnetaceae, Ephedraceae and Welwitschiaceae)
- A general account of Taxales.
- Gymnosperms as a source of wood, resins, essential oils, food and drugs.

CC-7 : Angiosperms

- Systematics: Outline of classification of Angiosperms; Hutchinson, Takhtajan, Cronquist, merits and demerits.
- Botanical nomenclature: International code of Botanic Nomenclature; principles: Rules and recommendations; priority; typification; Rules of effective and valid publications; retention and choice of names.
- Diagnostic characteristics, systematic phylogeny and economic importance of families**:** Magnoliaceae, Capparidaceae, Rosaceae**,** Apocynaceae, Asclepiadaceae, Convolvulaceae, Scrophulariaceae, Acanthaceae, Bignoniaceae, Lamiaceae, Verbenaceae, Polygonaceae, Euphorbiaceae, Orchidacae, Zingiberaceae, Araceae, Cyperaceae and Poaceae.
- Numerical taxonomy: Aims and objectives, characters and attributes, OTUs, coding, cluster analysis, merits and demerits.
- Chemotaxonomy**:** Role of phytochemicals (non-protein amino acids, alkaloids, betalins, cynogenic glucosides, silica, gypsum, raphides, glucosinolate, flavonoids, terpenoids) in taxonomy.
- Biosystematics: concepts; biosystematic categories; methods in experimental taxonomy; Embryology and Palynology in relation to taxonomy.
- Molecular approaches to plant taxonomy: Application of DNA markers in angiosperm taxonomy; molecular phylogeny.
- Apomixis: Adventive embryony, diplospory, apospory, practical application.
- Polyembryony: Categories; causes; practical application.
- Self incompatibility: Structural and biochemical aspects; methods to overcome incompatibility - mixed pollination, bud pollination; intra -ovarian pollination, in vitro pollination.
- Experimental Embryology: Haploid production; diploidization of haploids, importance of haploids; embyro culture; culture of differentiated and mature embryos; role of natural plant extracts and growth hormones; embryo-nurse endosperm transplantation; culturing of embryonal segments; practical aspects of embryo culture, endosperm culture.

CC-8 : Plant Physiology

- Water relations: Properties of water, water in tissues and cells, measurement of cellular water.
- Transport of water and solutes: Comparison of xylem and phloem transports, phloem loading and unloading, passive and active transports, soil-plant-atmosphere continuum.
- Photosynthesis: Basic principles of light absorption, excitation energy transfer, electron transports, proton electrochemical potential, evolution of photosynthetic processes, photosynthetic quantum yield and energy conversion efficiency, photorespiration and plant productivity, measurement of photosynthetic parameters.

- Physiological responses to abiotic stresses: Responses to the abiotic factors, light, temperature, water and salts; acclimation of physiological processes under abiotic stresses.
- Sensory photobiology : History, discovery of phytochromes and cryptochromes and their photochemical and biochemical properties, photophysiology of light induced repsonses, Cellular localisation, molecular mechanism of action of photomorphogenetic receptors, signalling and gene expression.
- Plant growth regulators : Physiological affects and mechanism of action of plant growth hormones, hormone receptors, signal transduction and gene expression.
- The flowering process : Photoperiodism and its significance, endogenous clock and its regulation, floral induction and development.

CC-9 : Plant Biochemistry and Biotechnology

- Energetics of metabolic processes: Energy rich phosphate compounds, Electron transport and phosphorylation, β -oxidation of lipids.
- Fundamentals of enzymology: General aspects, international classification of enzymes, prosthetic groups and coenzymes, mechanism of catalysis, kinetics, Michaelis-Menten equation, bisubstrate reactions, active sites, factors contributing to the catalytic efficiency, regulatory enzymes, isozymes.
- Biological nitrogen fixation: Introduction, nitrogenase enzyme, substrate for nitrogenase, reaction mechanism, strategies to exclude oxygen and need to control hydrogen evolution.
- Inorganic nitrogen and sulphur metabolism: Introduction, nitrate transport, nitrate and nitrite reductases, inhibitors of nitrate and nitrite reductases, localization and regulation of nitrate and nitrite reductases, sulphate uptake, activation and transfer, assimilatory pathways of sulphate reduction - APS and PAPS.
- Biosynthesis of proteins: Introduction, tRNA, ribosomes, transcription and translation, regulation of protein and enzyme synthesis.
- Plant cell and tissue culture: General introduction, concept of cellular differentiation and totipotency, application of plant tissue culture.
- Transgenic plants.
- Basic concept of genomics and proteomics.

CC-10 : Cell and Molecular Biology

- Cell: Concept, structural organization of plant cell.
- Mitochondria: Structure, genome organization, protein import and mitochondrial assembly.
- Chloroplast: Structure, genome organization, import and sorting of chloroplast proteins.
- Endoplasmic reticulum: Structure, translocation of secretory proteins across the ER membrane, insertion of protein into the ER membrane, protein folding and processing.

- Golgi apparatus: Organization, protein glycosylation, protein sorting and export from the Golgi, the vesicular transport mechanism.
- Nucleus: Nuclear envelop, nuclear pore complex, trafficking between nucleus and cytoplasm.
- DNA: structure, replication, DNA damage and repair, recombination.
- Cloning vectors: salient features, plasmids, cosmids, λ phage, phagemids.
- Mobile genetic elements: insertion elements, transposons.
- Microarrays, protein profiling and its significance.

CC- 11 : Environmental Management, Computer Application and Biostatistics

Environmental Management

- Introduction and scope of environmental management.
- Basic concepts of sustainable development, industrial ecology and recycling industry, role of natural products and biodiversity in international trade.
- Environmental impact assessment (EIA).
- General guidelines for the preparation of environmental impact statement.
- Scope and types of environmental audit, energy audit, cost benefit analysis.
- Environmental management plan, ISO 14000 standards and certification.
- Environmental risk management and environmental safety norms.
- International summits and treaties related with ecology and environment.

Computer Application and Biostatistics

- Basic concepts of computer hardware.
- Operating systems- Windows, Unix and Linux, use of common application software in biology- word processing, spreadsheets, graphics and database.
- Introduction to web browsing software and search engines with special reference to online bioscience resources.
- Introduction to sampling methodology.
- Measures of location, scale and shape.
- Graphical representation of data.
- Contingency tables and Chi - square test.
- Comparison of means: t-test, multiple range tests.
- The correlation measurement and regression analysis.
- Simple experimental design and analysis of variance.

- Introduction to multivariate methods for biology.

CC-12 : Biochemical and Molecular Techniques and Bioinformatics

- Electrophoresis: Polyacrylamide gel electrophoresis (PAGE), agarose gel electrophoresis, native PAGE, SDS-PAGE, 2D electrophoresis.
- Isolation and purification: (a) genomic and plasmid DNA, (b) RNA, (c) proteins.
- Isoelectric focusing (IEF): Principles, kinds of pH gradients used in IEF- free carrier ampholytes, immobilized pH gradients, preparative IEF.
- Blotting: Principles, types of blotting, blotting membranes, immunoblotting - Southern, Northern, Western and Dot blots.
- Amplification of DNA: Introduction, Polymerase Chain Reaction (PCR).
- DNA sequencing: Various methods of DNA sequencing and finger printing.
- Gene silencing: RNA interference (RNAi).
- Chromatography: Paper, capillary, column, HPLC, GLC- basic concept.
- Basic concept of spectrophotometer and electron microscope.
- Concept and application of Bioinformatics.

MAJOR ELECTIVES

MJE- 1A : Air Pollution and Climate Change

- Atmospheric composition and climate: Gaseous and particulate pollutants, trend, emission scenarios, climate change, drivers of climate change, greenhouse gas emission scenarios, indoor pollution.
- Sulphur derivatives (SO_2, H_2S): Sources and cycling of sulphur, effects on plants and human health, resistance and buffering, sulphur metabolism, threshold and injury.
- Nitrogen derivatives (NO_2, NO, NH_3): Formation and sources, Deposition, uptake, metabolism, critical load, effects on plants and human health.
- Fluoride derivatives (HF and fluoride ions): Sources and cycling, ecosystem effects, bioaccumulation, threshold and injury, effects on plants, animals, microbes and human health.
- Oxidants (Ozone and PAN): Formation and sources, tropospheric concentrations, photochemical smog, mechanism, resistance, critical load, effects on plants and human health.
- Stratospheric ozone depletion: Phenomenon, causes and consequences, biological action spectra, irradiation scenarios, effects on plants, microbes and human health.

- The greenhouse effects : Process, consequences, temperature, sea levels, rainfall, Albedo, oceanic influences, agriculture, natural vegetation, effects of increased CO_2 on plants, human implications.
- Acid rain: Formation, dispersion and deposition, trends in acid deposition, consequences to soil fertility, rivers and lakes, effects on plants, leaf injury, buffering, reproduction, forest decline, effects on fisheries.
- Biomonitoring of air pollution: Concept, active and passive monitoring, bioindicator parameters; Air pollution tolerance indices; Control of air pollution by plants.

MJE-1B : Photochemistry, Photobiology and Molecular Biology of Cyanobacteria

- Photobiological nitrogen fixation: Introduction, genetic structure of the N_2 fixation system, heterocyst differentiation and metabolism, nitrate, nitrite and ammonia assimilation.
- Light harvesting complex: Introduction, phycobiliproteins, chromatic adaptation - gene expression.
- Biochemical and molecular aspects of abiotic stresses: (a) UV radiation, (b) heat, and (c) salinity.
- Photoprotective mechanisms: Introduction, mycosporine-like amino acids (MAAs) and scytonemin.
- Cyanobacterial toxins: Types of cyanobacterial toxins, biochemical and molecular aspects of toxin production, ecological implications.
- Basic principles for the generation of transgenic cyanobacteria.

MJE-1 C : Plant Pathology and Plant Protection

- Historical and developmental aspects of plant pathology.
- Mode of infection and role of enzymes and toxins in plant disease.
- Defense mechanisms of plants against infection: Preexisting structural and chemical defense, induced structural and chemical defense, hypersensitive reaction, role of phytoalexins and other phenolic compounds.
- Management of plant diseases: Cultural, chemical, biological , biopesticides, breeding for resistant varieties, plant quarantine, integrated pest management.
- Post-harvest pathology: Fungal deterioration of food commodities, mycotoxins and health hazards, control measures.
- Molecular plant pathology: Molecular aspects of host pathogen interactions - PR proteins, degradation of phytoalexins, systemic resistance mechanism; application of molecular biology to plant disease control - transgenic approach for crop protection, engineering chemicals that elicit defense response to plants.
- Study of plant diseases caused by fungi, bacteria, viruses, nematodes and mycoplasma like organisms: Wart disease of potato, blight of colocasia, downy mildew of cucurbits, stem gall of coriander, peach leaf curl, ergot of bajra, smut of sugarcane , Karnal bunt of wheat, linseed rust, Tikka disease of groundnut, red rot of sugarcane, Panama disease (Fusarium wilt) of banana,

bacterial blight of rice, leaf curl of tomato, yellow vein mosaic of bhindi, mosaic of sugarcane, potato spindle tuber mosaic, ear cockles of wheat, grassy shoot of sugarcane, phylloidy of sesamum, Citrus greening.

MJE-2A : Conservation and Restoration Ecology

- Introduction to conservation ecology: Defining conservation, postulates of conservation biology.
- Assessment and monitoring: Assessment techniques for microbes, plants and animals, documenting rarities, collecting specimens, monitoring environmental variables, monitoring human impact, monitoring microbial, plant and animal diversity.
- Population dynamics and conservation: Genetic variation and its loss, variation in natural populations, mechanism of population regulation, habitat specific demography, population viability analysis.
- Diagnosis and prediction: Predicting ecological consequences of changes, environmental impact assessment.
- Species and habitat management: Prioritizing, criteria for choices of species for conservation with hotspots of global biodiversity, protected area networks, the theory of reserve design, managing access to protected areas.
- Conservation planning: The planning process, the species action plan process, the site management plan process.
- Managing exploitation: Human population growth and resource exploitation trends, determining sustainable yields through models, controlling exploitation.
- Ecology of disturbed ecosystems: Disturbance and its impact on the structure and functioning of terrestrial and aquatic ecosystems.
- Aims and strategies of restoration: Concepts of restoration, single vs. multiple end-points, ecosystem reconstruction, physical, chemical, biological and biotechnological tools of restoration.
- Restoration of biological diversity: Acceleration of ecological succession, reintroduction of biota.
- Degradation and restoration of natural ecosystems: Forests, grasslands/ savanna, aquatic.
- Restoration of degraded soils: Restoration of contaminated soils and soil fertility, mine spoil restoration.

MJE-2B : Stress Biology and Molecular Genetics of Cyanobacteria

- Stress environment: Abiotic factors; water, temperature, light, pH, salinity and nutrient concentration; Stress habitats: physico-chemical characterization, species diversity and population dynamics.
- Stress damages: Cell structure, proteins, nucleic acids, lipids and membranes, physiological processes, protein synthesis.
- Mechanism of adaptations: Role of carbohydrates, proteins, nucleic acids and lipids, pigment-involvements, signal transduction.

- Genome organization of model cyanobacteria *Synechocystis* sp. PCC 6803, *Anabaena* sp. PCC 7120, plasmids, use of bioinformatics in nucleic acid sequence database, brief knowledge of sequence alignment and its significance.
- Mode of gene transfer in cyanobacteria with special reference to conjugation, transformation, electroporation, spontaneous and induced mutagenesis, transposon mutagenesis, expression of foreign gene(s) in cyanobacteria and its consequences.
- Cyanobacteria in human welfare: Production of fine chemicals, polysaccharides, bioactive molecules, pigments, antioxidants, lipids and polyunsaturated fatty acids, biofertilizer and hydrogen.

MJE-2C : Plant Cell and Tissue Culture

- Historical perspectives.
- Principles of plant tissue culture: Organization of laboratory media composition and preparation, aseptic manipulation.
- Cell culture and cell cloning.
- Cellular totipotency: Process and mechanism.
- Somatic embryogenesis and synthetic seeds: Induction and controlling factors.
- Organogenesis: Process and controlling factors.
- Haploids: Androgenic and gynogenic; obtention and promises.
- Somatic hybridization: Isolation, culture and fusion of protoplasts, regeneration of hybrids and cybrids.
- Clonal propagation: Micropropagation.
- Somaclonal and gametoclonal variation and their selection.
- Transgenic plants: Method of transformation, selection, identification and applications.
- Germplasm conservation.
- Industrial application.

MJE-3A : Applied Phycology

- Models (Monod and Droop) of nutrient-regulated phytoplankton growth; common methods for mass cultivation of microalgae.
- Eutrophication: Causal factors, dynamics of freshwater and marine algal blooms, physical and chemical means and bio-manipulation (top-down and bottom-up) for controlling eutrophication and nuisance blooms.

- Consequences of blooms including toxins of cyanobacteria and dinoflagellates; algal biofouling of ships and its control .
- Commercial potential of *Spirulina, Dunaliella* and *Porphyra,* hydrogen production by algae.
- High-rate algal ponds for the treatment of wastewaters and for the production of useful biomass and energy, immobilized and inactivated algal biomass for metal and nutrient removal.
- Paddy field cyanobacteria: Qualitative and quantitative assessment of their biodiversity using molecular tools; their use as biofertilizer
- Influence of salt, heavy metals and acid rain on algae: Physiological and biochemical effects, biochemical and molecular mechanisms of tolerance.
- Bioassays and field assessment of pollutant effects; single and multispecies laboratory bioassays; taxonomic and non-taxonomic approaches for the assessment of pollutant effects in nature, cage and dialysis cultures; microcosms; mesocosms including CEPEX.

MJE- 3B : Applied Mycology

- Fungal diversity in different ecosystems: The structure and composition of fungal cell, effect of environment on fungal growth and behavior.
- Fermentation technology: Feedstock for fermentation process, fermentor design and operation, solid substrate fermentations.
- Enzyme technology: Fungal enzymes of commercial importance, production of fungal enzymes, free and immobilized cells and enzymes.
- Fungal toxins: Mycotoxicoses- fungi in dermatomycosis, aspergillosis and fungi allergenic to man and animal.
- Fungi as food and beverage: Alcoholic beverage, mushrooms and other macro fungi, edible biomass from yeast and moulds, single cell proteins (SCP).
- Fungi in food processing: Bread, soybean products, cheese and fermented milk, other fermented foods.
- Fungal metabolites: Primary metabolites of economic importance, secondary metabolites in medicine and agriculture.
- Biodeteriotation and biodegradation by fungi: Textiles, leather, plastic, hydrocarbons, metals and pesticides.
- Mycorrhyzal technology: Ectophytic and endophytic mycorrhiza, mycorrhiza in plant growth promotion, mycorrhizal interactions with soil microorganisms, mycorrhiza in plant disease control.
- Fungi in plant disease control: Current limits to biological control of fungal phytopathogens, molecular approach in control of fungal pathogens, biotrophic mycoparasitism, strain selection and their improvement for biocontrol.

- Future of fungal biotechnology: Production of mammalian proteins by fungi, other applications of gene cloning in fungi and their importance**.**

MJE-3C : Water Pollution Management

- Freshwater: Classification of water bodies, physico-chemical and biological properties of freshwater, water quality at euphotic and profundal zones, drinking, bathing and irrigational water quality standards.
- Water pollution sources: Major sources of water pollution, Physico-chemical and biological properties of sewage, quality of industrial effluents produced from textile, dairy, leather, thermal power and chemical industries.
- Effect on water quality: Changes in water quality due to discharge of city sewage, industrial effluents; effects on phytoplankton productivity; bio-indicators of water pollution.
- Domestic wastewater treatment: Various stages of treatment of sewage with special reference to advanced wastewater treatments; biological treatment of wastewater.
- Industrial wastewater treatment: Treatment of industrial effluents released from textile, dairy, leather, thermal power and chemical industries.
- Disinfection of treated water: Ozonization of secondary treated wastewater; chemical and other methods for disinfection.
- Water management strategies: Rain water harvesting, use of rain water, recharging of ground water, use of domestic waste water, recycling of waste water, recycling of industrial effluents after treatment.
- Water pollution monitoring and management bodies: Important organizations involved in water pollution monitoring in India and role of NGOs in water pollution management.

MJE-3D : Microbial Genetics and Biotechnology

- The tools of microbial genetics: *Escherichia coli*, *Bacillus subtilis*, bacteriophages (T_4, lambda, Mu), *Neurosopra crassa*.
- Mutation: Spontaneous and induced mutation, mutagens and mechanism of mutation, selection of auxotrophic and drug resistant mutants, suppressor mutations.
- Insertion sequences: plasmids, mechanism of insertion, effects of insertion sequences and its importance.
- Transposons: heritable properties conferred by transposons, physical organization of drug resistant transposons, genetic organization of TnA and its role in transposition.

- Gene expression and regulation : Regulation of virulent genes in pathogenic bacteria, heat shock regulon and signal transduction and Cps regulon.
- Microbial toxins: Microbial toxin types, biochemical and molecular basis of toxin production.
- Gene manipulation and production of novel commercial products, biopolymers, biosensors, biocatalysts.
- Biofertilizers and its application: Algalization, rhizobia, Azolla-Anabaena system.

MINOR ELECTIVES

MIE-1A : Herbal Medicine

- Floristic diversity and medicinal plant research scenario in India.
- Diagnostic features, bioactive molecules and therapeutic value of some common medicinal plants.
- Standardisation of herbal drugs.
- Commercial cultivation of medicinal plants.
- Conservation of medicinal plants.
- Neutraceuticals and medicinal food.
- Bioprospecting, biopiracy and protection of traditional medicinal knowledge (IPR).

MIE-1B : Microbial Biogeochemistry

- The role of microbes in biosphere: Microbes and the origin and evolution of life on earth, the impact of microbial communities on humans and the environment.
- Structure and organization of microbial communities: Development of microbial communities, mechanisms for positioning cells, scales of distance, defining limits of microbial communities.
- Exploration and quantification of the microbial diversity: Cultivation and non-cultivation approaches, complementarity between cultivation and non-cultivation approaches, the relevance of classical taxonomy of the postgenomic era, role of genomics in higher order classification.
- Microbial crusts: Characteristics and formation, composition, functions, response to disturbance.
- Microbial aspects of biogeochemical cycling of C, N, P and S.
- Survival strategies of microbes in extreme habitats.
- Microbial mediation of dissolution and precipitation of economically important minerals.
- Use of microbes in bioremediation of contaminated environment.

MIE-2A : Biodiversity and its Conservation

- Biodiversity: Concepts, significance and magnitude.
- Levels of biodiversity: Genetic, species, population, community, ecosystem and landscape.
- Uses of biodiversity: Source of food, medicine, raw material, aesthetic, cultural and ecosystem services.
- Distribution and assessment: Hypothesis regarding distribution, megadiversity zones and hot spots, assessment techniques.
- Threats to biodiversity: Causes of biodiversity loss, species extinction, vulnerability of species to extinction, IUCN threat categories, Red data book.
- Strategies for biodiversity conservation: Principles of biodiversity conservation, in-situ and ex-situ conservation strategies.

MIE-2B : Biofertilizer Technology

- Evolution of diazotrophs, adaptive potential, occurrence.
- Free living biofertilizers : Photosynthetic cyanobacteria and bacteria, non-photosynthetic forms.
- Symbiosis: Endo- and associate symbiosis.
- Enzymes and their regulation: Nitrogenase, hydrogenase.
- Biofertilizers and agricultural productivity: Algalization, rhizobia, Azolla-Anabaena system.

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