Name of programme: M.Sc. (Botany)

Programme outcomes

1. Advanced Knowledge: Graduates will have an in-depth understanding of advanced concepts and theories in various sub-disciplines of botany, including plant physiology, ecology, genetics, taxonomy, and molecular biology.
2. Research Proficiency: Students will develop advanced research skills, including the ability to formulate research questions, design and execute experiments, analyze data using statistical methods, and communicate findings effectively through scientific writing and presentations.
3. Specialization: The program may offer opportunities for students to specialize in specific areas of botany, such as plant biotechnology, conservation biology, ethnobotany, plant pathology, or ecosystem ecology, allowing them to develop expertise in their chosen field of interest.
4. Laboratory and Fieldwork Skills: Graduates will be proficient in a wide range of laboratory techniques and fieldwork methodologies relevant to their area of specialization, enabling them to conduct independent research and contribute to scientific advancements in botany.
5. Critical Thinking and Problem-Solving: Students will enhance their critical thinking abilities, learning to evaluate scientific literature, synthesize information from multiple sources, and develop innovative solutions to complex botanical problems.
6. Interdisciplinary Understanding: The curriculum may include interdisciplinary coursework that integrates botany with other fields such as biotechnology, environmental science, bioinformatics, and agronomy, providing students with a holistic understanding of plant biology and its applications.
7. Professional Development: The program may incorporate professional development activities such as seminars, workshops, internships, and collaborative research projects with industry partners or research institutions, enhancing students' employability and preparing them for leadership roles in academia, industry, government, or non-profit organizations.
8. Ethical Awareness and Environmental Stewardship: Graduates will be equipped with an understanding of the ethical implications of botanical research and practice, including issues related to biodiversity conservation, bioprospecting, genetic engineering, and sustainable agriculture, fostering a commitment to responsible conduct and environmental stewardship.
9. Communication and Collaboration: Students will develop advanced communication and collaboration skills, learning to effectively communicate scientific concepts and findings to diverse audiences, collaborate with colleagues from different disciplines, and participate in interdisciplinary research teams.
10. Lifelong Learning: The program will instill a passion for lifelong learning and professional growth, encouraging graduates to stay updated with the latest developments in botany, pursue further education or training as needed, and contribute actively to the advancement of the field through continuous research and innovation.

These outcomes prepare graduates for diverse career paths in academia, research institutes, government agencies, biotechnology companies, conservation organizations, botanical gardens, and other sectors where expertise in botany is valued.

SEMESTER I

THEORETICAL CORE COURSES

DBOT-CT-101: Phycology, Lichenology, Bryology, Pteridology, Gymnology and Paleobotany

Phycology:

i. Cell structure, pigments, reserve food and flagella
ii. Evolution of algal chloroplast and recent trend in algal classification and salient features of major groups
iii. Algal blooms, algal bio-fertilisers and uses in industry
iv. Economic and ecological importance of algae

Lichenology:

Thallus organisation in lichen and their physiological relationship

Bryology:

i. Recent classification of bryophytes and general account of major groups
ii. Bryophytic ecology, endemism, biogeographical distribution and hotspots of bryophytes
iii. Bryophytes through geological ages

Pteridology:

Origin and evolution of pteridophytes; General features of Psilopsida, Lycopsida, Sphenopsida and Pteropsida

Gymnology:

i. General account of Cycadeodales, Cordaitales and Pteridospermales
ii. Structure and reproduction in Cycadales, Ginkgoales, Coniferales and Gnetales

Paleobotany:

i. Geological time scale and stratigraphy\
ii. Continental drift and plate tectonics
iii. Radiometric dating

COURSE OUTCOMES

By the end of the course the students should be able to-

- Gain the adequate knowledge on structural organization, classification and economic importance ofalgae.
- Evaluate the thallus organization of Lichens.
- Learn about the recent classification of Bryophytes their general account, biogeographicaldistribution, hotspots, ecology and endemism.
- Assess the origin and evolution of Pteridophytes, general features of different groups ofPteridophytes.
- Learn about the general account of different groups of Gymnosperms. Their detailed structure andreproduction.
- Know about the Geological time scale, continental drift plate tectonics and Radiometric dating.

DBOT-CT-102: **Plant Anatomy and Development, Bioresource Utilization**

Plant Anatomy and Development:

i. Anatomy as a modern discipline; physiological-anatomical classification of plant tissue
ii. Development of root, shoot and leaf in higher plants
iii. Control of tissue differentiation
iv. Wood development in relation to environmental factors

Bioresource Utilisation

i. Plant and civilisation – centre of origin, botany, utilisation, cultivation an improvement of food plants, drugs, fibre
ii. Plant as a source of renewable energy
iii. Principles of plant breeding, conventional methods, non-conventional methods, polyploidy, genetic variability
iv. Chemistry and application of Swertia, Gloriosa, Digitalis, Taxus, Stevia, Chlorophytum and Podophyllum

COURSE OUTCOMES

By the end of the course the students should be able to

- Evaluate Anatomy as a modern discipline.
- Assess the physiological and anatomical classification of plant tissue.
- Evaluate the control of tissue differentiation.
- Know about the development of wood in relation to environmental factors.
- Learn about the overview of plant and civilization and plant as a source of renewable energy.
- Explain the principles of plant breeding.
- Learn about polyploidy and genetic variability.
- Know about chemistry and application of Swertia, Gloriosa, Digitalis, Taxus, Stevia, Chlorophytum and Podophyllum.

DBOT-CT-103: Taxonomy of Angiosperms

i. Classification: Phases of Taxonomy (α, β, ω and others), needs and philosophy of some major systems of classification – Cronquist, Takhtajan, Dahlgren, Thorne and APG system of classification
ii. Taxonomic hierarchy, species, genus, family and other categories; principles used in assessing relationship, delimitation of taxa and attribution of rank
iii. Nomenclature – different methods, sources of names, salient features of the International Code ofBotanical Nomenclature
iv. Biocode and Phylocode
v. Character concept and evolution of characters
vi. Taxonomic data sources; anatomy, palynology, embryology, cytology, phytochemistry andmolecular biology
vii. Herbarium, botanical garden, taxonomic literature and keys
viii. Taxonomy and phylogeny of Magnoliales, Amentifereae, Asterales, Helobiae, Glumiflorae,
Scitaminae and Orchidales
ix. Flora and vegetation of Eastern Himalayas
x. Traditional knowledge: Ethnological resources in India; documentation and utilisation of ethnicknowledge; Traditional methods of conservation; sacred grooves.

COURSE OUTCOMES

After the completion of these modules students are expected to know-

- Phases of Taxonomy, needs and philosophy of classification

- Hierarchical arrangement of species, genus, family and other categories; principles of assessing relationship, delimitation of taxa and attribution of rank
- Different methods of nomenclature sources of names, salient features of ICN
- Unified code of nomenclature and phylogenetic nomenclature
- Characters, their importance, evolution etc.
- Application of data from different branch of botany
- Important literature regarding taxonomic study, and institutes and documentation
- Features and evolution of different angiospermic natural groups
- Floral diversity of Eastern Himalaya
- Ethnic groups of India, related traditional knowledge, their documentation, traditional methods of conservation etc.

PRACTICAL CORE COURSES

DBOT-CP-104: Phycology, Lichenology, Bryology, Pteridology, Gymnology and Paleobotany

i. Morphological study of the following algal genera: *Scytonema, Rivularia, Zygnema, Fucus,*
Batrachospermum

ii. Morpho-anatomical studies of some locally available members of asco-, basidio- and cyano-lichen

iii. Morphological study of representative bryophyte members – *Lunularia, Porella, Dumortiera,*
Targionia, Plagiochasma

iv. Morphological study of representative pteridophyte members – *Gleichenia, Cheilanthus,*
Polystrichum, Athyrium, Cyathea

v. Comparative study of the anatomy of vegetative and reproductive parts of *Cryptomeria, Taxus,*
Cedrus, Cephalotaxus, Abies

vi. Study of important fossil pteridophytes and gymnosperms from prepared slides and specimens

COURSE OUTCOMES

By the end of the course the students should be able to-

- Identify morphology of different algal genera such as *Rivularia, Fucus*, *Scytonema*, *Zygnema,* and
  Batrachospermum.
- Know about the morpho-anatomical studies of some locally available members of asco, basidio andcyano lichen.
- Understand about the morphological study of representative bryophytes and Pteridophytes.
- Compare the anatomy of vegetative and reproductive parts of *Cryptomeria, Taxus, Cedrus*,*Cephalotaxus* and *Abies*.
- Study of important fossil pteridophytes and gymnosperms from prepared slides.

DBOT-CP-105: Taxonomy of Angiosperms & Plant Anatomy

i. Work out and identification of locally available plants, and preparation of artificial keys

ii. Training of using taxonomic literature

iii. Comparison of different species of a genus and different genus of a family to calculate similarity coefficient and preparations of dendrograms

iv. Palynological study of some taxa

v. Wood maceration from soft and hard tissues.

vi. Study of nodal anatomy.
vii. Anatomical study of different plant materials in relation to ecological adaptations.
viii. Study of secretary tissues.

COURSE OUTCOMES

Application and skill development towards conducting experiments related to Plant taxonomy and Anatomy by-

- Dissecting, describing, and identification of locally available plants, and preparation of artificial keys
- using taxonomic literature – flora, herbaria, Journals etc; familiarity with Taxonomic Literature (e.g. Index Kewensis, Wall-Cat, Icones, Bibliographies, Dictionaries, Keys, Floras, etc
- Comparing different species of a genus and different genus of a family to calculate similarity coefficient and preparations of dendrograms
- studying Palynological parameters of locally available taxa
- Viewing the tissue components of Wood from soft and hard tissues.
- Understanding nodal anatomy through visualizing leaf traces, leaf gap, branch traces and branch gap.
- Practical visualization of adaptive anatomical features in plants from different ecological habitats.
- Ability to identify the secretary tissues and developing in-depth knowledge relating its function.

SEMESTER II

THEORETICAL CORE COURSES

DBOT-CT-201: Microbiology

I. New approaches to Bacterial Taxonomy
II. Ultra-structure – cell wall, capsule and slime, flagella, pilli, ribosome, nuclear body, endospore, photosynthetic apparatus, reserve food material, gas vacuole, mesosome
III. Metabolism: photosynthesis (anoxygenic and oxygenic); chemosyntghesis, fermentation (alcoholic, EDP Pathway; lactic acid – homo and hetero, propionic acid, mixed acid, butanediol and butanol: Stickland reaction); Respiration (anaerobic and aerobic)
IV. Bacterial growth; measurement of growth, generation time, continuous culture, synchronised growth, diauxy, environmental growth factor
V. Bacterial growth; measurement of growth, generation time, continuous culture, synchronized growth, diauxic, environmental growth factor.
VI. Nutrition: Organic growth factors; inorganic requirements; physical and ionic requirements.
VII. Biological nitrogen fixation – Root nodulation; structure of nitrogenase and mode of action.
VIII. Food preservation and microbial control of food industry.
IX. Bacterial diseases of human– tuberculosis, leprosy, syphilis: causal organisms, mode transmission and control.

COURSE OUTCOMES

- The course aims to increase understanding of the students about various parameters relating to bacterial growth.
- This module would aid the pupils in having in-depth knowledge associated with bacterial nutrition.
- During this lesson students will learn about how atmospheric nitrogen is utilized by plants.
- Helping the learners acquire valuable information about the importance of microbes in food industry.
- The students will have a fair knowledge regarding role of microorganisms in disease development.

DBOT-CT-202: Mycology and Plant Pathology

i. Cellular ultra-structure and cell wall composition of fungi.
ii. Fungal growth and nutrition.
iii. Control of plant diseases – chemical and biological measures.
iv. Fungal toxins – host none selective toxins – mode of action of cerecosporin; host specific toxins– structure, mode of action and concept of Vb Gene, Mycotoxin – aflatoxin, biosyntheticpathway, genes and enzymes
v. Mycorrhizae; interaction; specific recognition in mychorrhizal association; application as biofertiliser and bioprotector in forestry and agriculture
vi. Molecular basis of disease development
vii. Control of plant diseases – chemical and biological measures
viii. Detailed studies of fungal disease: damping off, powdery mildew, down mildew, smut, burnt,rust, wilt, root rot, leaf spots, gall of economically important plants
ix. Virus diseases – symptoms, carrier, transmission, interaction of virus and the host, control strategies
x. Application of avirulence genes in control of plant pathogens

COURSE OUTCOMES

- Students will learn about the fungal cell wall and its composition in general.
- Students will learn about the growth of the fungus and the nutrition required by them.
- Students will get a complete overview of how different diseases of plant can be controlled.
- Knowledge about the industrial production and uses of different organic compounds such as citric acid ethanol enzymes antibiotic hormones by using the different species of fungi.

DBOT-CT-203: Cytology & Genetics

i. Chromosome structure and packaging of DNA molecule, organisation of centromere and telomere, nucleolus and ribosomal RNA genes; euchromatin and heterochromatin; karyotype analysis
ii. Mapping of genome; genetics of mitochondria and chloroplast
iii. Regulation of gene expression: prokaryotes and eukaryotes
iv. Genetic marker, construction of molecular maps, correlation of genetic and physical maps; somatic cell genetic and alternative approach to gene mapping
v. Transposable elements in prokaryotes and eukaryotes; mutation induced by transposons; site directed mutagenesis; DNA damage and repair mechanism, inherited human diseases and defects in DNA repair; initiation of cancer at cellular level, proto-oncogenes and oncogenes
vi. Breeding behaviour and genetics of structural heterozyogotes; complex translocation; heterozygotes translocation; tester sets; Robertsonian translocations; B – A translocations
vii. Flow cytometry, in situ hybridisation – concept and technique
viii. Transfer of whole genome, examples from wheat, Arachis and Brassica; transfer of individual chromosomes and chromosome segments; genetic basis of inbreeding and heterosis, exploitation of hybrid vigour

COURSE OUTCOMES

- Students will learn both classical and molecular concept of chromosome organisation, functions of nucleolus, and rRNA genes.
- Studentts will learn the genome mapping techniques, and genetics of mitochondria and chloroplast.
- Students will learn the in-depth ideas of gene regulation in both prokaryotes and eukaryotes
- Students will learn about the types and role of genetic markers and their roles in gene mapping.
- Students will learn types of transposable elements in both prokaryotes and eukaryotes, DNA damage and its repair, and molecular basis of cancer.
- Students will acquire the knowledge breeding behaviour and genetics of structural heterozyogotes; complex translocation; heterozygotes translocation; tester sets; Robertsonian translocations; B – A translocations
- Students will learn theoretical basis of flow-cytometry, in situ hybridisation
- Students will learn the role of whole genome and chromosome segments transfer, inbreeding and heterosis in plant breeding.

PRACTICAL COURSE OUTCOMES

DBOT-CP-204: Microbiology

i. Staining – simple, negative, endospore, flagella, Gram staining of bacteria.
ii. Sterilization methods, preparation of media and stains.
iii. Bacterial population count of soil, water, air.
iv. Enumeration of bacterial population of liquid culture by Breed method and Neubauer counting method.
v. Study of population of rhizospheric and phyllospheric microflora.
vi. Determination of thermal death point of different bacteria
vii. Biochemical studies of the nitrogen fixing, nitrifying, sulphur oxidizing and phosphate solubilizing bacteria.

COURSE OUTCOMES

- Applying the technique of staining in identifying bacteria.
- Understanding the principle of sterilization and hands on preparation of culture media.
- Having an in-depth knowledge of the methodology of bacterial population count of soil, water

and air.

- Awareness of the procedure and calculation relating to enumeration of bacterial population of liquid culture through Breed and Neubauer method.
- Acquiring knowledge about the ins and outs of rhizospheric and phyllospheric microflora.
- Developing skill towards determining thermal death point of bacterial strains.
- Application of biochemical tests to characterize nitrogen fixing, nitrifying, sulphur oxidizing and phosphate solubilizing bacteria.

DBOT-CP-205: Mycology and Plant Pathology

i. Morphological study of representative members of fungi – Yeast, *Mucor*, *Penicillium*, *Aspergillus*, *Alternaria*, *Xylaria*, *Fusarium*, Members of *Agaricales* and *Polyporales* (availablein Darjeeling).
ii. Sterilisation methods, preparation of media and stains, culture of fungus.
iii. Histopathological studies of fungal diseases of economically important crops.
iv. Identification of fungal culture: *Curvularia*, *Fusarium*, *Alternaria*, *Trichoderma*, *Pestalotiopsis*,*Exobasidium*, *Saccharomyces*.
v. Antibiotic bioassay by agar disc method.
vi. Detection of $ED_{50}$of fungicides by spore germination method.
vii. Thin layer chromatography and bioassay of antifungal compounds.
viii. Comparison of phenol content between healthy and artificially inoculated plants.
ix. Extraction and essay of phenylalanine ammonia lyase activity in plants following infection.

COURSE OUTCOMES

- Students will comprehend the function of fungi in several spheres of life, with a focus on agriculture.
- Students will gain knowledge of various plant-pathogen interactions, as well as how to diagnoseand treat them.
- Students will study sustainable farming practices.
- Additionally, students will learn about current advances in plant-microbe interactions the importance and mechanism of it.

DBOT-CP-206: Cytology & Genetics

i. Study of plant chromosome, chromosome staining schedules.
ii. Isolation of nuclei and identification of histones by SDS-PAGE.
iii. Isolation of plant DNA and its quantification by spectrophotometric method.
iv. Restriction digestion of plant DNA and separation by agarose gel electrophoresis and visualization of ethidium bromide staining.
v. Isolation of RNA and quantification by spectrophotometric method.
vi. Demonstration of SEM and TEM.
vii. Staining of nucleolus.

COURSE OUTCOMES

- Applying the technique of staining in karyotype and idiogram preparation.
- Understanding the principle of SDS-PAGE and gaining hands on experience in protein extraction and gel run.
- Developing an in-depth skill set of the methodology of DNA isolation and estimation.
- Awareness of the methodology regarding restriction digestion of plant DNA followed by separation and visualization by agarose gel electrophoresis.
- Acquiring knowledge about procedure of RNA isolation and quantification.
- Developing concept towards functional principles of TEM and SEM.

- Application of staining to identify nucleolus and have an understanding of its role.

SEMESTER III

THEORETICAL CORE COURSES

DBOT-CT-301: Plant Physiology

i. **Photosynthesis:** Photosynthetic light harvesting system and C1, C2, C3, C4 and CAM.
ii. **Plant growth substances:** Chemistry and biosynthesis and mode of action.
iii. **Plant water relation and mineral nutrition:** water potential and nutrient uptake.
iv. **Flowering:** phytochrome, biochemical signaling and photoperiodism.
v. **Seed germination and dormancy:** types, methods of breaking dormancy, hormonal role in seed germination.
vi. **Major biochemical pathways:** Glycolysis, Kreb's cycle, Pentose phosphate pathway, gluconeogenesis, Shikimate pathway; Senescence and programmed cell death: pattern, mechanism and PCD in plants.
vii. **Solute transport:** passive and active transport, membrane transport process, membrane transport proteins.
viii. **Membrane transport mechanism**: organization of import molecules, ion channels.

COURSE OUTCOMES

- Students may gain insights into the adaptations of different plant species to various environmental conditions and the ecological significance of these pathways.
- Analyzing the chemistry, biosynthesis, and mode of action of plant growth substances can deepen students' understanding of how hormones regulate plant growth, development, and responses to environmental cues.
- Students may learn about the mechanisms of water transport in plants and the role of mineral nutrition in plant growth and development.
- Exploring phytochrome, biochemical signaling, and photoperiodism in flowering can enhance students' understanding of how plants sense and respond to light cues to initiate flowering. This knowledge may have implications for crop production, floral biology, and plant breeding.

- Students may gain insights into strategies for improving seed germination rates and breaking dormancy in agricultural and ecological contexts.
- Understanding major biochemical pathways provides a foundation for comprehending cellular metabolism and energy production in plants.
- Students may gain a deeper understanding of membrane biology and its relevance to plant physiology.
- By analyzing each of these topics, students can develop a comprehensive understanding of plant physiology, biochemistry, and molecular biology, laying a strong foundation for further study and research in plant science.

DBOT-CT-302: Plant Biochemistry

i. **Bioenergetics**: thermodynamic principles, energy rich compounds and phosphorylation.
ii. **Carbohydrates**: classification, structure and biosynthesis, glycosides – structure and function.
iii. **Protein metabolism**: chemistry, structure and synthesis.
iv. **Lipid metabolism**: biosynthesis of fatty acids, lipid oxidation, triglycerol synthesis and membrane lipid biogenesis.
v. **Enzymes**: classification, kinetics and inhibition.
vi. **Nucleosides:** biosynthesis of purine and pyrimidine ribonucleotides and deoxy-ribonucleotides.
vii. **Nitrogen metabolism:** nitrate and nitrite uptake and reduction, regulation of nitrogen metabolism.
viii. **Cell wall**: molecular architecture, biosynthesis and assembly.
ix. **Secondary metabolites:** types, biosynthetic pathways, role in plant defense mechanism.

COURSE OUTCOMES

- understand how organisms utilize and store energy, crucial for understanding cellular metabolism and biochemical reactions.
- Knowledge of carbohydrates enhances understanding of their roles as energy sources, structural components, and signaling molecules in biological systems.
- studying proteins deepens our understanding of how cells produce and regulate these essential macromolecules, crucial for cellular structure, function, and regulation.
- Exploring Fatty Acids provides insights into lipid metabolism's regulation and its role in energy storage, membrane structure, and signaling.
- understanding enzyme elucidates how enzymes catalyze biochemical reactions, providing insight into cellular regulation, metabolism, and the design of therapeutic agents.
- knowledge of nucleosides deepens understanding of nucleotide metabolism, crucial for DNA and RNA synthesis and cell proliferation.
- understanding the cell wall provides insight into its roles in cell structure, protection, and communication, crucial for plant growth, development, and defense.
- Exploring the roles of secondary metabolites in plant defense mechanisms enhances understanding of plant biochemistry, ecological interactions, and potential applications in medicine and agriculture.

DBOT-CT-303: Ecology and Biostatistics

i. Pollution: parameters, regulation and genetics, community: concept, structure, dominance, fluctuations, succession
ii. Interaction between environment and biota, concept of habitat and niche, limiting factors, energy flow, food chain, food web and trophic level, ecological pyramids, biogeochemical cycles of nitrogen, phosphorous, sulphur, calcium, carbon, carbon-silicate, arsenic cycle in water

iii. Adaptation of wetland plants, plants on serpentine soil, phytoremediation, metallophyes, geobotany, cavernicolous life
iv. Air, water, soil and radioactive pollution sources, consequences and effect on biodiversity, different control measures
v. Global environmental issues – global warming, green-house effect and Goldilock's phenomenon, degradation mechanism, Montreal and Kyoto protocol, modern technology and environment, dams and rivers, climatic changes, population explosion, sustainable development, the Great Flood in old literatures, environmental impact assessment and PAP
vi. Biodiversity – type, causes of decline and extinction, bio-invasion and Blitzkrieg hypothesis, Case study of Dodo and Martha; importance of biodiversity, conservation, MA/b, key stone species and umbrella species, biodiversity and ecosystem stability, hotspots, Brazilian rain forest and Chico Mendes, Earth summit
vii. Population, statistics, data, mean, median, mode, SD, co-efficient of correlation, regression, ANOVA, probability, $\chi 2$ test, T test, F test, construction of dendrograms

COURSE OUTCOMES

- Understand the parameters and regulations related to pollution, the concept of ecological communities, their structure, species dominance, and dynamics such as fluctuations and succession.
- Explain the interaction between the environment and living organisms, including the concepts of habitat and niche.
- Understand phytoremediation techniques and the role of metallophytes in soil remediation.
- Explore various control measures to mitigate pollution and their effectiveness.
- Understand the importance of sustainable development and methods for environmental impact assessment.
- Explain the concepts of bio-invasion, keystone species, and umbrella species.
- Apply statistical tests such as ANOVA, chi-square test, t-test, and F-test in analyzing ecological data.

These outcomes aim to provide a comprehensive understanding of environmental science, pollution, biodiversity, and statistical methods used in ecological research and management.

PRACTICAL CORE COURSES

DBOT-CP-304: Plant Physiology

Course content

i. Determination of osmotic pressure of an integrated plant tissue
ii. Extraction and estimation of total chlorophyll from leaves of different chronological ages
iii. Effect of uncoupler and inhibitor on the rate of photosynthesis
iv. Determination of the effect of respiratory inhibitor on the rate of respiration
v. Study of leaf pigments by filter-paper chromatography
vi. Study and separation of leaf anthocyanin by thin layer chromatography
vii. Experiments on bioassay of IAA and kinetin
viii. Effect of plant hormone on water uptake
ix. Effect of heavy metal on seed germination
x. Photomorphogenetc effect of light on the development of seedling

COURSE OUTCOMES

Students will have the knowledge about the extraction and estimation of total chlorophyll pigment from the leaves of different ages, determining the effect of inhibitor on rate of photosynthesis and respiration.

They will also learn to separate the leaf pigments by different chromatographic techniques and also the effect of heavy metal and day length on seed germination and development of seedling.

DBOT-CP-305: Plant Biochemistry

i. Preparation of standard curve of a known protein (BSA) and estimation of an unknown protein by Lowry's method.
ii. Extraction and estimation of peroxidase from plant sample.
iii. Extraction and estimation of free amino acid from plant sample.
iv. Extraction and estimation of IAA-oxidase from plant sample.
v. Extraction and estimation of nitrate reductase from plant sample.
vi. Extraction and estimation of amylase from plant sample.
vii. Extraction and estimation of Ascorbic acid from plant sample.
viii. Extraction and estimation of Phenols from plant sample.
ix. Extraction of phosphorous using K2HP4 standard curve.
x. Extraction and estimation of titrable acids in plant sample.

COURSE OUTCOMES

- Understand the principles of the Lowry protein assay and its application in protein quantification.
- Understand the principles of amino acid extraction and estimation techniques.
- Interpret the results to determine the activity level of IAA-oxidase in the plant sample.
- Understand the principles of nitrate reductase extraction and estimation.
- Interpret the results to determine the activity level of amylase in the plant sample.
- Understand the principles of extraction and estimation of ascorbic acid.
- Interpret the results to determine the concentration of phenolic compounds in the plant sample.
- Understand the principles of phosphorus extraction and estimation.
- Interpret the results to determine the acidity level of the plant sample.
- These outcomes provide students with practical skills in biochemical analysis and laboratory techniques commonly used in plant biology research and agricultural sciences.

DBOT-CP-306: Ecology and Biostatistics

i. Determination of frequency, density and abundance in field by quadrat method or from a given data set
ii. Determination of soil pH, soil texture, moisture content and soil humus of a supplied sample
iii. Quantitative estimation of dissolved oxygen and carbon dioxide of supplied water sample
iv. Determination of SD, co-efficient of correlation, regression, ANOVA, $\chi 2$ test, T test, F test
v. Construction of dendrograms with the help of software

COURSE OUTCOMES

- Understand the quadrat method for sampling plant populations and learn to calculate the frequency, density, and abundance of plant species in a given area.
- Master the techniques for measuring soil pH, texture, moisture content, and humus content.
- Interpret water quality data to assess the health of aquatic environments.
- Interpret statistical results to draw conclusions and make recommendations based on ecological data.
- Learn to use software tools for constructing dendrograms to analyze ecological data.

SEMESTER IV

THEORETICAL CORE COURSES

DBOT-CT-401: Biophysics & Instrumentation in Biological Analysis

i. Physico-chemical properties of water; ionic product of water, pH, buffers, ampholytes, surface tension, viscosity, application of biomolecules.
ii. **Microscopy:** General principles and applications of compound microscopy, light microscope, bright field and dark field microscope, phase contrast microscope, fluorescent microscope, electron microscope, atomic force microscope.
iii. **Spectrophotometry**: Principle of colorimetry, visible, UV, IR, atomic absorption spectrophotometry.
iv. **Centrifugation:** Basic principles, fluorometry centrifugation.
v. **Radiobiology:** Law of radioactivity, radioactive carbon dating, application of radioactive isotopes in biological system.
vi. **Chromatography:** Basic principles and application of thin layer chromatograpy, gas liquid chromatography, HPLC, mass spectrometry.
vii. Protein immunoblotting, RIA, ELISA.
viii. Bio-electricity and bio-photons, rudimentary nervous mechanism in plants.
ix. Analysis of biomolecules by mass spectrometry and NMR.

COURSE OUTCOMES

- Understand the ionic product of water and its significance in chemical reactions.
- Apply the knowledge of water properties to understand the behavior of biomolecules in aqueous environments.
- Understand the principles underlying different types of microscopes including compound, light, bright field, dark field, phase contrast, fluorescent, electron, and atomic force microscopes.
- Explain the principles of colorimetry and its application in quantifying the concentration of colored compounds.
- Understand the principles of UV, visible, IR, and atomic absorption spectrophotometry.
- Understand the basic principles of centrifugation and its applications in separating particles based on size, density, and shape.
- Understand the basic principles of chromatography techniques including thin layer chromatography, gas-liquid chromatography, high-performance liquid chromatography (HPLC), and mass spectrometry.
- Understand the principles of protein immunoblotting, radioimmunoassay (RIA), and enzyme-linked immunosorbent assay (ELISA).
- Understand the principles of mass spectrometry and nuclear magnetic resonance (NMR) spectroscopy.
- These outcomes provide students with a comprehensive understanding of advanced laboratory techniques and instrumentation used in biochemistry, molecular biology, and biophysics research.

DBOT-CT-402: Environmental Biology

i. An introduction to environmental biology; ecosystem functions: energy flow and biogeochemical cycles.
ii. Pollutants and contaminants, photochemical smog, PAN, heavy metal stress, serpentine soil and plants there on, phytoremediation, metallophytes and geobotany, microbial clean up of oil spill on ocean surface, BOD, COD, NOD, SOD, degradation of pesticides by microbes, solid

waste management; electronic waste (e waste), sources and types, impacts, recycling and management.

iii. Environmental toxicology, LD50, case study of some pollution events: Bhopal disaster, Chernobyl, Three miles island, Itaiitai or ouch-ouch, Minamata, London smog, acid mine drainage, DDT disaster, thalidomide and teratogeny.

iv. El Nino and La Nina.

v. Environmental law and policies, environmental ethics, environmental economics.

vi. Impact of man-plant relationship on environment; aforestation, deforestation, reforestation, agroforestry and social forestry.

vii. Environmental Biotechnology: concept of waste management, biodegradation of xenobiotics and hydrocarbons, vermicomposting, farmyard manure, production and utilization of biofuels, biofertilizers and biopesticides.

viii. Useful statistics in Environmental Biology: Mean, median, mode, SD, co-efficient of correlation, regression, ANOVA, probability, $\chi 2$ test, T test, F test, construction of dendrograms.

COURSE OUTCOMES

- Understand the basic principles of environmental biology and the importance of ecosystems.
- Explain the processes of energy flow and biogeochemical cycles within ecosystems.
- Understand the impacts of pollutants on environmental health and ecosystems.
- Understand the mechanisms driving these phenomena and their impacts on weather, agriculture, and ecosystems.
- Understand the principles of environmental law and policies at national and international levels.
- Understand the economic implications of environmental degradation and the concept of sustainable development.
- Understand the principles and practices of sustainable forestry and land management.
- Understand the concept of waste management and the role of biotechnology in environmental remediation.
- Understand the principles of statistical analysis and their application in environmental biology.
- Apply statistical techniques to analyze environmental data and draw meaningful conclusions. These outcomes provide students with a comprehensive understanding of environmental biology, including the principles of ecosystem dynamics, pollution control, environmental law and policy, and the application of biotechnology in environmental management.

DBOT-CT-403A: Cytogenetics

i. Structural and functional genomics

ii. Cell cycles and cell signaling

iii. The techniques of Molecular Genetics: an overview of molecular genetic techniques, Southern- Northern-Western blot hybridisation, PCR, PAGE, FACS, TEM and SEM. Major plant genetic marker for crop improvement – AFLP, RFLP, RAPD, SSR, STS, EST, SNPs etc.

iv. Molecular concept of gene, regulation of gene expression in prokaryotes and eukaryotes

v. Gene silencing, DNA methylation and imprinting, gene amplification, Dosage compensation, Homeotic genes

vi. Tools of DNA technology-restriction enzymes, Vectors: plasmid, bacteriophage, other viral vectors, cosmid, phage M13, Ti plasmid, YAC, BAC, HAC, MAC etc. cDNA and gDNA library

COURSE OUTCOMES

i. Understand the structure and organization of genomes in different organisms and comprehend the relationship between genome structure and function.

ii. Describe the phases of the cell cycle and the regulatory mechanisms involved.

iii. Understand the principles and applications of each technique in molecular biology research.
iv. Grasp fundamental concepts underlying genetic control and cellular differentiation.
v. Explore potential applications of epigenetic manipulation in medicine and agriculture.
vi. Learn the principles and applications of cloning, gene libraries, and genetic engineering.

These units cover a broad spectrum of topics in molecular genetics, providing a comprehensive understanding of this field.

DBOT-CT-403B: Microbiology

i. General account: mycoplasma; gliding bacteria; actinomycetes
ii. Growth and growth control; counting viable but non-culturable prokaryotes; Quorum sensing; growth control by physical exclusion, heat, radiation and chemicals
iii. Microbial metabolism: Bacterial photosynthesis, respiration, fermentation
iv. Virus: Classification; principles of viral taxonomy; Purification and Assay of viruses; Lytic cycle and lysogeny
v. Extremophilic microorganisms: Characteristic of archaebacteria, thermophiles, halophiles, barophiles
vi. Water microbiology: Microbial load in water, examination of water quality, purification techniques
vii. Dairy microbiology: types and sources of microorganisms in milk, preservation techniques, role of microorganisms in production of different milk products
viii. Soil microbiology: Soil environment; soil microorganisms and interaction among them, role of microbes in biochemical transformations of nitrogen, phosphorous, carbon, sulphur compounds, PGPR, Plant-microbe interaction
ix. Human microbiome: Commensal microbiota of human body, interaction with the host; impact of gut microbiota in human body

COURSE OUTCOMES

- Knowledge on some primitive microorganisms and characters.
- knowledge about how growth occur in different environmental condition
- Knowledge about bacteria produce its food.
- Knowledge about virus, it's classification and how its reproduces.
- Knowledge about microorganisms growing in different environmental conditions.
- Knowledge about microbial contamination of water and how to purify water.
- Knowledge about different microbial diversity in milk and different microorganisms involved in production of different milk products.
- Knowledge about function of different microorganisms in different biogeochemical cycles.
- Knowledge about how different microbes interacts with human body.

DBOT-CT-403C: Mycology and Plant Pathology

i. Physiology and Biochemistry of fungi: Nutritive uptake, sensing and translocation; fungal growth; metabolism of fungi, secondary metabolites
ii. Cell Biology and Genetics of Fungi: Cell components of fungi; fungal cell division; chromosome theory, chromosome mapping; Parasexual cycle; gene as functional unit; the fine structure of genes; mechanism of genetics exchange, heterothallism; genetics of sporulation; extra cellular inheritance
iii. Molecular biology: yeast genome; the two micron circle; yeast cell cycle and its regulation; molecular biology of yeast killer system
iv. Applied mycoses: mycotoxins; mushroom cultivation, nutritional and medicinal importance, Industrial production of citric acid, alcohol, antibiotics, enzymes (amylase, cellulase and pectinase)
v. Plant disease epidemiology
vi. Genetics of plant disease

COURSE OUTCOMES

- Knowledge on how fungi survive and develop different metabolites. Also come to know about uses of fungal metabolites for human use.
- Knowledge about genetics of fungi and how inheritance occur in fungi.
- Knowledge about genetic makeup of type fungal specimen yeast and its unique molecular characters.
- Knowledge about application of fungi in human welfare.
- Knowledge how fungi cause damages and its impact on society and its possible prediction.
- Knowledge about how disease develop in plants and how some plants are resistant.

DBOT-CT-403D: Phycology

i. Prochlorophyta and Glaucophyta – General characteristics and phylogenetic importance.
ii. Cyanobacteria in geothermal habitat: Geographic distribution, distribution determination by lipbiomarker and 16s rRNA.
iii. Heterokontophyta – Different classes and phylogenetic significance of each group.
iv. Chlorophyta – Different classes and phylogenetic significance of each group.
v. Distribution of algal genera in the ocean with particular emphasis on the Indian Continent.

COURSE OUTCOMES

- Understanding the general characteristics of Prochlorophyta and Glaucophyta provides insights into the diversity of photosynthetic organisms and their evolutionary significance.
- Understanding distribution determination methods using lip biomarkers and 16S rRNA sequencing enhances knowledge of microbial ecology and biogeochemical cycling in extreme environments.
- Exploring the ecological roles and adaptations of heterokonts informs understanding of their ecological importance in aquatic ecosystems.
- Learning about different classes of Chlorophyta and their phylogenetic significance provides insights into the diversity and evolutionary history of green algae.
- Understanding the factors influencing algal distribution informs conservation efforts and management strategies for marine ecosystems.

DBOT-CT-403E: Plant Biochemistry & Molecular Biology

i. **Protein biochemistry:** Transcription and post-translational modifications, translation, protein targeting and characterization.
ii. **Amino acids metabolism:** Biosynthesis of aspartic and aromatic amino acids families.
iii. **Brassinosteroids**: structure, occurrence, biosynthesis, metabolism and effect on growth and development.
iv. **Sulphate metabolism**: chemistry, uptake and transport, assimilation pathway.
v. **Alkaloids:** chemistry, classification, biosynthesis, industrial application.
vi. **Protein sorting and vesicle traffic:** machinery of protein sorting, targeting to mitochondria, plastids, Peroxisomes, ER, vacuole, protein modification in Golgi apparatus.
vii. RNAi and antisense RNA technology.
viii. **Enzymes:** Purification of enzymes, enzyme immobilization, allosteric enzymes, multi-substrate reactions.

COURSE OUTCOMES

- Understand the processes of transcription and translation in gene expression.
- Understand the regulation of amino acid metabolism in response to cellular demands.
- Understand the chemistry, uptake, and transport of sulfate in plants.
- Describe the assimilation pathway of sulfate into organic sulfur compounds.
- Discuss the industrial applications of alkaloids in pharmaceuticals, agriculture, and other industries.
- Understand the machinery of protein sorting in eukaryotic cells.
- Understand the principles of RNA interference (RNAi) and antisense RNA technology.
- Understand the regulatory mechanisms of allosteric enzymes.
- These outcomes provide students with a comprehensive understanding of protein biochemistry, amino acid metabolism, plant hormones, sulfur metabolism, alkaloids, intracellular protein trafficking, RNA technologies, and enzyme biochemistry.

DBOT-CT-403F: Plant Physiology and Biochemistry

i. Plant pigments: Types biosynthesis and degradation
ii. Nitrogen fixation: Nitrogen fixation and assimilation, components of nitrogenase, urea cycle, genetic engineering of nitrogenase gene cluster and nodulation genes
iii. Stress physiology: abiotic and biotic stress, role of amino acids and polyamines in stress tolerance
iv. Fruit ripening: Biochemistry and molecular basis
v. Signal transduction: signaling pathways, chemical signals and cellular receptors
vi. Translocation in phloem: pathways, pattern of pressure flow model for phloem transport, phloemloading
vii. Blue light response-stomatal movements and morphogenesis
viii. Crop physiology: new ideotypes, physiological basis of crops, economic index, and harvest index
ix. Molecular physiology of mineral nutrients – mechanism and regulation or K^+ transport, phosphorous nutrition and transport, plant responses of mineral toxicity
x. Protein biochemistry: transcriptional and post-transcriptional modifications, translation, proteintargeting and characterization

COURSE OUTCOMES

- Students will learn about different kinds of plant pigment its biosynthesis and degradation.
- Students will learn about how atmospheric nitrogen is fixed by the plants
- They will learn about kinds of stress in plants and the mechanisms of combating the stress.
- They will learn about the process of fruit ripening in plants.
- They will learn the mechanism of signal transduction in plants.
- Students will learn about translocation in phloem: pathways, pattern of pressure flow model for phloem transport, phloem loading and unloading.
- Students will learn about the various kinds of plant responses to blue light.
- They will learn about the basics of crop physiology.
- Students will gain knowledge about mechanism and regulation or K^+ transport, phosphorous nutrition and transport, plant responses of mineral toxicity.
- They will learn about protein biochemistry including transcriptional and post transcriptional modification and translation.

DBOT-CT-403G: Taxonomy of angiosperms and Ecology

i. History of Indian Plant Taxonomy
ii. Pre-Darwinian and Post-Darwinian systems of classification:

iii. ICBN and other codes
iv. Molecular systematic, molecular clock, cladistics and numerical taxonomy
v. Taxonomic Literature, keys, methods of identification, nomenclatural problems
vi. Species concept, evolutionary terms of terms
vii. Biosystermatics:
viii. Origin, evolution of diversity and phylogeny of angiosperms, cradle of angiosperms
ix. Application of palynology as tool
x. Bioelectromagnetosystematics:
xi. Analysis of data

COURSE OUTCOMES

- Students will know the basic history of Indian plant taxonomy
- Historical background and basic featyres of classification of Takhtajan, Cronquist, Dahlgren, Thorne and APG system of classification
- Students will know different aspects of nomenclatural codes, their application, nomenclature of cultivated and hybrid plants
- They will learn about Molecular systematic, molecular clock, cladistics and numerical taxonomy
- To know Taxonomic Literature, keys, methods of identification, nomenclatural problems
- Will learn different concept of species and different evolutionary terms- homology, analogy, plesiomorphy, apomorphy, symplesiomorphy, synapomorphy, anagensis, cladogenesis, stasigenesis
- Importance, categories and major areas of biosystematics and its prospects,
- Genecology, interaction between genes and environment, genetic barrier, phenotypic plasticity, speciation, heterobathmy etc
- Application of palynology as taxonomic tool
- Will know Bioelectro-magne-tosystematics as a new tool in taxonomy
- Analysis of taxonomic data using software, construction of Dendrograms

DBOT-CT-404A: Cytogenetics

i. Somatic embryogenesis, somaclonal variation – application in crop improvement, synthetic seeds, haploid production – its applications, Protoplast culture-fusion somatic hybridisation and application of protoplast technology
ii. Biotechnological approaches to the expression of foreign genes in plants Agrobacterium tumefaciens a natural tools for plant transformation. Updated molecular mechanism for T-DNA transfer to plant cell by Ti-plasmid
iii. Genetically Modified Organisms (GMOs)
iv. Biodiversity and Intellectual Property Rights (IPR)
v. An overview of the general approaches of structural and functional proteomics, Evolution of genetic code and evolution of protein synthesis
vi. Embryonic stem cell technology

COURSE OUTCOMES

- Understand the principles and techniques of somatic embryogenesis and somaclonal variation and explain the applications of these techniques in crop improvement and the production of synthetic seeds.
- Describe biotechnological methods for expressing foreign genes in plants, including the use of Agrobacterium tumefaciens.
- Evaluate the benefits and risks associated with the use of GMOs in food production and environmental management.
- Understand the principles of intellectual property rights (IPR) and their implications for

biodiversity conservation, bioprospecting, and commercialization of genetic resources.
- Provide an overview of the general approaches used in structural and functional proteomics research.
- Explore the ethical, legal, and social implications of embryonic stem cell research and its potential therapeutic applications.

These curriculum outcomes aim to provide students with a comprehensive understanding of biotechnological techniques, their applications in agriculture and medicine, and the ethical and societal issues associated with their use.

DBOT-CT-404B: Microbiology

i. **Industrial microbiology:** Fermentation technology, Bioreactors; Strain development, Production of antibiotics (penicillin & streptomycin), organic acid (citric & acetic acid), enzymes (amylase, protease & lipase), insulin, biotrasformation of steroids, commercial production of biofertilizer
ii. **Antibiotics:** Sources, chemistry, biosynthesis and mechanism of action; probiotics; prebiotics; symbiotics
iii. **Genetics:** Genetic code – its nature and deciphering; transcription, post-translational RNA processing, translation, operon (Lac operon & Trp operon)
iv. **Genetic Engineering:** Splicing of DNA; insertion of DNA into vector; detection of recombinant molecules; PCR and its applications; expression of cloned genes
v. Role of plasmids and bacterophages as cloning vectors; resistance plasmids; cosmids
vi. **Immunology:** Antigens, immunoglbulins; antigen presentation; monoclonal antibodies; complement fixation, interleukin, immunodiagnosis; immunological techniques; development of vaccines; interferons – characteristics, production, chemical induction, regulation of production, mode of application
vii. Biodegradation of xenobiotics; degradativbe genes in the environment; genetically engineered microbes for biodegradation; biosurfactants; biopesticides
viii. **Microbiology of bio-energy production:** substrate digestor, production of biogas, biodesel, biohydrogen

COURSE OUTCOMES

- Knowledge about use of microorganisms in production of different products for human utilizations.
- Knowledge about uses of different types of microorganisms for production of different antibiotics.
- Knowledge about different molecular techniques occurring in microbes.
- Knowledge about use of microorganisms in different molecular techniques.
- Knowledge about use of microbes in genetic engineering.
- Knowledge about different immunological techniques.
- Knowledge about use of microbes in degradation of heavy metals.
- Knowledge about use of microbes in biogas production.

DBOT-CT-404C: Mycology and plant Pathology

i. Modern concept of plant immunity and mechanisms of plant defence signalling
ii. Biotechnological approaches for the viral disese management
iii. Phytopathogenic bacterial plasmids and their genetic engineering
iv. Molecular biology of plant pathogen interaction
v. Avirulent gene for crop disease management
vi. Molecular biological techniques for disease management

COURSE OUTCOMES

- Knowledge about how plants develop different strategies to protect themselves from pathogen

attack.

- Knowledge about new approaches to protect plants from viral attack.
- Knowledge about how a pathogen plasmid be modified and used in development of transgenic plants.
- Knowledge about how a pathogen infect a host plant and different events occur to develop disease.
- Knowledge about use of genes from pathogen in disease management.
- Knowledge about recent technique in disease management.

DBOT-CT-404D: Phycology

i. Palaeobotanical study and role of Algae in the Petroleum industry
ii. Algal light-harvesting complex: phycobiliproteins, constructing ore and rod elements of PBS, linkerpolypeptide, chromatic adaptation, structure and regulation of light harvesting genes
iii. Basic culturing techniques and mass cultivation: Biological principles, types of reactors for phototrophic algae, downstream processing of cell mass production, heterotrophic production of marine algae for aquaculture
iv. Role of algae in wetland ecology; Phytoplankton community – structure and function; water pollution, phytoremediation, Algal bloom, Red tides, Algae as ecological indicator and secondary metabolite production from algae
v. Environmental stress physiology:
a. Ecotoxicology of inorganic chemical stress on algae
b. Photoacclimation
c. Photo-inhibition and culture productivity
d. Salinity stress

COURSE OUTCOMES

- Exploring the knowledge about the ancient algal life and contribution to fossil fuel formation and extraction processes, highlighting their significance in energy production.
- Understanding of algal photosynthesis mechanisms and gaining knowledge that can inform bioengineering efforts to enhance algae-based biotechnological applications.
- Learning biological principles and culturing techniques for algae cultivation facilitates large-scale production for various applications.
- Understanding phytoplankton community structure and function informs conservation and management strategies, addressing water pollution, harmful algal blooms, and ecological indicators.
- Investigating the effects of inorganic chemical stress, and salinity stress on algae enhances understanding of environmental pollution impacts on aquatic ecosystems and algal community dynamics.
- Analyzing these topics equips students with a comprehensive understanding of algae biology, ecology, and biotechnological applications, addressing challenges and opportunities in energy production, environmental conservation, and sustainable development.

DBOT-CT-404E: Plant Biochemistry & Molecular Biology

i. DNA replication, role of topoisomerase, DNA repair.
ii. **Plant Molecular biology:** Restriction Endonucleases and cloning vectors, construction of cDNA and genomic libraries, identification of specific clones, DNA sequencing.
iii. Molecular concept of gene, gene duplication and pseudogenes.
iv. Regulation of gene expression in plants: plant gene structure and expression, regulatory mechanisms, control of transcription, post-transcriptional control of gene expression.
v. DNA manipulation and alien gene transfer and application of recombinant DNA technology.
vi. **Polymerase chain reaction:** PCR; types and application.

COURSE OUTCOMES

- Understand the process of DNA replication and its significance in cell division and inheritance.
- Understand the construction of cloning vectors and their use in recombinant DNA technology.
- Understand the molecular structure of genes and the concept of gene duplication.
- Understand the mechanisms of transcriptional regulation in plants, including transcription factors and enhancers.
- Understand the principles of DNA manipulation and the techniques of gene cloning and recombinant DNA technology.
- Understand the principles and steps involved in PCR amplification.
- These outcomes provide students with a comprehensive understanding of DNA replication, molecular biology techniques, gene regulation in plants, recombinant DNA technology, and PCR, preparing them for research and applications in plant biotechnology and genetics.

DBOT-CT-404F: Plant Physiology and Biochemistry

i. Amino acid metabolism: biosynthesis of aspartic acid and aromatic amino acid families
ii. Brassinosteroids – structure, occurrence, biosynthesis, metabolism and effect on growth anddevelopment
iii. Sulphate metabolism – chemistry, uptake and transport, assimilation pathway
iv. Alkaloids – chemistry, classification, biosynthesis, industrial application
v. Protein sorting and vesicle traffic: machinery of protein sorting, targeting to mitochondria, plastids, peroxisomes, ER, vacuole, protein modification in Golgi apparatus
vi. RNAi and antisense RNA technology
vii. Enzymes: Purification of enzymes, enzyme immobilisation, alllosteric enzymes, multi-substratereactions
viii. DNA replication, role of topoisomerase, DNA repair
ix. Plant Molecular biology: Restriction endonuclease and cloning vectors, construction of cDNAand genomic libraries, identification of specific clones, DNA sequencing

COURSE OUTCOMES

- Students will learn about the details of amino acid metabolism in plants.
- Students will learn about what Brassinosteriods are -its structure, occurrence and biosynthesis in plants.
- Students will learn the importance of sulphur in plants and its process of uptake and how it is assimilated in the plants.
- Students will learn about what are plant alkaloids and its application.
- Studenst will learn in details about protein sorting and how does the process of protein sorting take place in the cell.
- They will learn about the RNA interference technology and its application.
- They will learn about plant enzymes and how it is purified along with its immobilization.
- Students will learn about DNA replication in plants, role of topoisomers and DNA repair.
- Students will get a detailed knowledge of molecular plant biology.

DBOT-CT-404G: Taxonomy of angiosperms and Ecology

i. Phytogeography and floristic regions of India and World
ii. Biosphere II, origin of life and evolution
iii. Natural selection, mechanism of speciation and extinctions
iv. IUCN, Red List criteria, CITES, endemism and exotic flora of India, Ramsar sites
v. Ecological issues in India

vi. Environmental Biotechnology:
vii. Molecular and adaptive variation: hitch-hiking of gene, phylogeography and conservation genetics; role of NBPGR in conservation of Indian biodiversity
viii. Functional Genomics
ix. Remote sensing for study of ecosystem

COURSE OUTCOMES

After completion of these module students will learn:

i. Phytogeographic zones and floristic regions of India and World, megadiversity countries and conservation hotspot, major biomes of the world
ii. Biosphere II, planetary ecosystem and planetary engineering – biopoiesis and ecopoiesis, case study of a hypothetical planetary engineering project: terraformation on Mars, origin of life and evolution: Darwinism, Gaia and Red Queen hypothesis
iii. Natural selection and related concepts, mechanism of speciation and extinctions, Hardy-Weinberg Genetic Equilibrium, genetic polymorphism and selection, allele fixation, bottle neck, founder principle
iv. Different national and international bodies related to conservation- IUCN, Red List criteria, CITES, endemism and exotic flora of India, Ramsar sites
v. Case study of some ecological issues in India: Himalayan problems, desertification in India, salinity increase and decline of sundari tree in Sunderbans, Chipko movement, ecological and environmental problems leading to decline of Indus valley civilization, Narmada banchaoandolon, arsenic problem in drinking water, etc
vi. Concept of Environmental Biotechnology: waste management, biodegradation of xenobiotics and hydrocarbons, vermicomposting, farmyard manure, production and utilization of biofuels, biofertilizers and biopesticides
vii. Molecular and adaptive variation: hitch-hiking of gene, phylogeography and conservation genetics; role of NBPGR in conservation of Indian biodiversity
viii. Functional Genomics to study taxonomic and ecological variation -- approaches to analyze differential expression of genes - ESTs, SAGE, microarrays and their applications; principles in reverse genetics: gene tagging; gene trapping; gene silencing; knockout mutants; transcriptome; ribotype concept; concept, methodology and applications of proteomics
ix. concept of Remote sensing and its importance for study of ecosystem

PRCTICAL CORE COURSES

DBOT-CP-405A: Cytogenetics

i. Study of plant chromosome, chromosome staining schedule, chromosome staining by fluorescence dye, differential staining of euchromatin and heterochromatin
ii. Differential in-situ staining of DNA and RNA of plant cells
iii. Isolation of plant genomic DNA and RNA from plant tissues and Quantification by spectrophotometric method
iv. Separation of DNA and RNA on agarose gel electrophoresis and visualization by ethidium bromide staining
v. Digestion of genomic DNA with restriction enzymes
vi. PAGE and SDS-PAGE of plant proteins and chloroplast protein profile
vii. Anther-Pollen culture from tobacco and plant regeneration from embryo
viii. Isolation and culture of plant protoplast and its viability test
ix. Amplification of DNA by PCR
x. Study of plant genetic marker such as isozyme marker.

COURSE OUTCOMES

- Learn the techniques for chromosome staining using fluorescence dyes.
- Master the techniques for differential staining of DNA and RNA in plant cells.
- Learn protocols for isolating genomic DNA and RNA from plant tissues.
- Acquire skills in agarose gel electrophoresis for separating DNA and RNA fragments.
- Learn protocols for anther-pollen culture and plant regeneration from embryos.
- Understand the components and steps involved in PCR amplification.

These outcomes aim to equip students with practical skills and theoretical knowledge in plant genetics, molecular biology, and biotechnology, essential for research and applications in plant science and crop improvement.

DBOT-CP-405B: Microbiology

i. Study of physiological and biochemical activities of bacteria (hydrolysis of starch, lipid, protein and urea: degradation of cellulose and pectin; catalase activity; nitrate reduction, IMVIC reaction, liquefaction of gelatin, oxidation and fermentation of carbohydrates
ii. Microbial growth kinetics
iii. Chemical estimation of sugar by DNS method
iv. Separation and identification of amino acids/sugars by paper/thin layer chromatographic method
v. Effect of substrate concentration and temperature on enzyme activity
vi. PAGE separation of microbial proteins
vii. Agarose gel separation of prokaryotic DNA
viii. Bacteriological examination of water using multiple tube fermentation/membrane filtration method
ix. Enumeration of bacteriophage from environmental samples
x. Enrichment and isolation of photosynthetic, endospore forming, phosphate solubilising, sulphur oxidising, ammonifying, nitrogen fixing bacteria
xi. Isolation of antibiotic resistant mutants
xii. Isolation of antibiotic producers from soil
xiii. Estimation of microbial biomass carbon by chloroform fumigation incubation method
xiv. Isolation of Rhizobia from root nodules and Azotobacter, determination of their PGPR ability
xv. Isolation and characterization of pesticide degrading microorganisms from soil

COURSE OUTCOMES

- Knowledge about identification of different biochemical methods occurring in bacteria and presence of different bacteria in water.
- Knowledge about identification of environmental friendly microbes from environment.

DBOT-CP-405C: Mycology and plant Pathology

i. Growth curve and sporulation of yeast
ii. Fermentation of citric acid and alcohol
iii. Antifungal antibiotic sensitivity test
iv. Quantitative estimation of protein, carbohydrate, amino acid, fat, DNA, RNA from fungi
v. TLC and paper chromatography of amino acids
vi. Isolation DNA, RNA and plasmid from yeast
vii. Agarose gel electrophoresis of DNA, RNA and Plasmid
viii. PAGE of proteins
ix. Koch's postulate
x. Enzyme assay of cellulose and pectinase
xi. *In vitro* antagonism study by bio-control agents

COURSE OUTCOMES

Knowledge about different techniques in general used by modern scientists for identification and control of pathogens in recent era.

DBOT-CP-405D: Phycology

i. Survey on algal groups of different ecological niches of the surrounding locality.
ii. Chromosomal study of Algae.
iii. Study of different biochemical parameters (dissolved O_2, dissolved CO_2, pH, temperature, andsalinity in relation to different algal genera.
iv. Culture and maintenance of algae in laboratory conditions.
v. Study of algal flora in a permanent habitat.
vi. Study of cyanobacteria flora in rice fields.
vii. Standardization of extraction procedure of algal DNA.
viii. Chemical study of algal extracts in water ecosystem.

COURSE OUTCOMES

- Identification and documentation of algal diversity in local ecosystems, providing valuable data for ecological research, conservation efforts, and environmental monitoring.
- investigations of algal genome structure and organization, contributing to our understanding of genetic diversity, and evolution.
- Correlation of biochemical parameters with algal genera, providing insights into their physiological adaptations and ecological preferences, aiding in environmental assessment and management.
- Establishment and maintenance of algal cultures for research purposes, enabling experimentation on algal physiology, biochemistry, and biotechnological applications.
- Long-term monitoring and documentation of algal communities in a specific habitat, contributing to ecological research, and conservation planning.
- cyanobacteria in rice fields provide insights into their roles in nutrient cycling, soil fertility, and sustainable agriculture practices.
- Development of a standardized protocol for extracting DNA from algae, facilitating genetic studies, and molecular phylogenetics.
- Analysis of algal metabolites and their ecological significance in water ecosystems, providing insights into ecosystem health, biogeochemical cycling, and potential applications in pharmaceuticals, bioremediation, and biofuels.

DBOT-CP-405E: Plant Biochemistry & Molecular Biology

i. Effect of time and enzyme concentration on rate of reaction of enzyme, substrate concentration and Km value.
ii. Extraction and estimation of plant carbohydrate by Anthrone method.
iii. Extraction of plant protein and its estimation by Lowry's method and Bradford's method.
iv. Separation of isozymes of peroxidise by native–PAGE.
v. SDS-PAGE of soluble proteins extracted from plant material.
vi. Fractionation of protein by gel-filtration chromatography.
vii. Fraction of protein by ion exchange chromatography.
viii. Extraction and estimation of nucleic acids from plant material.
ix. Extraction and estimation of oil form fatty seeds.
x. Determination of saponification and iodine value of fat sample.
xi. Estimation of DNA and RNA.
xii. Extraction of genomic DNA and RNA from plants.

xiii. Isolation of gene (npt gene from PUC7KAPA with *Bam* H1).
xiv. Transformation of *E. coli*–DH5 with pUC19.
xv. Isolation of plasmid from the selected transformants by miniprep method.

COURSE OUTCOMES

- Understand the principles of enzyme kinetics and the factors affecting enzyme activity.
- Understand the principles of protein extraction and quantification using Lowry's and Bradford's methods.
- Understand the principles of polyacrylamide gel electrophoresis (PAGE) and its application in separating proteins based on charge and size under native conditions.
- Understand the principles of gel-filtration chromatography and its application in separating proteins based on size.
- Understand the principles of nucleic acid extraction and quantification.
- Understand the principles of saponification value and iodine value determination for fats and oils.
- Understand the principles of DNA and RNA quantification using spectrophotometric analysis.
- Understand the principles of gene isolation using restriction enzymes and plasmid vectors.
- Understand the principles of bacterial transformation and selection using plasmid vectors.
- These outcomes provide students with practical skills in biochemical analysis, molecular biology techniques, and genetic manipulation, preparing them for research and applications in plant biology and biotechnology.

DBOT-CP-405F: Plant Physiology and Biochemistry

i. Extraction and estimation of plant carbohydrate by Anthrone method
ii. Extraction of chlorophyll pigments from leaves and estimation of chlorophyll and carotenoids
iii. Extraction and estimation of phenols by Bray and Thrope method
iv. Extraction and estimation of lipids from seeds
v. Extraction of estimation of plant protein from Lowry’s method
vi. Determination of Iodine value of fat sample
vii. Determination of saponification value from fat sample
viii. Estimation of water content and dry matter
ix. Estimation of free amino acids
x. Seed viability of different seeds using TTC test
xi. Separation of amino acids by thin layer chromatography
xii. Estimation of DNA and RNA
xiii. Qualitative analysis of DNA by Agarose GEL Electrophoresis

COURSE OUTCOMES

Students will learn

- The different methods for extraction and estimation of different compounds like carbohydrate protein lipids phenols chlorophyll amino acids pigments from different plant samples and also separation of sugars and amino acids by using the different chromatographic techniques
- Estimation of DNA and RNA from plant samples and Qualitative analysis of DNA by using the technique like gel electeophoresis.

DBOT-CP-405G: Taxonomy of angiosperms and Ecology

i. Seasonal collection of local flora, processing, herbarium management
ii. Study of phenology of some common weeds
iii. Study of seed, endosperm, embryo and seedling morphology, study of leaf diversity including venation and vein islets in relation to identification of different angiosperm species

iv. Work out of different angiospermic plants (fresh and dry), their identification using literature and preparation of artificial keys, study of the trend of floral evolution of some locally available plants following some specific biota
v. Determination of correct name of a species
vi. Construction of dendograms or phenograms
vii. Preparation of pollen slides, description of common palynomorphs, preparation of identification keys
viii. Study of Raunkier's life forms and biological spectrum in field or from a given data set
ix. Determination different biodiversity indices from a field or given data set (Shannon, Simpson, Brillouin, Peat, McIntosh, Association index, Similarity index, etc.)
x. Physico-chemical analysis of soil in relation to organic carbon and N, P, K profile
xi. Determination of BOD and COD of a given sample
xii. Study of noise pollution in a congested area with a sound level meter
xiii. Measurement of slope, elevation and tree height with Abney Level

COURSE OUTCOMES

- Seasonal collection, processing, preparation of herbarium management
- How to Study of phenology of some common weeds and their differet phenophages
- How to Study of seed, endosperm, embryo and seedling morphology, study of leaf diversity including venation and vein islets in relation to identification of different angiosperm species
- By working out of different angiospermic plants (both fresh and dry), their identification, and preparation of artificial keys, and ultimately, they will learn to trace the of floral evolution of some locally available plants following some specific biota
- How to Determine the correct name of a species
- Construction of dendograms or phenograms from a given data on character states with the help of software
- Preparation of pollen slides, description of common palynomorphs, preparation of identification keys
- Study of Raunkier's life forms and biological spectrum in field or from a given data set
- Determination different biodiversity indices from a field or given data set (Shannon, Simpson, Brillouin, Peat, McIntosh, Association index, Similarity index, etc.)
- Physico-chemical analysis of soil in relation to organic carbon and N, P, K profile
- Determination of BOD and COD of a given sample
- How to study level in a congested area with a sound level meter
- How to measure the slope, elevation and tree height with Abney Level