Course Structure
For
BOTANY (M. Sc.)

A Four Semesters Course (Under CBCS)

(With effect from 2020-2021 academic session)

COOCHBEHAR PANCHANAN BARMA UNIVERSITY

COOCH BEHAR - 736101
WEST BENGAL, INDIA

COOCH BEHAR PANCHANAN BARMA UNIVERSITY
M.Sc. (Botany) CURRICULUM

There will be four semesters. The Curriculum consists of 11 Core Courses (Core 1-11), 3 Discipline Centric Elective (DCE 1-3) Courses and 2 Generic Elective (GE 1-2) Courses. Each course is of 100 marks i.e., 5 credits.

SCHEME FOR CHOICE BASED CREDIT SYSTEM

Semester	CORE COURSE (11)	Discipline Centric Elective DCE (3)	Generic Elective GE (2)
I	Core-1 (5 credit)		
	Core-2 (5 credit)		
	Core-3 (5 credit)		
	Core-4 (5 credit)		
II	Core-5 (5 credit)		
	Core-6 (5 credit)		
	Core-7 (5 credit)		
	Core-8 (5 credit)		
III	Core-9 (5 credit)		GE-1 (5 credit)
	Core-10 (5 credit)		
	Core-11 (5 credit)		
IV		DCE-1 Special Paper I: (5 credit)	GE-2 (5 credit)
		DCE-2 Special Paper II: (5 credit)	
		DCE-3 Special Paper III: (5 credit)	

SEMESTER	COURSE OPTED	COURSE NAME	Credits
I	Core course-1	Algae, Bryophytes and Pteridophytes	5
	Core course-2	Gymnosperm, Paleobotany and Palynology	5
	Core Course-3	Taxonomy of angiosperms and Biosystematics	5
	Core Course-4	Laboratory Course I	5
II	Core course-5	Mycology and Plant Pathology; Lichenology	5
	Core Course-6	Microbiology and Microbial Biotechnology	5
	Core course-7	Cytology and Genetics	5
	Core Course-8	Laboratory Course II	5
III	Core course-9	Ecology, Evolution and Plant Resource Utilization and Ethnobotany	5
	Core Course-10	Phytochemistry, Advanced Anatomy and Pharmacognosy	5
	Core course-11	Plant Physiology and Metabolism; Developmental Biology	5
	GE-1	Advanced Laboratory Course III	5
IV	DCE-1	Cytogenetics and Molecular Biology/Microbiology/Plant Physiology and Biochemistry (one course from the cluster)	5
	DCE-2	Mycology and Plant Pathology/ Angiosperms and Biosystematics/ Ethnobiology and plant Resource Management (one course from the cluster)	5
	DCE-3	Laboratory Course IV (based on DCE-1 and DCE- 2 courses) and Project	5
	GE-2	Biotechnology/Bioinformatics/Biostatistics/Research Methodology(two courses from the cluster)	5
Total Credits			80

Semester wise distribution of Marks

SEMESTER – I							
Sl. No.	**Paper**	**Theory**	**Continuous evaluation**	**Attendance**	**Project**	**Total**	**Credit**
1.	**Core-1**	**75**	**20**	**05**	**-**	**100**	**05**
2.	**Core-2**	**75**	**20**	**05**	**-**	**100**	**05**
3.	**Core-3**	**75**	**20**	**05**	**-**	**100**	**05**
Sl. No.	**Paper**	**Practical**	**Continuous evaluation**	**Attendance**	**Project**	**Total**	**Credit**
4.	**Core-4**	**75**	**20**	**05**	**-**	**100**	**05**

SEMESTER – II							
Sl. No.	**Paper**	**Theory**	**Continuous evaluation**	**Attendance**	**Project**	**Total**	**Credit**
1.	**Core-5**	**75**	**20**	**05**	**-**	**100**	**05**
2.	**Core-6**	**75**	**20**	**05**	**-**	**100**	**05**
3.	**Core-7**	**75**	**20**	**05**	**-**	**100**	**05**
Sl. No.	**Paper**	**Practical**	**Continuous evaluation**	**Attendance**	**Project**	**Total**	**Credit**
4.	**Core-8**	**75**	**20**	**05**	**-**	**100**	**05**

SEMESTER – III							
Sl. No.	**Paper**	**Theory**	**Continuous evaluation**	**Attendance**	**Project**	**Total**	**Credit**
1.	**Core-9**	**75**	**20**	**05**	**-**	**100**	**05**
2.	**Core-10**	**75**	**20**	**05**	**-**	**100**	**05**
3.	**Core-11**	**75**	**20**	**05**	**-**	**100**	**05**
Sl. No.	**Paper**	**Practical**	**Continuous evaluation**	**Attendance**	**Project**	**Total**	**Credit**
4.	**GE-1**	**75**	**20**	**05**	**-**	**100**	**05**

SEMESTER – IV							
Sl. No.	**Paper**	**Theory**	**Continuous evaluation**	**Attendance**	**Project**	**Total**	**Credit**
1.	**DCE-1**	**75**	**20**	**05**	**-**	**100**	**05**
2.	**DCE-2**	**75**	**20**	**05**	**-**	**100**	**05**
Sl. No.	**Paper**	**Practical**	**Continuous evaluation**	**Attendance**	**Project**	**Total**	**Credit**
3.	**DCE-3**	**50**	**20**	**05**	**25**	**100**	**05**
4.	**GE-2**	**75**	**20**	**05**	**-**	**100**	**05**

SEMESTER-I

Course No. 101 – Algae, Bryophytes andPteridophytes

Phycology

1. Algae in diversified habitats: Terrestrial, fresh water and marine
2. Thallus organization,
3. Cell ultra structure
4. Reproduction
5. Criteria for classification: Pigments, Reserve foods and flagella
6. Salient features of major groups: Cyanophyta, Prochlorophyta, Chlorophyta,Bacillariophyta, Phaeophyta and Rhodophyta.
7. Economic importance: Algal blooms, Algal biofertilizers, Algae as food,feed and uses in industry.

Bryology

1. Salient features of major groups
2. Spore germination in liverworts and mosses
3. Alternative pathways in life cycles of bryophytes
4. Bryophytes as indicators of pollution
5. Useful chemical constituents
6. Fossil bryophytes as indicators of past environment and past plant communities

Pteridology

1. Basic adaptation on land
2. Salient features of major groups
3. Origin and evolution of pteridophyta
4. Stelar evolution in pteridophyta
5. Telome theory and origin of megaphylly
6. Eusporangiate and leptosporangiate ferns
7. Useful chemical constituents
8. Economic importance

Course No. 102 - Gymnology, Palaeobotany and Palynology

Gymnology

1. Classification and salient features of major taxa
2. Origin and evolution of gymnosperms
3. Distribution through different era
4. Distribution in India: Fossil and living

Palaeobotany

1 Sedimentary rocks; Stratigraphy; Geological Time Scale; Basic concepts of continental drift and plate tectonics

2 Taphonomy

3 Coal, petroleum – origin and depositional environment coal and petroliferous basins of India

4 Reconstruction of fossil plants

5 Dating of fossils
6 Colonization of land; emergence of seed plants; appearance of angiosperms
7 Fundamentals of palaeogeograpgy, palaeoecology and palaeoclimatology

Palynology

1. Branches of palynology
2. Spore, pre-pollen and pollen morphology,
3. Wall chemistry, exine ornamentation
4. Evolution of aperture types
5. Application of neopalynology and palaeopalynology

Course No. 103 - Taxonomy of Angiosperms and Biosystematics

1. **Nomenclature** - different methods. Sources of Names
2. Concept of ICBN and ICN; brief knowledge of nomenclatural types as per Melbourne-ICN (2012); Major Rules: (a) Type concept; (b) Principle of priority; (c) Valid publication; (d) Starting points of Nomenclature, and (e) Limitations to the principle of priority
3. Evolution of characters and differentiation of species
4. **Taxonomic Data Sources**: (a) Anatomy, (b) Cytology, (c) Embryology, (d) Palynology, (e) Phytochemistry, (f) Genome Analysis, (g) Nucleic acid hybridization
5. **Taxonomic Tools**: Herbaria, Floras, Serological & Molecular Techniques
6. **Botanic Gardens** - importance, examples and acronyms. Processing of herbarium specimens
7. Taxonomic hierarchy
8. History of Plant Classification, Pheneticversus phylogenetic systems, cladistics; Current systems of Classifications; broad outline of APG-III (2009) including its merits and demerits.
9. Taxonomic literature and artificial keys
10. Salient features, Floral range and phylogenetic importance of the following families:
11. *Dicots*- Amborellaceae, Annonaceae, Papilionaceae, Caryophyllaceae, Apocynaceae,Lamiaceae, Droseraceae, Nepenthaceae, Rubiaceae, Ericaceae, Asteraceae, Dipsacaceae.
12. *Monocots*- Alismataceae, Potamogetonaceae, Zingiberaceae, Commelinaceae,Orchidaceae, Poaceae, Iridaceae, Juncaceae.
13. **Biodiversity** - importance and preservation; Conservation Hotspots, IUCN guide lines;invasions & introductions, endemism
14. **Numerical Taxonomy:** Aims and objectives, characters and attributes, OTUs. Codingcluster analyses, merits and demerits.
15. **DNA bar-coding** for identification of plants.

Course No. 104 – Laboratory Course-I-Practical
Algae, Bryophytes and Pteridophytes

1. .Morphological study of representative members of Cyanophyceae, Chlorophyceae, Phaeophyceae, Bacillariophyceae, Rhodophyceae
2. Study of reproductive members of different groups of Bryophytes
3. Study of reproductive structures of different groups of Pteridophyta.
4. Detection and bioassay of allelopathic substances of fern.

Gymnology, Palaeobotany and Palynology

1. Comparative study of vegetative and reproductive structures of representatives of different groups Gymnosperms
2. Study of important fossil Gymnosperms from prepared slides and specimens

Taxonomy of Angiosperms and Biosystematics

1. Workout of plant specimens and description of vegetative and reproductive characters from representative families locally available.
2. Training in using local floras and other literature and herbaria for identification of specimens described in the classes.
3. Study of various taxa of a genus, location of key characters and preparation of keys at species level.
4. Field excursion for familiarization with and study of vegetation type(s) and flora(s) of different areas in and outside the state, and in the local areas, and training in collection and preservation.

SEMESTER-II

Course No. 201 - Mycology and Plant Pathology; Lichenology

Mycology

1. Introduction to Mycology: General principles of classification of fungi, Major Groups of Fungi; Fungal reproduction, Spore forms, Fungal Phylogeny and Evolution, fungal physiology, nutrition, and growth.
2. Ultrastructure of fungal cell and composition
3. Genetics and Cell cycle in yeast
4. Applied mycology: Overview; Fungi in fermentation technology; mycorrhiza in agriculture; Bioremediation
5. Cultivation of edible mushroom: *Pleurotus*sp, and *Agaricus*sp

Plant pathology

1. Principles of Plant Pathology.
2. Host pathogen interactions: Mechanism of penetration and the process of disease development.
3. Mode of infection and role of enzymes and toxins in plant disease.
4. Plant defense mechanism: Preexisting structural and induced structural and chemical defense
5. Structural and chemical decay of wood by wood decaying microorganisms
6. Major Fungal, Bacterial, Viral and Nematode diseases of Crop Plants.
7. Molecular methods for detection of plant pathogens
8. Methods of plant disease control
9. Epidemiology of plant diseases

Lichenology

1. Lichens: Introduction, Salient features, Occurrence, Thallus structure-External and Internal
2. Types, reproduction, and importance
3. Uses in human welfare.

Course No. 202 – Microbiology& Microbial Biotechnology

1. Diversity: Phototrophic bacteria; Chemolithotrophic bacteria; Spirochetes; Rickettsias;Chlamydias; Mycoplasmas; Myxobacteria and Archaea.

2. Taxonomy: Classification and survey of microorganisms; Microbial phylogeny as revealedby rRNA sequencing Nomenclature; Species concept; Criteria for classification; Bergey's Manual

3. Functional anatomy of cells: Cell surfaces (glycocalyx, cell wall, flagella and pili) andtheir role; Plasma membrane (bacterial and archaeal) and transport across them; Survival through the production of spores and cysts

4. Metabolism: Photosynthesis (an oxygenic and oxygenic); Chemosynthesis; Fermentation(alcoholic, Entner-Doudoroff pathway; lactic acid – homo and hetero, propionic acid, mixed acid, butane diol and butanol; Stickland reaction); Respiration (anaerobic and aerobic), Nitrogen metabolism and Biological nitrogen fixation

5. Growth: Measurements of growth; Growth cycle of populations; Generation time;Continuous culture; Synchronized growth; Diauxic; Growth on solid media; Environmental factors influencing growth

6. Genetics: Storage and expression of genetic information (prokaryotic chromosome,plasmid and ribosome); Replication of prokaryotic chromosomes; Molecular basis of mutation; Isolation of mutants; Gene transfer mechanisms (transformation, transduction and conjugation); Regulatory mechanisms in bacteria- induction, repression, feedback inhibition, catabolite repression and attenuation; Vital operons

7. Medical Microbiology: Pathogenic properties of bacteria: toxins and extracellularenzymes; brief account of major human disease and their bacterial pathogens. Principles of chemotherapy, general account of chemotherapeutic agents, sulfa drugs and antibiotics.

8. Fundamentals of Immunology: History of immunology, innate and acquired immunity,humoral and cell mediated immunity, organ and cells involved in immunity, T cells and B cells; antigens: characteristics and types, adjuvants. Immunoglobins: types, structure and properties.

9. Viruses and acellular microbes: Nomenclature and classification, distinctive properties ofvirus, morphology and ultrastructure, capsid and their arrangements, types of envelopes and their composition, viral genome, their types and structure, virus related agents (viriods and prions). Viral replication: lytic and lysogenic.

10. Fermentation technology

11. **Actinomycetes-** Characteristics, Classification, Use in agriculture and industry.

Course No. 203 - Cytology and Genetics

1. Chromosome structure and packaging of DNA; Euchromatinand heterochromatin; Karyotype analysis and evolution; specialized type of chromosomes; Molecular basis of chromosome pairing.
2. Cellular organelles: ultrastructure, function and their evolution.
3. Molecular mechanism of recombination; Plasmids, IS elements; Transposons and retro-elements;Sex-linked, sex-limited and sex-influenced traits; Sex differentiation; Dosage compensation and genetic imprinting; Maternal effects and cytoplasmic inheritance.
4. Mutation at morphological, biochemical and molecular level; modification and repair of DNA; Repetitive and unique DNA sequences.
5. Transcription in prokaryotes and eukaryotes; RNA processing; RNA editing; Regulation of gene expression; Operon circuits.
6. The genetic code and its evolution; Translation in prokaryotes and eukaryotes.
7. Population Genetics- populations, gene pool, gene frequency; Hardy-Weinberg Law; concepts and rate of change in gene frequency through natural selection, migration and random genetic drift; molecular clock and phylogenetic evolution.
8. DNA fingerprinting; RAPD, RFLP, AFLP; genetic, cytogenetics and physical mapping using molecular markers; Fluorescent in situ hybridization (FISH) and Genomic in situ hybridization (GISH) and their implications.
9. Genomics; the Human genome project and its importance; Functional and comparative genomics.

10. Principles of Plant breeding; conventional methods of breeding self and crosspollinated plants; Polyploidy and Evolution of major crop plants wheat, cotton, rice; pre-breeding for crop improvement; green revolution and rice breeding.

Course No. 204 –Laboratory Course-II-Practical

Mycology and Plant Pathology

1. Sterilization and incubation- principles and uses of instruments.
2. Culture media and their preparation.
3. Preparation of stabs, slants and pouring of plates.
4. Isolation of fungi from water/soil/air by culture plate technique.
5. Isolation of pathogen from diseased tissues.
6. Preparation of pure culture and sub culturing.
7. Inoculation of tuber and fruit.
8. Morphological and reproductive structure of some macro and micro fungi.
9. Symptomology and histopathology of some common diseases with diagnostic characteristics.
10. Isolation of fungal DNA and PCR based analysis.
11. Fungal tissue- culture; Preparation of spawn and cultivation of *Pleurotus.*
12. Identification of specimens from field trip.

Microbiology and Microbial Biotechnology

1. Differential Staining (Gram and endospore) and study of morphology of prokaryotic cells.
2. Isolation of bacteria using streak-plate, pour-plate and spread-plate techniques.
3. Evaluation of disinfectants (phenol coefficient) as a measure of controlling microbial growth.
4. Isolation and enumeration of viable microorganisms from soil by serial dilution agar plate method; isolation and study of rhizobia from root nodules.
5. Study of bacterial growth using turbid metric method.
6. Measurement of wet weight and dry weight of bacterial cells during growth.
7. Determination of quality of milk using Breed's and methylene blue reduction methods
8. Antibiotics sensitivity test using paper disc method.
9. Determination of the influence of temperature, pH, osmotic pressure and aeration on microbial growth.

Cytology and Genetics

1. Orcein and Feulgen staining of metaphase plates; Preparation of karyotype and idiogram with analysis.
2. Linear differentiation of chromosomes through G-banding, C-banding and Qbanding
3. Induction of polyploidy using colchicine; different methods of application of colchicines
4. Study of Meiosis in *Allium, Tradescantia, Petunia,* and other plants.
5. Study of chromosomal aberrations with chemical mutagen treatments.

SEMESTER-III

Course No. 301: Ecology, Evolution and Plant Resource Utilization; Ethnobotany

Ecology:

1. Concept and dynamics or ecosystem, components, food chain and energy flow, ecological pyramids; productivity and biogeochemical cycles; Different types of ecosystems (grassland and Savannas, shrub land and deserts, Tundra and taiga, Temperate forests, Tropical forests, Lakes and ponds, freshwater wetlands, Streams and rivers, Oceans, Estuarine and mangrove)
2. Population ecology (Basic characteristics with examples, life table, survivorship curves, growth curves) and biological control; Community structure and organization; Environmental pollution; Sustainable development
3. Ecosystem dynamics and management; Stability and complexity of ecosystems; Environmental Impact assessment, Principles of conservation; conservation strategies; cryopreservation, Sustainable development.

Evolution:

1. Origin of cells and unicellular evolution- origin of basic biological molecules; concept of Oparin and Haldane; Miller's experiment (1953); evolution of prokaryotes; origin of eukaryotic cells and evolution of unicellular eukaryotes.
2. Theories of organic evolution: Lamarck; Darwin–concepts of variation, adaptation, struggle, fitness and natural selection; Mendelism; Spontaneity of mutations; the evolutionary synthesis.
3. Molecular evolution; Concepts of neutral evolution; Molecular divergence and molecular clocks; origin of new genes and proteins; gene duplication and divergence.
4. Adaptive radiation; isolating mechanisms; Speciation; Allopatricity and Sympatricity; Convergent evolution; Sexual selection; Co-evolution.

Plant resource utilization and Ethnobotany

1. Traditional knowledge on the use of Bio resources: - Utilization, need, survey, evaluation and conservation. Non-Timber Forest Producers
2. Microbial Resources: - Biofertilizers, Biopesticides, Mycorrhizae, Edible Mushroom
3. (*Agaricus, Pleurotus and Volvariella*) - cultivation and management .
4. Plants and Civilization: Centres of origin and gene diversity; Botany, utilization, cultivation
5. and improvement of food plants, drug, fibre and industrial values; Unexploited plants of potential economic value; Plants as a source of renewable energy; Genetic resources and their conservation, cryopreservation
6. Ethnobotany: Meaning, Branches, History, Practices in India with special reference to North Bengal, Use of plant materials by various ethnic groups(survey), Traditional
7. Knowledge and its Importance

Course No. 302: Phytochemistry, Advanced Anatomy and Pharmacognosy

Section A (INTRODUCTION /CLASSIFICATION/ PHARMACOLOGICAL ACTIONS OF PLANT DRUGS)

Introduction, history, scope.

Classification and pharmacological action of plant drugs: drugs acting on nervous system; heart, Circulation & blood; gastrointestinal tract; nasal and respiratory system; urinary and

reproductive system; skin and mucous membranes; steroidal and nonsteroidal anti-inflammatory drugs; malignant diseases; antibacterial, allergies, vitamins; Hallucinogenic, allergenic and other toxic plants, pesticides etc.

Section B (ORIGIN OF SECONDARY METABOLITES)

Acetate pathway (fatty acids and polyketides), mevalonate and deoxyxylulose phosphate pathway (for production of terpenoids and steroids), shikimate pathway (phenols, amino acids etc.): a brief account.

Section C & D (PHYTOCHEMISTRY/ PHARMACEUTICAL IMPORTANCE)

Carbohydrates –sugar alcohols, starch, cellulose derivatives, gums and mucilages.

Glycosides: general account, biosynthesis, glycosidal drugs**;** Cyanogenic glycosides and glucosinolate compounds.

Alkaloids: definition, properties, classification, alkaloidal drugs–*Datura stramonium, Atropa belladona*, opium, *Cinchona*, tea, ergot, *Rauvolfia, Holarrhena, Catharanthus* – alkaloidal constituents, uses.

Phenolic compounds produced by plants: types, biological activity, drugs–Senna, Aloe, Hypericum, Capsicum.

Steroidal compounds: different types, biological activity and general pharmaceuticalimportance

Carotenoids: chemistry, types, apocarotenoids, bioactivities.

Volatile oils: composition, drugs – clove, *Mentha, Eucalyptus, Foeniculum, Cinnamomum,* citronella

Resins: chemistry, different types, uses

Lipids: fatty acids, nomenclature, fats, fixed oils, waxes

SECTION E (METHODS RELATED TO PHYTOCHEMICAL ANALYSIS & QUALITY CONTROL)

Methods of extraction, separation, isolation (Chromatographic techniques) and characterization of secondary metabolites (Spectroscopic techniques).

Quality control of plant drugs: Classical and modern approaches.

Advanced Anatomy:

I. Differentiation of primary and secondary plant bodies: Origin and development of sclereids, fibres and their control of differentiation; vascular cambium, factors influencing cambial activity; Periderm structure and development; nature and development of cell wall of sieve elements; nature and function of p-protein.

II. Plant anatomy in systematics, ecology and evolution: Phylogeny of xylem and phloemelements; wood anatomy, nodal anatomy, mineral inclusion in systematics and evolution; leaf and wood anatomy in ecological perspective; anatomical response to pollutants.

III.Physiological plant anatomy: Structure and function of cuticle and epicuticular waxes**;** anatomical response to mineral deficiency; response of plants to wounding and invasion by microorganisms; leaf structure in C3 and C4 plants; xylem structure and water movement.

IV.Reproductive plant anatomy: Floral vasculature; development of pollen grains; structure of floral nectaries and seed coat.

V.Applied plant anatomy: Application of anatomical studies in climatology, genetics and plantbreeding, Genetics and Forensic science.

Course No. 303 - Plant Physiology and Metabolism; Developmental Biology

1. Transport and translocation of water and solutes Properties and movement of watermolecules; Water balance of the plant; Water transport through xylem; Mechanism of loading and unloading of photo assimilates and translocation in the phloem

2. Sensory Photobiology: Structure, function and mechanisms of action of phytochromes,cryptochromes and phototropins; Photo physiology of light induced responses; Stomatal movement; photoperiodism and biological clocks

3. Plant growth regulators and elicitors: Physiological effects, mechanism of action andsignal transduction of auxins, gibberellins, cytokinins, ethylene and abscisic acid; Biological action of Brassinosteroids and peptide hormones.

4. Physiology of plant development and flowering: Embryogenesis - apical-basal & radialpatterning; Developmental control of root and shoot apical meristem; leaf development and; Endogenous clock and its regulation; Concept of Florigen; Genetic and molecular analysis of floral induction and development.

5. Stress Physiology: Concept of tolerance and acclimation; Plant responses to biotic(pathogen and insects) and abiotic water deficit, salinity, metal toxicity, freezing and heat stress; Mechanism of oxidative stress and abiotic stress tolerance

6. Secondary metabolites: Characteristic features of secondary metabolites of plant origin;Basic metabolic pathways and origin of secondary metabolites; biosynthesis and biological significance of terpenes, phenolics and nitrogen-containing compounds**.**

7. Photochemistry and photosynthesis: General concepts; photosynthetic pigments and light harvesting complexes; photo-oxidation of water; mechanisms of electron and proton transport; Benson-Calvin cycle; CO_2 concentrating mechanisms

8. Respiration: Overview of plant respiration; Glycolysis; TCA cycle, Electron Transportsystems and ATP synthesis; Photorespiration Alternative oxidase system.

9. Regulation of cell division, meristem activity, plant stem cells, embryogenesis and morphogenesis, signal transduction and plant hormones, environmental constraints upon plant growth.

GE-1: Advanced Laboratory Course-III-Practical
Ecology, Evolution and Plant resource utilization; Ethnobotany

1. Estimation of dissolved oxygen content.
2. Estimation of dissolved carbonate & bicarbonate content.
3. Determination of soil pH.
4. Determination of soil quality: i) Organic matter or ii) Exchangeable calcium and magnesium
5. Mushroom culture techniques
6. Nursery techniques of propagation
7. Ethnobotanical studies.

Phytochemistry, Advanced Anatomy and Pharmacognosy

1. Choice of solvent for extraction of plant metabolites.
2. Chemical tests for the detection of alkaloids, phenols, anthraquinones, cardenolides, anthocyanins,betacyanins, carotenoids, steroids.
3. Study of unorganized drugs – starches, gums, resins etc.
4. Extraction and chromatographic detection of some common plant drugs.

Plant Anatomy

1. Cell types- trichomes, sclerides, tracheids, vessels and sieve tube elements.
2. Secretary structures and cell inclusions- nectaries, glandular hairs, oil glands, salt glands, canals,laticifers, phytoliths, cystolith and crystals.
3. Nodal anatomy- unilacunar, trilacular, multilacunar
4. Anatomy of bark and lenticels.
5. Wood anatomy from TS, TLS, RLS of woody plants.
6. Study of shoot apical organization in pteridophytes, gymnosperms and angiosperms.
7. Ecological leaf anatomy: sun and shade leaves, xeromorphic, succulent, halophytic and hydromorphicleaves.
8. Histology of seed coats: *Gossypium, Citrus, Phaseolus, Phoenix*/ *Musa*.

Plant Physiology and Metabolism

1. Preparation of buffers, solutions and dilutions.
2. Extraction of proteins from plant materials and estimation by Lowry's method using BSA standard curve.
3. Extraction of carbohydrates from plant materials and estimation of reducing sugars by Somogyi-Nelson method.
4. Determination of acid value of fat.
5. Extraction of plant phenolics and estimation of total phenols and O-dihydroxy phenols.
6. Separation of amino acid mixture by thin layer chromatography.
7. SDS-PAGE analysis of proteins
8. Isolation of plant genomic DNA, estimation by UV spectroscopy.

Isolation of plant total RNA, estimation by UV spectroscopy and gel electrophoresis

Semester-IV

GE-2 (Students have to choose any two courses out of the following courses)

(A) Biostatistics:

1. Sampling and sample designs; Classification and tabulation of data; Visualizing data (diagrammatic and graphical presentation)
2. Measures of central tendency and dispersion
3. Probability distributions
4. Difference between parametric and non-parametric statistics
5. Confidence interval; Errors; Levels of significance
6. Regression and correlation; t-test; ANOVA; Chi-square test
7. Basic introduction to multivariate statistics
8. Application of SPSS, Sigma plot, XLSTAT etc. in solving statistical problems

(B) Bioinformatics:

1. Introduction to the concept of hardware and software.
2. Introduction to Windows, UNIX and Linux; Introduction to Perl and Python.
3. Different types of biological databases like sequence databases, structural, genomic and pathway interaction databases; information retrieval from biological databases; sequence analysis overview.
4. Introduction to genome browsers; Online bioinformatics tools; Different types of file formats used in bioinformatics analysis; Genome annotation.
5. Nucleotide and protein sequence analysis, sequence alignment and applications.
6. Phylogenetic analysis.
7. Introduction to protein structure prediction and analysis; drug designing.

(C) Research Methodology

1. Basic concepts of research

Research-definition and types of research (Descriptive vs analytical; applied vs fundamental; quantitative vs qualitative; conceptual vs emperical).Research methods vs methodology.Literature-review and its consolidation; Library research; field research; laboratoryresearch.

2. General laboratory practices

Common calculations in botany laboratories.Understanding the details on the label of reagent bottles, molarity and normality of common acids and bases, Preparation of solutions. Dilutions. Percentage solutions. Molar, molal and normal solutions.Technique of handling micropipettes; Knowledge about common toxic chemicals and safety measures in their handling.

3. Data collection and documentation of observations

Maintaining a laboratory record; Tabulation and generation of graphs. Imaging of tissuespecimens and application of scale bars. The art of field photography.

4. Overview of Biological Problems

History; Key biology research areas, Model organisms in biology (A Brief overview): Genetics, Physiology, Biochemistry, Molecular Biology, Cell Biology, Genomics, Proteomics-Transcriptional regulatory network.

5. Methods to study plant cell/tissue structure

Whole mounts, peel mounts, squash preparations, clearing, maceration and sectioning; Tissue preparation: living vs fxed, physical vs chemical fxation, coagulating fxatives, non-coagulant

fxatives; tissue dehydration using graded solvent series; Parafn and plastic infltration; Preparation of thin and ultrathin sections.

6. Plant microtechniques

Staining procedures, classifcation and chemistry of stains.Staining equipment. Reactive dyes andfuorochromes (including genetically engineered protein labeling with GFP and other tags). Cytogenetic techniques with squashed plant materials.

7. The art of scientific writing and its presentation

Numbers, units, abbreviations and nomenclature used in scientifc writing.Writing references.PowerPoint presentation.Poster presentation, Scientifc writing and ethics, Introduction to copyright-academic misconduct/plagiarism.

(D) Plant Biotechnology

1. Recombinant DNA technology

Restriction Endonucleases (History, Types I-IV, biological role and application); Restriction Mapping (Linear and Circular); Cloning Vectors: Prokaryotic (pUC 18 and pUC1t, pBR322, Ti plasmid, BAC); Lambda phage, M13 phagemid, Cosmid, Shuttle vector; Eukaryotic Vectors (YAC).

2.Gene Cloning

Recombinant DNA, Bacterial Transformation and selection of recombinant clones, PCR mediated gene cloning; Gene Construct; construction of genomic and cDNA libraries, screening DNA libraries to obtain gene of interest by genetic selection; complementation, colony hybridization; PCR

3.**Methods of gene transfer**

Agrobacterium -mediated, Direct gene transfer by Electroporation, Microinjection, Microprojectile bombardment; Selection of transgenics– selectable marker and reporter genes (Luciferase, GUS, GFP)

4. Applications of Biotechnology

Pest resistant (Bt-cotton); herbicide resistant plants (Roundup Ready soybean); Transgenic crops with improved quality traits (FlavrSavr tomato, Golden rice); Improved horticultural varieties (Moon dust carnations); Role of transgenics in bioremediation (Superbug); edible vaccines; Industrial enzymes (Aspergillase, Protease, Lipase); Genetically Engineered Products–Human Growth Hormone; Humulin; Biosafety concerns.

DCE-1: (Students have to choose any one course)

Group A: Cytogenetics and Molecular Biology-I

1. Gene structure: Genetic fine structure,*cis-trans*test, complementation test, overview ofpromoter structures and 5' capping, 3' polyadenylation in eukaryotic gene transcription, RNA transport, splicing-editing.

2. Genome organization and Analysis: An overview with nucleosome packaging, DNAstructure, 'A', 'B' & 'Z' forms, Chromosome sorting by FACS, PFGE and microdissection.

3. **NGS:** High-throughput DNA sequencing (Illumina/Solexa technique), genome probingusing DNA microarray (DNA chip), DNA databases and accessing genetic information *via* Bioinformatics algorithms

4. Recombinant DNA Technology: Gene cloning principles; Tools-techniques, constructionof genomic and cDNA libraries and screening-expression, choice of vectors and their structural features, *In vitro* mutagenesis and application. Antisense, ribozyme and RNAi technology and importance.

5. Genome function: Characterization of gene transcripts-transcriptomics*via*SAGE,Differential display, RNase protection assay, Northern blotting, nuclear run-on assay and genetic information passed on to protein-proteomics, and protein-protein interaction *via* pull-down and yeast two-hybrid assay, FRET; DNA-protein interactions: EMSA, DNase I foot printing, ChIP

6. Transgenic crops: Strategies to develop transgenic crops through*Agrobacterium*mediatedor physical mediated gene transfer methods. Control and silencing of transgene expression.

7. GM crops and ecological concern: GM crops for disease/drought /insect/ herbicidetolerance and terminator technology. Advantages of Transplastomics and its development. Gene targeting through gene-knock-out using Cre-LoxP system and gene tagging in plants. Ecological risk and ethical issues of GM crops

Group (B): Microbiology-I

1. Microbial Systematics: Classical and modern approaches to bacterial taxonomy, chemo-taxonomic characteristics (peptidoglycan, lipids, fatty acids and proteins) and genotypic characteristics (DNA-base composition, -fingerprinting, -relatedness; RNA sequence analysis, DNA-RNA hybridization); bacterial phylogeny.

2. Genetics: Genetic code- its nature and deciphering; Transcription; Translation; Plasmidbiology (Types; Detection and purification; Replication); Transposons– Insertion sequences and composite transposons, phages as transposons, replicative, non-replicative and conservative transposition. Transformation; Conjugation; transduction; Bacterial genome mapping; Mutation and detection.

3. Environmental microbiology: Biofilms; Microbial competition and cooperation;Biogeochemical cycles (nitrogen, sulfur, phosphorus and iron); Microbial leaching of ores; Wastewater treatments; Biodegradation of petroleum and xenobiotics; Bacterial plastics; Metagenomics; Brief idea of exobiology; Methods in microbial ecology.

4. Food Microbiology: Food produced by microbes: Fermented foods (fermented dairyproducts, alcoholic beverages, vinegar, fermented vegetables), microbial cells as food. Food as substrate for microorganism, food borne disease; contamination and spoilage of food (meat and meat products, fish, fruits and vegetables, milk and milk products), methods of food preservation (physical and chemical); Probiotics

5. Microbes in Agriculture: Biological nitrogen fixation, nitrogenase and alternativenitrogenase system, *nif*genes; degradation of cellulose, hemicellulose and lignin, production of biofertilizers. Microbial control of insects. Use of viruses in agriculture.

6. Bioinformatics & Computational Biology: Advanced biological sequence analysis;Predictive methods using nucleotide and protein sequences; Advanced BLAST techniques; Codon usage analysis; Advanced molecular phylogenetics; Molecular modelling; Concepts of Next Generation Sequencing and NGS data analysis.

Group-C: Mycology & Plant Pathology-I

1. Fungal diversity in different ecosystems: The structure and composition of fungal cell,effect of environment on fungal growth and behavior.

2. Fermentation technology: Feedstock for fermentation process, fermentor design andoperation, solid substrate fermentations.

3. Enzyme technology: Fungal enzymes of commercial importance, production of fungalenzymes, free and immobilized cells and enzymes.

4. Fungal toxins: Mycotoxicoses- fungi in dermatomycosis, aspergillosis and fungi allergenicto man and animal.

5. Fungi as food and beverage: Alcoholic beverage, mushrooms and other macro fungi,edible biomass from yeast and moulds, single cell proteins (SCP).

6. Fungi in food processing: Bread, soybean products, cheese and fermented milk, otherfermented foods

7. Fungal metabolites: Primary metabolites of economic importance, secondary metabolitesin medicine and agriculture

8. Future of fungal biotechnology: Production of mammalian proteins by fungi, otherapplications of gene cloning in fungi and their importance

9. Recombinant DNA technology: Manipulation of industrially important fungi, ediblemushroom and bio-control agents

Group D: Plant Physiology, and Metabolism-I

1. Nitrogen metabolism: Nitrate assimilation in plants, structure, function and regulation ofnitrate assimilation enzymes, nif genes, nod genes - structure, function and regulation.

2. Stress physiology: Physiology and molecular biology of abiotic stress, biotic stress,reactive oxygen species and their protection mechanisms, role of polyamines in stress physiology.

3. Senescence and its regulation: Programmed cell death (PCD): Types, developmental andMolecular Biology of PCD, fruit ripening.

4. Pumps, carriers and channels: Structure and function, energetics of active transport,isophore and ionophore; Vacuoles – origin, structure and function.

5. Sulfate metabolism: Sulfur chemistry and function; Uptake and transport; reductivesulfate assimilation pathway; synthesis and function of glutathione and its derivatives.

6. Floral induction and development: Hormonal control, molecular genetics of floraldevelopment and floral organ differentiation; Effect of low temperature on floral bud initiation (FBI) through silencing of FLC gene.

7. Protein targeting: Protein transport in cell organelles, common features of the transportmechanism, chaperon, chaperonin and protein folding, protein glycosylation and its significance.

8. Cell signalling: Signal molecules, signal perception and transduction in plants; MAP-kinase, Ca-calmodulin complex – role in plant signaling.

9. **Protein chemistry:** Protein purification, characterization, methods for the determination ofamino acids sequences in proteins, protein folding pathways and Levinthal Paradox.

10. Alkaloids and carotenoids: Classification, occurrence and biological properties,biosynthesis, and biological significance.

Group E: Taxonomy of Angiosperms andBiosystematics-I

1. History of studies in Taxonomic Botany in India

2. Survey of Taxonomic Literature: Dictionaries, Indices, Monographs, Manuals, Floras, Journals, and taxonomic websites

3. The Species Concept

4. International Code of Botanical Nomenclature: Principles, articles, recommendations and special provisions; application of code with problems; nomenclature of cultivated and hybrid plants; taxonomic hierarchy.

5. Biocode and Phylocode

6. Use of Herbaria; role of Botanic Gardens in the 21st Century.

7. Biosystematics: definition, importance and categories. Major areas of biosystematic studies:

A. *Palynology*: morphology, chemistry of exine, bearing on phylogeny, reconstruction ofvegetation structure

B. *Embryology*: Diversity in structures of gametophytes, endosperm formation,developing embryo; ovule morphology

C. *Cytology, genetics* and *breeding*

D. *Phytochemistry*(including serology, pigments & secondary metabolites) E. *Molecular Biology*: Definition, determination of relationship through Protein & Nucleic Acidstudies; uses of electrophoresis, PCR & HPLC. F. *Remote sensing & GIS*.

8. Analysis of data; commonly available software, construction of dendrograms

Group F: Ethnobiology and Plant Resource Management-I

Ethnobiology:

1. Botanical Foundations of Ethnobotany
2. Ethnobotany as an interdisciplinary subject. Relation of Ethnobotany with Anthropology, Chemistry, Geography, Pharmacology,Sociology, Zoology etc.
3. History of Ethnobotany worldwide and in India and its contemporary trends.
4. Contemporary issues of Ethnobtany and Environmental Anthropology.
5. Traditional Knowledge and it implication in modern society.
6. Ethnomedicine: scope and arena, Ethnomedicine as emerging research subject.
7. Tribes in India with special reference to North Bengal and Northeast India: Their culture and traditional knowledge on utilization of plants.
8. Biocultural diversity in North Bengal and North East India
9. Agroforestry: Concept and application at regional and global level.
10. Role of Ethnobotanical and its Allies societies in India and Abroad.
11. Ethnopharmacology: Origin and modern trends.

DCE-2: (Students have to choose any one course)

Group A: Cytogenetics and Molecular Biology-II

1. Genetic Markers and PCR amplification: RFLP, RAPD, SNPs, FISH & Chromosome painting, Gene amplification and PCR: Basic principles and methodologies of PCR, design of PCR primers, RT-PCR and Real-Time PCR and their utility.

2. Genome mapping: Genetic mapping, physical mapping, sequencing genomes- assemblyof a continuous DNA sequence, understanding of genome sequence- ORF, homology search and comparative genomics, exon-intron boundaries.

3. Molecular plant breeding: Theory and practices, molecular breeding tools- markers andmaps; molecular techniques in Omics- functional and comparative genomics; breeding populations – DH, RIL, NIL, CSSL; marker assisted selection (MAS)- theory and practice; breeding informatics-plant Databases, prospects of breeding informatics, rice genome analysis-

SNPs and InDels variations, analyses based on different genome browser-NCBI, Gramene, RAP-DB.

4. Molecular dissection of complex traits- QTLs, QTLs mapping across species (Rice); Ricebiology in the genomic era; Development of improved rice varieties through molecular breeding - submergence tolerance, blight - blast resistant rice, salt tolerance rice- through gene introgression from donor parents and gene pyramiding.

5. Genomes of prokaryotes and eukaryotic organelles: Chromosomes of prokaryotes,genetic features of prokaryotic genomes; physical features of organelle genome and genetic content of organelle genomes.

6. Molecular phylogenetics: The origins of genome; RNA genome and DNA genome,acquisition of new genes, noncoding DNA and genome evolution; reconstruction of DNA-based phylogenetic trees and applications of molecular phylogenetics.

7. **Gene manipulation and applications**: Producing useful therapeutic molecules,pharmacogenomics, new drugs, improving agronomic traits by genetic modification.

8. Metabolomics and global biochemical networks; analysis of transcriptomics and proteomics; gene inhibition at the protein level.

Group-(B): Microbiology-II

1. **Medical Microbiology:** Normal microbiota of human body; host-parasite relationship in baterial pathogenicity: non-specific mechanisms of host defense, mechanism of bacterial virulence, genetics of bacterial virulence; chemotherapy: antibiotics (origin, classification, chemistry and mode of action); semisynthetic antibiotics; antibiotic resistance in bacteria, mechanism(s) of antibiotic resistance.

2. **Immunology:** Theories of antibody production, antibody diversity; antigen-antibodyreactions; immunoassay methods and their applications, major histocompatibility complex (structure and function), complement system and complement activation; monoclonal antibodies (production and applications); Immunological techniques like immunoelectrophoresis and ELISA.

3. **Water microbiology:** Waterborne diseases; Microbial contamination of water;Examination of potability of water; Purification of water.

4. **Biotechnology and Industrial microbiology:** Major products of industrial microbiology;Biofuel production; Microorganisms used in industrial microbiology and their genetic manipulation.

5. **Virology:** Mechanism of virus adsorption and entry into the host cell including genomereplication and mRNA production, mechanism of RNA synthesis, mechanism of DNA synthesis, transcription mechanism and post transcriptional processing, translation of viral proteins, assembly, exit and maturation of progeny virions, multiplication of bacteriophages.

6. Host and virus factors involved in pathogenesis, patterns of infection, pathogenesis of animal viruses, pathogenesis of plant and insect viruses. Host cell transformation by viruses and oncogenesis of DNA and RNA viruses; Characteristics of interferons; Induction and regulation of interferon production; Mechanism of interferon action.

Group-C: Mycology& Plant Pathology-II

1. **Biology of Mycorrhizae:** Diversity of Mycorrhizae and its development, Ectophytic andendophyticmycorrhiza (VAM), mycorrhiza in plant growth promotion, mycorrhizal interactions with soil microorganisms, mycorrhiza in plant disease control

2. Molecular tools and methods: Detection of Mycorrhiza; plant pathogens in soil, waterand plant tissues.

3. Plant defense mechanisms: Plants defense against infection: Preexisting structural andinduced structural and chemical defense, hypersensitive reaction, role of phytoalexins and other phenolic compounds,

4. Management of plant diseases: Cultural, chemical, biological, biopesticides, breeding forresistant varieties, plant quarantine, integrated pest management.

5. Post-harvest pathology: Fungal deterioration of food commodities, mycotoxins and healthhazards, control measures.

6. Molecular plant pathology: Molecular aspects of host pathogen interactions - SystemicAcquired Resistance (SAR) and Induced systemic resistance (ISR), defense enzymes. PR proteins, degradation of phytoalexins; application of molecular biology to plant disease control - transgenic approach for crop protection, engineering chemicals that elicit defense response to plants.

7. Plant Diseases: Study of major plant diseases caused by fungi, bacteria, viruses, nematodeand mycoplasma like organisms

Group D: Plant Physiology and Biochemistry-II

1. Antisense technology and regulatory RNAs:RNAi antisense oligonucleotides, basicprinciples and mechanisms. Small interfering RNAs (siRNA), MicroRNA (miRNA); synthesis and function of miRNA molecules.

2. Protein modification: Site specific and PCR-based random mutagenesis, characterizationof the mutants.

3. Epigenomics: DNA methylation, Histone modifications (methylation, acetylation) theirrole in epigenetic control of gene.

4. Importance of weak chemical interactions: Concept of free energy, weak bonds inbiological systems, hydrophobic bonds stabilize macromolecules; weak bonds attach enzymes to substrate, protein-protein interactions, protein-DNA interactions; specific conformation of a protein depends on pattern of Hydrogen bonds.

5. Transcriptional regulation: In prokaryotes and eukaryotic systems, gene silencing bymodifications of histones and DNAs.

6. Gene regulation in development and evolution: Strategies for establishing differentialgene expression in developmental stages, Homeotic genes- an important class of developmental regulators, positive autoregulation delays gene expression.

7. Biogenesis, traffic, and functions of cellular membrane system, Protein synthesis andfolding in the cytoplasm; translocation into the endoplasmic reticulum- the signal hypothesis; Golgi function in biosynthetic processing.

8. Catalytic RNA: Introduction, group I and group II introns, catalytic activity of RNase P,Viroids have catalytic activity, protein splicing is autocatalytic.

9. Somatic recombination and hypermutation in the immune systems: Introduction,clonal selection amplifies lymphocytes, allelic exclusion; class switching is effected by DNA recombination.

Group E:Taxonomy of Angiosperms and Biosystematics-II

1. Philosophy of classification. Recent trends in classification.

2. Indian flora. Endemism- in Indian perspective

3. Migration, dispersal and discontinuous distribution of plants

4. Management of Herbarium: Methods of collection, identification and documentation

5. Biodiversity Conservation: IUCN categories, Effects of Rio de Genero world summit, Hotspots, India as a megadiversity country; Ramsar sites

6. Methods of *in situ* and *ex situ* conservation. Biodiversity protected areas in India

7. Concise accounts of the phylogeny and economic importance of the following taxa: a. SUBCLASSES:

i) Magnoliidae, (ii) Dilleniidae, (iii) Caryophyllidae, (iv) Alismatidae, (v) Commelinidae.

b.ORDERS:

i) Nymphaeales, (ii) Fagales, (iii) Gentiales, (iv) Dipsacales,(v)Liliales/Zingeberales, (vi) Orchidales.

8. Traditional knowledge: Ethnobotanical resources in India; documentation and utilization of ethnic knowledge. Traditional methods of conservation; sacred groves

Group F: Ethnobiology and Plant Resource Management-II

Plant Resource Management

1. Plant Biodiversity:Concept, status in India, Utilization and concerns.
2. Sustainable Development: Concept and applications.
3. Origin of Agriculture and Agrobiodiversity
4. World centres of primary diversity of domesticated plants: the Indo Burmese centre; plant introduction and secondary centres.
5. Origin, evolution, botany, cultivation and uses of: Field crops (Rice, Wheat, Maize); Fruits (Mango, Citrus, Banana); Forage and fodder crops; Fibrecrops(Cotton, jute, Indian mat cane); Medicinal and aromatic plants; Vegetable oil-yielding plants.
6. Important fire-wood and timber-yielding plants and non-wood forest products (NWFPs)
7. such as bamboos, rattans, raw materials for paper-making, gums, tannins, dyes, resins ad fruits.
8. Green revolution: Benefits and adverse consequences.
9. Innovations for meeting world food demands.
10. Plants used as avenue trees for shade, pollution control and aesthetics. Principles of conservation; extinctions; environmental status of plants based on International Union for Conservation of Nature.
11. Strategies for Conservation- *in situ* conservation: International efforts and Indian initiatives;
12. Protected areas in India-sanctuaries, national parks, biosphere reserves, wetlands, mangroves and coral reefs for conservation of wild biodiversity.

13. Strategies for conservation- ex situ conservation: Principles and practices; botanical gardens, field gene banks, seed banks, in vitro repositories, cryobanks; general account of the activities of Botanical survey of India(BSI), National Bureau of Plant Genetic Resources (NBPGR),Indian councilof Agricultural Research(ICAR), Council of Scientific& Industrial Research), and the Department of Biotechnology (DBT) for conservation, non-formal conservation efforts; International bodies like Food and Agriculture Organization (FAO), Biodiversity International, International Plant Genetic Resources Institute (IPGRI), CGIAR etc.

DCE-3: (Students have to choose any one course)

Group A: Cytogenetics &Molecular Biology-III

1. Isolation of plant genomic DNA, estimation by UV spectroscopy.
2. Isolation of plant total RNA, estimation by UV spectroscopy and gel electrophoresis.
3. Meristem tip culture
4. Somatic embryogenesis
5. Separation of amino acid mixture by thin layer chromatography.
6. RAPD amplification and data analysis of a typical plant and dendrogram preparation and genetic distance measurement.
7. Immunological techniques- ELISA and Western Blotting.
8. Fractionation of proteins by molecular exclusion chromatography on Sephadex G 100.
9. SDS-PAGE analysis of the proteins and determination of molecular weights.
10. Enzyme extraction/assay of activity and isozyme analysis by PAGE.

Group B: Microbiology-III

1. Quantifying the thermal death (D-values) of microorganisms
2. Study of physiological and biochemical activities of bacteria (hydrolysis of starch, lipid, protein and urea; degradation of cellulose and pectin; catalase; βgalactosidase; nitrate reduction; Voges-Proskauer reaction; indole production; liquefaction of gelatin; citrate utilization; fermentation/oxidation of sugars)
3. Study of bacterial growth and determination of generation time
4. Assay of antibiotics using tube dilution, well diffusion and agar dilution methods
5. Detection of coliforms using membrane filter method to determine water purity
6. Enrichment and isolation of anoxygenic prototrophic, endospore-forming and diazotrophic bacteria
7. Induction of mutation, and selection of mutants using replica plating technique
8. Isolation of antibiotic-resistant mutants
9. DNA isolation from bacteria/environmental sample and its quantification.
10. Restriction enzyme digestion of DNA
11. Polymerase Chain Reaction and Gel Electrophoresis.
12. Transformation of *E. coli*
13. Quantitative estimation of proteins by Folin-Lowry / Biuret method.
14. Chromatographic techniques
15. Nucleic acid and protein sequence analysis
16. Basic techniques of molecular modeling
17. Basics of NGS data analysis.

Group C: Mycology& Plant Pathology

1. Isolation of fungal/plant DNA and its quantification by spectrophotometric method.
2. Separation of DNA by agarose gel electrophoresis.
3. Restriction endonuclease digestion of fungal / plant DNA.
4. DNA blots hybridization.
5. Isolation of fungal protoplast.
7. Polymerase chain reaction.
8. Extraction and bioassay of phytoalexin(s) from plant tissue induced by biotic and abiotic stresses.
9. Partial purification of antifungal compounds by TLC methods and UV spectrophotometric analysis.
10. Extraction and SDS-PAGE analysis of defense protein in artificially inoculated plants/induced by abiotic elicitor(s).
11. Separation of proteins/polyphenols by column chromatography.
12. Extraction and assay of defense enzyme(s).
13. Immunological characterization of defense enzyme(s).
14. Preparation and purification of plant and fungal antigens.
15. Production of polyclonal antibody and purification of IgG.
16. Evaluation of antigens in raising antibodies using immunodiffusion and immune-electrophoretic test.
17. Optimization of antigen and antisera dilution by ELISA.
18. Detection of pathogen in artificially inoculated plant using DAC-ELISA formats.
19. Detection of pathogen in soil by dot blot and western blot method.
20. Detection of pathogen in host tissue by indirect immunofluorescence test.

Group D: Plant Physiology & Biochemistry-III

1 Preparation of buffers, solutions and dilutions.

2 Extraction of proteins from plant materials and estimation by Lowry's method using BSA standard curve.

3 Extraction of carbohydrates from plant materials and estimation of reducing sugars by Somogyi-Nelson method.

4 Determination of acid value of fat.

5 Extraction of plant phenolics and estimation of total phenols and O-dihydroxy phenols.

6 Separation of amino acid mixture by thin layer chromatography

7 Protein extraction, precipitation by salting out, desalting by dialysis/ Sephadex G 25 column

8 Enzyme extraction/assay of activity and isozyme analysis by PAGE.

9 Isolation of chloroplast and determination of Hill activity.

10 Separation of pigments by TLC and their identification.

11 Extraction and estimation of carotenoid pigments.

12 Determination of pKa values of amino acids.

13 Separation and detection of secondary metabolites through TLC.

14 Determination of antioxidant fingerprint on TLC.

15 Isolation, purification and identification of alkaloids by application of column chromatography.

Group E: Taxonomy of Angiosperms and Biosystematics-III

1. Seasonal collection of local flora, processing, Herbarium management.

2. Phenology of some common weeds.

3. Seed, endosperm, embryo and seedling morphology.

4. Identification of plants by matching.

5. Working out of different angiospermic plants (fresh and dry), their identifications using literature and preparation of artificial keys.

6. Phytosociological studies; Biological Spectrum; Determination of Diversity Indices (Shannon-Wiener, Species Richness & β-diversity).

7. Use of GPS and demonstration on the use of at least one remote-sensing software

8. Familiarity with Taxonomic Literature (e.g. Index Kewensis, Wall-Cat., Icones, Bibliographies, Dictionaries, Keys, Floras, etc.).

9. Preparation of temporary and permanent pollen slides; description of common palynomorphs, preparation of identification keys.

10. Variation of characters - influence of ecological factors.

11. Ethnobotanical survey in a forest village/ village market.

12. Use of Electrophoresis, PCR, HPLC and other instruments useful in molecular taxonomy.

13. Basic techniques of micropropagation.

14. Identification of secondary metabolites and pigments.

Group F: Ethnobiology and Plant Resource Management-III

1. Food & fruit Crops: Wheat, rice, maize, chick pea, potato, citrus, mango, banana-morphology, anatomy and microchemical tests.

2. Plant Fibres: Jute, Cannabis, Silk, Cotton, SitalPati- Morphology, anatomy, microscopic study of whole fibres using appropriate staining procedures.

3. Medicinal and Aromatic Plants: Five available medicinal and aromatic plants -Study of live or herbarium specimens

4. Vegetable oils: Mustard, ground nut, soya bean, coconut, sunflower and castor-morphology, microscopic structure of the oil yielding tissue, test for oil and Iodine number.

5. Gums, Raisins, tannins and Dyes: Perform simple tests for gums and raisins from available plants. Prepare water extracts for vegetable tannins. For dyes perform teats to understand their chemical nature.

6. Organoleptic studies of local ethno medicinal plants.

7. Study of objective ethnobotany on herbal medicine, agroecology, dietary culture and rituals.

8. Field survey: Firewood and timber yielding plants and NWFPs, traditional healers.

9. Scientific visits to i. Protected area ii. Wetland iii. NBPGR stations iv. BSIv. CSIR laboratoryvi. ICAR research institute.

2. Project: Students will have to submit and present one project work.

Suggested Readings

Bio-resource utilization

1. Advances in Mushroom Biotechnology- M.C. Nair, Ed.
2. A text book of Biotechnology-R.C. Dubey (S. Chand & Co.)
3. Food and Natural Resources- D.Pimentel and C.W.Hall, Academic Press
4. Plant Genetic Resources Conservation and Management- R.S.Paroda and R.K.Arora, IPGRI
5. Sustainable Management of Non-Wood Forest Products- M.N.B.Nair
6. The Useful Plants of India- CSIR, Publication and Information Directorate

Biostatistics

1. Fundamentals of Biometry – L.N.Balaam
2. Fundamentals of Biostatistics – I.A>Khan and A.Khanum,Ukaaz Publications
3. Principles of Biometry- C.M.Woolf
4. Statistical Methods – G.W.Snedecor and W.G.Cochran

Bryology

1. Bryophyta - N.S.Parihar , Central Book Depot, Allahabad
2. Bryophye Ecology – A.J.E.Smith (Ed)
3. Bryophytes – P.Puri, Atma Ram & Sons Publishers, N.Delhi
4. Cryptogamic Botany, Vol.II – G.M.Smith
5. Liverworts of the Western Himalayas and Punjab Plain – S.R.Kashyap

Cytology and Genetics

1. Genetics: PJ Russell. Benjamin Cummings Pub. Inc. USA.
2. Principles of Genetics: Snustad and Simmons, John Wiley and Sons, USA
3. Concepts of Genetics: Klug and Cummings, Pearson Education, USA
4. Genome 3: T.A. Brown, Pearson Education, USA
5. Principles of Gene Manipulation and Genomics: Primrose and Twyman, Blackwell Scientific, Oxford.
6. Plant chromosome: Analysis; Manipulation and Engineering: Sharma & Sharma, Harwort Academic Pub. Australia
7. The Science of Genetics: Sauders College Publishing, Fort Worth, USA
8. Genetics: Principles and Analysis, Hartl and Jones, EW Jones &Bartlettt Pub, USA.
9. Gene IX: Lewin, B. Oxford University Press, USA.
10. Essential Genes, Lewin, B. Pearson Education.
11. Functional Genomics: A practical Approach. Hunt And Rick, Oxford University Press.
12. Genetic Engineering: An Introduction to Gene Analysis and Exploitation in Eukaryotes: Kingsman&Kingsman, Blackwell Scientific .Pub. Oxford.
13. Molecular Biotechnology: Glick &Pasternock, Indian Edition.
14. Molecular Cloning: A Laboratory Manual, Sambrook&Russel, CSHL press, N.York.
15. DNA Cloning: A Practical Approach, Glover &Hames, IRL press, Oxford.

16. Methods in Enzymology, Guide to molecular Technique, Vol. 152. Berger & Kimmel, Academic Press, San Diego.
17. DNA Science: A first course in recombinant Technology, Mickloss&Freger, CSHL Press, NY.
18. Recombinant DNA Technology: Watson, Academic Press.

Ecology

1. Basic Ecology –E.P. Odum , Saunders Publication
2. Fundamentals of Ecology-E.P. Odum , Saunders Publication
3. Elements of Ecology – R.L. Smith & T.M. Smith , Benjamin/ Cummings Publishers
4. Air pollution and Plant Life –M.T. reshow , Willy Interscience
5. Concepts of ecology- E.J. Kormondy, Prentice-Hall of India
6. Fundamentals of Ecology- M.C. Dash , Tata McGraw Hill
7. Environmental Science-S.C. Santra , New Central Book agency(P) Ltd. Kolkata.
8. Biology of Fresh water pollution-C.F. Mason , Longman Publishers

Gymnology

1. An Introduction to Gymnosperms – S.C. Dutta
2. Comparative Morphology of Vascular Plants – A.S. Foster and G.M. Gifford
3. The Morphology of Vascular Plants – D.W. Bierhorst

Microbiology

1. Bacterial Metabolism - G. Gottschalk, Springer
2. Bergey's Manual of Systematic Bacteriology, 4 vols, - N.R. Krieg & J.G. Holt, eds, Springer
3. Brock Biology of Microorganisms - M.T. Madigan, J.M. Martinko& J. Parker, Prentice-Hall
4. Encyclopedia of Microbiology, 4 vols -J. Lederberg, ed, Academic Press
5. Food Microbiology - M.R. Adams & M.O. Moss, RSC
6. Food Microbiology- Fundamentals and Frontiers, 3rd edition, M.P. Doyle & L.R. Beuchat, ASM Press
7. Foundations in Microbiology - K.P. Talaro& A. Talaro, WCB/McGraw-Hill
8. Fundamentals of Microbiology - Alcamo, Benjamin/Cummings
9. Fundamentals of Microbiology and Immunology - A.K. Banerjee & N. Banerjee, Central
10. General Microbiology - H.G. Schlegel, Cambridge University Press
11. General Microbiology - R.Y. Stanier, E.A. Adelberg& J.L. Ingraham, McMillan
12. Genes VIII - B. Lewin, Oxford University Press
13. Immunology -J. Kuby, Freeman
14. Introduction to Modern Virology - N.J. Dimmock& S.B. Primrose, Blackwell Science
15. Microbial Energetics - E. A. Dawes, Blackie
16. Microbial Physiology - A.G. Moat & J.W. Foster, John Wiley & Sons
17. Microbiology - B.D. Davis et al., Harpeer& Row
18. Microbiology - L.M. Prescott, J.P. Harley & D.A. Klein, McGraw-Hill
19. Microbiology - M.J. Pelczar, E.C.S. Chan & N.R. Krieg, McGraw-Hill
20. Microbiology – An Introduction -G.J. Tortora, B.R. Funke& C.L. Case, Addison Wesley, Longman

21. Microorganisms in Our World - R.M. Atlas, Mosby

Molecular Plant Pathology and Fungal Biotechnology

1. Molecular Plant Pathology - M. Dicinson. BiosScientific Publishers, Taylor and Francis group , London and New York

2. Fungal genetics: Principles and practice - Cees J. Bos , ed. Marcel Dekker, Inc. **3.** The Mycota:Vol. I -XII : Ed. K. Esser :Springer Verlag, Berlin

4. Gene VI-Gene IX: Benjamin Lewin, Oxford University press.

5. Molecular and cellular biology of filamentous fungi-Nick Talbot , Oxford University Press.

6. Plant Pathology- 4thEdn. -G. N. Agrios, Elsevier Publications.

7. An Introduction to mycology - R. S. Mehrotra and K. R. Aneja., New age Interntional publishers, New Delhi.

8. Topics in Mycology and Plant Pathology - L.N. Nair,New Central Book agency(P) Ltd. Kolkata.

9. Plant Pathology -concepts and laboratory Exercises - Robert N. Trigiano, Mark T. Windham and Alan S. Windham eds., CRC Press.

10. A text book of Plant Pathology - A.V.S.S. Sambamurty

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