RAMAKRISHNA MISSION VIVEKANANDA CENTENARY COLLEGE

RAHARA, KOLKATA, WEST BENGAL
www.rkmvccrahara.org

DEPARTMENT OF BOTANY

PROGRAMME OFFERED: M.Sc. BOTANY

PROGRAMME CODE: PGBOT

DURATION: 4 SEMESTERS

TOTAL CREDIT: 100

The CBCS curriculum in Botany is introduced from 2018 - 2019 onwards

with approx. 52% revision vide BOS resolution dated 17.05.2018

2018

PROGRAMME OUTCOMES (PO)

After completion of the M.Sc. Degree programme, the students will be able to

PO No.	Programme Outcome	Cognitive Level
PO1	Outline and demonstrate the basic concepts by acquiring a comprehensive knowledge in the newer emerging field of knowledge.	R, U
PO2	Perform experiments, analyse & interpret the obtained accurate results and thus gain the ability to solve problems.	Ap, An, E
PO3	Apply and evaluate the basic ideas to their thoughts, actions, and interventions for the societal benefits through the development of entrepreneurships.	Ap, E
PO4	Develop the ability to involve in critical, independent, and inventive thinking for the engagement in research and development on the emerging topics.	C

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PROGRAMME SPECIFIC OUTCOMES (PSO)

After completion of M.Sc. Degree programme the student will be able to

PSO No.	Programme Specific Outcome	Cognitive Level
PSO1	Understand the diversity & classification of plants from cryptogams to spermatophyte. Identification of flora in field. Study of biodiversity, physiology, biochemistry, molecular cytogenetics and application of statistics etc. Application of Botany in agriculture and industry.	R, U
PSO2	Learn about practical techniques in detail of plant cell structure, reproduction, anatomy, systematics. Maintain a high level of scientific excellence in botanical research with specific emphasis on the role of plants.	Ap, An, E
PSO3	Identify, formulate and analyze the critical problems ultimately providing a conclusion. Logical thinking with application of biological, physical and chemical sciences. Learning that develops analytical and integrative problem-solving approaches.	U, Ap, E
PSO4	Develop problem-solving skills that would encourage them to carry out innovative research projects thereby making them to use knowledge creation in depth.	Ap, An, C
PSO5	Attain good values, ethics, and kind heart and should be aware of ethical issues and regulatory considerations while addressing society needs for growth with honesty that provide a foundation for future career.	E, C

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Post Graduate Course Structure in Botany

Semester - I			July - December		
		Course Code	Topic	Marks	Credit
	Core Course	PGBOTCC1.1 (Th)	Phycology + Microbiology	25 + 25 = 50	4
		PGBOTCC1.2 (Th)	Mycology + Plant Pathology	25 + 25 = 50	4
		PGBOTCC1.3 (Th)	Biostatistics + Biophysics	25 + 25 = 50	4
		PGBOTCC1.4 (Th)	Ecology + Evolution	25 + 25 = 50	4
		PGBOTCC1.5 (Pr)	Phycology + Microbiology	25 + 25 = 50	4
		PGBOTCC1.6 (Pr)	Mycology + Plant Pathology	25 + 25 = 50	4
			Total	= 300	24
		PGBOTSOC1	Yoga	= 25	1

Semester - II			January - June		
		Course Code	Topic	Marks	Credit
	Core Course	PGBOTCC2.1 (Th)	Plant Anatomy + Developmental Biology	25 + 25 = 50	4
		PGBOTCC2.2 (Th)	Taxonomy of Angiosperms + Embryology of Seed Plants	25 + 25 = 50	4
		PGBOTCC2.3 (Th)	Biochemistry & Metabolism + Plant Physiology	30 + 20 = 50	4
		PGBOTCC2.4 (Th)	Environmental Science + System Biology	25 + 25 = 50	4
		PGBOTCC2.5 (Pr)	Taxonomy + Plant Anatomy	30 + 20 = 50	4
		PGBOTCC2.6 (Pr)	Biochemistry + Plant Physiology	30 + 20 = 50	4
			Total	= 300	24
		PGBOTSOC2	Communicative English	= 25	1

Semester - III			July - December		
		Course Code	Topic	Marks	Credit
	Core Course	PGBOTCC3.1 (Th)	Cell & Molecular Biology	= 50	4
		PGBOTCC3.2 (Th)	Genetics & Genomics	= 50	4
		PGBOTCC3.3 (Th)	Plant Biotechnology & Recombinant DNA technology	= 50	4
		PGBOTCC3.4 (Th)	Allied Elective	= 50	4
		PGBOTCC3.5 (Pr)	Plant Biotechnology	= 50	4
		PGBOTCC3.6 (Pr)	Cytology and Molecular Biology	= 50	4
			Total	= 300	24
		PGBOTSOC3	Value Education and Indian Culture	= 25	1

Semester - IV			January - June		
		Course Code	Topic	Marks	Credit
	CC	PGBOTCC4.1 (Th)	Research Methodology & Bio-Instrumentation	= 50	4
		PGBOTCC4.2 (Th)	Phytochemistry & Herbal Technology	= 50	4
	Major Elective	PGBOTME4.1 (Th)	Special Paper: 1out of 4 (Part-I Basic)	= 50	4
		PGBOTME4.2 (Th)	Special Paper: 1out of 4 (Part-II Applied)	= 50	4
		PGBOTME4.3 (Pr)	Special Paper (Practical)	= 50	4
		PGBOTME4.4 (Pr)	Special Paper (Project work)	= 50	4
			Total	= 300	24
		PGBOTSOC4	IPR/ Biosafety management / Post-harvest management of crops	= 25	1
			Total	= 1300	100

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Addition = 85%, Modification = 10%, total change = 45%

Semester – I	
Course name	Phycology and Microbiology (Theory)
Course code	PGBOTCC1.1
Number of lectures	60
Credits	4
Marks	50

Course Objectives: This course aims to

Course Objectives
• Explain the physiology of bacteria & algae, their growth, metabolism, development and phylogeny.
• Aware the students about antibiotics and control of harmful microbes
• Increase the understanding of microbial impact on the environment.
• Assess the utilization of beneficial microbes in industrial microbiology.

Core Course 1.1 (Group A: Phycology)

Theory **Full Marks: 25**

A. **General accounts of algae:** Principles and modern trends in algal classification; Concepts of Chromista, Archaeplastida, Chromoalveolates, Alveolates; Ultra structure of prokaryotic and eukaryotic algal cells; Primary, secondary and tertiary endosymbiosis; Comparative account of algal pigments and reserve food & evolution of algal chloroplasts; Cytomorphology of algal cells, Cell wall, Photoreceptor apparatus and Flagella; *Chalamydomonas reinhardtii* (genomic model) and *Porphyra* as experimental systems.

B. **General overview of algal groups:** Cyanobacteria/Cyanophyta, Glaucophyta, Chlorophyta, Cryptophyta, Heterokontophyta, Rhodophyta, Euglenophyta and Dinophyta. Concept of Chloroarachniophyta; special emphasis on emerging trends in molecular phylogeny and inter relationship of principal groups of algae.

C. Algal metabolism: Differentiation of heterocyst, biochemistry of nitrogen fixation, nif gene regulation and rearrangement; Nonheterocystous nitrogen fixation; Algal toxin (Chemical nature and biological effects), Bioluminiscence, molecular regulation of bioluminescence. Concept of Complementary Chromatic Adaptation (CCA).

D. Algal ecology: Algal blooms and their environmental impacts & its control, Algal indicators, Types of phytoplankton, classification of phytoplankton on basis of size variations, species diversity index (Species Diversity Index, Species evenness, Species richness), Redfield's ratio, Concept of eutrophication; Monod's and Droop's model for algal growth, Algae in diversified habitats (terrestrial, freshwater and marine); Harmful Algal Blooms (HAB), Red tide; Algae as symbionts (association in different plant groups) and parasites (*Cephaleuros*, *Harveyella*).

E. Algal biotechnology and human welfare: Nutraceuticals, Pharmaceuticals, Cosmetics, Biofertilizers, Hydrogen and hydrocarbon productions; Isolation, Purification & Growth characteristics of algal cultures; Brief idea about Chemostat and Turbidostat, Concept of photobioreactors; Preparation of culture media, unialgal & axenic culture, Concept of continuous culture, Principles & methods of algal mass cultivation techniques.

Group B: Microbiology

Theory **Full Marks: 25**

A. Classification of Bacteria: Bergey's manual of determinative bacteriology; Evolution and Phylogeny of bacteria (Woese's system); Concept of serotypes and its application. Application of 16srDNA sequencing in classification of bacteria, metagenomics in bacteriology.

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B. Ultrastructure and inclusions of bacteria: Ultrastructure and function of cell wall and cell membrane of eubacteria and archaea; ultrastructure of flagella and its movement, Molecular mechanism of flagellar development. Cell inclusions; ultrastructure of gas vacuoles, carboxysome, magnetosome.

C. Bacterial growth: Growth and cell division, mechanism of divisome complex formation and its regulation in relation to endospore formation; growth factors, kinetics of growth; continuous, synchronous and enrichment culture, diauxic growth, control of bacterial growth.

D. Microbial genetics: Genome organization in bacteria; Plasmids – Types, plasmid replication; host range and incompatibility; regulation of copy number; curing of plasmids; Concept of different plasmid vectors and their application. Mechanism of genetic exchange: Discovery, mechanism of natural competence, mapping through co-transformation frequencies; Conjugation: Discovery, mechanism, Hfr and F' strains, interrupted mating technique and time of entry mapping; Transduction: Generalized and specialized, LFT and HFT lysates, abortive transduction; mapping of bacterial chromosome.

E. Environmental Microbiology: Interaction between Microbes & Plants- (a) Interaction with Plant Roots (b) Nitrogen fixation in Nodules; Bioremediation of soil and Aquifers. Quorum sensing.

F. Microbiology of water: Microbiological analysis of water (total count, indicative organism), B.O.D. & C.O.D. - determination and implication. Coliform test - detection of faecal and non-faecal coliform), IMViC test, Concept of nano-plastic and water quality.

G. Bacterial pathogenicity and chemotherapy: Properties of pathogenic bacteria- adhesions, invasions and extracellular enzymes. Bacterial toxins - endotoxin and exotoxins. Chemotherapy - chemotherapeutic agents, antiviral, antibacterial and antifungal antibiotics; Concept of antimicrobial drug design and their potential target determination, antibiotic resistance.

H. Fundamentals of immunology: Innate and acquired immunity, humoral, cell mediated immunity, T-cells, B-cells and Cytokines. Antigens - characteristics, types, structure and functions of different classes of immunoglobulins, application of immunological techniques.

I. Viruses and acellular microbes: Nomenclature and classification of plant virus. Distinctive properties of virus, morphology and ultrastrucutre, capsid and their arrangements, types of envelops and their composition, viral genome: their types and structure. Phage growth and estimation of phage numbers. Replication of T4 phage, Lytic and lysogenic life cycle of bacteriophage lambda; mechanism(s) that determines lytic and lysogenic life cycle, SOS response of E coli host; Plant retroviruses; Other acellular agents: viriods, virusoides and prions- General characteristics.

J. Industrial microbiology: Basic concepts: bioreactors, application of microbes in industry, benefits, role of microbes in agriculture, pharmaceuticals, food technology etc.

Course Outcome: After completion of this course the student will be able to

Sl. No.	Course Outcomes	Cognitive Level	POs Addressed	PSOs Addressed
CO1	Outline diversity of bacteria & algae.	R, U	PO1	PSO1, PSO2
CO2	Summarize microbial physiology of & their growth, metabolism, development and phylogeny.	U, Ap, An	PO2	PSO1, PSO2
CO3	Design and execute experiments using microbes.	An, E	PO2, PO3	PSO3
CO4	Assess eutrophication, water quality & understand bacterial genetics and its application.	An, E	PO3, PO4	PS03, PSO4
CO5	Develop concepts on antibiotics & chemotherapy, environmental and industrial microbiology.	E, C	PO4	PSO4, PSO5

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Semester – I	
Course name	**Mycology and Plant Pathology (Theory)**
Course code	**PGBOTCC1.2**
Number of lectures	**60**
Credits	**4**
Marks	**50**

Course Objectives: This course aims to

Course Objectives
• Impart knowledge to students on fungus and plant pathogens
• Provide an understanding of pathogenesis in plant systems
• Provide information on disease incidences and immune responses of plant systems
• Enrich students about plant-pathogen interactions.

Core Course 1.2 (Group A: Mycology)

Theory **Full Marks: 25**

A. **Introduction:** Fungi – Forms and functions; Diversity of fungi and fungus-like organisms, evolution and phylogeny including systematics, life cycle patterns of meiosporic and mitosporic fungi.

B. **Fungal growth and nutrition:** Introduction; Nutrient sensing and uptake; Mechanics and cellular mechanisms of growth, kinetics and measurement of growth, factors affecting growth.

C. **Fungal Reproduction:** Asexual and sexual reproduction, spore forms, nutritional and environmental factors affecting sporulation, spore dispersal, spore dormancy and germination – biochemical and molecular changes accompanying spore germination; sex pheromones.

D. **Genetics of Fungi:** Structure and organization of fungal genome, nuclear division, systems and mechanisms of variation.

E. **Applied Mycology:** Single cell protein, alcohol production and other fermentation products, antibiotics (penicillin & griseofulvin), organic acids, enzymes and alkaloids.

F. Biotechnological applications of fungi -Mushrooms and mushroom cultivation

G. **Lichen Biology:** Photobionts and mycobionts; Morphogenesis; Ecological and economic importance.

Group B: Plant Pathology

Theory **Full Marks: 25**

A. **Introduction:** An overview of nature of pathogens and pests and their impact on plant growth; Terminologies involved, pathogen penetration, establishment and host colonization.

B. **Host Parasite Interactions:** Genetic and molecular basis for disease resistance or susceptibility, disease surveillance, epidemics and epidemiology.

C. **Plant Défense Mechanisms:** Preformed plant defences, induced defences, biochemical and physiological responses, host-pathogen interaction mechanisms, pathogen recognition and signal transduction, Physiology and biochemistry of plant disease reaction, role of cell wall in plant defense.

D. **Molecular Plant Pathology:** Molecular determinants of pathogenicity, virulence, effectors, elicitors, defensins, phytoalexins, phenolics, plant cell wall degrading enzymes, host specific toxins, host non-specific toxins, hormones and their role in signalling, plant immunity.

E. **Plant Disease Resistance:** Concept, classes of resistance genes, adapted and non-adapted resistance, Systemic acquired resistance, Induce Systemic resistance.

F. **Defence Response:** Pathogenesis-related (PR)-proteins, Hypersensitive Reaction, Reactive oxygen species (ROS) generation, oxidative burst, scavenging of ROS.

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G. **Applied Plant Pathology:** Transgenic and genetic manipulation approach and molecular marker approach to tag disease resistance and avirulence genes; Use of databases and applications of bioinformatics in plant pathology.

H. **Plant Disease Management:** Principles of plant disease management by cultural, physical, biological, chemical and organic amendments; mode of action of antifungal, antibacterial and antiviral chemicals; integrated control measures of plant diseases; molecular approach.

Course Outcome: After completion of this course the student will be able to

Sl. No.	Course Outcomes	Cognitive Level	POs Addressed	PSOs Addressed
CO1	Explain the life cycle patterns of pathogenic fungi and their host specificity	R, U, Ap	PO1	PSO1
CO2	Analyze how host immune systems respond to pathogenic infections.	Ap, An	PO1, PO2	PSO1, PSO2, PSO3
CO3	Explain the importance of plant defence systems in combating infections.	An, E	PO2, PO3	PSO3
CO4	Determine the importance of mycology and plant pathology as a discipline of plant science.	E	PO3, PO4	PSO3
CO5	Exploit the scope of database and bio-informatics in plant disease management.	C	PO4	PSO4, PSO5

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Semester – I	
Course name	**Biostatistics & Bio-Maths; Biophysics (Theory)**
Course code	**PGBOTCC1.3**
Number of lectures	**60**
Credits	**4**
Marks	**50**

Course Objectives: This course aims to

Course Objectives
• Enable students to learn through real examples by application of statistical techniques. • Analyze and interpret the data generated in biology using modern statistical methods. • A thorough grasp of mathematical, biophysical and statistical methodology, before going on to apply these skills to solve real-life problems in various field.

Core Course 1.3 (Group A: Biostatistics & Bio-Maths)

Theory **Full Marks: 25**

A. **Data Collection:** Types of Biological Data: Qualitative Data -Nominal, Ordinal, Ranked; Quantitative Data: Discrete and Continuous. Concept of Population and sample. Tables: Frequency Distributions, Relative Frequencies. Graphical Presentation: Bar charts, Histograms, Frequency Polygons, Box plots, two-way scatter plots, line graphs.

B. **Descriptive Statistics:** Measures of Central Tendency: Mean, Median and Mode, quartiles, deciles and percentiles (both for raw data and grouped data) Measures of Dispersion: Range, Variance, Standard deviation and Coefficient of variation; tests of significance, t-test, chi- square, ANOVA.

C. **Probability and Probability Distributions:** Probability: Marginal and Conditional Probability, Independent Events. Laws of probabilities; Probability Distributions (Binomial, Poisson and normal)

D. **Design of experiments:** Principles of Randomized block design, Latin square design, Split-plot designs; Basic concept on bivariate and Multivariate data set.

E. **Bivariate and Multivariate Data:** Examples on bivariate and multivariate data; Correlation: Simple, partial and multiple correlation Coefficients; Regression: Simple and multiple linear regressions; Use of software packages like SPSS, SAS etc. for experiment analysis.

F. **Biomaths:** Single species population dynamics: Discrete and Continuous population models; Logistic models and their stability analysis; Population dynamics of two interacting species: Lotka-Volterra model of predator-prey system; Gauss's model, Kolmogorov model and their stability analysis; Chemostat model: Bacterial growth in a chemostat, formulation of chemostat, stability analysis; continuous model for three or more interacting population: Food chain model, competitive and mutualistic model, models on harvesting of species in a competitive environment.

Group B: Biophysics

Theory **Full Marks: 25**

A. **Physico-chemical properties of water:** Ionic product of water; pH - definition, effect of pH in enzyme catalyzed reaction. Acids, bases and buffers in biological system; Arrhenius, Bronsted-Lowry theories of acid and bases. Polyprotic acids, ampholytes, dissociation of polyprotic acid; titrable and true acidity. Surface tension, viscosity: application to biomolecules.

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B. Microscopy: General principles of optics in relation to microscopy; different components of light wave (UV, IR, visible); principles and applications of Compound Microscope; Light Microscope; Dark field Mircroscope; Bright field Microscope; Phase Contrast Microscope; Fluorescent Microscope; Electron Microscope; Resolving power; Numerical aperture: Chromatic Aberration.

C. Spectrophotometry: visible, UV, IR.

D. Isotopes in Biology: Law of Radioactivity, Decay constant, half-life, average life. Properties of α, β, γ radiations, unit of radioactivity, radioactive carbon dating. Applications of radioactive isotopes (^{14}C, ^{3}H, ^{32}P) in biological systems.

E. Chromatography: Basic principle; principle and applications of Thin Layer chromatography (TLC), Gas Liquid Chromatography (GLC) and High-Performance Liquid chromatography (HPLC).

Course Outcome: After completion of this course the student will be able to

Sl. No.	Course Outcomes	Cognitive Level	POs Addressed	PSOs Addressed
CO1	Explain the various application of biostatistics.	R, U	PO1, PO2	PSO1, PSO2
CO2	Distinguish different types of data and sampling methods.	Ap, An	PO1, PO2	PSO2
CO3	Analyze and interpret quantitative data.	An	PO3	PSO3
CO4	Identify appropriate tests to perform hypothesis testing and experimental design and its interpretation.	Ap, An	PO3	PSO3, PSO4
CO5	Explain the use of statistical software packages in biostatistics.	E, C	PO4	PSO4, PSO5

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Semester – I	
Course name	Ecology; Evolution (Theory)
Course code	PGBOTCC1.4
Number of lectures	60
Credits	4
Marks	50

Course Objectives: This course aims to

Course Objectives
• Provide hands-on training on fieldwork and assessment of biodiversity of habitats.
• Provide knowledge on ecological niche, selection, population and course of evolution.
• Helps students in developing an insight of competition, and other biotic interactions.
• Gather ideas on modes of evolution, speciation and genetic variation.

Core Course 1.4 (Group A: Ecology)

Theory **Full Marks: 25**

A. **Habitat and niche:** Concept of habitat and niche; niche width and overlap; fundamental and realized niche; resource partitioning; character displacement.

B. **Population ecology:** Characteristics of a population; population growth curves; population regulation; life history strategies (*r* and *k* selection); concept of metapopulation – demes and dispersal, interdemic extinctions, age structured populations.

C. **Species interactions:** Types of interactions, interspecific competition, herbivory, carnivory, pollination, symbiosis.

D. **Community ecology:** Nature of communities; community structure and attributes; levels of species diversity and its measurement; edges and ecotones.

E. **Ecological succession:** Types; mechanisms; changes involved in succession; concept of climax.

F. **Ecosystem:** Structure and function, energy flow and mineral cycling (CNP), primary production and decomposition; structure and function of some Indian ecosystems: terrestrial (forest, grassland) and aquatic (fresh water, marine, eustarine).

G. **Biogeography:** Major terrestrial biomes; theory of island biogeography; biogeographical zones of India.

H. **Biodiversity:** Goals and constraints of biodiversity science.

I. **Loss of Biodiversity:** Species Extinction - Fundamentals causes; The IUCN threat Categories, (Extinct, Endangered, Vulnerable, Rare, Intermediate and Insufficiently known) - The threat factors (Habitat loss, over-exploitation for uses, introduction of Exotics, Diseases, habitat fragmentation etc.) - Common threat plant taxa of India - Red data Books.

J. **Values of Biodiversity:** An outline account on methods of valuing biodiversity.

K. **Sustainable management of Biodiversity and Bioresources:** National polices. Sustainable utilization and improvement. A general account on multilateral treaties- the role of CBD, IUCN, IBPGR, NBPGR, GSPC and CITES.

L. **Conservation of Biodiversity:** *In situ* (Afforestation, Social Forestry, Agro forestry, Botanical gardens, Biosphere reserves, National parks, Sanctuaries, Sacred groves and Sthalavrikshas) and *Ex situ* (Cryopreservation, Gene Banks, Seed Banks, Pollen Banks, Sperms Banks, DNA Banks, Tissue Culture and Biotechnological Strategies).

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Group B: Evolution

Full Marks: 25

Group B:

A. Introduction: Origin of life, prebiotic environment, panspermia, Biological Fitness, Adaptation, and Selection, Darwin's theory of evolution and neo Darwinism, Evolutionary synthesis- Fact and theory. RNA World & Evolution

B. Species and Evolution: Species and Speciation, Biological species concept, Speciation with or without geographic separation, Time course of speciation, Hierarchical classification, Phylogenetic trees, reading and using trees, Geological fundamentals, geological time scales, Fossil record provides several lines of evidence for evolution, Phylogeny and the fossil records, Evolutionary trends, Rates of evolution, Major patterns of distribution.

C. Gene, Genome and Evolution: Genes, genomes, mutations, karyotype and evolution, Nucleotide substitution in DNA sequences, Rate of nucleotide substitution, New material on the evolution of *de novo* genes, Genome restructuring and evolution, Phenotypic variation and their source, Variation in chromosome structure; variation in protein structure, Variation of evolutionary rates between genes, Genetic variation in populations. Variation among populations; Mutation creates new alleles in a gene pool, Gene flow (Hardy Weinberg equilibrium), Natural selection is a major force driving allele frequency change, Molecular clock of evolution, Role of inbreeding in evolution.

D. Macroevolution & Microevolution: Concept; source of genetic variation, Genetic drift, sampling, coalescence; bottleneck effects, Founder effects; Neutral theory of molecular evolution, Natural selection; Role of natural selection in adaptive evolution, Adaptive radiation, Levels of selection; Genetical theory of natural selection; Evolution of phenotypic traits; Species and speciation; Co-evolution.

Course Outcome: After completion of this course the student will be able to

Sl. No.	Course Outcomes	Cognitive Level	POs Addressed	PSOs Addressed
CO1	Analyze the biodiversity of a habitat by application of key concepts.	Ap, An	PO1	PSO1
CO2	Interpret and outline how biotic interactions affect biotic communities in natural ecosystems.	U, Ap	PO2, PO3	PSO2, PSO3
CO3	Relate the biogeography and biodiversity of plants in Indian perspective.	U, Ap	PO3	PSO3
CO4	Perceive knowledge on biomes and ecosystems and their evolution.	An, E	PO3	PSO3
CO5	Apply key concepts in conservation and estimate biodiversity of diverse habitats.	Ap, E, C	PO4	PSO5

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Semester – I	
Course name	**Phycology & Microbiology (Practical)**
Course code	**PGBOTCC1.5**
Number of lectures	**60**
Credits	**4**
Marks	**50**

Course Objectives: This course aims to

Course Objectives
• Develop knowledge on preparation of different culture media for bacteria and algae
• Identify bacteria and algae under microscope based on staining properties, morphology
• To develop skills of isolation of bacteria/algae from natural sources and formulation of pure culture
• To analyse antibiotic resistance, metabolic and growth parameters of bacteria

Core Course 1.5 (Phycology & Microbiology)

Practical **Full Marks: 50**

Microbiology

1. Preparation of nutrient media (LB/PDA).
2. Simple staining of bacterial cells.
3. Gram staining of bacterial cells.
4. Isolation of bacteria from rhizospheric soil.
5. Isolation of pure culture by slant.
6. Isolation of microbes from air.
7. Isolation of microbes from water.
8. Isolation of bacteria from rotten food.
9. Isolation of fungi from rotten food.
10. Antibiotic assay by agar cup method.
11. Antibiotic assay by paper disc method.
12. Determination of bacterial growth by nephalometric method.
13. Effect of pH, temperature, Irradiation on bacterial growth.
14. Isolation of amylase producing bacteria from natural sources.
15. Microbial examination of water.
16. Tests for bacterial characteristics (Indole production, methyl red, Voges-Proskauer Test, citrate test).
17. Staining of bacterial endospores.
18. Determination of bacterial motility.

Phycology

1. Study of algal diversity of Cyanophyceae, Chlorophyceae, Rhodophyceae and Phaeophyceae.
2. Collection, Isolation and Identification of algae from diverse habitat.
3. Preparation of culture media (BG-11 & BBM) for microalgae.

Course Outcome: After completion of this course the student will be able to

Sl. No.	Course Outcomes	Cognitive Level	POs Addressed	PSOs Addressed
CO1	Develop media and culture different algae/ bacteria in laboratory condition.	Ap, An	PO2, PO3	PSO1, PSO2
CO2	Identify bacteria/ algae based on their staining properties, morphology.	U, Ap	PO3	PSO1, PSO3
CO3	Examine metabolic, growth and developmental properties of bacteria.	U, Ap	PO3	PSO3
CO4	Isolate and culture microbes from different natural sources.	An, E	PO3, PO4	PSO4
CO5	Identify antibiotic resistance in bacteria from different environmental and clinical samples.	Ap, E, C	PO4	PSO4, PSO5

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Semester – I	
Course name	**Mycology & Plant Pathology (Practical)**
Course code	**PGBOTCC1.6**
Number of lectures	**60**
Credits	**4**
Marks	**50**

Course Objectives: This course aims to

Course Objectives
• Acquaintance with laboratory techniques and instruments used in mycology and plant pathology
• Develop knowledge on preparation of specific media for fungal culture.
• Analyze mycoflora from air, leaf surface and root surface.
• Develop skill on mushroom production.
• Survey plant diseases and its causal organisms.

Core Course 1.6 (Mycology & Plant Pathology)

Practical **Full Marks: 50**

Mycology & Plant Pathology

1. Principles & working of tools, equipments and other requirements in the Mycology & Plant Pathology laboratory.
2. Micrometry and measurement of organisms/spores/propagules.
3. Sterilization processes viz. moist heat, dry heat, chemical and radiation.
4. Preparation of different cultural media for cultivation of fungi.
5. Monitoring and analysis of Aeromycoflora, Phyllosphere and Rhizosphere mycoflora.
6. Demonstration of antifungal activities of different antibiotics.
7. Cultivation of Mushrooms.
8. Demonstration of Koch's Postulate.
9. Calculation of spore count using haemocytometer.
10. Estimation of sugars, proteins and amino acids in fungal mycelium and culture filtrate.
11. Study of mycorrhiza (VAM)
12. Monographic study of locally available plant diseases caused by fungi.
13. Demonstration of morphological & physiological changes in diseased plants.

Course Outcome: After completion of this course the student will be able to

Sl. No.	Course Outcomes	Cognitive Level	POs Addressed	PSOs Addressed
CO1	Demonstrate culture media preparation and culture of fungi in laboratory.	R, U	PO1	PSO1
CO2	Develop idea on laboratory instruments, sterilization and safety in plant pathology laboratory.	U, An	PO1	PSO1, PSO2
CO3	Analyze & estimate biomolecules and essential compounds from fungal sources.	Ap, An	PO2	PSO2, PSO3
CO4	Survey local crop diseases and propose probable remedies.	An, E	PO2, PO3	PSO3
CO5	Design and formulate commercial mushroom cultivation.	E, C	PO4	PSO4, PSO5

*R = remembering, U = understanding, Ap = applying, An = analyzing, E = evaluating, and C = creating

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Addition = 35%
Modification = 10%
Total change = 45%

Semester – II	
Course name	**Plant Anatomy; Developmental Biology (Theory)**
Course code	**PGBOTCC2.1**
Number of lectures	**60**
Credits	**4**
Marks	**50**

Course Objectives: This course aims to

Course Objectives
• Provide knowledge to the learners on the differentiation of plant tissues.
• Impart in-depth understanding of wood anatomy and reproductive anatomy.
• Help students to develop concepts on ecological anatomy and plant developmental biology.

Core Course 2.1 (Plant Anatomy and Developmental Biology)

Group A: **Plant Anatomy** **Full Marks: 25**

A. Differentiation of Plant Tissues: Ontogeny and phylogeny of sclereids, fibres and their control of differentiation; nature and function of p-protein, vascular cambium, factors influencing cambial activity; Peridern structure and development; Cell wall: temporal and spatial dynamism in structure, growth and differentiation, and functional roles.

B. Wood Anatomy: Physical and Mechanical Properties of Wood; Growth rings, Ring porous wood, Diffuse porous wood, diversity in axial parenchyma distribution and diversity in ray system; Xylem and Phloem Structure, Water Movement, Conductance.

C. Reproductive Plant Anatomy: Floral vasculature; development of pollen grains; structure of floral nectaries and seed coat.

D. Ecological Plant Anatomy: Epiphytic Plants; Ecological Stem Anatomy: Hydraulic Architecture; Ecological Root Anatomy: Aerial, Xeromorphic, Hydromorphic, Flooded and Drought-Stressed Roots; Frost Hardiness.

E. Applied Plant Anatomy: Application of anatomical studies in climatology, genetics and plant breeding, biomedical research and forensic science.

Group B: **Plant Developmental Biology** **Full Marks: 25**

1. **Plant development**: Concept, definition and unique features of development in plants.

2. **Differentiation**: Determination, Differentiation, and Dedifferentiation in Plants. Role of PGR (auxin & cytokinin) as a regulator of cellular differentiation.

3. **Control of Growth in Plants**: Genetic control of plant organ growth.

4. **Plant Architecture:** Dynamic, multilevel and comprehensive approach to plant form, structure and ontogeny.

5. **Plant Stem Cell**: concept, functions, importance; Stem Cell Niches, WUSCHEL, CLAVATA and other genes in stem cell.

4. **Meristem**: Development of Shoot Apical Meristem (SAM), Development of Root Apical Meristem (RAM), Development of Inflorescence Meristem (IM) and Development of Floral Meristem (FM).

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5. Shoot Development: Shoot development--genetic interactions in the meristem, Role of cytokinin in shoot development, Role of small RNAs in vegetative shoot development

6. Root Development: Root types, Molecular and environmental regulation of root development, Genetic variation in root architecture, Environmental factors influencing root architecture, Patterning during root embryogenesis.

7. **Shoot Organ**: Genetic control of shoot organ boundaries, Morphogenesis and patterning of the organ boundaries.

8. **Leaf**: Determining sites of leaf initiation, Evolution of leaf-shape; Development of leaf lamina, Modifying leaf shape.

9. **Axillary Shoot Branching in Plants**: Axillary shoot development, Bud Initiation, Genes control axillary shoot branching, Hormones involved in axillary bud formation.

10. **Development of flowering plant gametophytes**. Molecular genetics of male and genetics of female gametophyte development. Pollen tube development.

11. **Transition from vegetative to reproductive phase**: morpho-histochemical changes in shoot apex floral meristem and floral organ development in Arabidopsis.

12. **Flower development**: Developmental genetic pathways involved in flower formation in model plant Arabidopsis; identify genes, gene families, and gene networks in the regulation of flower initiation, growth and differentiation.

13. **Embryo development:** Pattern Formation in the early plant embryo; Genetic and molecular control of embryogenesis; zygote polarity and elongation; zygotic genome activation; zygote division and separation of apical and basal cell fate; hypophysis specification and root pole formation.

14. **Endosperm formation**: Genetic and molecular basis of the endosperm formation.

15. **Seed and fruit development**: Genetic, Developmental, and molecular bases of fruit size and shape variation (Solanaceae); Genetic and epigenetic processes in seed development.

Course Outcome: After completion of this course the student will be able to

Sl. No.	Course Outcomes	Cognitive Level	POs Addressed	PSOs Addressed
CO1	Extend state of the art knowledge on how plant tissues differentiate.	R, U	PO1, PO2	PSO1
CO2	Relate their existing know-how on genes involved in plant developmental processes.	Ap, An	PO2, PO3	PSO2
CO3	Develop their concepts on aerial, xeromorphic, hydromorphic and stressed root systems and their anatomical features.	Ap, An	PO3	PSO2, PSO3
CO4	Evaluate the role of PGRs in developmental biology.	An, E	PO3, PO4	PSO3, PSO4
CO5	Interpret the molecular details of plant developmental process.	An, E, C	PO4	PSO4, PSO5

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Addition = 40%
Modification = 10%
Total change = 50%

Semester – II	
Course name	**Taxonomy and Biosystematics; Embryology of seed plants (Theory)**
Course code	**PGBOTCC2.2**
Number of lectures	**60**
Credits	**4**
Marks	**50**

Course Objectives: This course aims to

Course Objectives
• Provide knowledge on identification, nomenclature, classification of plants and their evolution.
• Recognize members of the major angiosperm families by identifying their diagnostic features and economic importance.
• Gain knowledge on plant reproductive organs and fertilization process.

Core Course 2.2

(Taxonomy and Biosystematics; Embryology of seed plants)

Group A: **Taxonomy and Biosystematics** **Full Marks: 25**

A. Introduction: Aims and scope of taxonomy, history and phases of taxonomy, alpha and omega taxonomy.

B. Nomenclature: History of ICBN, aims and principles, rules (including fossils and cultivated plants) and recommendations: nomenclatural type, different types of names, authors citation, priority of publications, effective and valid publication, proposed bio and phylocodes.

C. Concepts of Taxonomical Hierarchy: Species/ Genus/ Family and other categories, species concept: (Taxonomical/ Biological/ Evolutionary/ Phylogenetic/ Ecological)

D. Tools of Taxonomy: Basic concept on field/ excursion, herbarium, botanic gardens, different taxonomic literature, GPS, GIS.

E. Biosystematics: Definition, methods, categories, relationship and differences with classical taxonomy.

F. Major systems of angiosperm classification: Outline of classification of Cronquist (1988), Takhtajan (1997) and Thorne (2007) upto subclasses/ superorders. Broad outlines of Angiosperm Phylogeny Group (APG): APG I (1998), APG II (2003), APG III (2009), APG IV (2016) and their merits and demerits.

G. Numerical taxonomy: Principles; Basic concept: OTU, phenon line, phenogram; methods, application, merits and demerits

H. Cladistics: Principles; Basic concept: cladogram, symplesiomorphy, synapomorphy, monophyly, polyphyly, paraphyly; methods; merits & demerits

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I. Angiosperm diversity: Salient features, evolutionary trends and phylogeny in magnoliidae, Hamamelidae, Caryophyllidae, Asteridae, Alismatidae and Liliidae (*sensu* Cronquist ,1981), concepts of palaeoherbs, eu-dicots etc.

J. Molecular Systematics: Molecular markers used in Taxonomy; Nuclear and Chloroplast genome; DNA Barcode

Group B: **Embryology of seed plants** **Full Marks: 25**

1. Then and Now: Plant embryology during and after Panchanan Maheshwari's time – Changing face of research in the embryology of flowering plants.
2. An overview of angiosperm reproduction
3. Apomixis, Apospory, Diplospory, Parthenogenesis, Apogamy, Classification of Apomixis, Embryo- Endosperm Interrelations in Apomixis
4. Male and female gametophytes: Regulation of anther and ovule development, microsporogenesis and microgametogenesis, megasporogenesis and megagametogenesis; anther wall layers and functions; Tapetum-types, Concept of male germ unit.
5. Pollen-pistil interaction: Pollen germination and pollen tube growth, double fertilization, Pollen recognition & rejection reactions-Types; structures; methods to overcome incompatibility reactions.
6. Fertilization: A general account; double fertilization; single fertilization; heterofertilization & polyspermy.
7. Embryogenesis and seed development.

Course Outcome: After completion of this course the student will be able to

Sl. No.	Course Outcomes	Cognitive Level	POs Addressed	PSOs Addressed
CO1	Outline the range of variations in angiosperms.	R, U	PO1	PSO1
CO2	Relate the trends in angiosperm classification.	U, Ap	PO1	PSO2
CO3	Compare the various rules, principles and recommendations of plant nomenclature.	An	PO2, PO3	PSO2, PSO3
CO4	Discuss the methods of pollination fertilization and embryogeny.	E, C	PO3	PSO3, PSO4
CO5	Explain the use of molecular biology & computers in angiosperm taxonomy.	E, C	PO4	PSO4, PSO5

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Addition = 45 %

Modification = 10 %

Total change = 55 %

Semester – II	
Course name	**Biochemistry and Metabolism; Plant Physiology (Theory)**
Course code	**PGBOTCC2.3**
Number of lectures	**60**
Credits	**4**
Marks	**50**

Course Objectives: This course aims to

Course Objectives
• Impart knowledge to students on the general aspects of plant physiology and biochemistry
• Develop concepts in different aspects of plant metabolism.
• Familiarize students to different anabolic and catabolic pathways.

Core Course 2.3

(Biochemistry and Metabolism; Plant Physiology)

Group A: **Biochemistry and Metabolism** **Full Marks: 25**

A. Nucleic Acids (DNA and RNA): Nucleotide biosynthesis, single and double-stranded structures, non-Watson-Crick pairing, Sugar puckering and base stacking; torsion angle, Supercoiling; Denaturation kinetics of DNA, Cot curves.

B. Lipid Metabolism: Biosynthesis and metabolism of lipids, structural and storage lipids, storage and mobilization of lipids, oxidation of fatty acids, lipidomics concept.

C. Glycobiology: Monosaccharides and polysaccharides: chemistry, classification, and function; glycoproteins and proteoglycans.

D. Amino Acids & Proteins: Hierarchy of protein structure, motifs and domains, torsion angle and Ramachandran plot, Forces stabilizing protein structure, fibrous proteins (keratins and collagen), globular protein; Protein folding: different models and concept of chaperones, protein sequencing.

E. Enzymology and Bioengergetics: Application of principal of thermodynamics in biology, origin and evolution of biocatalytic reactions; Features of enzyme catalysis, Mechanism of action of enzymes, Enzyme kinetics, Bisubstrate reactions, Enzyme inhibition, Applications of enzymes, significance of ribozymes, abzymes artificial enzyme technology regulation of enzymatic activity, evolution of electron transport chain and its coupling to ATP synthesis, bioelectricity.

Group B: **Plant Physiology** **Full Marks: 25**

A. Photosynthesis: Genes and polypeptide components of photosynthetic complexes; Bioenergetics of light reaction, Generation of proton gradient and ATP synthesis; Water to Water Cycle; CO2 concentrating mechanism in plants; Rubisco and its genes, Regulation of C2, C3, C4 and CAM cycles

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B. Respiration: Metabolic regulation of glycolysis, acetyl CoA synthesis and citric acid cycle; Mitochondrial electron transport complexes – structure, function; Mechanism of ATP synthesis; Gluconeogenesis; Glyoxylate cycle, cyanide resistant pathway and alternative oxidase

C. Sensory Photobiology: Structure, function and mechanisms of action of phytochromes, cryptochromes and phototropins; scotomorphogenesis and photomorphogenesis; photoperiodism, Chronobiology: Circadian rhythms, clock mechanisms, biological clock

D. Physiology of senescence and aging: Senescence promoters, whole plant senescence and organ senescence, hormonal and environmental control of senescence, programmed cell death in life cycle of plants.

E. Seed physiology: Types of dormancy, seed viability, dormancy enforcement and termination, biochemical and molecular basis of dormancy, hormonal regulation of dormancy and germination, Circadian clock and regulation of germination.

F. Nitrogen metabolism: Structure and function of nitrogenase, Mechanism of nodule formation; Nitrate assimilation in plants.

G. Plants and Water: Concept of chemical potential, Surface tension and capillary rise, Water potential and its component, Soil Plant Atmosphere continuum- Water movement in soil and root, root pressure, Cohesion tension theory of water uptake, Hydraulic lift, Aquaporins.

H. Solute Transport: Nernst potential and Goldman equation, membrane transport processes Pumps, carriers and Channels – Structure and function, energetics of active transport, isophore and ionophore, Phloem transport Long distance transport in phloem, vacuoles – structure and function.

I. Plant Growth Regulators: Biosynthesis, transport, mechanism of action, bioassay. Concept of hormones as chemical messengers, Classical approaches and use of mutants in understanding hormone actions, hormones in defense against biotic stresses synthetic regulatory compounds and their uses.

J. Stress Physiology: Water stress: Concept, stomatal response to water stress, role of ABA, osmotic adjustment and mechanism of drought tolerance. Temperature stress: effects of low and high temperature on plants, cellular and molecular responses to low and high temperature, heat shock proteins. Salinity stress: effect of high salt concentration on plants, ion toxicity, regulation of salt content: salt exclusion, salt elimination, and salt succulency, mechanism of salt tolerance.

Course Outcome: After completion of this course the student will be able to

Sl. No.	Course Outcomes	Cognitive Level	POs Addressed	PSOs Addressed
CO1	Outline the various biochemical pathways.	R, U	PO1	PSO1
CO2	Develop knowledge on the concepts of anabolism and catabolism.	U	PO1	PSO1, PSO2
CO3	Summarize enzymatic catalysis & apply the concepts of enzymology and bioenergetics.	U, Ap	PO2	PSO3
CO4	Inspect the substrate specificity of enzymes.	An, E	PO3	PSO3, PSO4
CO5	Develop concepts of plant growth regulators (PGRs) and stress physiology.	E, C	PO4	PSO4, PSO5

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Addition = 35%

Modification = 15%

Total change = 50%

Semester – II	
Course name	Environmental Science; System Biology (Theory)
Course code	PGBOTCC2.4
Number of lectures	60
Credits	4
Marks	50

Course Objectives: This course aims to

Course Objectives
• Provide knowledge on basic concepts of pollution and pollutants with emphasis on their management.
• Provide idea about toxicology and heavy metal toxicity.
• Impart technical know-how of fossil fuel in light of the global environment and EIA.

Core Course 2.4

Environmental Science and System Biology

Group-A: **Environmental Science** **Full Marks: 25**

A. Environmental Pollution: Basic concept of pollution and pollutants; Sources, nature, types and environmental effects of air, water, noise and radioactive pollution; Sources and recycling of e-waste, solid waste-pollution and management; Pesticides: types and its effect on living organisms.

B. Heavy Metal Toxicology: Principles of toxicology and types of toxins, sources, metabolism and biological monitoring of Arsenic, Mercury, Cadmium, Lead and Nickel.

C. Toxicology: Principles of toxicology, dose-response relationships, Chronic and acute toxicity, Effective concentration, LD-50, Median tolerance limit and Margin of safety; Toxicity testing.

D. Global Environmental Issues: Greenhouse gases and global warming, Stratospheric ozone depletion, causes of depletion and consequences, acid rain and their impact on the environment; biotechnological approaches for sustainable development.

E. Fossil Fuels and the Environment: Conservation of non-renewable energy resources and alternative energy resources and environment.

F. Bioindicators of Pollution: Bioindicators and biomarkers of environmental condition, Biomonitoring, Biodegradation and bioremediation of chemicals, Biofueling, Biofilm and Biocorrosion.

G. Environmental Impact Assessment: Concept of Environmental Impact assessment, key steps in EIA process with reference to big dams/ chemical industries/ nuclear power plants /mining, methods for forecasting, assessing and preparing environmental impact statement, reviewing and evaluating EIA report, Restoration of ecosystem.

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Group B: **System Biology** **Full Marks: 25**

A. Introduction to System biology: The elements of systems biology and its key frameworks; Basic tools - Genomics, Transcriptomics, proteomics, metabolomics, phenomics, interactomics and bioinformatics; Importance in modern biology.

B. Network Analysis: Biological network; Key components – edge, node, degree distribution, path length and hub; Network properties – random and scale free network; Modules and its significance; Different types of motif - Feed-forward loop, Single input motif, Dense overlapping regulons, Network Types - Gene-to-metabolite networks, Protein–protein interaction networks, Transcriptional regulatory networks and Gene regulatory networks.

C. Modeling in system biology: Software for modeling and simulation; Deterministic and stochastic models of genetic regulatory networks; Boolean Networks and its significance.

D. Systems biology of plant: *Arabidopsis thaliana* - a model organism for system biology; Metabolic networks in plant system; Regulatory networks in developmental processes; Biotic and abiotic stress - a system biology perspective.

Course Outcome: After completion of this course the student will be able to

Sl. No.	Course Outcomes	Cognitive Level	POs Addressed	PSOs Addressed
CO1	Summarize how pollutants affect our immediate environment.	R, U	PO1	PSO1
CO2	Examine the toxicity levels of various heavy metals.	Ap, An	PO1, PO2	PSO2
CO3	Inspect how greenhouse gases are affecting the environment and depleting ozone layer.	An, E	PO2, PO3	PSO3, PSO4
CO4	Assess the rules and regulations of Environmental Impact Assessment (EIA).	An, E	PO3	PSO4
CO5	Formulate the use experimental, computational and mathematical methods in systems biology.	C	PO3, PO4	PSO4, PSO5

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Addition = 25%
Modification = 10%
Total change = 35%

Semester – II	
Course name	**Taxonomy & Plant Anatomy (Practical)**
Course code	**PGBOTCC2.5**
Number of lectures	**60**
Credits	**4**
Marks	**50**

Course Objectives: This course aims to

Course Objectives
• Study of Plant families w.r.t systematic position, morphological characters, floral formula and floral diagram.
• Successful preparation of artificial key.
• Perform the techniques in plant anatomy.

Core Course 2.5 (Taxonomy & Plant Anatomy)

Practical **Full Marks: 50**

Taxonomy

1. Familiarity with Taxonomic literature: Floras, Monographs, Manuals, Journals, etc.
2. Description and identification of some representative plants from locally available families.
3. Preparation of artificial key of some locally available plants.
4. Field excursions (both local and at phytogeographically different areas).
5. Submission minimum 25 herbarium specimens (arranged according to APG IV, 2016).

Plant Anatomy

1. Trichomes, resin canals, laticifers, crystals.
2. Nodal anatomy – Unilacunar, Trilacunar and Multilacunar nodes.
3. Wood anatomy – T.S., R.L.S. & T.L.S. of wood.
4. Bark anatomy – T.S., R.L.S. & T.L.S. of barks.
5. Maceration technique.
6. Ecological anatomy.

Course Outcome: After completion of this course the student will be able to

Sl. No.	Course Outcomes	Cognitive Level	POs Addressed	PSOs Addressed
CO1	Illustrate the internal tissue system and secondary growths in plant.	R, U	PO1, PO2	PSO1
CO2	Summarize normal & anomalous secondary growth in plants.	U, Ap	PO1, PO2	PSO1, PSO2
CO3	Demonstrate maceration of vascular tissue.	U, Ap	PO2	PSO2, PSO3
CO4	Identify plants based on morphological data and preparation of artificial key.	Ap, An	PO3	PSO3
CO5	Analyze local flora and flora of different phytogeographical zone	An	PO4	PSO4

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Addition = 35%
Modification = 15%
Total change = 50%

Semester – II	
Course name	**Plant Physiology & Biochemistry (Practical)**
Course code	**PGBOTCC2.6**
Number of lectures	**60**
Credits	**4**
Marks	**50**

Course Objectives: This course aims to

Course Objectives
• Provide idea on enzyme isolation and activity assay.
• Deliver knowledge on isolation and characterization of different biomolecules from plant tissue.
• Offer skill for analyzing photosynthetic parameters in plant.
• Provide knowledge on assessment of various pigments, metabolites in plants.

Core Course 2.6 (Plant Physiology & Biochemistry)

Practical **Full Marks: 50**

Plant Physiology

1. Determination of Catalase activity by Permanganate Titration method
2. Determination of alpha-amylase activity in germinating Wheat grains.
3. Estimation of Leghaemoglobin in the root nodules.
4. Isolation of chloroplast and determination of Hill activity
5. Determination of chl a/ chl b ratio in C3 and C4 plants.
6. Estimation of Ascorbic acid content in fruits.
7. Determination of Isoelectric point (pI) of Legume Proteins.
8. Colorimetric estimation of IAA by salkowski reagent
9. Effect respiratory inhibitors on rate of respiration in germinating seeds

Biochemistry:

1. Colorimetric estimation of proteins from different plant materials by Lowry reagent
2. Comparative analysis of phenolic content in plant tissues using Folin–Ciacalteu reagent
3. Colorimetric estimation of Ascorbic acid from different plant material
4. Peroxidase enzyme assay from plant source
5. Urease enzyme assay from plant material
6. Catalase assay from plant source
7. Colorimetric estimation of total flavonoid content
8. Determination of Free radical-scavenging ability using DPPH radical
9. Separation of carbohydrates by Thin-layer Chromatography
10. Separation of amino acids by Thin Layer Chromatography

Course Outcome: After completion of this course the student will be able to

Sl. No.	Course Outcomes	Cognitive Level	POs Addressed	PSOs Addressed
CO1	Demonstrate isolation of enzymes from plant organs and their quantitative estimation.	U	PO1, PO2	PSO2, PSO3
CO2	Examination of photosynthetic parameters in plants.	Ap, An	PO2	PSO2, PSO3
CO3	Demonstrate isolation of biomolecules, hormones and design bioassay for the same.	U, Ap, An	PO2, PO3	PSO3, PSO4
CO4	Inspect redox state of plants and analyze scavenging enzymes.	An, E	PO3	PSO4
CO5	Design and formulate chromatographic techniques.	C	PO3, PO4	PSO4, PSO5

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Addition = 35%
Modification = 10%
Total change = 45%

Semester – III	
Course name	**Cell & Molecular Biology (Theory)**
Course code	**PGBOTCC3.1**
Number of lectures	**60**
Credits	**4**
Marks	**50**

Course Objectives: This course aims to

Course Objectives
• Provide concept of cells and cell as constituents of living organisms.
• Impart knowledge about cellular organization and their roles in the functioning of a cell.
• Provide concepts of cell cycle, protein sorting and transport and regulation of cellular processes.
• Make students aware about the concepts of DNA replication, transcription and translation.

Core Course 3.1

(Cell & Molecular Biology)

Theory

Full Marks: 50

A. **Cell Concept:** Life began as a self-replicating structure; Living creatures are made of cells, Essential properties of a living cell.

B. **Cell Envelope:** Structure, components, functions and biogenesis of cell wall and plasma membrane; Transport of ions & molecules; Pumps, Carriers, Channels; Receptors.

C. **Cell Organelles:** Biogenesis and evolution of Mitochondria and Chloroplasts, Trans-golgi Network, endocytosis and exocytosis, Vesicular Traffic from ER through Golgi Apparatus; The Endomembrane system, Peroxisomes and Vacuoles; Nucleus & Nucleolus: Ultrastructure, Nuclear Pore Complex, nuclear transport.

D. **Cell Shape and Motility:** The cytoskeleton; their role in cell organization and movement, interaction among cytoskeletal elements; motor proteins, implications in cell division, flagellar & other movements.

E. **Cell Multiplication and Turnover:** Basic features of eukaryotic cell cycle; overview of control mechanisms of different check points; Apoptosis & Necrosis, Significance, Extrinsic & Intrinsic pathways of apoptosis, trophic factors, Mechanism and regulation of cytokinesis.

F. **Protein Sorting and Transport:** Chaperon and protein folding, protein cleavage, glycosylation, attachment of lipids, protein targeting to Cell Organelles; protein folding and processing in ER and Golgi, smooth ER and lipid synthesis, export, mechanism of vesicular transport.

G. **Cell interaction:** Cellular adhesions, junctions and junction proteins.

H. **Cell signalling:** Overview, receptors and G-proteins, phospholipid signalling, role of cyclic nucleotides, calcium-calmodulin cascades, diversity in protein kinases and phosphatases, receptors (GPCR, PTRK, JAK/STAT), second messenger and pathways, specific signalling mechanisms e.g. two-component sensor-regulator system in bacteria and plants, sucrose sensing mechanism.

I. **Organization of Genes and Chromosomes:** Chromatin Remodelling in Eukaryotes, Chromosome organization, Centromere & Telomere; Packaging of Chromatin & gene activity, Histone code and role of non-histones; Special types of chromosomes, C-value Paradox; Brief introduction to Chromosome banding; Unique and repetitive DNA, Euchromatin and Heterochromatin;

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J. **RNA and Ribosomes:** RNA World; Structure, forms and types; small RNAs and their biogenesis; Catalytic RNA, hammerhead and hairpin ribozymes, Ribosome ultrastructure.

K. **Nature of Nucleic Acids:** Physical chemistry of Nucleic acids; DNA and RNA as genetic material; DNA supercoiling & Topoisomerases, DNA Reassociation Kinetics (Tm and cot curves).

L. **DNA Replication:** Basic mechanism and Enzymology of DNA replication in prokaryotes and eukaryotes; Replication in phages and retroviruses.

M. **Transcription:** Prokaryotic and Eukaryotic RNA polymerases; Promoters, Transcription factors and activators; Mechanisms of transcription-initiation, elongation and termination.

N. **Operon concept:** Operon concept – inducible and repressible operons. (lac, trp, ara Operons).

O. **Post-transcriptional modifications:** Exons and introns, Splicing – mechanism, catalytic role of RNA, Group I, II and nuclear introns, nuclear splicing and role of snRNA, tRNA splicing, modification of mRNA - 5' cap formation, 3' polyadenylation; RNA editing.

P. **Translation:** Genetic code – universality and degeneracy, Wobble hypothesis; Translation machinery – ribosomes; charging of tRNA molecules and formation of aminoacyl tRNA; mechanism - initiation, elongation and termination, Antibiotic inhibitor and translation.

Course Outcome: After completion of this course the student will be able to

Sl. No.	Course Outcomes	Cognitive Level	POs Addressed	PSOs Addressed
CO1	Summarize the various aspects of cellular & molecular biology.	R, U	PO1	PSO1
CO2	Develop concepts on cellular processes like DNA replication, transcription and translation.	Ap	PO1, PO2	PSO2, PSO3
CO3	Develop and analyze an overall idea about cellular interaction, cell signalling and protein sorting.	Ap	PO1, PO2	PSO3
CO4	Explain the events of post transcriptional modification and regulation of gene expression	U, Ap	PO3	PSO4
CO5	Improve their understanding on the molecular mechanism of cell division and its regulation.	E, C	PO3, PO4	PSO4, PSO5

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Addition = 45%
Modification = 10%
Total change = 55%

Semester – III	
Course name	**Genetics & Genomics (Theory)**
Course code	**PGBOTCC3.2**
Number of lectures	**60**
Credits	**4**
Marks	**50**

Course Objectives: This course aims to

Course Objectives
• Update the current Knowledge on genetics and genomics.
• Restate various types of gene interactions, inheritance of complex traits and genetic recombination
• Teach the mechanisms of chromosome and genome variation.

Core Course 3.2 (Genetics & Genomics)

Theory

Full Marks: 50

A. **Mendelism and Gene Interaction:** Mendels laws, concepts of dominance, segregation, independent assortment; Extensions of Mendelism; Allelism; Gene-environment interactions; Penetrance and Expressivity; Epistasis; Pleiotropy; Continuous and Discontinuous Variations; Forward and Reverse Genetics, Overview of Genetic Analysis: genetic analysis pathways, complementation test for alleles, Sex Determination and Sex-Linked Characteristics; Sex chromosome, *SRY* gene concept.

B. **Linkage, crossing over and gene mapping:** Crossing over as the physical basis of recombination; Molecular mechanism of recombination; chromosome mapping; three-point test cross, construction of genetic and physical map; Haploid mapping (tetrad analysis), LOD score, QTL mapping.

C. **Transposable elements:** Ac/Ds transposable controlling elements, Transposable elements in prokaryotes, Transposon tagging.

D. **Mutation:** *Chromosome Mutation*: Numerical changes: Haploids, aneuploids and euploids, Polyploidy and crop improvement, Rearrangement of chromosome structure; *Gene Mutation*: Molecular basis of gene mutation, Transposon mutagenesis, site-directed mutagenesis, environmental mutagenesis, in vitro mutagenesis, DNA damage and repair mechanism.

E. **Population Genetics:** Definition of populations, Allele frequency, Genetic equilibrium, Hardy-Weinberg principle, highly polymorphic DNA sequences in DNA typing, Inbreeding and genetic consequences of self-pollination in plants.

F. **Cancer:** Normal cell versus Cancer cell, Cell immortalization and tumorigenesis, Oncogenes and tumor suppressor genes, cancer and cell cycle, virus induced cancer.

G. **Genomics:** Technologies for high-throughput sequencing, sequence alignment and gene annotation; Approaches to analyze differential expression of genes - ESTs, SAGE, microarrays and their applications; gene tagging; gene and promoter trapping; Comparative genomics; RNAi and gene silencing, genome imprinting, small RNAs and their biogenesis, role of small RNAs in heterochromatin formation and gene silencing.

H. **Organellar Genomes:** Organization and function of mitochondrial and chloroplast genomes, diversity and evolution of organelle genomes, chloroplast protein targeting to different compartments, transfer of genes between nucleus and organelles.

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I. **Proteomics:** Proteome, separation and identification, protein tagging systems, expression profiling, protein microarray, protein-protein interaction: yeast two hybrid system and co-immunoprecipitation.

J. **Introduction to Bioinformatics:** Overview, Databases in Bioinformatics, Protein and Nucleotide sequence Databases (NCBI, EMBL, DDBJ, Genbank, Pubmed, Patent databases and TAIR), Sequence analysis: Pairwise alignment, local and global alignment, multiple sequence alignment, tools for sequence alignment.

Course Outcome: After completion of this course the student will be able to

Sl. No.	Course Outcomes	Cognitive Level	POs Addressed	PSOs Addressed
CO1	Outline concepts of mendelian inheritance, and its deviation.	R, U	PO1	PSO1
CO2	Illustrate different types of mutations and their impact	U, Ap	PO1, PO2	PSO1, PSO2, PSO3
CO3	Illustrate characteristics of genetics linkage and crossing over.	Ap	PO2	PSO2, PSO3
CO4	Explain the structure and function of prokaryotic and eukaryotic genomes.	An, E	PO3	PSO4
CO5	Develop software skills related to structural and functional aspects of genes and proteins.	C	PO4	PSO5

*R= remembering, U = understanding, Ap = applying, An = analyzing, E = evaluating, and C = creating

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Addition = 25%
Modification = 08%
Total change = 33%

Semester – III	
Course name	**Plant Biotechnology and Recombinant DNA Technology (Theory)**
Course code	**PGBOTCC3.3**
Number of lectures	**60**
Credits	**4**
Marks	**50**

Course Objectives: This course aims to

Course Objectives
• Introduce students to the principles, practices and applications of plant biotechnology, and tissue culture.
• Describe the applications of genetic engineering in various fields.
• Aware students with ethical issues concerned with Genetic engineering.

Core Course 3.3

(Plant Biotechnology and Recombinant DNA Technology)

Theory

Full Marks: 50

A. **Introductory Plant Biotechnology:** Introductory concept of plant biotechnology. historical perspective and basic principles of plant tissue culture, totipotency, cytodifferentiation, morphogenesis.

B. **Types of Plant Tissue Cultures:**

- **Callus:** concept at cellular level, Dedifferentiation concept & principle, role of *WIND* in callus formation, Mechanisms of induction and repression of callus.
- **Cell culture:** Techniques and applications.
- **Organogenesis:** general organogenesis, de novo organogenesis, cellular origins and molecular mechanisms, applications of organogenesis, Advantage and disadvantage of organogenesis.
- **Somatic embryogenesis:** Concept, totipotency and somatic embryogenesis, factors depending somatic embryogenesis, Signalling and Plant somatic embryogenesis, Genetic and molecular control of somatic embryogenesis.
- **Synthetic seeds:** concept, components required of synthetic seeds, chemical properties of each component and applications.
- **Haploid culture**: concept procedure, androgenesis, gynogenesis, in vivo haploid induction and efficiency, factors depending haploid culture, determination of haploid nature in culture, applications.
- **Embryo Culture:** Concept, history, Technique of embryo culture; wide hybridization and embryo-rescue for crop improvement; Applications of embryo cultures.
- **Protoplast culture:** Methods and applications, Somatic hybridization.
- **Somaclonal Variation**- concept, Gametoclonal variation; factors contributing to occurrence of somaclonal variation; Identification of Variants; Genetic Improvement of Crops through Somaclonal Variation; Advantages and disadvantages of somaclonal variation.

C. **Plant Genetic Resources (PGR):** Concept and importance, PGR conservation and utility for Plant Improvement. Conservation of Plant Genetic Resources and Genebank Management; In vitro conservation of Plant Germplasm- concept, importance of in vitro conservation.

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D. Tools of rDNA technology: RDT- Concept and History; DNA manipulation enzymes- Restriction Endonucleases, Ligases, Kinases, Phosphatases, DNA Methylases and Topoisomerases; methods of gene isolation; PCR technology and its application in RDT, RT-PCR and cDNA synthesis.

E. Cloning Vectors and Cloning Methodologies

- ***Use of vectors in cloning*:** Basic concepts of cloning vector, Plasmids – general concepts (eg. pUC,), Expression vectors (pET); Bacteriophage λ vectors and replacement vectors (EMBL); Phagemids (M13-derived vectors); cosmids - Artificial chromosome vectors (YACs; BACs); other viral vectors (SV-40).
- ***Cloning strategies:*** Basic concepts of cohesive and blunt end ligation; directional cloning, use of linkers and adaptors; Homopolymer tailing, TA- vectors and cloning of PCR products
- ***Genomic and cDNA libraries:*** Genomic and cDNA libraries - Construction, size, full length cDNA cloning, Subtraction libraries, Screening of cloned libraries, Expression of cloned gene. Selection and screening of recombinant molecules, Nucleic acid hybridization- Southern, Northern blotting techniques, dot-blot, immunoblotting or immunoprecipitation.

F. Gene Transfer Techniques for Transgenic Plants

- ***Methods of DNA delivery:*** PEG mediated DNA uptake, electroporation, biolistic transfer, Microinjection, organelle transformation, Mechanism of integration of foreign DNA into plant genomes; *Agrobacterium tumefaciens* mediated gene transfer – Basis of tumour formation, features of Ti and Ri plasmids, mechanisms of DNA transfer, role of virulence genes.
- ***Applications Transgenics:*** Concept of transgene, Transgenic plants for disease and Insect resistance, abiotic stress tolerance, Modification of wood quality, herbicide resistance; Approaches to marker-free transgenics.

G. Marker-assisted selection in plant breeding

H. Molecular farming Concept of molecular farming: Biopolymer production, Planti-bodies and plant vaccines.

I. Pharmaceutically active compounds from plants- concept, application biotechnological methods for improving secondary metabolite production in tissue cultures.

J. Bioethics and Biosafety: Biosafety, Biosafety during industrial production, Risk assessment, Bioethics- Ethical and moral issues, Moral arguments supporting patenting, Ethical arguments against patenting.

Course Outcome: After completion of this course the student will be able to

Sl. No.	Course Outcomes	Cognitive Level	POs Addressed	PSOs Addressed
CO1	Recall the basic concepts of plant tissue culture and explain fundamental cellular events during the process.	R, U	PO1	PSO1
CO2	Explain the basic principles, tools and techniques of Genetic engineering	U, Ap	PO1, PO2	PSO2, PSO3
CO3	Evaluate the impact of biotechnology in medical science, forensics, and conservation of biodiversity.	An, E	PO3	PSO3
CO4	Translate the concepts in future studies and debate on the GMO related issue and evaluate its significances	E	PO3, PO4	PSO3, PSO4
CO5	Design and formulate experiments to address a research problem	C	PO4	PSO5

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Addition = 40%
Modification = 05%
Total change = 45%

Semester – III	
Course name	**Plant Biotechnology (Practical)**
Course code	**PGBOTCC3.5**
Number of lectures	**60**
Credits	**4**
Marks	**50**

Course Objectives: This course aims to

Course Objectives
• Introduce students to the plant biotechnology laboratory. • Hands on training on media preparation, sterilization and tissue culture. • Aware students with the lab safety issues in PTC laboratory.

Core Course 3.5 (Plant Biotechnology)

Practical **Full Marks: 50**

Plant Biotechnology

1. Organization of a tissue culture laboratory; Equipment and supplies; Basic techniques in aseptic plant tissue culture.
2. Different types of basal medium; media components; Preparation of MS, B5 and SH medium.
3. Sterilization of medium and equipments.
4. Surface sterilization of seed, bulb/ rhizome and culture in different types of basal medium.
4. Effects of phytohormones (2,4-D/NAA with and without KN/BA) and basal medium (MS/B5/SH) on callus induction from explants excised from aseptically germinated seedlings and bulbs.
5. Study of de novo direct organogenesis / somatic embryogenesis (monocot and dicot)
6. Study of callus mediated organogenesis/somatic embryogenesis
7. Study of stages of micropropagation using shoot tip/ nodal buds
5. Preparation of competent cells and *Agrobacterium* mediated transformation.
6. Agrobacterium rhizogenes (wild type strain A4) mediated transformation.
7. Visit to a commercial Tissue Culture Facility in West Bengal.

Course Outcome: After completion of this course the student will be able to

Sl. No.	Course Outcomes	Cognitive Level	POs Addressed	PSOs Addressed
CO1	Outline the basic organization of a plant tissue culture lab and functioning of its instruments.	U	PO1	PSO1
CO2	Demonstrate different type of sterilization technique.	Ap, An	PO2	PSO2, PSO3
CO3	Evaluate the effect of various PGRs (diff conc.) in plant tissue culture.	U, Ap, An	PO2, PO3	PSO2, PSO3
CO4	Formulate tissue culture from different plant explants.	An, E	PO2, PO3	PSO3, PSO4
CO5	Design and formulate Agrobacterium mediated transformation technique.	C	PO2, PO3, PO4	PSO4, PSO5

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Semester – III	
Course name	**Cytology and Molecular Biology (Practical)**
Course code	**PGBOTCC3.6**
Number of lectures	**60**
Credits	**4**
Marks	**50**

Course Objectives: This course aims to

Course Objectives
• Develop basic foundation of stain preparation and techniques of cytology.
• Equip students for karyotype analysis.
• Develop knowledge on isolation and qualitative and quantitative estimation of DNA.

Core Course 3.6 (Cytology and Molecular Biology)

Practical **Full Marks: 50**

Cytology and Molecular Biology

1. Preparation of stains and staining techniques for chromosome analysis.
2. Karyotype analysis in diploids and polyploids.
3. Phases of division in PMC: chromosome pairing in diploids and polyploids.
4. Isolation of Plant genomic DNA.
5. Quantitative estimation of DNA.
6. Agarose Gel electrophoresis.
7. Polymerase chain reaction.

Course Outcome: After completion of this course the student will be able to

Sl. No.	Course Outcomes	Cognitive Level	POs Addressed	PSOs Addressed
CO1	Outline basic foundation of stain preparation and techniques of cytology.	R, U	PO1	PSO1
CO2	Plant mitotic & meiotic chromosomal analyses.	Ap, An	PO2, PO3	PSO2, PSO3
CO3	Compare & contrast karyotype in different plant species.	An	PO2, PO3	PSO2, PSO3, PSO4
CO4	Formulate isolation, qualitative and quantitative estimation of DNA.	E, C	PO4	PSO3, PSO5
CO5	Design and formulate amplification of DNA.	E, C	PO4	PSO4, PSO5

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Addition = 60%.
Modification = 10%.
Total change = 70%.

Semester – IV	
Course name	**Research Methodology and Bioinstrumentation (Theory)**
Course code	**PGBOTCC4.1**
Number of lectures	**60**
Credits	**4**
Marks	**50**

Course Objectives: This course aims to

Course Objectives
• Select and define appropriate research problem and parameters
• Discuss different methodologies and techniques used in research work.
• Assess the basic function and working of analytical instruments used in biological research.

Core Course 4.1

(Research Methodology and Bioinstrumentation)

Group A: **Research Methodology** **Full Marks: 25**

A. Foundations of Research: Meaning, Objectives, Motivation, Utility. Concept of theory, empiricism, deductive and inductive theory, research vs research methodology, development of research methodology.

B. Research Design: Concept and Importance in Research – Features of a good research design, Experimental Designs –concept, types and uses, details of types of research with example, quantitative, qualitative, empirical, conceptual, applied, fundamental etc.

C. Sampling: Concepts of Statistical Population, Sample, Sampling Frame, Sampling Error, Sample Size, Non-Response. Characteristics of a good sample.

D. Data Interpretation and Paper Writing: Layout of a Research Paper, Journals, Impact factor of Journals, H-index, Citation; Scientific misconducts and ethical issues related to publishing, Plagiarism and Self-Plagiarism.

E. Use of tools for Research: Methods to search required information effectively, Software for paper formatting like LaTeX /MS Office, process to reduce duplication, software for detection of Plagiarism (open source and subscription based).

F. Codes in research: Basic concept and outline of Nuremburg code, declaration of Helsinki.

Group B: **Bioinstrumentation** **Full Marks: 25**

A. Electrochemistry: pH and buffers, potentiometric and conductometric titration.

B. Microscopy: Principles of image formation, magnification, aberrations (chromatic and geometric), resolution, Sectioning; Microtomy and types of Microtomes, Principle and application of light, phase contrast, fluorescence, scanning and Transmission electron microscopy, scanning tunneling microscopy, atomic force microscopy, confocal microscopy.

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C. Spectroscopy: Beer and Lambert law, Colorimetry and spectrophotometry; UV, visible, IR, NMR and ESR spectroscopy. Atomic absorption and plasma emission spectroscopy; MS and MALDI-TOF; cytophotometry and flow cytometry.

D. Centrifugation: Basic principle and application; Sedimentation coefficient, types of rotors and centrifuges; Differential, density and Ultracentrifugation.

E. Electrophoresis: Principle and applications of Native and SDS PAGE; Agarose and 2D gel electrophoresis, western blotting. Agarose gel electrophoresis, Southern and Northern blotting.

F. Chromatography: Paper chromatography, Thin layer chromatography (TLC), 2-Dimensional chromatography, HPTLC. Column chromatography, gel filtration, adsorption, partition, affinity, ion exchange and HPLC and FPLC. Gas chromatography.

G. Radiobiology: Principle and applications of tracer technique in biology: Radioactive Isotopes and half-life; Effect of radiation on biological system; autoradiography; scintillation counting.

H. Biosensors: Principle and application.

Course Outcome: After completion of this course the student will be able to

Sl. No.	Course Outcomes	Cognitive Level	POs Addressed	PSOs Addressed
CO1	Develop the ability to apply the methods while working on a research project work	U, Ap	PO1, PO3	PSO1
CO2	Explain different sampling methods, research designs and codes of research.	An	PO2, PO3	PSO2, PSO3
CO3	Assess the quality of research paper and scientific misconduct.	An, E	PO2, PO3	PSO3
CO4	Develop necessary skills to perform research in their own field.	E, C	PO3	PSO3, PSO4
CO5	Develop basic knowledge on function and working of analytical instruments used in biological research.	C	PO4	PSO4, PSO5

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Addition = 50%
Modification = 15%
Total change = 65%

Semester – IV	
Course name	**Phytochemistry and Herbal Technology (Theory)**
Course code	**PGBOTCC4.2**
Number of lectures	**60**
Credits	**4**
Marks	**50**

Course Objectives: This course aims to

Course Objectives
• Elaborate cultivation, collection, processing, storage and conservation of medicinal plants.
• Discuss the therapeutic applications of herbs, poisonous plants; and Edible Vaccines.
• Describe different types of secondary metabolites, their properties, classification, test for identification and isolation techniques.
• Develop knowledge on quality assessment of plant-based drugs.

Core Course 4.2

(Phytochemistry and Herbal Technology)

Theory **Full Marks: 50**

1. Importance of plants in modern pharmacy and medicine. Historical importance of morphine, aspirin, quinine, digoxin.

2. **Plant natural products and drug discovery**: Herbal Drug Discovery, Concept of new chemical entities (NCEs), classes of sources for NCEs, High Throughput Screening (HTS), HTS of plant source materials for new lead chemical entities, Antimalarial anticancer drug discovery.

3. **Medicinal Phytochemistry**- Role of phytochemistry in Pharmacognosy, Classification of Phytochemistry; Occurrence, Biosynthesis, Structure and Chemistry, Distribution: Alkaloids, Terpenoids, and Phenolics; Scope of medicinal phytochemistry in herbal industry.

4. **Herbal therapeutic systems**: Popular practices- from the beginning; Graeco-Roman and Islamic medicine, Chinese herbal medicine; Ayurvedic herbal medicine, Nineteenth-century North American herbal medicine, Middle European herbal medicine.

5. Herbal Medicine: Criteria for use in health and disease; Phytocomplexes versus Single-Entity Drugs,

Modes of action of drugs used in Phytomedicine, Pharmacovigilance methods and systems in herbal medicines, WHO guidelines on safety monitoring of herbal medicines.

6. Indian Systems of Medicine- Ayurveda, Unani System of Medicine, Homeopathic System of Medicine, Siddha, Yoga and Naturopathy.

7. Traditional Knowledge-based Medicine: Indian & China; Indian Traditional Herbal Drugs- cardiovascular drugs, antidiabetic drugs, antineoplastic drugs.

8. Materia medica: basic concept, Pharmacopoeia: concept, types, importance. Brief idea of Indian Pharmacopoeia:, British pharmacopoeia, US Pharmacopoeia:, European Pharmacopoeia

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9. Systematic Examination of Powdered Drugs: Examination of Organised and Unorganised Drugs

10. Phytochemical Analysis: Extraction, fractionation identification and characterization of herbal extracts.

11. Bioassays Herbal Drug: Bioassays for screening of phytopharmaceuticals, clinical trials of herbal Extracts

12. Immunomodulatory Effects of Phytocompounds.

13. Chromatography and Spectroscopy: Application of Chromatography and Spectroscopy in Plant Drug Analysis

14. Quality assessment: Botanical authenticity and quality assurance of medicinal herbs; Plant analysis both chemical and biological.

14. WHO and Herbal drug: WHO guidelines on good manufacturing practices (GMP) for herbal medicines

15. **Fingerprinting and Marker Compounds:** Identification and Standardization of Herbal Drugs.

16. DNA barcoding: An efficient tool to overcome authentication challenges in the herbal market

17. Commercialization of Herbal Drugs: Perspective of Indian and Global Industry.

18. Regulatory issues: Regulatory issues concerning the safety, efficacy and quality of herbal remedies.

Course Outcome: After completion of this course the student will be able to

Sl. No.	Course Outcomes	Cognitive Level	POs Addressed	PSOs Addressed
CO1	Outline the history and scope of herbal medicine.	R, U	PO1	PSO1
CO2	Summarize the cultivation, collection, processing, storage and conservation of medicinal plants.	U, Ap	PO1, PO2	PSO2, PSO3
CO3	Evaluate different types of secondary metabolites, their properties, classification, test for identification and isolation techniques.	An, E	PO2, PO3	PSO2, PSO3
CO4	Discuss the therapeutic applications of herbs, poisonous plants; and edible vaccines.	An, E	PO3	PSO4
CO5	Develop knowledge on quality assessment of plant-based drugs.	E, C	PO3, PO4	PSO4, PSO5

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Addition = 30%
Modification = 05%
Total Change = 35%

Semester – IV	
Course name	**Genetics and Plant Biotechnology 1 (Theory)**
Course code	**PGBOTME4.1A**
Number of lectures	**60**
Credits	**4**
Marks	**50**

Course Objectives: This course aims to

Course Objectives
• Elaborate basics of genetics covering prokaryotic to yeast and higher eukaryotic domains.
• Explain relationship between phenotype and genotype in genetic traits.
• introduce students to the principles, practices and application of plant biotechnology, germplasm conservation and biopharmaceuticals.

Major Elective 4.1A
(Genetics and Plant Biotechnology - I)

Theory **Full Marks: 50**

1. **Chromosomes Techniques:** Karyotype concept, principle of chromosome banding technique, chromosome labeling, in situ hybridization, and FISH techniques.
2. **Molecular Markers:** Concept, biochemical vs molecular marker, types of PCR and non-PCR based markers, application of molecular marker; DNA barcoding and DNA fingerprinting.
3. **Regulation of Eukaryotic Gene Expression:** Operons in Eukaryotes; Regulation at transcriptional and post- transcriptional level; control at translational level & Post translational level; Interaction of multiple regulatory mechanisms: determining protein stability.
4. **Molecular basis of Crossing Over in plants**
5. **Gene Duplication:** Concept and importance of Whole Genome Duplication (WGD), Evolution of Gene Duplication in Plants, Applications of in vitro method for plant genome duplication
6. **Epigenetics:** Introduction to concept and definition of Epigenetics, Epigenetic alterations to the Genome, Methylation, Histone Modification and RNA Interference, Role of epigenetics for Crop Improvement
7. **Genetics and genomics of crop domestication:** Genetics of domestication and diversification, Genes Controlling Domestication Traits, Plants and Domestication, Domestication Processes, Hybrid Species and New Polyploids in Domestication, Evolution of crop species- genetics of domestication and diversification, Molecular mechanisms involved in convergent crop domestication

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8. **Plant Bioresources and Biotechnological Utilization**: Bioresource concept, Value of Bioresources, Genetic assessment of Plant genetic resources, Bioresources for sustainable living, Bioresources for Food and Nutrition Security.
9. **Gene Banking for Ex Situ Conservation of Plant Genetic Resources:** In vitro Conservation of Plant Germplasm, Cryopreservation.
10. **Applications of in vitro techniques in Plant Breeding**: in vitro flowering and seed production; Embryo Rescue, Overcoming Self- and Cross-Incompatibility, trait improvement through somaclonal variation.
11. **Plant Natural Product biotechnology**: Steps of Plant Secondary Metabolite Production in In Vitro Conditions, Optimization of Medium Composition and Culture Conditions, Elicitation and Precursor Feeding, Biotransformation and Metabolic Engineering, Immobilization, Hairy Root Cultures, Combinatorial Biosynthesis, Strategies and approaches for biomass improvement and metabolite accumulation.
12. **Bioreactors in plant biotechnology**: Principle, Classification and Types of bioreactor; applications of bioreactors in plant biotechnology.

Course Outcome: After completion of this course the student will be able to

Sl. No.	Course Outcomes	Cognitive Level	POs Addressed	PSOs Addressed
CO1	Outline basic ideas on chromosome biology and apply molecular markers for crop improvement.	U, Ap	PO1	PSO1
CO2	Explain the mechanism of eukaryotic gene regulation and epigenetics.	Ap, An	PO1, PO2	PSO1, PSO2
CO3	Analyze and interpret quantitative genetic experiments	An, E	PO3	PSO2, PSO3
CO4	Discuss knowhow and exhibition of contemporary knowledge in Biotechnology for economic utilization.	E, C	PO3	PSO4
CO5	Develop concepts on plant tissue culture techniques on research problems pertinent to crop improvement and biotechnology industry.	C	PO4	PSO4, PSO5

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Addition = 40%
Modification = 15%
Total change = 55%

Semester – IV	
Course name	**Genetics and Plant Biotechnology II (Theory)**
Course code	**PGBOTME4.2A**
Number of lectures	**60**
Credits	**4**
Marks	**50**

Course Objectives: This course aims to

Course Objectives
• Describe fundamental principles of structural & functional genomics.
• Develop an understanding of basic theory of these computational tools implicated in biological research.
• Gain working knowledge on different methodologies, techniques commonly used in genomics, proteomics and metabolomics

Major Elective 4.2A
(Genetics and Plant Biotechnology - II)

Theory **50 Marks**

1. **Genetic disorders:** Basic concept of genetic disorder, Single gene vs complex disorder: Cystic Fibrosis, Thalassemia, Marfan syndrome, IEM (Inborn errors of metabolism), Haemophilia as models.
2. **Stem Cells**: Concept, Division and self-renewal; Potency defines a stem cell; Sources and types of Stem Cells; Stimulating ESCs to differentiate, Adult-Derived Stem Cells (ASC's), Amniotic Fluid-Derived Stem Cells and Cancer Stem Cells.
3. **Genome Editing:** Basic concept and Principles, clustered regularly interspaced short palindromic repeats (CRISPR)-CRISPR-associated protein 9 (Cas9), transcription activator-like effector nucleases (TALENs), and zinc-finger nucleases (ZFNs), Steps of CRISPR gene editing, Applications of Genome Editing for crop improvement, Regulation and Biosafety of Genome editing crops.
4. **Functional Genomics:** Gene disruption techniques, knockdown and knockouts, the study of developmental regulation by using DNA chips, Benefits of genome sequencing.
5. **Data mining and Sequence Alignment:** Data mining, Data mining tools & techniques, Pair wise sequence Alignments, Global & Local Alignments, Multiple Sequence Alignments, Gaps & scoring matrices, Homology, Orthology, Analogy & Paralogy; Primer designing.
6. **Molecular Phylogenetics**: From Classification to Molecular Phylogenetics, Reconstruction of DNA-based Phylogenetic Trees, and Applications of Molecular Phylogenetics.
7. **Gene Prediction & Genome analysis:** ORF prediction, Methods for gene prediction in prokaryotes & eukaryotes; Evaluation of gene prediction; Comparative genomics.
8. **Protein structure prediction:** Terms used for classifying protein structure & sequences, Alignment of protein structures, Structural prediction and its evaluation, Structural modelling, Energy minimization, Protein -ligand docking.
9. **Applications of Bioinformatics:** Current perspective & emergence of bioinformatics; Microbial genome applications, Crop improvement; Commercial use of bioinformatics.

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10. **Proteomics Identifies and Analyses the Protein Composition of Cells:** reconciling the number of genes and the number of proteins expressed by a cell or tissue, Proteomics Technologies: Two-Dimensional Gel Electrophoresis for Separating Proteins, Proteomics Technologies: Mass Spectrometry for Protein Identification
11. **Plant Proteomics:** Genome Sequencing to Proteome Databases and Repositories; Stress inducible proteomic changes in plants. Proteomic analysis of male sterile and maintainer lines.
12. **Molecular Pharming in Plants**: Basic concept, Recombinant Proteins in Plants, Plant-derived vaccine antigens, Plant-derived antibodies, Therapeutic and nutraceutical proteins, Non-pharmaceutical plant-derived proteins, Plant Glycosylation, Biosafety and regulatory issues.
13. **Metabolomics in Plant Biotechnology:** Basic concept, Analytical Technologies for the plant metabolome, Informatics Techniques for metabolomic studies, Biotechnological Applications.
14. **Plant Metabolic Engineering**: basic strategies; Plants with altered nutrient content; bioactive molecule production, biofuel production, enhancing photosynthetic efficiency.
15. **Biotechnological methods for cleaning of environment:** Phytoremediation
16. **Transgenic Crops:** Status, Potential, and Challenges.
17. **Consumer Acceptance of GM Food**: Regional differences, Factors influencing acceptance; Risks and benefits associated with consumer Choice.
18. Biosafety, Bioethics, Indigenous Knowledge and IPR Issues in Plant Biotechnology.

Course Outcome: After completion of this course the student will be able to

Sl. No.	Course Outcomes	Cognitive Level	POs Addressed	PSOs Addressed
CO1	Summarize the fundamental principles of structural & functional genomics.	U, Ap	PO1	PSO1
CO2	Develop a thorough idea on genome editing and its tools.	Ap, An	PO1, PO2	PSO2, PSO3
CO3	Develop an in-depth understanding of the computational tools implicated in biological research.	Ap, An	PO3	PSO3, PSO4
CO4	Examine and interpret the structural and functional aspects of gene through in silico research.	An, E	PO2, PO3	PSO4, PSO5
CO5	Discuss techniques commonly used in genomics, proteomics and plant metabolic engineering.	E, C	PO3, PO4	PSO5

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Addition = 40 %
Modification = 10 %
Total change = 50 %

Semester – IV	
Course name	**Genetics and Plant Biotechnology (Practical)**
Course code	**PGBOTME4.3A**
Number of lectures	**60**
Credits	**4**
Marks	**50**

Course Objectives: This course aims to

Course Objectives
• Develop basic foundation of stain preparation and techniques of cytology. • Equip students for karyotype analysis, and study of chromosome abnormalities. • Develop knowledge on in silico techniques to understand DNA structure, gene organization, translation and protein structure prediction.

Core Course 4.3A

(Genetics and Plant Biotechnology)

Practical **Full Marks: 50**

Genetics and Plant Biotechnology

1. Chromosome banding analysis and karyotyping.
2. Study Sequence file formats in Bioinformatics
3. Study of chromosome abnormalities.
4. Organogenesis, embryogenesis and synthesis of artificial seeds.
5. Production of secondary metabolites in plant tissue culture.
6. Exploration of sequence databases (NCBI, EMBL, DDBJ)
7. BLAST analysis, Multiple sequence alignment (MSA) and Construction of phylogenetic tree
8. *In silico* translation and domains and motif search
9. Analysis of plant promoters.
10. Generation of protein structure and Pathway network analysis (STRING)
11. *In silico* designing of PCR primers
12. Isolation of plant genomic DNA from different sources.
13. Isolation of animal genomic DNA from goat liver.
14. Isolation of bacterial genomic DNA from *E. coli*
15. Isolation of plant total RNA and protein
16. Agarose gel electrophoresis and Poly Acrylamide Gel Electrophoresis (SDS-PAGE)
17. Polymerase chain reaction
18. Mutagenesis experiments in *E. coli*.

Course Outcome: After completion of this course the student will be able to

Sl. No.	Course Outcomes	Cognitive Level	POs Addressed	PSOs Addressed
CO1	Analyze gene, protein sequence, develop protein interaction map and decode biological significance therein.	Ap, An	PO2, PO3	PSO2, PSO3
CO2	Develop knowledge on DNA, RNA, protein isolation techniques from different plant samples.	Ap, An	PO2, PO3	PSO2, PSO3
CO3	Design and formulate electrophoretic techniques and PCR primers for their own experiments.	E, C	PO3, PO4	PSO3, PSO4
CO4	Design and execute mutagenesis experiments.	E, C	PO4	PSO4, PSO5
CO5	Design and execute plant tissue culture experiments.	E, C	PO4	PSO4, PSO5

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Addition = 30%
Modification = 10%
Total change = 40%

Semester – IV	
Course name	**Diversity and Ecology of algae (Theory)**
Course code	**PGBOTME4.1A**
Number of lectures	**60**
Credits	**4**
Marks	**50**

Course Objectives: This course aims to

Course Objectives
• Familiarize the student with diversity of the major life forms of algae.
• Provide knowledge on the biology, ecology and interrelationships among different algal groups.
• Gain working knowledge on different methodologies, techniques commonly used in genomics, proteomics and metabolomics

Major Elective 4.2A
(Diversity and Ecology of algae)

Group A. Systematics of Algae:

1. Algal classification on the basis of phylogeny with concepts of nucleic acid sequence analysis and sequence alignment; concepts of chemotaxonomy

2. Comparative accounts of algal subgroups: Chlorophyta, Rhodophyta, Dinophyta and Heterokontophyta.

3. *Chlamydomonas* sp. and *Dunaliella* sp. as a model algal system.

4. Ultrastructural details of diatom cell architecture with reference to frustule symmetry and biofabrication; SDV formation and molecular regulation of frustules biosynthesis

5. Dinoflagellates: Cell ultrastructure, pleiotropic movement, concept of peridinin plastid and mixotrophy.

Group-B. Algal Ecology & Diversity:

6. Biodiversity and conservation of algae, Importance of algal ex-situ and in-situ conservation, phytoplankton community structure analysis, diversity assessment (Shannon Weiner's Index, Simpson's Index, Pielou's species evenness, species richness). Community pattern analysis using mathematical calculations for diversity indices

7. Concepts of eutrophication, "Top down" and "bottom up" regulation of phytoplankton population; Size based classification of phytoplankton; Concepts of holoplankton and meroplankton, Application of phytoplankton-based indices for water quality and trophic state of habitat (Nygaard's Index, Palmer's Index, Trophic Diatom Index).

8. Concepts of carbon dioxide sequestration, global warming and biological ocean acidification

9. Concepts of Cyanobacterial bioremediation, Algae as source of nanoparticles, Algae as source of carotenoids and phycocolloids.

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Course Outcome: After completion of this course the student will be able to

Sl. No.	Course Outcomes	Cognitive Level	POs Addressed	PSOs Addressed
CO1	Outline knowledge on the biology, ecology and interrelationships between algal groups.	R, U	PO1	PSO1
CO2	List the habitats and biodiversity of algae.	Ap, An	PO1	PSO1
CO3	Categorize algal members on the basis of their harmful/beneficial role.	An,	PO1, PO2, PO3	PSO2, PSO3
CO4	Develop understanding on the evolutionary interrelationships between different algal groups.	E, C	PO3	PSO3, PSO4
CO5	Discuss the role of algal members in carbon sequestration, global warming and biological ocean acidification	E, C	PO3, PO4	PSO3, PSO5

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Addition = 40 %
Modification = 10 %
Total change = 50 %

Semester – IV	
Course name	**Advanced phycology and algal biotechnology (Theory)**
Course code	**PGBOTME4.2B**
Number of lectures	**60**
Credits	**4**
Marks	**50**

Course Objectives: This course aims to

Course Objectives
• Familiarize the student with distribution of algae in various habitats.
• Provide knowledge on algal bioresources and their uses.
• Gain working knowledge on different industrial applications of algae.

Major Elective 4.2B

(Advanced phycology and algal biotechnology)

Theory **Full Marks: 50**

A. Algal Metabolism:

1. Light Harvesting Complex: Algal Light Harvesting Complex (LHC) in the model system *Chlamydomonas* sp. and Cyanobacteria; light harvesting pigments- chlorophylls, carotenoids and phycobiliproteins; Carbon reactions of Cyanobacteria, process and genetic regulation of chromatic adaptation in cyanobacteria.

2. Nitrogen Assimilation: Assimilation of nitrate, nitrite and ammonia. Genetic regulation of nitrogen fixation.

3. Stress Physiology: Physiological responses of algae to stress (salinity, desiccation, temperature, light).

4. Cyanobacterial bioactive metabolites: Types of cyanobacterial toxins with focus on biochemical and molecular aspects of toxin production. Factors effecting toxin productions.

B. Algal Commercial & Industrial Applications

5. Algal culture: Axenic culture, batch culture, continuous and semi-continuous culture; Basic concepts of algal mass cultivation (raceway pond, photobioreactors). Merits and demerits of algal mass cultivation.

6.Biotechnological applications: Secondary metabolites of algae; Use of algae as source of pharmaceuticals and cosmetics products; Biofuel production from microalgae and their industrial applications; Cyanobacteria as alternative energy source (Hydrogen production, etc.); Cyanobacterial bioplastics (polyhydroxyalkanoates, PHA).

7.Neutracutical applications: Production of fine chemicals from microalgae (polysaccharides, LCPUFA); commercial potential of *Spirulina* sp., *Chlorella* sp., *Nannochloropsis* sp. and *Botryococcus braunni*; algal single cell protein (SCP) and Phycocolloides.

8. Principles of marine algae cultivation and utilization; Seaweed liquid biofertilizer.

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9. Production of Algae: Laboratory to land - Mass multiplication of economically important algae (Rhodophyta, Phaeophyta, Chlorophyta, Cyanophyta) Large scale cultivation, processing, Yield, Chemical composition, Nutrition, quality standards.

Course Outcome: After completion of this course the student will be able to

SL No.	Course Outcomes	Cognitive Level	POs Addressed	PSOs Addressed
CO1	Outline algal distribution, habitats in freshwater & marine environments	R, U	PO1	PSO1
CO2	Develop an idea how the algal bio resources will be utilised and explored.	U, Ap	PO2	PSO1, PSO2
CO3	Dissect the various aspects of algal economic importance with special reference to biotechnological & other industrial applications	An	PO3	PSO3
CO4	Explain how the micro & macro algal natural products will processed in industry for different purposes	E	PO3, PO4	PSO3, PSO4
CO5	Evaluate the impact of abiotic stress in algal species	C	PO3	PSO4

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Addition = 40%.
Modification = 05%.
Total change = 45%.

Semester – IV	
Course name	**Phycology (Practical)**
Course code	**PGBOTME4.3B**
Number of lectures	**60**
Credits	**4**
Marks	**50**

Course Objectives: This course aims to

Course Objectives
• Develop knowledge on various algal habitats and algal identification. • Equip students for isolation and culture of microalgae from different habitats. • Develop knowledge various economically important algal species.

Major Elective 4.3B

(Phycology)

Practical **Full Marks: 50**

1. Microalgae diversity study (up to species level) for planktonic and benthic forms.
2. Isolation and culturing of microalgae from different habitats (a) freshwater, (b) marine and (c) soil
3. Quantification of algal pigments by spectroscopy (UV–Vis): (a) Chlorophyll, (b) Carotenoids, (c) Phycocyanin and (d) Phycoerythrin
4. Isolation and quantification of micro molecules: (a) Total carbohydrate (Duboi's method), (b) Total protein (Folin Ciacalteau method)
5. Enzyme assay from algal samples: (a) Catalases, (b) Peroxidases, (c) SOD
6. Assessment of antimicrobial and antioxidant activitites of microalgal secondary metabolites.
7. Extraction of genomic DNA from algal samples.
8. Hydrobiology: Phytoplankton sampling, taxonomic identification, water chemistry (quantification of nitrate, phosphate, silicate and dissolved oxygen content of water samples) and productivity estimation (GPP, NPP, CRR by Winkler's Iodometric Titration Method)
9. Ecological data analysis by application of software (SPSS, XLSTAT, CANOCO).
10. Observation and identification of selected seaweed taxa (visit to depository of algal seaweeds)
11. Field work and collection of micro algal samples.

Course Outcome: After completion of this course the student will be able to

Sl. No.	Course Outcomes	Cognitive Level	POs Addressed	PSOs Addressed
CO1	Develop knowledge on various algal habitats.	Ap, An	PO1	PSO1
CO2	Analyze enzyme, pigment, secondary metabolite composition from various algal sources.	Ap, An	PO2	PSO2, PSO3
CO3	Identification of algal microflora from different habitats.	An	PO2, PO3	PSO3
CO4	Design and execute water quality assessment.	E, C	PO3, PO4	PSO4
CO5	Execute handling and culture of economically important algae.	E, C	PO4	PSO4, PSO5

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Addition = 25%
Modification = 15%
Total change = 40%

Semester – IV	
Course name	**Taxonomy of Angiosperms (Theory)**
Course code	**PGBOTME4.1C**
Number of lectures	**60**
Credits	**4**
Marks	**50**

Course Objectives: This course aims to

Course Objectives
• Deals with naming and classification of plants their interrelationships.
• Aware the students with recent developments in plant systematic and phylogenetics.
• Understand various classification systems, nomenclature and interdisciplinary approaches.
• Recognize members of the major angiosperm families by identifying their diagnostic features.

Major Elective 4.1C

(Taxonomy of Angiosperms)

Theory **Full Marks: 50**

1. History of taxonomic study in India including the contributions by W. Roxbugh, N. Wallich, J. D. Hooker, G. King, T. Cooke, J. S. Gamble, D. Prain, J. F. Duthie, K. P. Biswas, H. Santapau, and S. K. Mukherjee

2. Taxonomic Literatures: Floras, efloras, manuals, monographs, journals: national and international, index, conceptus, synopsis.

3. International Code of Nomenclature for Algae, Fungi & Plants (ICN): Brief knowledge on Principles, Rules and Recommendations: Nomenclatural types, Different types of names, author citations, name of new taxon and Appendices on International Code of Nomenclature: rejected names, conserved name (Shenzhen code, 2017); proposed Bio Code and Phylo Code.

4. Major systems of angiosperm classification: Outline of classification of Cronquist (1988), Takhtajan (2007) and Thorne (2007) upto subclasses/ superorders. Broad outlines of Angiosperm Phylogeny Group (APG): APG I (1998), APG II (2003), APG III (2009), APG IV (2016) and their merits and demerits.

5. Angiosperm Diversity: A general survey of the following taxa of angiosperms (*sensu* APG IV, 2016) with special reference to their characteristics, interrelationships, evolutionary trends: Magnoliales, Nymphaeales, Caryophyllales, Asterales, Zingiberales, Poales.

6. Centres of origin and diversity of cultivated plants (Vavilov, 1926); Indian centres of wild plant genetic resources; Role of NBPGR and IBPGR in conservation of plant genetic resources.

7. Floristic regions of the world (after Takhtajan 1997): General idea about different kingdoms and sub-kingdoms.

8. Vegetation of India: Classification; description of Himalayan, Peninsular, Sundarbans and Desert vegetation; Endemism: palaeoendemism and neoendemism, Speciation: types and causes.

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Course Outcome: After completion of this course the student will be able to

Sl. No.	Course Outcomes	Cognitive Level	POs Addressed	PSOs Addressed
CO1	Outline the wide activities in angiosperm and trends in classification system.	R, U	PO1	PSO1
CO2	Develop the concepts of taxonomy and systematics	Ap	PO1, PO3	PSO3
CO3	Explain concept of species and speciation.	An, E	PO3	PSO3
CO4	Discuss the importance of rules, principles and recommendations in taxonomy.	E, C	PO3	PSO3
CO5	Discuss the general range of variations in the group of angiosperms.	C	PO3	PSO4

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Addition = 25 %.
Modification = 15 %.
Total change = 40 %.

Semester – IV	
Course name	**Taxonomy of Angiosperms (Theory)**
Course code	**PGBOTME4.2C**
Number of lectures	**60**
Credits	**4**
Marks	**50**

Course Objectives: This course aims to

Course Objectives
• Provide knowledge on evolution of floral organs.
• Elucidate the contribution of various data sources in plant taxonomy.
• Comprehend the role biodiversity and conservation in plant taxonomy.

Major Elective 4.2C

(Taxonomy of Angiosperms)

Theory **Full Marks: 50**

1. Phenotypic plasticity, difference with heteroblastic development

2. Evolution of floral organs: perianth, stamen, and carpels

3. Taxonomic Data Sources: Vegetative morphology (leaf architecture and seedling morphology), Ultrastructural characters (SEM and TEM characters), anatomy (nodal and wood), embryology, phytochemistry, palynology (pollen characters and applied palynology), serology, cytology, and DNA barcoding.

4. Cladistic approaches of classification: Definition; Basic concept: cladogram, symplesiomorphy, synapomorphy, monophyly, polyphyly, paraphyly, convergence, parallallism, homoplasy, methodology of cladistics: parsimony, neighbour joining, maximum likelihood, merits and demerits of cladistics.

5. Biodiversity: Concept, levels/types, importance; bioprospecting, biopiracy and traditional knowledge (ITK & CTK) on medicinal plant and ethnobotany; Biodiversity Act, Role of National Biodiversity Authority (NBA) in biodiversity management.

6. Conservation of plants: Causes of threat, IUCN - categories; procedure of conservation - *in-situ* conservation: Biosphere Reserve, Wild life Sanctuaries, National Parks, World Heritage Cites, activities of Protected Area Networks; *ex-situ* conservation - principles, methods, definition, aims and activities of W.W.F., Red Data Book, MAB, CITES, Genetic resources centre: international networks, national institutions, genetic stock collection. DNA bank and seed bank as Germplasm Collection.

7. Brief knowledge of Botanical Survey of India (B.S.I), Central National Herbarium and Indian Botanic Garden in relation to taxonomic studies; role of herbaria and botanic gardens

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8. GIS and Remote Sensing and their applications in Botany.

Course Outcome: After completion of this course the student will be able to

Sl. No.	Course Outcomes	Cognitive Level	POs Addressed	PSOs Addressed
CO1	Develop knowledge on evolution of floral organs.	U	PO1	PSO1
CO2	Survey the contribution of various data sources in plant taxonomy.	Ap, An	PO1, PO2	PSO2
CO3	Discuss the principles of biosystematics numerical taxonomy.	E, C	PO3	PSO3
CO4	Estimate the role biodiversity and conservation in plant taxonomy.	C	PO3, PO4	PSO4, PSO5

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Addition = 35%
Modification = 05%
Total change = 40%

Semester – IV	
Course name	**Taxonomy of Angiosperms (Practical)**
Course code	**PGBOTME4.3C**
Number of lectures	**60**
Credits	**4**
Marks	**50**

Course Objectives: This course aims to

Course Objectives
• Provide a thorough overview of taxonomic literature.
• Aware students in preparation of artificial keys.
• Collect plant samples and preparation of herbarium specimens.

Major Elective 4.3C

(Taxonomy of Angiosperms)

Practical **Full Marks: 50**

1. Familiarity with Taxonomic literature: Floras, Monographs, Manuals, Journals, etc
2. Description and identification of some representative plants from locally available families and preparation of artificial key.
3. Study of floral trends using floral characters of flowers in different angiosperm taxa using Hutchinson's Dicta (1926)
4. Work out of pollen morphology of angiosperm taxa.
5. Work out with different data sources on angiosperm taxa.
6. Exercises on biostatistics with different data sources.
7. Practice on numerical taxonomy by application of software (STATISTICA, PAST, etc).
8. Field excursions (both local and at phytogeographically different areas)
9. Submission 50 herbarium specimens (arranged according to APG IV)

Course Outcome: After completion of this course the student will be able to

Sl. No.	Course Outcomes	Cognitive Level	POs Addressed	PSOs Addressed
CO1	Preparation of botanical keys by locating key characters.	U	PO1, PO2	PSO1, PSO2
CO2	Collection of plants and preparation of herbarium specimens	Ap, An	PO2	PSO2
CO3	Use of computer based softwares and statistical methods as an aid in plant taxonomy	E, C	PO3	PSO3
CO4	Provide lab-based training in writing species descriptions and illustration.	C	PO3, PO4	PSO5

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Total Change = 100%

Semester – IV	
Course name	**Intellectual Property Rights (IPR) (Theory)**
Course code	**PGBOTSOC4A**
Number of lectures	**15**
Credits	**1**
Marks	**25**

Course Objectives: This course aims to

Course Objectives
• Recognize the importance of IP and to educate the pupils on basic concepts of IPR.
• Identify the significance of practice and procedure of Patents.
• Learn the procedure of obtaining patents, copyrights, trademarks & industrial design.

PGBOTSOC4A

Intellectual Property Rights (IPR)

Theory **Marks 25**

A. General Regime of Intellectual Property Rights: 1. Concept of Property vis-à-vis Intellectual Property (a) Concept of Property and Theories of Property - An Overview. (b) Theories of Intellectual Property Rights. (c) Intellectual Property as an Instrument of Development (d) Need for Protecting Intellectual Property- Policy Consideration- National Perspectives and International demands.

2. Types of Intellectual Property- Origin and Development- An Overview.

3. Intellectual Property Rights as Human Right

4. Role of Institutions (a) World Intellectual Property Organisation (WIPO) (b) Function of WIPO (c) Membership of WIPO (d) Agreement between the WIPO and the WTO (e) Dispute Settlement- New Treaties

5. Commercialisation of Intellectual Property Rights by Licensing

B. Patent Law: 1. Introduction to Patent Law: (a) Paris Convention (b) Patent Cooperation Treaty (c) WTO- TRIPS (d) Harmonisation of CBD and TRIPs

2. Indian Patent Law (a) The Patents Act, 1970 (b) Amendments to the Patents Act (c) Patentable Subject Matter, Patentability Criteria (d) Procedure for Filing Patent Applications, Patent Granting Procedure (e) Revocation, Patent Infringement and Remedies (f) Relevant Provisions of the Biological Diversity Act, 2002 (g) Access and Benefit Sharing Issues

C. Copyright, Neighbouring Rights and Industrial Designs: 1. Introduction to Copyright (a) Conceptual Basis (b) International Protection of Copyright and Related rights- An Overview (International Convention/Treaties on Copyright)

2. Indian Copyright Law (a) The Copyright Act, 1957 with its amendments (b) Copyright works (c) Ownership, transfer and duration of Copyright (d) Renewal and Termination of Copyright (e) Neighbouring Rights (f) Infringement of copyrights and remedies

D. Trademarks: 1. Introduction to Trademarks 2. Need for Protection of Trademarks

Course Outcome: After completion of this course the student will be able to

Sl. No.	Course Outcomes	Cognitive Level	POs Addressed	PSOs Addressed
CO1	Distinguish and explain various forms of IPRs.	An, E	PO3	PSO3
CO2	Apply statutory provisions to protect particular form of IPRs.	An, E	PO3	PSO4
CO3	Analyse rights and responsibilities of holder of Patent, Copyright, Trademark, Industrial Design.	Ap, An	PO3, PO4	PSO3, PSO4
CO4	Identify procedure to protect different forms of IPRs national and international level.	E, C	PO3, PO4	PSO5

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Total Change = 100%

Semester – IV	
Course name	**Biosafety Management (Theory)**
Course code	**PGBOTSOC4B**
Number of lectures	**15**
Credits	**1**
Marks	**25**

Course Objectives: This course aims to

Course Objectives
• Recognize public health definitions and their relative advantages.
• Perform a detailed Biological Risk Assessment, based on agent and procedure-specific properties.
• Define the different Biosafety Levels, list the minimum controls required, and describe the type of agents appropriate for each level.
• Implement the principles of biological containment.

PGBOTSOC4B

Biosafety Management

Theory **Marks 25**

1. Introduction to Biosafety and Biocontainment
2. Biosafety and Biocontainment Concepts and Strategies
3. Biosecurity Concepts and Strategies
4. Risk Assessment
5. Program Management
6. Risk Communication
7. Biocontainment Facilities
8. Operational Biosafety Practices and Procedures
9. Biological Safety Cabinets
10. Animal Biosafety and Facilities
11. Facility Operations and Maintenance
12. Disinfection and Decontamination
13. Waste Management
14. Bioethics
15. Transportation of Infectious Substances
16. Emergency Planning and Response

Course Outcome: After completion of this course the student will be able to

Sl. No.	Course Outcomes	Cognitive Level	POs Addressed	PSOs Addressed
CO1	Outline the benefit of a framework for essential public health functions.	R, U	PO1	PSO1
CO2	Plan a detailed Biological Risk Assessment, based on agent and procedure-specific properties.	An	PO2, PO3	PSO2, PSO3, PSO4
CO3	Evaluate the different Biosafety Levels, and describe the type of agents appropriate for each level.	Ap, E	PO3, PO4	PSO3, PSO4
CO4	Adapt and formulate the principles of biological containment.	C	PO3, PO4	PSO4

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Total Change = 100%

Semester – IV	
Course name	**Post-harvest management of Crops (Theory)**
Course code	**PGBOTSOC4C**
Number of lectures	**15**
Credits	**1**
Marks	**25**

Course Objectives: This course aims to

Course Objectives
• Cover every aspect from "farm to table".
• Study various changes occurring in fruits and vegetables during the pre-and post-harvest stages.
• Gain knowledge on physiology, biochemistry and on various technologies involved relevant to shelf-life extension.

PGBOTSOC4C

Post-harvest management of Crops

Theory **Marks 25**

1. Good Agricultural Practices: Concept & importance; Water quality & safety, Manure handling & application.

2. Importance of Post-Harvest Management

3. Harvesting

3. Post-harvest Handling–Cleaning–Packing & Processing–Storage–Transportation–Distribution

4. Post harvest processing: cereals, pulses, oilseeds, horticultural crops, medicinal plants

5. Packing: Packing facility sanitation, Building, Equipment, Storage –Water quality–Worker hygiene.

6. Packing House Sanitation: Proper sorting and culling of product

•Maintaining detectable free chlorine in wash waters.

•Enforcing good worker hygiene.

•Cleaning and sanitizing equipment

7. Postharvest Physiology and Technology of Horticultural Crops

Processing and Preservation of Fresh-Cut Fruit and Vegetable Products

Fresh-Cut Fruit and Vegetables: Emerging Eco-friendly Techniques for Sanitation and Preserving Safety

8. Modified Atmosphere Packaging: Design and Optimization Strategies for Fresh Produce

9. Prevention of Losses

10. Socio-economic factors

11. Beneficial to Producers and Consumers

Course Outcome: After completion of this course the student will be able to

Sl. No.	Course Outcomes	Cognitive Level	POs Addressed	PSOs Addressed
CO1	Outline the principles of post-harvest technology.	R, U	PO1	PSO1, PSO2
CO2	Illustrate the physiological & biochemical changes occurring during fruits and vegetables development.	U, An	PO1, PO2	PSO2, PSO3
CO3	Discuss the role and the significance of proper post-harvest handling to maintain the quality of fruits and vegetables.	E, C	PO3	PSO3
CO4	Analyse various aspects of quality control and evaluation.	An, C	PO4	PSO4, PSO5

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