

***Academic Syllabus for
M. Sc. Botany***

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Syllabus for M.Sc. (Botany) Examination in Choice Based Credit System (CBCS)

The M.Sc. (Botany) course shall consist of four Semesters, each Semester of six month duration, as detailed in the University Regulation. The course structure will be as follows:

Semester-I

- 1st Paper (Theory) : BOT F01 -Foundation
- 2nd Paper (Theory) : BOT C02 - Core Course 1
- 3rd Paper (Theory) : BOT C03 - Core Course 2
- 4th Paper (Practical) : BOT C04 - Practical based on Papers 2nd & 3rd Papers.

Semester-II

- 5th Paper (Theory) : BOT S05 - Skill Development
- 6th Paper (Theory) : BOT C06 - Core Course 3
- 7th Paper (Theory) : BOT C07 - Core Course 4
- 8th Paper (Practical) : BOT C08 - Practical based on 6th & 7th Papers.

Semester-III

- 9th Paper (Theory) : BOT A09 - Generic Elective (Open Elective)
- 10th Paper (Theory) : BOT C10 - Core Course 5
- 11th Paper (Theory) : BOT C11 - Core Course 6
- 12th Paper (Practical) : BOT C12 - Practical based on 10th & 11th Papers.

Semester-IV***Elective A: Cytogenetics and Crop Improvement***

- 13th Paper (Theory) : BOT E13 - Elective Theory
- 14th Paper (Theory) : BOT E14 -Elective Theory
- 15th Paper (Practical) : BOT E15 -Practical based on 13th & 14th Papers.
- 16nd Paper (Practical) : BOT E16 -Project

Semester-IV***Elective B: Applied Ecology and Environmental Biotechnology***

- 13th Paper (Theory) : BOT E13 - Elective Theory
- 14th Paper (Theory) : BOT E14 -Elective Theory
- 15th Paper (Practical) : BOT E15 -Practical based on 13th & 14th Papers.
- 16nd Paper (Practical) : BOT E16 -Project

Semester-IV

Elective C: Plant Biotechnology

- 13th Paper (Theory) : BOT E13 - Elective Theory
- 14th Paper (Theory) : BOT E14 -Elective Theory
- 15th Paper (Practical) : BOT E15 -Practical based on 13th & 14th Papers.
- 16nd Paper (Practical) : BOT E16 -Project

Paper-I
BOT F01
Foundation Course

Credits: 05

Full Marks: 70

Time: 03 Hrs.

In all nine questions of equal value will be set, out of which a student shall have to answer five questions. Q.no. 1 will be compulsory, consisting of seven very short answer type questions (each of two marks) covering the entire syllabus and the candidates are required to give their answers in maximum 50 words.

- 1) Structure and evolutionary relationship of Prokaryote, Mesokaryote and Eukaryote
- 2) Salient features and life cycle patterns in algae.
- 3) Salient features and life cycle patterns in fungi.
- 4) Salient features and life cycle patterns in Bryophytes.
- 5) Salient features and life cycle patterns of Pteridophytes.
- 6) Salient features and distribution of Gymnosperms.
- 7) International Code of Botanical Nomenclature (ICBN): History of ICBN, principles, rules, types method, author citation, valid and effective publication, principle of priority.
- 8) Herbarium, important herbaria and botanical gardens of India and the world

Paper-II

BOT C02

Core Course-I

Microbiology, Mycology, Phycology and Plant Pathology

Credits: 05

Full Marks: 70

Time: 03 Hrs.

In all nine questions of equal value will be set, out of which a student shall have to answer five questions. Q.no. 1 will be compulsory, consisting of seven very short answer type questions (each of two marks) covering the entire syllabus and the candidates are required to give their answers in maximum 50 words.

- 1) Bacteria: Reproduction in Bacteria-Binary Fission, Recombination-Conjugation, Transformation and Transduction, Economic importance of bacteria with special reference to agriculture, industry and medicine.
- 2) Cyanobacteria : Ultra-Structure of a typical Cyanobacterial Cell, Economic importance.
- 3) Virus:- Nomenclature and classification, distinctive properties of virus, morphology and ultra structure, Viral replication: lytic and lysogenic.

- 4) Mycoplasma : Structure, life cycle and significance.
- 5) Fungi : Structure, life cycle and phylogeny of Chytridiales and Moniliales;
General account of Mycotoxin, mycorrhizae; Fungi as biocontrol agents.
- 6) Algae:- Role of pigments, reserve food and flagella in the Classification of algae, Structure, life cycle and phylogeny of Charales and Fucales; Evolution of sex in algae; Economic Importance of Algae with special reference to Algal bloom, biofertilizers and indicator of water pollution.
- 7) Symptoms, etiology and control measures of the following diseases:
 - (i) Bacterial leaf blight of paddy
 - (ii) Leaf curl of papaya
 - (iii) Little leaf of brinjal.

Paper III

BOT C03

Core Course-II

Bryophyta, Pteridophyta, Gymnosperms

Credits: 05

Full Marks: 70

Time: 03 Hrs.

In all nine questions of equal value will be set, out of which a student shall have to answer five questions. Q.no. 1 will be compulsory, consisting of seven very short answer type questions (each of two marks) covering the entire syllabus and the candidates are required to give their answers in maximum 50 words.

- 1) **Bryophytes:** Structure, reproduction, affinities and evolutionary trends of the following orders- Sphaerocarpaceae, Sphagnales; Evolution of gametophytes and sporophytes in bryophytes; Fossil Bryophytes
- 2) **Pteridophytes: Classification of Pteridophytes (Sporne 1975) ;** Telome theory; its merits and weaknesses ; Stele organization and evolution of stele in pteridophytes ; Heterospory in pteridophytes; Economic importance of Pteridophytes; Structure, reproduction, affinities and evolutionary trends of the following orders: Psilotales, Psilotales and Marsiliales.
- 3) **Gymnosperm: Classification of Gymnosperm (Sporne 1965);** Structure, reproduction, affinities and evolutionary trends of Pinaceales, Ginkgoales, Taxales, Gnetales (emphasis on angiospermic features) ; Evolution of female gametophytes in gymnosperms; Fossil gymnosperm flora of Jharkhand.

Paper-IV : Practical Paper

BOT C04

Credits: 05

Full Marks: 70

Time: 06 Hrs.

- 1) Identification of the members of different Groups of algae.
- 2) Study and identification of the genera of different Groups of fungi.
- 3) Study of general habit, external and internal morphology of vegetative and reproductive features of the bryophytes.
- 4) Study of general habit, external and internal morphology of vegetative and reproductive features of the members of different groups of pteridophytes.
- 5) Study of general habit, external and internal morphology with special reference to their male and female reproductive structures of the members of different group of gymnosperms.
- 6) Spotting; related to Microbiology, Phycology, Mycology, Bryophyta, Pteridophyta, Gymnosperms and fossils.
- 7) General overview of plant diseases.
- 8) Viva-voce
- 9) Practical records, field reports, herbarium, charts, models etc.

Paper-V
BOT S05
Skill Development
BIOFERTILIZERS

Credits: 05
(Theory 70+ Practical 30)

Full Marks: 100

Time: 03 Hrs.

In all nine questions of equal value will be set, out of which a student shall have to answer five questions. Q.no. 1 will be compulsory, consisting of seven very short answer type questions (each of two marks) covering the entire syllabus and the candidates are required to give their answers in maximum 50 words.

- 1) General account about the microbes used as biofertilizer – *Rhizobium* – isolation, identification, mass multiplication, , Actinorrhizal symbiosis.
- 2) *Azospirillum*: isolation and mass multiplication – carrier based inoculants, associative effect of different microorganisms. *Azotobacter*, characteristics – crop response to *Azotobacter* inoculum, maintenance and mass multiplication.
- 3) Cyanobacteria (blue green algae), *Azolla* and *Anabaena azollae* association, nitrogen fixation, factors affecting growth, blue green algae and *Azolla* in rice cultivation.
- 4) Mycorrhizal association, types of mycorrhizal association, taxonomy, occurrence and distribution, phosphorus nutrition, growth and yield – colonization of VAM – isolation and inoculum production of VAM, and its influence on growth and yield of crop plants.
- 5) Organic farming – Green manuring and organic fertilizers, Recycling of bio-degradable municipal, agricultural and Industrial wastes – biocompost making methods, types and method of vermicomposting – field application.

PRACTICAL: Practical will be based on the topic of this paper.

Paper-V
Skill Development
BOT S05

PLANT DIVERSITY AND HUMAN WELFARE

Credits: 05
(Theory 70+ Practical 30)

Full Marks: 100

Time: 03 Hrs.

In all nine questions of equal value will be set, out of which a student shall have to answer five questions. Q.no. 1 will be compulsory, consisting of seven very short answer type questions (each of two marks) covering the entire syllabus and the candidates are required to give their answers in maximum 50 words.

1. Plant diversity and its scope- Genetic diversity, Species diversity, Plant diversity at the ecosystem level, Agrobiodiversity and cultivated plant taxa, wild taxa. Values and uses of Biodiversity: Ethical and aesthetic values, Precautionary principle, Methodologies for valuation, Uses of plants, Uses of microbes.
2. Loss of Biodiversity: Loss of genetic diversity, Loss of species diversity, Loss of ecosystem diversity, Loss of agrobiodiversity, Projected scenario for biodiversity loss, Management of Plant Biodiversity: Organizations associated with biodiversity management-Methodology for execution-IUCN, UNEP, UNESCO, WWF, NBPGR; Biodiversity legislation and conservations, Biodiversity information management and communication.
3. Conservation of Biodiversity: Conservation of genetic diversity, species diversity and ecosystem diversity, *In situ* and *ex situ* conservation, Social approaches to conservation, Biodiversity awareness programmes, Sustainable development.
4. Role of plants in relation to Human Welfare; a) Importance of forestry their utilization and commercial aspects b) Avenue trees, c) Ornamental plants of India. d) Alcoholic beverages through ages. Fruits and nuts: Important fruit crops their commercial importance. Wood and its uses.

PRACTICAL: Practical will be based on the topic of this paper.

Paper-V
Skill Development
BOT S05
MUSHROOM CULTIVATION
Credits: 05
(Theory 50+ Practical 50)

Full Marks: 100

Time: 03 Hrs.

In all nine questions of equal value will be set, out of which a student shall have to answer five questions. Q.no. 1 will be compulsory, consisting of seven very short answer type questions (each of two marks) covering the entire syllabus and the candidates are required to give their answers in maximum 50 words.

- 1.** Introduction, history. Nutritional and medicinal value of edible mushrooms; poisonous mushrooms. Types of edible mushrooms available in India - *Volvariella volvacea*, *Pleurotus citrinopileatus*, *Agaricus bisporus*.
- 2.** Cultivation Technology : Infrastructure: substrates (locally available) Polythene bag, vessels, Inoculation hook, inoculation loop, low cost stove, sieves, culture rack, mushroom unit (Thatched house) water sprayer, tray, small polythene bag. Pure culture: Medium, sterilization, preparation of spawn, multiplication. Mushroom bed preparation - paddy straw, sugarcane trash, maize straw, banana leaves. Factors affecting the mushroom bed preparation - Low cost technology, Composting technology in mushroom production.
- 3.** Storage and nutrition : Short-term storage (Refrigeration - upto 24 hours) Long term Storage (canning, pickels, papads), drying, storage in salt solutions. Nutrition - Proteins - amino acids, mineral elements nutrition - Carbohydrates, Crude fibre content - Vitamins.
- 4.** Food Preparation: Types of foods prepared from mushroom. Research Centres - National level and Regional level. Cost benefit ratio - Marketing in India and abroad, Export Value.

Paper-VI
BOT C06
Core Course III
Cell biology, Molecular Biology and Genetics
Credits: 05

Full Marks: 70

Time: 03 Hrs

In all nine questions of equal value will be set, out of which a student shall have to answer five questions. Q.no. 1 will be compulsory, consisting of seven very short answer type questions (each of two marks) covering the entire syllabus and the candidates are required to give their answers in maximum 50 words.

- 1) Structure and function of microbodies, Golgi apparatus, lysosomes and endoplasmic reticulum; Cytoskeleton-Nature of cytoskeleton, intermediate filaments, microtubules, cilia and centrioles.
- 2) Cell cycle: Introduction, phases, cell cycle control.
- 3) Structure of chromatin and chromosomes; packaging of DNA; interrupted genes; gene families; unique and repetitive DNA; heterochromatin and euchromatin; banding patterns; transposable elements.
- 4) B-Chromosomes: Origin, structure and significance.
- 5) Nuclear DNA content; C- value paradox; Cot-curve and its significance; restriction mapping - concept and technique.
- 6) **RNA** synthesis and processing : Transcription factor and machinery, formation of initiation complex, transcription activators and repressors, RNA polymerases, capping, elongation and termination, RNA processing, RNA editing, RNA splicing, polyadenylation, structure and functions of different types of RNA.
- 7) Regulation of gene expression in prokaryotes and eukaryotes.
- 8) DNA replication, repair and recombination: Unit of replication, enzymes involved, replication origin and replication fork, fidelity of replication, extra chromosomal replicons, DNA damage and repair mechanisms.
- 9) Extra chromosomal inheritance: Inheritance of mitochondria and chloroplast genes; maternal inheritance.
- 10) Quantitative genetics: Polygenic inheritance (characteristic, multiple factor hypothesis, seed colour in wheat, corolla length in tobacco); heritability and its measurements; QTL-mapping.
- 11) Structural alteration in chromosomes: Origin, meiosis and breeding behavior of duplication, deficiency, inversion and translocation. Numerical alterations in chromosomes: Origin, Occurrence, Production and meiosis of haploids, aneuploids and euploids; origin and production of autopolyploids; genome constitutions and analysis of allopolyploids; evolution of major crop plants; induction and characterization of trisomics and monosomics.

- 12) Correlation - types and methods of correlation, regression, simple regression equation, fitting prediction, similarities and dissimilarities of correlation and regression. Measures of central tendency and dispersal; probability distributions (Binomial, Poisson and normal); sampling distribution; difference between parametric and non-parametric statistics; confidence interval; errors; levels of significance; regression and correlation. Statistical inference - hypothesis - simple hypothesis - student 't' test – chi-square test.

Paper-VII
BOT C07
Core Course IV
Ecology and Environmental Biology
Credits: 05

Full Marks: 70

Time: 03 Hrs

In all nine questions of equal value will be set, out of which a student shall have to answer five questions. Q.no. 1 will be compulsory, consisting of seven very short answer type questions (each of two marks) covering the entire syllabus and the candidates are required to give their answers in maximum 50 words.

1) Ecosystem :

Modern concept, structural components, trophic structure, food chain, food web and ecological pyramids.

Structure and function of some Indian ecosystem: terrestrial ecosystem (Forest and grassland) and aquatic ecosystem (fresh water and marine).

Ecological energetics: concept and mode of energy flow in aquatic ecosystem.

Productivity: types and methods of primary productivity and its measurement.

2) Community:

Structure: Analytic and synthetic characters with emphasis on I.V.I, and species diversity index (H).

Ecological niche, edges and ecotones.

Ecological succession : Types and process of succession, hydrosere and xerosere, concept of climax.

- 3) Plant Geography:
 - a) Biomes of world
 - b) Major vegetation types of India with special reference to Jharkhand
 - c) Major floristic regions of India

Resource Ecology

- 4) Plant biodiversity : Concept, status in India, utilization and concerns.
- 5) Strategies for plant conservation:
 - (a) *In situ* conservation : Protected areas in India-sanctuaries, national parks, biosphere reserves, wetlands, mangroves, sacred groves and coral reefs for conservation of wild biodiversity.
 - (b) *Ex situ* conservation : Botanical gardens, gene banks, seed banks, cryobanks.
 - (c) Genetically modified (GM) crops
- 6) Air pollution: Sources, effects and control with special reference to global warming, green house effect, Ozone depletion and acid rain,
- 7) Water pollution: Sources, effects and control with emphasis an eutrophication and biological magnification.
- 6) Role of biotechnology in pollution control.
- 8) Application of biotechnology in solid waste management
- 9) Forest management:
 - a) Forest: forest types found in India, importance of forest, strategies for conservation and management of forest, with special reference to deforestation , Chipko movement, Social forestry and Biosphere reserves.
 - b) National forest policy and forest laws.
- 10) Brief account of the following:
 - a) Bioindicators
 - b) Convention on Biological Diversity (CBD)
 - c) Kyoto protocol and carbon trading
 - d) IUCN (International Union for Conservation of Nature)
 - e) Gene campaign
 - f) Rare, threatened and endangered flora of India

Paper-VIII : Practical Paper

BOT C08

Credits: 05

Full Marks: 70

Time: 06 Hrs.

- 1) Plant anatomy related to ecological adaptations.
- 2) To determine frequency /density/ abundance in a grassland vegetation.
- 3) Study of temperature, pH and transparency of dissolved. O₂/free CO₂ from aquatic ecosystem.
- 4) Isolation of algae and bacteria from aquatic ecosystem.
- 5) Productivity study by Light and Dark bottle.
- 6) Cytological techniques: Pre-fixation, fixation, mounting, squashing of root tips for the study of various stages of mitosis.
- 7) Study of different stages of meiosis.
- 8) Problems based on Mendelian ratios and their modifications, statistical analysis and genetic explanation
- 9) Spotting related to Theory papers VI & VII.
- 10) Viva-voce.
- 11) Practical records, field reports, herbarium, charts, models etc.

**Paper-IX
BOT A09**

Generic (Open) Elective

1. Industrial and Environmental Microbiology

(Credits: 05)

(Theory 70 + Practical 30)

Full Marks: 50

Time: 03 Hrs

In all nine questions of equal value will be set, out of which a student shall have to answer five questions. Q.no. 1 will be compulsory, consisting of seven very short answer type questions (each of two marks) covering the entire syllabus and the candidates are required to give their answers in maximum 50 words.

- 1) Scope of microbes in industry and environment
- 2) Bioreactors/Fermenters and fermentation processes: Solid-state and liquid-state (stationary and submerged) fermentations; Batch and continuous fermentations. Components of a typical bioreactor, Types of bioreactors-laboratory, pilotscale and production fermenters; Constantly stirred tank fermenter, tower fermenter, fixed bed and fluidized bed bioreactors and air-lift fermenter.
- 3) A visit to any educational institute/ industry to see an industrial fermenter, and other downstream processing operations.
- 4) Microbial production of industrial products: Microorganisms involved, media, fermentation conditions, downstream processing and uses; Filtration, centrifugation, cell disruption, solvent extraction, precipitation and ultrafiltration, lyophilization, spray drying; Hands on microbial fermentations for the production and estimation (qualitative and quantitative) of Enzyme: amylase or lipase activity, Organic acid (citric acid or glutamic acid), alcohol (Ethanol) and antibiotic (Penicillin).
- 5) Microbial enzymes of industrial interest and enzyme immobilization: Microorganisms for industrial applications and hands on screening microorganisms for casein hydrolysis; starch hydrolysis; cellulose hydrolysis. Methods of immobilization, advantages and applications of immobilization, large scale applications of immobilized enzymes (glucose isomerase and penicillin acylase).
- 6) Microbes and quality of environment: Distribution of microbes in air; Isolation of microorganisms from soil, air and water.

PRACTICAL: Practical based on topics of paper industrial and environmental microbiology.

Paper-IX
BOT A09
Generic (Open) Elective

2. BIOINFORMATICS

(Credits: 05)

(Theory 50 + Practical 50)

Full Marks: 50

Time: 03 Hrs

In all nine questions of equal value will be set, out of which a student shall have to answer five questions. Q.no. 1 will be compulsory, consisting of seven very short answer type questions (each of two marks) covering the entire syllabus and the candidates are required to give their answers in maximum 50 words.

- 1) Introduction to Bioinformatics: Introduction, Branches of Bioinformatics, Aim, Scope and Research areas of Bioinformatics.
- 2) Databases in Bioinformatics : Introduction, Biological Databases, Classification format of Biological Databases, Biological Database Retrieval System.
- 3) Biological Sequence Databases: National Center for Biotechnology Information (NCBI): Tools and Databases of NCBI, Database Retrieval Tool, Sequence Submission to NCBI, Basic local alignment search tool (BLAST), Nucleotide Database, Protein Database, Gene Expression Database.
- 4) EMBL Nucleotide Sequence Database (EMBL-Bank): Introduction, Sequence Retrieval, Sequence Submission to EMBL, Sequence analysis tools.
- 5) Swiss-Prot: Introduction and Salient Features.
- 6) Sequence Alignments: Introduction, Concept of Alignment, Multiple Sequence Alignment (MSA), MSA by CLUSTALW, Scoring Matrices, Percent Accepted Mutation (PAM), Blocks of Amino Acid Substitution Matrix (BLOSUM).
- 7) Molecular Phylogeny: Methods of Phylogeny, Software for Phylogenetic Analyses, Consistency of Molecular Phylogenetic Prediction.

PRACTICAL: Practical based on topics of paper Bioinformatics.

Paper-IX
BOT A09
Generic (Open) Elective

3. CROP IMPROVEMENT

(Credits: 05)

(Theory 50 + Practical 50)

Full Marks: 50

Time: 03 Hrs

In all nine questions of equal value will be set, out of which a student shall have to answer five questions. Q.no. 1 will be compulsory, consisting of seven very short answer type questions (each of two marks) covering the entire syllabus and the candidates are required to give their answers in maximum 50 words.

PLANT BREEDING Introduction and objectives. Breeding systems: modes of reproduction in crop plants. Important achievements and undesirable consequences of plant breeding. Introduction: Centres of origin and domestication of crop plants, plant genetic resources; Acclimatization; Selection methods: For self pollinated, cross pollinated and vegetatively propagated plants; Hybridization: For self, cross and vegetatively propagated plants – Procedure, advantages and limitations. Role of mutations; Polyploidy; Distant hybridization and role of biotechnology in crop improvement.

TISSUE CULTURE AND GENETIC TRANSFORMATION

- | Micropropagation: Introduction, techniques, micropropagation of elite plants, advantages, micropropagation research in India.
 - | Somatic hybridization; Introduction, techniques of somatic hybridization, selection of fused protoplast and significance; Cybrids-techniques, advantages and uses.
 - | Genetic transformation of plants: Vector mediated transformation; Agrobacterium - the natural genetic engineer; Methods of direct gene transfer in plants.
- PRACTICAL:** Practical based on topics of paper crop improvement.

Paper-IX
BOT A09
Generic Elective

4. BIODIVERSITY (Microbes, Algae, Fungi and Archegoniate)
(Credits: 05)

(Theory 50 + Practical 50)

Full Marks: 50

Time: 03 Hrs

In all nine questions of equal value will be set, out of which a student shall have to answer five questions. Q.no. 1 will be compulsory, consisting of seven very short answer type questions (each of two marks) covering the entire syllabus and the candidates are required to give their answers in maximum 50 words.

Microbes

Viruses – Discovery, general structure; Economic importance; Bacteria – Discovery, General characteristics and cell structure; Economic importance.

Algae and Fungi

General characteristics; Ecology and distribution; Range of thallus organization and reproduction; Economic importance of algae.

Introduction- General characteristics; Economic importance of fungi; Edible fungi.

Introduction to Archegoniate

Unifying features of archegoniate, Transition to land habit, Alternation of generations.

Bryophytes

General characteristics, adaptations to land habit, Range of thallus organization. Ecology and economic importance of bryophytes.

Pteridophytes

General characteristics, classification, Early land plants Heterospory and seed habit, stellar evolution. Ecological and economical importance of Pteridophytes.

Gymnosperms

General characteristics, Ecological and economical importance.

PRACTICAL: Practical based on topics of paper biodiversity.

Paper-X
BOT C10
Core Course VI
Plant Physiology and Biochemistry
Credits: 05

Full Marks: 70

Time: 03 Hrs

In all nine questions of equal value will be set, out of which a student shall have to answer five questions. Q.no. 1 will be compulsory, consisting of seven very short answer type questions (each of two marks) covering the entire syllabus and the candidates are required to give their answers in maximum 50 words.

Plant-Water relation

- 1) Water and mineral relation of plants : water potential and membrane, transport system;
- 2) Absorption of water.
- 3) Role of macro - and micronutrients; mineral salt absorption.
- 4) Uptake, transport and translocation of water, ions, solutes and macromolecules from soil, through cells, across membranes, through xylem and phloem; transpiration; mechanisms of loading and unloading of photoassimilates.
- 5) Mechanism of stomatal opening and closing

: Biochemistry

- 4) Enzymes: Nomenclature and classification, nature and properties, coenzymes & prosthetic groups, Enzymes kinetic; mechanism and mode of enzyme action, isoenzymes, allosteric enzymes, ribozyme.
- 5) Classification and Biochemistry of:
 - a) Carbohydrates
 - b) Amino acid
 - c) Proteins (including secondary, tertiary & quaternary structure, domains)
 - d) Vitamins
- 6) Secondary metabolites: Biosynthesis of terpenes, phenols and nitrogenous compounds and their roles.

: Metabolism

Photosynthesis : Light harvesting complexes; mechanisms of electron transport; photoprotective mechanisms; CO₂ fixation-C₃, C₄ and CAM pathways; photorespiration.

Respiration: Citric acid cycle; plant mitochondrial electron transport and ATP synthesis; alternate oxidase; photorespiratory pathway.

- 9) Lipid metabolism: Biosynthesis of fatty acids, oxidation of fats, triglycerides, Glyoxylate cycle, α & β oxidation of lipids.
- 10) Biological nitrogen fixation.
- 11) Protein synthesis and processing: Ribosome, formation of initiation

complex, initiation factors, elongation and elongation factors, termination, genetic code, aminoacylation of tRNA, aminoacyl tRNA synthetase, translational proof-reading, translational inhibitors.

: Growth and Development

- 12) Phytohormones: Chemical nature, biosynthesis, mode of action and role of Auxins, Gibberellins, Cytokinins, ABA and Ethylene.
- 13) Sensory photobiology: Phytochromes, Cryptochromes; Photoperiodism; Vernalization and Biological clocks.
- 14) Stress Physiology: Responses of plants to biotic (pathogen and insects) and abiotic (water, temperature and salt) stresses; mechanism & resistance to biotic stress and tolerance to abiotic stress."
- 15) Senescence and Programmed Cell Death (PCD)

Paper-XI

BOT C11

Core Course VI

Anatomy, Embryology and Genetic Engineering

Credits: 05

Full Marks: 70

Time: 03 Hrs

In all nine questions of equal value will be set, out of which a student shall have to answer five questions. Q.no. 1 will be compulsory, consisting of seven very short answer type questions (each of two marks) covering the entire syllabus and the candidates are required to give their answers in maximum 50 words.

: Anatomy

- 1) Organization of Shoot Apical Meristem (SAM); Leaf development and differentiation; Organization of Root Apical Meristem (RAM).
- 2) Stomata: Morphology, different types and ontogeny.
- 3) Periderm : Formation and function; lenticels, Abscission and healing of wounds
- 4) Nodal anatomy and its significance.
- 5) Leaf and wood anatomy in ecological perspective.

: Embryology

- 6) Male sterility; Self and Interspecific incompatibility; double fertilization.
- 7) Endosperm: types and development, functions, cytology, morphogenetic nature.
- 8) Polyembryony: Classification, development, experimental induction, causes and practical value of polyembryony.

- 9) Apomixis : Types, diplospory, apospory, parthenogenetic development of embryo; causes; genetics and significance of apomixis.
- 10) Palynology: Pollen morphology, pollen wall features, germination of pollen grains, scope of palynology.

: Tissue Culture

- 11) Embryo culture: Introduction, types, objectives, protocol and applications, Somatic embryogenesis: Introduction, development of somatic embryos, factors and significance of somatic embryogenesis; Artificial seeds - their advantages and limitations.
- 12) Anther and Pollen culture : Introduction, history, protocol for anther & pollen culture, advantages of pollen culture over anther culture, factors and significance of anther and pollen culture, use of haploids in crop improvement.
- 13) Plant protoplast culture: Introduction, isolation and culture of protoplasts, regeneration of plants and importance, Somatic hybridization; Introduction, techniques of somatic hybridization, selection of fused protoplast and significance; Cybrids-techniques, advantages and uses.
- 14) Somaclonal variations: Introduction, causes, method of selection and uses of somaclonal variation; somaclonal works in India.

: Genetic Engineering

- 15) Tools of genetic engineering: Restriction endonucleases; Gel electrophoresis; Ligases and Probes, Cloning Vectors: Plasmids, Cosmids, Phage vectors, BAC and YAC Vectors.
- 16) Nucleic Acid hybridization: Southern, Northern and Western blotting techniques.
- 17) Polymerase Chain Reaction (PCR): Principles and uses of PCR.
- 18) Gene transformation of plants: Vector mediated transformation; Agrobacterium - the natural genetic, engineer; Methods of direct gene transfer in plants, Transgenic plants: Principles and Techniques; Exploitation in the production of transgenic plants; transgenic plants for resistance to herbicide, insecticide, viral and other diseases; transgenic plants for molecular farming.

Paper-XII : Practical Paper
BOT C12
Credits: 05

Full Marks: 70

Time: 06 Hrs.

- 1) Anatomical study of the stem showing anomalous secondary growth.
- 2) Deposition of pollen grains on the stigma and development of pollen tubes through the style.
- 3) Study of different stages of the developing embryo.
- 4) Study and identification of tissue elements from the macerated stem.
- 5) Hybridization techniques.
- 6) Techniques of Inoculation of the explant to the nutrient medium.
- 7) Separation of chlorophyll pigments (Paper chromatography).
- 8) Biochemical tests of Carbohydrates/Protein/Lipids.
Spotting related to Theory papers X & XI.
- 9) Viva-voce.
- 10) Practical records, field reports, herbarium, charts, models etc.

ELECTIVE THEORY
Paper-XIII
BOT E13
Elective Theory 'A'
Cytogenetics and Crop Improvement
Credits: 05

Full Marks: 70

Time: 03 Hrs

In all nine questions of equal value will be set, out of which a student shall have to answer five questions. Q.no. 1 will be compulsory, consisting of seven very short answer type questions (each of two marks) covering the entire syllabus and the candidates are required to give their answers in maximum 50 words.

CYTOGENETICS

Cell cycle: Interphase and mitosis, cytokinesis; stages of meiosis, significance of meiosis, synaptonemal complex and its significance in meiosis; recombination nodules and their role in meiotic recombination.

DNA replication, repair and recombination: Unit of replication, enzymes involved, replication origin and replication fork, fidelity of replication, extrachromosomal replicons, DNA damage and repair mechanisms.

RNA synthesis and processing: Transcription factors and machinery, formation of initiation complex, transcription activators and repressors, RNA polymerases, capping, elongation and termination, RNA processing, RNA editing, splicing, polyadenylation, structure and function of different types of RNA, RNA transport.

- 4) Physical basis of heredity : the nucleus (including new basket model of nuclear pore, complex, nucleocytoplasmic traffic); structure of chromatin fibre; special types of chromosomes (lampbrush, salivary gland and B chromosomes)
- Fine structure of gene: at the genetic level: Gene Vs allele : a new concept of allelomorphism (recombination, complementation, position effect, pseudoalleles, cis-trans effect); fine structure of gene (lozene in *Drosophila*, r II in T4 phage); cistron, recon and muton).
- Regulation of gene expression: Operon circuits in bacteria and other prokaryotes; circuits for lytic cycle and lysogeny in bacteriophages; regulation of gene expression in eukaryotes (including cell signaling and cell receptors).

: Plant Breeding

- 7) Inbreeding and heterosis: Effects of inbreeding; degrees of inbreeding depression; concept of heterosis and hybrid vigour; manifestation of heterosis; genetic basis of heterosis; exploitation of heterosis in self, cross and vegetatively propagated crops; fixation of heterosis.
- 8) Breeding for disease resistance: Concept of plant diseases; vertical and horizontal disease resistance; procedures for breeding disease resistant crops; achievements.

- 9) Ploidy breeding : Classification of ploidy; ways of creating various ploidy level; haploid breeding; morphological and cytological features of euploids and aneuploids; role of autopolyploidy and allopolyploidy in evolution of crops, use of autopolyploidy and allopolyploidy in crop improvement.
- 10) Mutation breeding : Use of the physical and chemical mutagens in induction of mutation; LD₅₀; procedure of mutation breeding ; advantages, disadvantages and limitations of mutation breeding; achievements made through mutation breeding.
- 11) Allelopathy Brief history; definition; Evidence of allelopathy, Allelochemicals – occurrence, mode of allelochemicals release, mode of action of allelochemicals. Interactions between plant communities – crop-crop interaction, crop-weed interaction. Exploitation of allelopathy in crop production and protection, future prospects.

Paper-XIV

BOT E14

Elective Theory 'A'

Cytogenetics and Crop Improvement

Credits: 05

Full Marks: 70

Time: 03 Hrs

In all nine questions of equal value will be set, out of which a student shall have to answer five questions. Q.no. 1 will be compulsory, consisting of seven very short answer type questions (each of two marks) covering the entire syllabus and the candidates are required to give their answers in maximum 50 words.

: Plant Tissue Culture

Somatic embryogenesis: Introduction; sources for somatic embryogenesis; direct and indirect embryogenesis; protocol and the factors affecting somatic embryogenesis; significance; the artificial seeds.

Micropropagation : Introduction; protocol; sources; advantages.

Protoplast culture and Somatic hybridization: Objectives; protocol; selection of the fused protoplasts; chromosome status of the somatic hybrids; significance; cybrids.

Anther and Pollen culture: Objectives; protocols for anther and pollen culture; comparison between anther and pollen culture; screening of haploids; methods of diploidization; significance of anther and pollen culture.

: Recombinant DNA Technology

Tools of genetic engineering: The cloning vectors - plasmids, cosmids, phages, BAC and YAC vectors; restriction endonucleases; ligases; gel electrophoresis; probes; Southern, Northern and Western blottings.

6) Polymerase Chain Reaction (PCR).

Method of gene transfer in plants: Vectors - mediated gene transfer; *Agrobacterium tumefaciens*, the natural genetic engineer; methods of direct transformations- electroporation, chemically stimulated DNA uptake, use of liposomes, microinjections, sonication, microprojectile gun method, laser microbeam, and silicon carbide fibers.

The transgenic plants : Objectives; method of obtaining transgenic plants; production of transgenic plants in monocots; the transgenic plants having herbicide resistance, insect resistance, altered fatty acid composition in Brassica oil, resistance against stresses, male sterility and fertility restoration, molecular farming, production of edible vaccines, plants with enhanced nitrogen fixing ability; release of GM plants to the environment

Paper-XV : Practical Paper
BOT E15
Elective Theory 'A'
Cytogenetics and Crop Improvement

Credits: 05

Full Marks: 70

Time: 06 Hrs.

- 1) Method of preparing prefixatives.
- 2) Method of preparing Acetocarmine, Fielgen stains etc.
- 3) Squashing techniques.
- 4) Technique and method of permanent preparation of cytological materials.
- 5) Karyotype study of Metaphase chromosomes from root tips (*Allium cepa*, *Allium sativum*, *Vicia faba*, *Zea mays*, *Pisum sativum*, *Triticum aestivum* etc.).
- 6) Study of chromosomes of different stages of mitosis by squash technique.
- 7) Study of different stages of meiosis from the floral buds (*Allium cepa*; *Vicia faba*, *Zea mays*, *Pisum sativum*, *Triticum aestivum*, *Rhoeo discolor*, *Tradescantia* sp.).
- 8) Estimation of DNA by spectrophotometer.
- 9) Study of abnormalities in mitosis and meiosis.
- 10) Problems related to Mendelian ratios and their modifications; statistical analysis and genetic explanation.
- 11) Emasculation and hybridization techniques.
- 12) Study of chromocentres found in the stigmatic receptive cells of crucifers.

Paper-XIII
BOT E13
Elective Theory II
Applied Ecology and Environmental Biotechnology
Credits: 05

Full Marks: 70

Time: 03 Hrs

In all nine questions of equal value will be set, out of which a student shall have to answer five questions. Q.no. 1 will be compulsory, consisting of seven very short answer type questions (each of two marks) covering the entire syllabus and the candidates are required to give their answers in maximum 50 words.

: General Ecology

1) Ecosystem :

- a) Modern concept, structural components, trophic structure, food chain, food web and ecological pyramids.
- b) Ecological energetics: concept and mode of energy flow in aquatic ecosystem.
- c) Productivity: types and methods of primary productivity and its measurement.

2) Community:

- a) Structure: Analytic and synthetic characters with emphasis on I.V.I, and species diversity index (H).
- b) Ecological niche, edges and ecotones.
- c) Ecological niche succession : Types and process of succession, hydrosere and xerosere, concept of climax.

3) Phytogeography:

- a) Biomes of world
- b) Major vegetation types of India with special reference to Jharkhand.

: Resource Ecology

4) Natural resources:

- a) Biodiversity-concept, importance and quantum of biodiversity.
- b) Forest, wetland, mangroves, agriculture, fisheries and wild life resources of India.

5) Modern fuel and their environmental effect:

- a) Methenogenic bacteria and biogas.
- b) Conversion of sugar to ethanol.
- c) Solar energy converters.
- d) Petroplants.
- 6) Traditional knowledge and natural resources. Basic concept of traditional knowledge; traditional knowledge in management of biodiversity and water resources.

7) Microbial diversity:

- a) Role of microbes in environment.
 - b) Microbes as biofertilizers.
 - c) Enrichment of ore by microbes (biohydrometallurgy, biobenefication, bioleaching).
 - d) Microbial hydrogen production.
- 8) Wetlands: Definition, characteristic and productivity, major wetlands of India and their biotic resources.

: Limnology

- 9) Introduction and History of Limnology.
- 10) Lentic and Lotic ecosystem, quality of drinking water, strategies for conservation of fresh water.
- 11) Physico-chemical Characteristic of lentic and lotic ecosystem - Temperature, pH, conductivity, dissolved oxygen and free CO₂. B.O.D and C.O.D, Total nitrogen, phosphorus, TDS (Total Dissolved Solid).
- 12) Biological diversity of aquatic ecosystem with special reference to Algae and Maesophytes.
- 13) Measurement of Primary Productivity in fresh water ecosystem.

: Applied Ecology

- 14) Remote sensing : Basic concept and application in pollution management and natural resource management.
- 15) Environmental protection act and forest protection act.
- 16) Sustainable development: Basic concept, principle and application.
- 17) Biomonitoring:
- a) Concept of biomonitoring
 - b) Biomonitoring of water and air pollution.
 - c) Advantages of biomonitoring over conventional techniques.
- 18) A brief account of:
- a) Biopiracy
 - b) Bioprospecting
 - c) Environmental economics
 - d) Village biodiversity register
 - e) Bioethics.

Paper-XIV
BOT E14
Elective Theory 'B'
Applied Ecology and Environmental Biotechnology
Credits: 05

Full Marks: 70

Time: 03 Hrs

In all nine questions of equal value will be set, out of which a student shall have to answer five questions. Q.no. 1 will be compulsory, consisting of seven very short answer type questions (each of two marks) covering the entire syllabus and the candidates are required to give their answers in maximum 50 words.

: Pollution Ecology

-) Radiation pollution : Types and measurement of radiation, sources of radiation, impact of radiation on human health and its mode of action, strategy for control/minimizing radiation
-) Climate change: Basic concept of climate change vis-a-vis global warming; present status and future projections of climate change; impact of climate change on agriculture, biodiversity and human health; adaptation and mitigation of climate change.
-) Solid waste management:
 - a) Source, generation and classification of solid waste.
 - b) Management and utilization of solid waste.
 - c) Fly ash and mine spoil and their management.
-) Air pollution:
 - a) Critical air pollutants and their Indian standard.
 - b) Air pollution due to coal mining.
 - c) Management of air pollution.
-) Depletion of water resources :
 - a) Alarming situation of ground and surface resources.
 - b) Rain water harvesting and recharging aquifers.
 - c) Conservation and management of fresh water ecosystem.

: Environmental Biotechnology

-) Concept of environmental biotechnology, its scope and achievement.
-) Thuringensis toxin as natural pesticides.
-) Biotechnology for pollution abatement:
 - a) Bioscrubber b) Biofilter c) Biochips d) Biosensor
-) Bioremediation
 - a) Concept of bioremediation, hyperaccumulators.

- b) Technology: phytoextraction, rhizofiltration, phytoestabilization, phytodegradation.
- c) Bioremediation of polluted water, air and soil.
- d) Advantages of bioremediation over conventional techniques.
- 0) Waste water treatment: Introduction, sources of water pollution; technology of waste water treatment-chemical and biological treatment.
- 1) Brief account of:
 - a) Vermitechnology.
 - b) Bioplastics.
 - c) Biomass from waste.

: Conservation Ecology

- 2) Principles and strategies for plant conservation:
 - l) *In situ* conservation : International effect and Indian initiatives; protected areas in India-sanctuaries, national parks, biosphere reserves, wetlands, mangroves, sacred groves and coral reefs for conservation of wild biodiversity.
 - (e) *Ex situ* conservation : Gene banks, seed banks, cryobanks; General account of the activities of Botanical Survey of India (BSI); National Bureau of Plant Genetic Resources (NBPGR); Indian Council of Agriculture Research (ICAR); Council of Scientific and Industrial Research (CSIR); Central Institute of Medicinal and Aromatic Plants (CIMAP) and Department of Biotechnology (DBT) for conservation.

14): Local Environmental Problems and their Remedies

- a) Forest degradation
- b) Agrobiodiversity erosion.
- c) Deforestation
- d) Water depletion
- e) Anthropogenic activities and its impact on environment.

Paper-XV : Practical Paper
BOT E15
Elective Theory II
Applied Ecology and Environmental Biotechnology
Credits: 05

Full Marks: 70

Time: 06 Hrs.

- 1) To determine the pH, temperature, dissolved oxygen and free CO₂ from aquatic ecosystem.
- 2) To determine the chloride content of water.
- 3) Collection, identification of different biota of fresh water ecosystem.
- 4) To determine the frequency, density, abundance, IVI and species diversity index (H) of grassland vegetation.
- 5) To determine the BOD and COD of different types of water samples.
- 6) Isolation of algae, bacteria and fungi from aquatic ecosystem.
- 7) Preparation of bacterial specimen and stain it with gram stain.
- 8) To determine the productivity by Dark & Light Bottle method.
- 9) A sum based on-standard error, 't' test or Analysis of variance.
- 10) Isolation of VAM from soil samples.

Paper-XIII
BOT E13
Elective Theory 'C'
Plant Biotechnology
Credits: 05

Full Marks: 70

Time: 03 Hrs

In all nine questions of equal value will be set, out of which a student shall have to answer five questions. Q.no. 1 will be compulsory, consisting of seven very short answer type questions (each of two marks) covering the entire syllabus and the candidates are required to give their answers in maximum 50 words.

: Molecules and their Interactions

- 1) Structure of atoms, molecules and chemical bonds.
- 2) Stabilizing interactions (Van der Waals, electrostatic, hydrogen bonding, hydrophobic interaction, etc.).
- 3) Conformation of nucleic acids (A-, B-, Z-,DNA), t-RNA, micro-RNA).
- 4) Stability of protein and nucleic acid structures.

: Fundamental Processes

- 5) DNA replication, repair and recombination: Unit of replication, enzymes involved, replication origin and replication fork, fidelity of replication, extrachromosomal replicons, DNA damage and repair mechanisms.
- 6) RNA synthesis and processing: Transcription factors and machinery, formation of initiation complex, transcription activators and repressors, RNA polymerases, capping, elongation and termination, RNA processing, RNA editing, splicing, polyadenylation, structure and function of different types of RNA, RNA transport.
- 7) Control of gene expression at transcription and translation level: Regulation of phages, viruses, prokaryotic and eukaryotic gene expression, role of chromatin in regulating gene expression and gene silencing.

: Molecular methods

- 8) Isolation and purification of RNA, DNA (genomic and plasmid) and proteins, different separation methods; analysis of RNA, DNA and proteins by one and two dimensional gel electrophoresis.
- 9) DNA sequencing methods, strategies for genome sequencing.
- 10) RFLP, RAPD and AFLP techniques

: Bioinformatics

- 11) Biological Databases, Classification format of Biological Databases, Biological Database Retrieval System.
- 12) National Center for Biotechnology Information (NCBI): Tools and Databases of NCBI, Database Retrieval Tool, Sequence Submission to NCBI, Basic local alignment search tool (BLAST), Nucleotide Database, Protein Database, Gene Expression Database.
- 13) EMBL Nucleotide Sequence Database (EMBL-Bank): Introduction, Sequence Retrieval, Sequence Submission to EMBL, Sequence analysis tools.
- 14) Sequence Alignments - Introduction, Concept of Alignment, Multiple Sequence Alignment (MSA), Scoring Matrices, Percent Accepted Mutation (PAM), Blocks of Amino Acid Substitution Matrix (BLOSUM).
- 15) Molecular Phylogeny - Methods of Phylogeny, Software for Phylogenetic Analyses.

Paper-XIV
BOT E14
Elective Theory 'C'
Molecular Biology and Plant Biotechnology
Credits: 05

Full Marks: 70

Time: 03 Hrs

In all nine questions of equal value will be set, out of which a student shall have to answer five questions. Q.no. 1 will be compulsory, consisting of seven very short answer type questions (each of two marks) covering the entire syllabus and the candidates are required to give their answers in maximum 50 words.

: Plant Tissue Culture

- 1) Somatic embryogenesis: Introduction; sources for somatic embryogenesis; direct and indirect embryogenesis; protocol and the factors affecting somatic embryogenesis; significance; the artificial seeds.
- 2) Somaclonal variations: Introduction; causes of Somaclonal variations; method for the screening of Somaclonal variants; achievements.
- 3) Micropropagation : Introduction; protocol; sources; advantages.
- 4) Somatic hybridization: Objectives; protocol; selection of the fused protoplasts; chromosome status of the somatic hybrids; significance; cybrids.
- 5) Anther and Pollen culture: Objectives; protocols for anther and pollen culture; comparison between anther and pollen culture; screening of haploids; methods of diploidization; significance of anther and pollen culture.

: Applied Biology

- 6) Method of gene transfer in plants: Vectors - mediated gene transfer; *Agrobacterium tumefaciens*, the natural genetic engineer; methods of direct transformations- electroporation, chemically stimulated DNA uptake, use of liposomes, microinjections, sonication, microprojectile gun method, laser microbeam, and silicon carbide fibers.
- 7) The transgenic plants : Objectives; method of obtaining transgenic plants; production of transgenic plants in monocots; the transgenic plants having herbicide resistance, insect resistance, altered fatty acid composition in Brassica oil, resistance against stresses, male sterility and fertility restoration.
- 8) Molecular farming, production of edible vaccines, plants with enhanced nitrogen fixing ability; release of GM plants to the environment and public perception.
- 9) Intellectual Property Rights.

: Genetic Engineering

- 10) Polymerase Chain Reaction (PCR): Basic concept; comparison of gene cloning through vectors and PCR procedure; applications of PCR in site-directed mutagenesis, preparation of probes, DNA polymorphism, molecular mapping, mutation studies, confirmation of a transferred gene, sex determination at the embryonic stage, and DNA fingerprinting.
- 11) Molecular Markers: Restriction Fragment Length Polymorphism (RFLP), VNTR, RAPD, AFLP.
- 12) The gene banks : Objective, procedure of making cDNA library and its advantages; construction of the genomic library; ligation; packaging and implications; the chromosome specific library; method of screening cDNA and genomic libraries; significance of the gene banks.

: Biostatistics

- 13) Biostatistics - definition - statistical methods - basic principles. Variables - measurements, functions, limitations and uses of statistics.
- 14) Collection of data, primary and secondary - types and methods of data collection procedures - merits and demerits. Classification - tabulation and presentation of data - sampling methods, Sampling errors – Type I error, Type II error.
- 15) ANOVA – Introduction, Test of ANOVA, F-test, Assumptions of ANOVA
Statistical inference - hypothesis - simple hypothesis - student 't' test - chi square test.
- 16) Non-Parametric or distribution free statistical tests- Introduction, Advantages and Non-advantages of non-parametric test, Situations for the use of non-parametric tests.

Paper-XV : Practical Paper
BOT E15
Elective Theory 'C'
Molecular Biology and Plant Biotechnology
Credits: 05

Full Marks: 70

Time: 06 Hrs.

1. Preparation of LB medium and raising *E.Coli*.
2. Isolation of genomic DNA from the given leaf sample.
3. DNA estimation by UV Spectrophotometry.
4. To separation DNA (marker) using AGE.
5. Demonstration of *in vitro* sterilization and inoculation methods using leaf and nodal explants .
6. Restriction digestion and gel electrophoresis of plasmid DNA
7. Sequence alignment.
8. Sequence homology and Gene annotation.
9. Construction of phylogenetic tree.
10. Problems related to Mendelian ratios and their modifications; statistical analysis and genetic explanation.

Paper-XVI : Project Work
BOT E16
Credits: 05

Full Marks: 100

Time: 06 Hrs.

Each student will have to perform Project Work (Experimental or Review) Under the Supervision of a teacher and will submit a Project Report in the Department at the end of the session i.e. before Theory Papers Examination begins.