Indira Gandhi National Tribal University
Amarkantak (M.P.)

SYLLABI

(Based on NEP-2020)

Department of Botany

Faculty of Science

Undergraduate Programme in Botany

(Effective from 2021-22)

Undergraduate Course Structure

Semester-I

Course Code	Category	Title	Credits
BBTDMJ01 & BBTIMJ1	Major	Microbial & Plant Diversity	4
BBPDMJ01& BBPIMJ1			2
BBTDMI01 & BBTIMI1	Minor	Economic Botany	2
BBTV01	Vocational	Biofertilizer-I	2
BBPV01			2

Semester-II

Course Code	Category	Title	Credits
BBTDMJ02 & BBTIMJ2	Major	Morphology and Taxonomy of Angiosperms	4
BBPDMJ02 & BBPIMJ2			2
BBTDMI02 & BBTIMI2	Minor	Plant Pathology	2
BBTV02	Vocational	Biofertilizer-II	2
BBPV02			2

Semester-III

Course Code	Category	Title	Credits
BBTDMJ03 & BBTIMJ03	Major	Plant Anatomy and Embryology	4
BBPDMJ03 & BBPIMJ03			2
BBTDMI03 & BBTIMI03	Minor	Plant Tissue Culture	2
BBTV03	Vocational	Biofertilizer-III	2
BBPV03			2

Semester-IV

Course Code	Category	Title	Credits
BBTDMJ04 & BBTIMJ04	Major	Plant Physiology and Metabolism	4
BBPDMJ04 & BBPIMJ04			2
BBTDMI04 & BBTIMJ04	Minor	Elements of Ecology	2
BBTV04	Vocational	Biofertilizer-IV	2
BBPV04			2

Semester-V

Course Code	Category	Title	Credits
BBTDMJ05 & BBTIMJ05	Major	Cytogenetics & Evolution	4
BBPDMJ05 & BBPIMJ05			2
BBTDMI05 & BBTIMI0 5	Minor	Instrumentation & Biostatistics	2
BBINT01	Internship		2

Semester-VI

Course Code	Category	Title	Credits
BBTDMJ06 & BBTIMJ06	Major	Molecular Biology	4
BBPDMJ06 & BBPIMJ06			2
BBTDMJ07	Major	Plant Biotechnology	4
BBPDMJ07			2
BBTDMI06 & BBTIMI06	Minor	Bioinformatics	2

Course: Disciplinary Major (BBTDMJ01)
Course: Interdisciplinary Major (BBTIMJ01)

Microbial and Plant Diversity

(Credits: Theory-4, Practicals-2)
THEORY
Lectures: 60

Unit 1: Bacteria & Viruses (10 Lectures)

Viruses – Discovery, general structure, replication (general account), DNA virus (T-phage); Lytic and lysogenic cycle, RNA virus (TMV); Economic importance; Bacteria – Discovery, General characteristics and cell structure; Reproduction – vegetative, asexual and recombination (conjugation, transformation and transduction); Economic importance.

Unit 2: Fungi (12 Lectures)

Introduction- General characteristics, ecology and significance, range of thallus organization, cell wall composition , nutrition, reproduction and classification; True Fungi- General characteristics, ecology and significance, life cycle of *Rhizopus* (Zygomycota) *Penicillium, Alternaria* (Ascomycota), *Puccinia, Agaricus* (Basidiomycota); Symbiotic Associations-Lichens:
General account, reproduction and significance; Mycorrhiza: ectomycorrhiza and endomycorrhiza and their significance.

Unit 3: Algae (12 Lectures)

General characteristics; Ecology and distribution; Range of thallus organization and reproduction; Classification of algae; Morphology and life-cycles of the following: *Nostoc*, *Chlamydomonas,Oedogonium*, *Vaucheria, Fucus, Polysiphonia*. Economic importance of algae

Unit 4: Bryophytes (10 Lectures)

General characteristics, adaptations to land habit, Classification, Range of thallus organization.Classification (up to family), morphology, anatomy and reproduction of *Marchantia* and *Funaria*. (Developmental details not to be included). Ecology and economic importance of bryophytes with special mention of *Sphagnum*.

Unit 5: Pteridophytes & Gymnosperms (16 Lectures)

General characteristics, classification, morphology, anatomy and reproduction of *Rhynia, Selaginella*, *Equisetum* and *Pteris*. (Developmental details not to be included). Heterospory and seed habit, stelar evolution. Ecological and economical importance of Pteridophytes.General characteristics, classification. morphology, anatomy and reproduction of *Cycas* and *Pinus*. (Developmental details not to be included). Ecological and economical importance.

Course: Disciplinary Major (BBPDMJ01)
Course: Interdisciplinary Major (BBPIMJ01)

PRACTICAL

1. Types of Bacteria from permanent slides/photographs; EM bacterium.
2. Gram staining.
3. Study of vegetative and reproductive structures of *Nostoc, Chlamydomonas* (electron micrographs)*, Oedogonium, Vaucheria, Fucus and Polysiphonia* through temporary preparations and permanent slides.
4. *Rhizopus and Penicillium*: Asexual stage from temporary mounts and sexual structures through permanent slides.
5. *Alternaria:* Specimens/photographs and tease mounts.
6. *Puccinia*: Herbarium specimens of Black Stem Rust of Wheat and infected Barberry leave;section/tease mounts of spores on Wheat and permanent slides of both the hosts.
7. *Agaricus*: Specimens of button stage and full grown mushroom; Sectioning of gills
8. Lichens: Study of growth forms of lichens (crustose, foliose and fruticose).
9. Mycorrhiza: ecto mycorrhiza and endo mycorrhiza (Photographs).
10. *Marchantia*- morphology of thallus, w.m. rhizoids and scales, v.s. thallus through gemma, Antheridiophore, archegoniophore, l.s. sporophyte (all permanent slides).
11. *Funaria*- morphology, w.m. leaf, rhizoids, operculum, peristome, annulus, spores (temporary slides); permanent slides showing antheridial and archegonial heads, l.s. capsule and protonema.
12. *Selaginella*- morphology, w.m. leaf with ligule, t.s. stem, w.m. strobilus, w.m. icrosporophyll and megasporophyll (temporary slides), l.s. strobilus (permanent slide).
13. *Equisetum*- morphology, t.s. internode, l.s. strobilus, t.s. strobilus, w.m. sporangiophore, w.m. spores (wet and dry)(temporary slides); t.s rhizome (permanent slide).
14. *Pteris*- morphology, t.s. rachis, v.s. sporophyll, w.m. sporangium, w.m. spores (temporary slides), t.s. rhizome, w.m. prothallus with sex organs and young sporophyte (permanent slide).
15. *Cycas*- morphology (coralloid roots, bulbil, leaf), t.s. coralloid root, t.s. rachis, v.s. leaflet, v.s. microsporophyll, w.m. spores (temporary slides), l.s. ovule, t.s. root (permanent slide).
16. *Pinus*- morphology (long and dwarf shoots, w.m. dwarf shoot, male and female), w.m. dwarfshoot, t.s. needle, t.s. stem, , l.s./t.s. male cone, w.m. microsporophyll, w.m. microspores (temporary slides), l.s. female cone, t.l.s. & r.l.s. stem (permanent slide).

Suggested Readings

1. Kumar, H.D. (1999). Introductory Phycology. Affiliated East-West. Press Pvt. Ltd. Delhi. 2nd edition.
2. Tortora, G.J., Funke, B.R., Case, C.L. (2010). Microbiology: An Introduction, Pearson Benjamin Cummings, U.S.A. 10th edition.
3. Sethi, I.K. and Walia, S.K. (2011). Text book of Fungi & Their Allies, MacMillan Publishers Pvt. Ltd., Delhi.
4. Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996). Introductory Mycology, John Wiley and Sons (Asia), Singapore. 4th edition.
5. Raven, P.H., Johnson, G.B., Losos, J.B., Singer, S.R., (2005). Biology. Tata McGraw Hill, Delhi, India.
6. Vashishta, P.C., Sinha, A.K., Kumar, A., (2010). Pteridophyta, S. Chand. Delhi, India.

Course: Disciplinary Minor (BBTDMI01)
Course: Interdisciplinary Minor (BBTIMI01)

Economic Botany

(Credits: Theory-2)
THEORY
Lectures: 30

Unit 1: Cereals and Millets, Pulses and Legumes, Sugars/Starches) (10 lectures)
Origin, morphology, and uses of some selected crops: Cereals: Wheat, Rice, maize, sorghum, pearl millet. Pulses: Origin, morphology, uses, of pulses (Pigeon pea, Chickpea, Black gram, Green gram, Cowpea, Soyabean, Pea, Lentil, Horsegram), and Legumes (lab-lab bean, ricebean, winged bean, French bean, lima bean, sword bean). Morphology and processing of sugarcane, products and by-products. Morphology, propagation & uses of Sugarbeet, Sugarpalm and sweet sorghum. Potato, Sweet Potato and Tapioca.

Unit 2: Spices, Beverages, Oil seeds fats and Essential oils) (10 lectures)
Spices: Botany of important spices (Saffron, Cloves, Cardamom, Cinnamon, Tejpat, Nutmeg and Mace, Anise, Cumin, Celery, Tamrind, Vanilla, Asafoetida, Dill, Fenugreek, Fennel, Coriander); Botany, cultivation practices, processing of Turmeric, Ginger, Capsicum, Black Pepper, Coriander. **Beverages:** Tea and Coffee: History, origin, Botany, cultivation practices, common diseases and pests; **Oil seeds and fats:** Extraction and uses of groundnut, coconut, linseed, soybean, mustard. **Essential Oils:** General description, uses, extraction of Rose, Geranium, Lemongrass / Palmarosa / Citronella, Vetiver, Menthol mint, Basil, Lavender, Eucalyptus, Clove, Camphor and Sandal wood.

Unit 3: Aromatic/Medicinal plants, Timber, Fibers/ Seaweeds (10 lectures)
Botany and cultivation *Papaver,Cannabis* and Tobacco, Ashwagandha, Kalmegh, Satavar, Ghrit Kumari. Isabgol, Senna, Bhui Amla Stevia, Sarpagandha, Atropa, Digitalis, Licorice, Gilloi (Tinospora)**, Timber plants and Fibres:** General account and Botany of Saal, Teak and Pine. General account Cotton, Sunhemp, flax, Coir, Jute.
Seaweeds: Production of carrageenan, algin, agar and agarose, seaweeds as fertilizers, edible seaweeds, seaweeds as fodder, drugs from algae, cosmetics and neutraceuticals from algae, algae based biofuel.

Suggested Readings
1. Kochhar, S.L. (2016). Economic Botany: A Comprehensive Study. 5th Edition Cambridge.
2. Sambamurty, AVSS and Subrahmanyam, N.S. (2008). A Textbook of Modern Economic Botany. 1st Edition, Paperback . CBS Publishers & Distributors Pvt.Ltd.;
3. Wickens, G.E. (2001). Economic Botany: Principles & Practices. Kluwer Academic Publishers, The Netherlands.

Course: Vocational Course (BBTV01)

Biofertilizer- I

(Credits: Theory-2, Practical-2)
THEORY
Lectures: 30

Unit 1: Introduction to biofertilizers **(10 Lectures)**

Definition and history, role of biofertilizers in sustainable agriculture, general account about the microbes used as biofertilizer, working principles of biofertilizers, advantages and challenges of using bioferilizers.

Unit 2: Rhizobium **(10 Lectures)**

Classification, occurrence, symbiotic N_2 fixation mechanism, isolation, identification, mass multiplication, carrier-based inoculant preparation, methods of application.

Unit 3: *Azospirillum* **(10 Lectures)**

Classification, isolation, identification and mass multiplication, carrier based inoculants, associative effect of different microorganisms. *Azotobacter*: classification, characteristics – crop response to *Azotobacter* inoculum, maintenance and mass multiplication.

Course: Vocational Course (BBPV01)

PRACTICAL

1. Isolation of *Rhizobium* strains from root nodules.
2. Isolation and detection of N-fixing and P-solubilizing isolates from rhizosphere.
3. Morphology-based identification of bacterial biofertilizers: colony morphology, Gram staining and flagella staining.
4. Molecular identification of bacterial biofertilizers based on 16S rRNA gene.

Suggested Readings

1. Deshmukh, A. M., Khobragade, R. M., and Dixit, P. P. (2007). Handbook of biofertilizers and biopesticides. Oxford Book Company.
2. Dubey, R.C. (2005). A Text book of Biotechnology. S. Chand & Co, New Delhi.
3. John Jothi Prakash, E. (2004). Outlines of Plant Biotechnology. Emkay Publication, New Delhi.
4. Subha Rao, N.S. (2000). Soil Microbiology. Oxford & IBH Publishers, New Delhi.
5. Vayas, S.C, Vayas, S., and Modi, H.A. (1998). Bio-fertilizers and organic Farming Akta Prakashan, Nadiad

Course: Disciplinary Major (BBTDMJ02)
Course: Interdisciplinary Major (BBTIMJ02)
(Credits: Theory-4, Practical-2)

Morphology and Taxonomy of Angiosperms

THEORY
Lectures: 60

UNIT 1: Morphology of Angiosperms (Vegetative phase) (12 Lectures)
History: plant morphology. Classification of plants, Technical terms related to plant morphology.
Leaf: parts, functions, types, duration, venation, shape, arrangement, leaf insertion, margin, stipules (types), Phyllotaxy, Heterophylly, modifications of leaf
Stem: Forms, Types and modifications (aerial, sub aerial and underground, special),
Root: parts, types, and modifications.

UNIT 2: Morphology of Angiosperms (Reproductive phase) (12 Lectures)
Flower: parts, floral whorls (Calyx, Corolla: forms, aestivation; Androecium, Gynoecium, Pistil Floral Formula, Floral diagram.
Fruit: classification (simple, aggregate, composite), Fruit and seed dispersal.

Unit 3: Taxonomy and Botanical nomenclature (12Lectures)
History of Plant taxonomy, principles and rules of plant nomenclature, typification, categories and taxonomic hierarchy, Herbarium concept and techniques, Botanical Survey of India, Role of botanical garden.

Unit 4: Systems of classification (8 Lectures)
Outline classification of Bentham & Hooker, Engler & Prantal and Hutchinson's with their principle, merits and demerits.

Unit 5: Plant families (16 Lectures)
A detailed account of following families: Brassicaceae, Papavaraceae, Malvaceae, Fabaceae, Asteraceae, Asclepiadiaceae, Cucurbitaceae, Solanaceae, Lamiaceae, Euphorbiaceae, Poaceae.

Course: Disciplinary Major (BBPDMJ02)
Course: Interdisciplinary Major (BBPIMJ02)

PRACTICAL

1. Study of vegetative and floral characters of angiosperm families Brassicaceae, Papavaraceae, Malvaceae, Fabaceae, Asteraceae, Asclepiadiaceae, Cucurbitaceae, Solanaceae, Lamiaceae, Euphorbiaceae, Poaceae (Description, VS flower, section of ovary, floral diagram/s, floral formula/e and systematic position according to Bentham & Hooker's system of classification).
2. Field trips to nearby areas, compilation of field notes and preparation of herbarium sheets from collected plants (wild as well as cultivated).

Suggested Readings:

1. Principle of Angiospermic Taxonomy, PH Davis, VH Heywood (1991), Today & Tomorrow Publications, New Delhi.
2. Fundamentals of Plant Sytematics, AE Radford (1986), Harper & Row Publications, USA.
3. Principles of Plant Taxonomy, VVSivarajan (1999), Oxford & IBH Publishing Co., New Delhi.
4. Contemporary Plant Systematics, DW Woodland (1991) Prentice Hall, New Jersey
5. Plant Taxonomy, OP Sharma (2009) Tata McGraw Hill, Mumbai
6. Taxonomy of Angiosperms, BP Pandey (2007) S Chand & Co., New Delhi
7. Plant Systematics - Theory and Practices, Gurucharan Singh, Oxford and I.B.H. Publishing Co. New.

Course: Disciplinary Minor (BBTDMJ02)
Course: Interdisciplinary Minor (BBTIMJ02)
(Credits: Theory-2)

Plant Pathology

THEORY
Lectures: 30

Unit 1: Introduction to Phytopathology (10 Lectures)
Terms and concepts, History, Geographical distribution of plant diseases, Etiology, Symtomatology, Disease cycle and environmental relation, Host-pathogen relationships, Prevention and control of plant diseases.

Unit 2: Bacterial and Viral Diseases (10 Lectures)
Causal organism, symptoms, disease cycle and control measures of citrus canker and angular leaf spot of cotton. Viral diseases – Tobacco mosaic viruses, Vein clearing, Yellow vein mosaic of okra.

Unit 3: Fungal diseases (10 Lectures)
Causal organism, symptoms, disease cycle and control measures of early and late blight of potato, Black stem rust of wheat, White rust of crucifers.

Suggested readings

1. Oliver R. (2024). Agrios' Plant Pathology, 6th Edition, Academic Press, U.K.
2. Sharma P.D. (2011). Plant Pathology, Rastogi Publication, Meerut, India.

Course: Vocational Biofertilizer-II (BBTV02)
(Credits:Theory-2, Practical-2)

Biofertilizers-II

THEORY
Lectures: 30

Unit 1: **Algae as biofertilizer** **(10 Lectures)**
History, type, status, scope, and importance, structure and characteristic features enabling algae as a suitable biofertilizer - nitrogen fixation, phosphate solubilization, growth hormone production; consortium concept.

Unit 2:Production technology **(10 Lectures)**
strain selection, sterilization, growth and fermentation; carriers and their characteristics;storage, shelf life, quality control, and marketing of algal fertilizers; factors influencing the efficacy of algae as a biofertilizer.

(10 Lectures)
Unit 3: Requirements, cost effectiveness, mass scale production of *Anabaena, Nostoc, Azolla*.

Course: Vocational Biofertilizer-II (BBPV02)

PRACTICAL

1. Collection and identification of *Nostoc, Anabaena,* etc.
2. Collection and identification of *Azolla.*
3. Purification of the selected species
4. Visit to the nearby mass production facility.
5. Writing a pilot project on large-scale biofertilizer production.

Suggested Readings

1. Mahapatra DM, Chanakya HN, Joshi NV, Ramachandra TV, Murthy GS (2018) Algae-Based Biofertilizers: A Biorefinery Approach. In: Panpatte, D., Jhala, Y., Shelat, H., Vyas, R. (eds) *Microorganisms for Green Revolution*. Microorganisms for Sustainability, Vol 7. Springer, Singapore, doi.org/10.1007/978-981-10-7146-1_10.
2. Kannaiyan S, Kumar K. (2005) *Azolla: Biofertilizer for sustainable rice production*, Daya Publishing House, p. 468.
3. Pati BR, Mandal SM (2016) *Recent Trends in Biofertilizers*, IK International Publishing House, p. 284
4. Giri B, Prasad R, Wu Q-S, Verma A (2019) Biofertilizers for sustainable agriculture and environment, www.ebook3000.com, p. 547.

Course: Disciplinary Major (BBTDMJ03)
Course: Interdisciplinary Major (BBTIMJ03)

Plant Anatomy and Embryology

(Credits: Theory-4, Practical-2)
THEORY
Lectures: 60

Unit 1: Meristematic and permanent tissues (12 Lectures)
Classification of tissues (Simple and complex), Root and shoot apical meristems, Organization of shoot and root apex (Apical cell theory, Histogen theory, Tunica Corpus theory, Korper-Kappe theory), Quiescent centre, Root cap. Epidermis, cuticle, stomata and their classification, Structure of dicot and monocot root, stem and leaf.

Unit 2: Secondary Growth (12 Lectures)
Vascular cambium - structure and function, seasonal activity. Secondary growth in root and stem, Sapwood and heartwood, Early and latewood, Dendrochronology, tyloses, lenticels.

Unit 3: Structural organization of flower (12 Lectures)
Structure of anther and pollen, Structure and types of ovules, Types of embryo sacs, organization and ultrastructure of mature embryo sac.

Unit 4: Pollination and fertilization (12 Lectures)
Types of Pollination, mechanisms and adaptations, Double fertilization and triple fusion.

Unit 5: Embryo and endosperm (12 Lectures)
Endosperm types, structure and functions, Embryogeny in Dicot and monocot, Seed-structure and dispersal, Apomixis and polyembryony.

Course: Disciplinary Major(BBPDMJ03)
Course: Interdisciplinary Major (BBPIMJ03)

PRACTICAL

1. Study of meristems through permanent slides and photographs.
2. Tissues (parenchyma, collenchyma and sclerenchyma), Macerated xylary elements, Phloem (Permanent slides, photographs)
3. Stem, root, leaf: Monocotand Dicot (Temporary/Permanent slides).
4. Adaptive anatomy: Xerophyte/Hydrophyte.
5. Structure of anther (Permanent slides).
6. Types of ovules: Permanent slides.
7. Female gametophyte: *Polygonum* (monosporic) type of Embryo sac Development (Permanent slides/photographs).

Suggested Readings

1. Bhojwani, S.S. &Bhatnagar, S.P. (2011). Embryology of Angiosperms. Vikas Publication House Pvt. Ltd. New Delhi. 5th edition.
2. Mauseth, J.D. (1988). Plant Anatomy. The Benjamin/Cummings Publisher, USA.

Course: Disciplinary Minor (BBTDM103)
Course: Interdisciplinary Minor (BBTIM103)

Plant Tissue Culture

(Credits: Theory-2)
THEORY
Lectures: 30

Unit 1: Introduction (10 Lectures)

Concept of cellular totipotency, history of plant tissue culture, laboratory requirements, different culture media, media preparation, the role of chemicals and growth regulators in plant tissue culture, Sterilization of media, tissues, and other accessories.

Unit 2: Techniques in cell and tissue culture (10 Lectures)

Micropropagation: stages of micropropagation, organogenesis and somatic embryogenesis, clonal propagation, callus culture, cell suspension culture, embryo culture, synthetic seed and its application.

Unit 3: Applications of plant tissue culture (10 Lectures)

In vitro conservation, haploid and triploid plant production and its applications, protoplast fusion and somatic hybridization, somaclonal variation for crop improvement,industrial application of plant tissue culture for production of secondary metabolites.

Suggested Readings

1. Bhojwani SS & Dantu PK (2013) Plant Tissue Culture: An Introductory Text, Springer.
2. Bhojwani SS& Razdan MK (1996) Plant tissue culture:theory and practice, a revised edition. Elsevier,Amsterdam.
3. White PR (1943) A handbook of plant tissue culture.Jacques Cattell Press, Lancaster.

Course: Vocational Course (BBTV03)

Biofertilizer-III

(Credit: Theory-2, Practical-2)
THEORY
Lectures: 30

Unit I **(10 Lectures)**

General concept of fungal biofertilizer, Types of mycorrhiza (Ectomycorrhiza, Endomycorrhiza, Orchidaceous mycorrhiza, Ericaceous mycorrhiza, Arbutoid mycorrhiza, Monotropoid mycorrhiza) with photobionts and mycobionts. Benefits of mycorrhizal biofertilizer

Unit II **(10 Lectures)**

Taxonomy of VAM fungi, observation of VAM fungi in roots, isolation and identification of VAM fungi, Culturing of VAM fungi, VAM inoculums production, Inoculation of VAM fungi with plants.

Unit III **(10 Lectures)**

Taxonomy of ectomycorrhizal fungi, Isolation of ectomycorrhizal fungi, Multiplication of ectomycorrhizal fungi, Inoculation of ectomycorrhizal fungi with plants, Role of fungal biofertilizer in agriculture and social forestry.

Course: Vocational Course (BBPV03)

PRACTICAL

1. To study the isolation of endophytic fungi from plant parts.
2. To study the isolation of mycobiont from lichens.
3. To study ectomycorrhizal association plant roots.
4. To study endomycorrhizal (VAM) association plant roots.

Suggested Readings

1. Smith, S.E. and Read, D.J. *Mycorrhizal Symbiosis, 2nd edition*, Academic Press (1997).
2. Sieverding, E. *Vesicular-Arbuscular Mycorrhizal Management in Tropical Ecosystems,* Deutche Gesllshaft für TEchnische Zusammnearbeit (GTZ) GmbH (1991)
3. Norris, J.R., Read, D.J. and Varma, A.K. (ed.) *Methods in Microbiology, Vol. 24, Techniques for the Studyof Mycorrhiza,* Academic Press (1992).

Course: Disciplinary Major (BBTDMJ04)
Course: Interdisciplinary Major (BBTIMJ04)

Plant Physiology and Metabolism

(Credits: Theory-4, Practical-2)
THEORY
Lectures: 60

Unit 1: Plant-water relations (8 Lectures)
Importance of water, water potential and its components, Transpiration and its significance, Factors affecting transpiration, Root pressure and guttation.

Unit 2: Mineral nutrition & Solute transport (12 Lectures)
Essential elements, macro and micronutrients, Criteria of essentiality of elements, Role of essential elements, Transport of ions across cell membrane, active and passive transport, carriers,channels and pumps. Composition of phloem sap, girdling experiment, Pressure flow model,Phloem loading and unloading.

U**nit 3: Phytohormones and photomorphogenesis (10 Lectures)**
Discovery and physiological roles of auxins, gibberellins, cytokinins, ABA, ethylene. Photoperiodism (SDP, LDP, Day neutral plants), Phytochrome (discovery and structure), Redand far-red light responses, Vernalization.

Unit 4: Photosynthesis and respiration (18 Lectures)
Photosynthetic Pigments (Chl a, b, xanthophylls, carotene), Photosystem I and II, reaction center, antenna molecules, Electron transport and mechanism of ATP synthesis, C3, C4 and CAM pathways of carbon fixation, Photorespiration.Glycolysis, anaerobic respiration, TCA cycle, Oxidative phosphorylation, Oxidative Pentose Phosphate Pathway.

Unit 5: Enzymes and Nitrogen metabolism (12 Lectures)
Structure and properties, Mechanism of enzyme catalysis and enzyme inhibition. Biological nitrogen fixation, Nitrate and ammonia assimilation.

Course: Disciplinary Major (BBPDMJ04)
Course: Interdisciplinary Major (BBPIMJ04)

PRACTICAL

1. Determination of osmotic potential of plant cell sap by plasmolytic method.
2. To study the effect of two environmental factors (light and wind) on transpiration by excised twig.
3. Calculation of stomatal index and stomatal frequency of a mesophyte and a xerophyte.
4. Demonstrate the activity of catalase and study the effect of pH and enzyme concentration.
5. To study the effect of light intensity and bicarbonate concentration on O2 evolution in photosynthesis.
6. Comparison of the rate of respiration in any two parts of a plant.
7. Separation of pigments and amino acids by paper chromatography.

Demonstration experiments (any four)

1. Bolting.
2. Effect of auxins on rooting.
3. Suction due to transpiration.
4. R.Q.
5. Respiration in roots

Suggested Readings

1. Taiz, L., Zeiger, E. (2010). Plant Physiology. Sinauer Associates Inc., U.S.A. 5th Edition.
2. Hopkins, W.G., Huner, N.P. (2009). Introduction to Plant Physiology. John Wiley & Sons,U.S.A. 4th Edition.
3. Bajracharya, D. (1999). Experiments in Plant Physiology- A Laboratory Manual. Narosa Publishing House, New Delhi.
4. Heldt, Plant Biochemistry.
5. LEHNINGER , Principles of Biochemistry by Michael M. Cox. and David L. Nelson
6. Instant notes in Biochemistry.

Course: Disciplinary Minor (BBTDMI04)
Course: Interdisciplinary Minor (BBTIMI04)

Elements of Ecology

(Credits: Theory-2)
THEORY
Lectures: 30

Unit 1: Ecological factors **(10 Lectures)**
Biotic (producers, consumers, and decomposers) and abiotic factors and their variations (Light, temperature, humidity, Precipitation, soil formation, composition, soil profile).Species Interactions: symbiosis, mutualism, amensalism, protocoperation, competition, parasitism,commensalism, Keystone Species, Ecotypes, Ecad.

Unit 2: Ecosystem **(10 Lectures)**
Ecosystem: Concept and structure, energy flow, trophic organisation, Food chains and food webs, Ecological, pyramids, productivity estimation, Biogeochemical cycles (Carbon and Nitrogen), Ecotone and edge effect, Niche, Concept of Population, Succession, Life forms, ecological sampling.

UNIT 3: Phytogeography **(10 Lectures)**
Continental drift, Endemism, Brief description of major terrestrial biomes (one each from tropical, temperate and tundra), Global warming. Greenhouse effect, Climate change

Suggested Readings

1. Kormondy, E.J. (1996). Concepts of Ecology. Prentice Hall, U.S.A. 4th edition.
2. Sharma, P.D. (2010) Ecology and Environment. Rastogi Publications, Meerut, India. 8th edition.
3. Simpson, M.G. (2006). *Plant Systematics.* Elsevier Academic Press, San Diego, CA, U.S.A.
4. Singh, G. (2012). *Plant Systematics:* Theory and Practice. Oxford & IBH Pvt. Ltd., New Delhi. 3rd edition.
5. Fundamentals of Ecology, EPOdum (1996), Natraj Publishers, Dehradun.

Course: Vocational Course (BBTV04)

Biofertilizers IV

(Credits: Theory-2, Practical-2)

THEORY

Lectures: 30

Unit I: Organic farming (10 Lectures)

Concepts and principles of organic farming, Green manuring and organic fertilizers, Recycling of agricultural and industrial wastes, Biocompost making methods.

Unit II: Vermicomposting (10 Lectures)

Introduction and scope of vermicompost, Role in waste management, soil detoxification and regeneration, Method of vermicomposting - preparation of vermibed and their types, Harvesting and packing of vermicompost, Field application.

Unit III: Importance of biofertilizers in sustainable agriculture (10 Lectures)

Integrated plant nutrient management (IPNM) – role of bacterial siderophores, Management of plant diseases by microbial metabolites, Concept of synthetic microbial communities (SynCom) in agriculture, Current status of biofertilizer production in India and world – Challenges and constraints.

Course: Vocational Course (BBPV04)

PRACTICAL

1. Isolation and screening of siderophore producing bacteria.
2. Isolation and screening of phosphate solubilizing bacteria.
3. Procedures for quality control of biofertilizer – Mother culture test, Broth test, Peat test.
4. Assay to test bacteria as biocontrol agents.
5. Visit to the nearby biocompost production facility.

Suggested Readings

1. Deshmukh, A. M., Khobragade, R. M., and Dixit, P. P. (2007). Handbook of biofertilizers and biopesticides. Oxford Book Company.
2. Sathe, T.V. (2004). Vermiculture and Organic Farming. New Delhi, Delhi: Daya publishers.
3. John Jothi Prakash, E. (2004). Outlines of Plant Biotechnology. Emkay Publication, New Delhi.
4. Subha Rao, N.S. (2000). Soil Microbiology. Oxford & IBH Publishers, New Delhi.
5. Vayas, S.C, Vayas, S., and Modi, H.A. (1998). Bio-fertilizers and organic Farming Akta Prakashan, Nadiad

Course: Disciplinary Major (BBTDMJ05)
Course: Interdisciplinary Major (BBTIMJ05)

Cytogenetics & Evolution

(Credits: Theory-4, Practical-2)
THEORY
Lectures: 60

Unit 1:Cell Structure and Functions (12 Lectures)
Cell theory, Germplasm theory, ultrastructure of plant cell-Mitochondria, Chloroplast, Nucleus & Cytoskeleton, plasma membrane (fluid-mosaic model).

Unit 2: Cell Cycle and Cell Division (12 Lectures)
Cell cycle, cell division (Mitosis, Meiosis), genetic significance of meiosis, structure of eukaryotic chromosome, euchromatin and heterochromatin, special types of chromosomes-Polytene and Lampbrush Chromosome.

Unit 3: Mendel's laws of inheritance (12 Lectures)
Law of segregation, law of independent assortment, deviations from Mendel's laws (Neo-Mendelism), Test and Back Crosses.

Unit 4: Interaction of genes (12 Lectures)
Intragenic and Intergenic interactions, Complementary genes, Duplicate genes, incomplete dominanace, lethal genes and epistatic genes, linkage and crossing over, sex determination in plants.

Unit 5:Theories of Organic evolution (12 Lectures)
Inheritance of acquired characters (Lamarckism), natural selection (Darwinism), de Vries mutation theory, synthetic theory.

Course: Disciplinary Major (BBPDMJ05)
Course: Interdisciplinary Major (BBPIMJ05)

PRACTICAL

1. Study of cell organelles using Photographs (Mitochondria, Chloroplast, Nucleus etc.)
2. Demonstration of Models of plasma membrane.
3. Staining and observation of plant cell.
4. Study of Polytene and Lampbrush Chromosomes using Photographs.
5. Preparation of temporary squash of onion root tips to observe mitosis.
6. Study of meiosis from young flower buds.
7. Comparison chart of Lamarckism, Darwinism, Mutation Theory and Synthetic Theory.
8. Case studies on natural selection.

Suggested Readings

1. A Text Book of Cytology, Genetics and Evolution, Gupta, PK, Rastogi Publication, Meerut.
2. Cell and Molecular Biology, Roberties EDP De & Roberties EMF De, Walters Kluwer (India) Pvt. Ltd.
3. Cell Biology, Karp G, (2010), 6th Edition, John Wiley & Sons, U.S.A.
4. Becker's World of the Cell, Hardin J, Becker G, Skliensmith LJ, (2012), 8th edition, Pearson Education Inc. USA.
5. The Cell: Molecular Approach, Cooper GM, Hausman RE,(2009), 5TH edition ASM press &

Sunderland, Washington, DC, Sinauer Associates, MA.
6. Principles of Genetics, Gardner EJ, Simmons MJ, Snustad DP, John Wiley & Sons India.
7. Genetics: Classical to Modern, Gupta PK (2007), Rastogi Publication, Meerut.
8. Principles of Genetics, Snustad DP, Simmons MJ (2010), 5th edition, John Wiley & Sons, Inc., India.
9. Concept of Genetics , Klug WS, Cummings MR, Spencer CA, (2012), 10th edition , Benjamin Cummings, USA.
10. Introduction to Genetic Analysis, Griffiths AJF, Wessler SR, Carroll SB, Doebley J, (2010), 10th edition, W.H. Freeman and Co., USA.
11. Variation and evolution in Plants, Stebbins, GL, Columbia University Press.

Course: Disciplinary Minor (BBTDMI05)
Course: Interdisciplinary Minor (BBTIMI05)

Instrumentation and Biostatistics in Plant Sciences

(Credits: Theory-2)
THEORY
Lectures: 30

Unit 1: Spectrophotometry and chromatography (10 Lectures)

Spectroscopy: Principles and applications of UV-Vis spectroscopy, AAS, NMR, Chromatography: Paper, TLC, Column (HPLC, GC), Size exclusion.

Unit 2: Microscopy (10 Lectures)

Principles and applications of - Light, Electron microscopy (SEM, TEM), Agarose Gel Electrophoresis, RT- PCR

Unit 3: Biostatistics (10 Lectures)

Importance and application, tabulation and classification of data, frequency distribution and graphical distribution of data, measures of central tendencies: Mean, Median and Mode, Chi square, T-Test, Regression (Linear, Polynomial), Correlation, ANOVA.

Suggested Readings

1. Biotechnology: A Laboratory Course, JM Becker, GA Caldwell, EA Zachgo (1996), Academic Press, Inc, San Diego, California
2. Principles and Techniques of Biochemistry and Molecular Biology, K Wilson, J Walker (1997), Cambridge University Press, Cambridge
3. Molecular Cloning: A Laboratory Manual, J Sambrook, EF Fritsch, T Maiatis (2000), Cold Spring Harbor Laboratory Press, New York
4. Molecular Biotechnology, SB. Primrose (1994), Blackwell Scientific Pub, Oxford.
5. Statistical methods, GW Snedecor, WG Cochran, eigth edition, East-West Press
6. Biomtery, RR Sokal, FJ Rohlf, third edition, Freeman
7. Statistical Methods, SP Gupta (1984), S Chand & Company.
8. Biostatistical Analysis, JH Jarr (2006), Prentice-Hall.

Course: Disciplinary Major (BBTDMJ06)
Course: Interdisciplinary Major (BBTIMJ06)

Molecular Biology

(Credits: Theory-4, Practical-2)
THEORY
Lectures: 60

Unit 1: Nucleic acids : Carriers of genetic information (8 Lectures)
Historical perspective; DNA as the carrier of genetic information (Griffith's, Hershey & Chase, Avery, McLeod & McCarty, Fraenkel-Conrat's experiment.

Unit 2. The Structures of DNA and RNA / Genetic Material (12 Lectures)
DNA Structure: Salient features of double helix, Types of genetic material, Organization of DNA- Prokaryotes, Viruses, Eukaryotes. RNA Structure, mitochondria and chloroplast DNA. The Nucleosome: Chromatin structure- Euchromatin, Heterochromatin- Constitutive and Facultative heterochromatin.

Unit 3: The replication of DNA (10 Lectures)
General principles – bidirectional, semi- conservative and semi discontinuous replication. Replication in prokaryotes and eukaryotes.

Unit 4: Transcription and modification of RNA (18 Lectures)
Transcription in prokaryotes and eukaryotes. Principles of transcriptional regulation; Prokaryotes: Regulation of lactose metabolism and tryptophan synthesis in *E.coli.* Eukaryotes: transcription factors. Split genes-concept of introns and exons, removal of introns, spliceosome machinery, capping and polyadenylation, mRNA transport.

Unit 5: Translation (12 Lectures)
Genetic code (deciphering & salient features**).** Ribosome structure and assembly, aminoacyl tRNA synthetases, charging of tRNA,; Translation in prokaryotes and eukaryotes Inhibitors of protein synthesis; Post-translational modifications of proteins.

Course: Disciplinary Major (BBPDMJ06)
Course: Interdisciplinary Major (BBPIMJ06)

PRACTICAL

1. Preparation of LB medium and raising *E. Coli.*
2. Isolation of genomic DNA from *E. Coli.*
3. DNA isolation from cauliflower head.
4. DNA estimation by diphenylamine reagent/UV Spectrophotometry.
5. Study of DNA replication mechanisms through photographs (Rolling circle, Theta replication and semi-discontinuous replication).
6. Study of structures of prokaryotic RNA polymerase and eukaryotic RNA polymerase II through photographs.
7. Photographs establishing nucleic acid as genetic material (Meselson and Stahl's, Avery et al, Griffith's, Hershey & Chase's and Fraenkel & Conrat's experiments).

Suggested Readings

1. Watson J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M., Losick, R. (2007). Molecular Biology of the Gene, Pearson Benjamin Cummings, CSHL Press, New York, U.S.A. 6th edition.

2. Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics. John Wiley and Sons Inc., U.S.A. 5th edition.

3. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. Benjamin Cummings. U.S.A. 9th edition.

4. Russell, P. J. (2010). i-Genetics- A Molecular Approach. Benjamin Cummings, U.S.A. 3rdedition.

5. Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., Doebley, J. (2010). Introduction to Genetic Analysis. W. H. Freeman and Co., U.S.A. 10th edition.

Course: Disciplinary Major (BBTDMJ07)

Plant Biotechnology

(Credits: Theory-4, Practical-2)
THEORY
Lectures: 60

Unit 1: Recombinant DNA technology (15 Lectures)
Restriction Endonucleases (History, Types I–IV, biological role and application); Cloning Vectors: rokaryotic (pBR322, Ti plasmid, BAC); Lambda phage, M13 phagemid, Cosmid, Shuttle vector; Eukaryotic Vectors (YAC).

Unit 2: Gene Cloning (15 Lectures)
DNA, PCR- and RT-PCR mediated gene cloning; Construction of genomic and cDNA libraries, colony ybridization; PCR Gel electrophoresis, blotting, DNA sequencing.

Unit 3: Methods of gene transfer (15 Lectures)
Agrobacterium-mediated, Direct gene transfer by Electroporation, Microinjection, Microprojectile bombardment. DNA fingerprinting by RAPD and RFLP.

Unit 4: Applications of Biotechnology (15 Lectures)
Pest resistant (Bt-cotton); Herbicide resistant plants (RoundUp Ready soybean); Transgenic crops with improved quality traits (Flavr Savr tomato, Golden rice); Role of transgenics in bioremediation (Superbug); Industrial enzymes (Aspergillase, Protease, Lipase); Genetically Engineered Products – biosafety concerns.

Course: Disciplinary Major (BBPDMJ07)

PRACTICAL

1. To separate the target of DNA using gel electrophoresis.
2. To isolate genomic DNA from E. coli.
3. To isolate plasmid DNA from bacterial sample.
4. To amplified the target DNA using thermocycle.

Suggested Readings

1. Watson, J. D., Baker, T. A., Bell, S. P., Gann, A., Levine, M., & Losick, R. (2013). *Molecular Biology of the Gene* (7th ed.). Pearson Education.
2. Brown, T. A. (2016). *Gene Cloning and DNA Analysis: An Introduction* (7th ed.). Wiley-Blackwell.
3. Chawla, H. S. (2009). *Introduction to Plant Biotechnology* (3rd ed.). Oxford & IBH Publishing.
4. Satyanarayana, U. (2008). *Biotechnology*. Books & Allied (P) Ltd.

Course: Disciplinary Minor (BBTDMI06)
Course: Interdisciplinary Minor (BBTIMI06)

Bioinformatics

(Credits: Theory-2)
THEORY
Lectures: 30

Unit I: Introduction to Bioinformatics (10 Lectures)

Aim and scope of bioinformatics, Branches and applications of bioinformatics in plant, microbes and medical science, Relationship of bioinformatics with molecular biology, DNA structure and sequence (coding and non-coding sequences, Repeated sequences, Satellite DNA, Tandem repeats, Palindromes, Inverted repeats), Protein structure and sequences.

Unit II: Biological Databases (10 Lectures)

General introduction of biological database, Nucleic acid databases - NCBI GenBank, DDBJ and EMBL, Protein databases - NCBI Protein, EMBL Protein, SwissProt and PDB.

Unit III: Online Tools (10 Lectures)

Similarity searches on sequence databases - BLAST, PSI-BLAST; Building multiple sequence alignment (MSA) - Clustal W and Clustal X; Building phylogenetic tree - MEGA; Designing PCR primers - Primer3; Finding protein coding regions - ORF finder.

Suggested Readings

1. Rastogi, S.C., Mendiratta, N. and Rastogi, P. (2004). Bioinformatics: Concepts, Skills & Applications. CBS Publishers & Distributors, New Delhi
2. Claverie, J.M. and Notredame, C. (2003). Bioinformatics - A beginner's Guide. Wiley.
3. Ghosh, Z. and Bibekanand, M. (2008). Bioinformatics: Principles and Applications. Oxford University Press.