Learning Outcome based Curriculum Framework (LOCF)

For

Choice Based Credit System (CBCS)

Syllabus

B.Sc. (Honours) in Botany

w.e.f. Academic Session 2020-21

Kazi Nazrul University

Asansol, Paschim Bardhaman

West Bengal 713340

Semester – I

Course Name: Phycology and Microbiology

Course Code: BSCHBOTC101

Course Type: **Core**	Course Details: **CC-1**			L-T-P: **4-0-4**	
Credit: 6	Full Marks: 100	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**10**	20	**40**

Course Learning Outcomes:

On completion of this course, the students will be able to:

- Develop understanding on the concept of microbial nutrition
- Classify viruses based on their characteristics and structures
- Develop critical understanding of plant diseases and their remediation.
- Examine the general characteristics of bacteria and their cell reproduction/ recombination
- Increase the awareness and appreciation of human friendly viruses, bacteria, algae and their economic importance
- Conduct experiments using skills appropriate to subdivisions

Unit I: Introduction to microbial world

- Histroy and development of microbiology (In brief) – contributions of Antoni van Leuwenhoek, Edward Jenner, Loius Pasteur, Robert Koch, De Bary and A. Flemming.
- Principles and modern approaches of bacterial taxonomy, General idea about Bergey's Mannual, Three domain system by C. Woese (1991).
- Microbial nutrition, nutritional types, growth and metabolism.
- Economic importance of bacteria with reference to their role in agriculture (Biofertilizers, Biopesticides) and industry [fermentation (Alcohol production general account) and medicine (Penicillin production general account).
- Medical Mocrobiology – Epidemiology, pathogenesis, causal organism and control of air borne disease (influenza), water borne disease (Cholera) and food borne disease (Staphylococcal food poisoning).
- Economic importance of viruses with reference to vaccine production, role in research, medicine and diagnostics, as causal organisms of plant diseases.

Unit II: Viruses and Bacteria

- Viruses: General characteristics of viruses (size, symmetry, culture characteristics, general structure including concept of capsomere and peplomere, chemical composition), structure of TMV and T_2;
- Viral multiplication – Lytic cycle and Lysogeny (excluding regulation). Classification (by Baltimore)
- Brief idea about Prions and Viroids.
- Bacterial structure and function - Capsule, flagella, pili, cell wall (chemical composition and characteristics), plasma membrane, ribosomes, cytoplasmic inclusions (PHB, Volutin). Plasmids and bacterial chromosome, endospore (structure only);
- General characteristics of domain Archaea, wall-less forms (Mycoplasmas)
- Basics of genetic recombination in bacteria: Transformation, Conjugation and Transduction. Artificial transformation.
- Basic immunology (only outline) – Innate and acquired immunity, active and passive immunity, humoral (antibody mediated) and cellular (cell mediated) immunity, primary and secondary response, general structure of antibody and its types.

Unit III: Algae, Cyanophyta and Xanthophyta

- Introduction; Habitat and distribution; thallus organization; origin and evolution of sex in algae; Life cycle patterns.
- Broad outline of classification of Fritsch (1935) and Lee (2008) up to class and divisions respectively. Phylogenetic consideration.
- Comparative account of: Cyanophyceae, Chlorophyceae, Charophyceae, Xanthophyceae, Bacillariophyceae, Phaeophyceae, Rhodophyceae.
- Cell structure and reproduction of Cyanophyceae and Diatoms.
- Life histories of *Oedogonium, Trentepohlia, Chara, Vaucheria, Ectocarpus* and *Polysiphonia*.

Unit IV: Algal Biotechnology

- Economic importance of algae; Algal cultivation methods, Commercial cultivation and economic importance of green algae, brown and red algae.
- Algae in pollution control (sewage treatment), Biofertilizer, Single Cell Protein (SCP), Biofuel, β-carotene production.

Practical Microbiology

- Demonstration of the functioning of Autoclave, Hot-air oven, Laminar air-flow, Filtration, Incubator and tools like inoculating loops/needles, petriplates, spreader, culture tubes etc.
- Preparation of standard bacteriological media (Nutrient agar and Nutrient broth).
- Preparation of slants, stabs and agar plates.

- Demonstration of Sub-culturing technique.
- Microscopic examination of bacteria from natural habitats: curd and root nodules of leguminous plants (simple staining only)
- Differential staining: Gram staining (Using standard *E. coli* and *Bacillus* cultures)

Phycology

- Study of the following genera: *Oscillatoria, Gloeotrichia, Scytonema, Oedogonium,Vaucheria and Chara.*
- Identification of all the genera included in the theoretical syllabus by their vegetative and reproductive structures

Suggested Readings

1. Atlas, R. M. (recent Edition) – Principle of Microbiology, W. E. B. Mc Graw Hill.
2. College Botany Vol. –II.- Gangulee and Kar, New Central Book Agency, Kolkata.
3. Fundamentals of Microbiology and Immunology – A. K. Banerjee & N . Banerjee. New Central Book Agency.
4. Lee, R.E. (2008). Phycology, Cambridge University Press, Cambridge. 4th edition.
5. Pelczar, M.J. (2001). Microbiology, 5th edition, Tata McGraw-Hill Co, New Delhi.
6. Powar, C. B. and Dasinawalla, H. F. General Microbiology. Vol. II. Himalayan Publishing House, Delhi. Mombay.
7. Sharma, P. D. Microbiology; Rastogi Publications, Meerut.
8. Vashishta B.R., Sinha A.K. and Singh V. P. (2008). Botany for Degree Students. Algae. S Chand and Co, New Delhi.
9. Wiley, J.M, Sherwood, L.M. and Woolverton, C.J. (2013). Prescott's Microbiology. 9th Edition. McGraw Hill International.
10. Sharma T.A., Dubey, R.C. and Maheshwari, D.K. (1999). A Text Book of Microbiology. S Chand and Co, New Delhi.
11. Studies in Botany, Vol. I. - Mitra, Mitra, Choudhury. Moulik Library, Kolkata.
12. Text Book of Botany, Voli-1, Hait, Ghosh and Bhattacharya, New Central Book Agency.

Course Name: Biomolecules and Cell Biology

Course Code: BSCHBOTC102

Course Type: **Core**	Course Details: **CC-2**			L-T-P: **4-0-4**	
Credit: 6	Full Marks: 100	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**10**	20	**40**

Course Learning Outcomes:

On completion of this course, the students will be able to:

- Develop understanding on chemical bonding among molecules
- Identify the concept that explains chemical composition and structure of cell wall and membrane
- Classify the enzymes and explain mechanism of action and structure
- Compare the structure and function of cells & explain the development of cells
- Describe the relationship between the structure and function of biomolecules

Unit I: Bioenergetics

Laws of thermodynamics, concept of free energy, endergonic and exergonic reactions, coupled reactions, redox reactions. ATP: structure, its role as an energy currency molecule. Types and significance of chemical bonds (give emphasis to weak interactions); Structure and properties of water; significance of pH and buffers, ionic product of water, biological role of water.

Unit II: Biomolecules

Carbohydrates: Nomenclature and classification and isomeric form; Monosaccharides; Disaccharides; Oligosaccharides and polysaccharides. Lipids: Definition and major classes of storage and structural lipids; Fatty acids structure and functions; Essential fatty acids; Triacylglycerols structure, functions and properties; Phosphoglycerides. Proteins: Structure of amino acids; Levels of protein structure-primary, secondary, tertiary and quaternary; Protein denaturation and biological roles of proteins. Nucleic acids: Structure of nitrogenous bases; Structure and function of nucleotides; Types of nucleic acids; Structure of A, B, Z types of DNA; Types of RNA; Structure of tRNA.

Unit III: Enzymes

Structure of enzyme: holoenzyme, apoenzyme, cofactors, coenzymes and prosthetic group; Classification of enzymes; Features of active site, substrate specificity, mechanism of action (activation energy, lock and key hypothesis, induced - fit theory), Michaelis – Menten equation, Lineweaver–Burk equation, enzyme inhibition and factors affecting enzyme activity.

Unit IV: Cell Biology and Signal transduction

Cell as a unit of structure and function; Characteristics of prokaryotic and eukaryotic cells; Plant and animal cells; Origin of eukaryotic cell (Endosymbiotic theory). Chemistry, structure and function of Plant cell wall. Overview of membrane function; fluid mosaic model; Chemical composition of membranes; Membrane transport – Passive, active and facilitated transport, endocytosis and exocytosis. Nucleus: Structure-nuclear envelope, nuclear pore complex, nuclear lamina, molecular organization of chromatin; nucleolus. Cytoskeleton: Role and structure of microtubules, microfilaments and intermediary filament; Chloroplast, mitochondria and peroxisomes: Structural organization; Function; Semiautonomous nature of mitochondria and chloroplast. Lysosomes and Vacuoles. Endomembrane system: Endoplasmic Reticulum – Types and Structure. Golgi Apparatus – organization, protein glycosylation, protein sorting and export from Golgi Apparatus;

Practical

- Qualitative tests for carbohydrates, reducing sugars, non-reducing sugars, lipids, proteins.
- Study of plant cell structure with the help of epidermal peel mount of Onion/ *Rhoeo*.
- Demonstration of the phenomenon of protoplasmic streaming in *Hydrilla* leaf.
- Counting the cells per unit volume with the help of haemocytometer. (Yeast/pollen grains/ any cell).
- Measurement of cell size by the technique of micrometry (any cell).
- Amylase activity measurement (from germinating rice seeds).

Suggested Readings

1. Alberts, B., Johnson, A.D., Lewis, J., Morgan, D., Raff, M., Roberts, K., Walter, P. (2014). Molecular Biology of Cell. 6th Edition. WW. Norton & Co.
2. Berg, J.M., Tymoczko, J.L. and Stryer, L. (2011) Biochemistry, W.H.Freeman and Company
3. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009). The World of the Cell. 7th edition. Pearson Benjamin Cummings Publishing, San Francisco.
4. Campbell, M.K. (2012) Biochemistry, 7th ed., Published by Cengage Learning.
5. Campbell, P.N. and Smith, A.D. (2011). Biochemistry Illustrated, 4th ed., Published by Churchill Livingstone.
6. Cooper, G.M. and Hausman, R.E. (2009). The Cell: A Molecular Approach. 5th edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.
7. G.M. Cooper. (2015). The cell: A Molecular Approach. 7th Edition. Sinauer Associates.
8. Hardin, J., Becker, G., Skliensmith, L.J. (2012). Becker's World of the Cell. 8th edition.Pearson Education Inc. U.S.A.

9. Karp, G. (2010). Cell Biology, John Wiley & Sons, U.S.A. 6th edition. 9. Hardin, J., Becker, G., Skliensmith, L.J. (2012). Becker's World of the Cell. 8th edition.Pearson Education Inc. U.S.A.
10. Nelson, D.L. and Cox, M.M. (2008). Lehninger Principles of Biochemistry, 5th Edition, W.H. Freeman and Company.
11. Sanjeev Pandey, Advance Botany, Volume-1, 2nd Edn, Pub. Books and Allied (P) Ltd. Kolkata.
12. Tymoczko, J.L., Berg, J.M. and Stryer, L. (2012). Biochemistry: A short course, 2nd ed, W.H.Freeman.

Semester – II

Course name: Mycology And Phytopathology

Course Code: BSCHBOTC201

Course Type: **Core**	Course Details: **CC-3**			L-T-P: **4-0-4**	
Credit: 6	Full Marks: 100	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**10**	20	**40**

Course Learning Outcomes:

On completion of this course, the students will be able to;

- Identify true fungi and demonstrate the principles and application of plant pathology in the control of plant disease.
- Demonstrate skills in laboratory, field and glasshouse work related to mycology and plant pathology.
- Develop an understanding of microbes, fungi and lichens and appreciate their adaptive strategies
- Identify the common plant diseases according to geographical locations and device control measures

Unit I: Introduction to fungi and classification

- Introduction, Salient features - fungal tissue organization, modification of hyphae; Ecology of fungi; Structure of fungal cell, cell wall, fungal flagella, septum, nutrition, heterothallism, parasexuality.
- Broad outline Classification of Gwynne-Vaughan and Barnes (1926) and Ainsworth and Bisby (1983).

- Plasmodiophoromycetes (Slime molds) – General features, Taxonomic status, Occurrence, Types of plasmodia, types of fruiting bodies.
- Phycomycetes: Salient features, life histories of *Synchytrium*, *Phytophthora*, *Saprolegnia* and *Rhizopus.*
- Ascomycetes: Salient features, Ascus development, types of ascocarps; life histories of *Saccharomyces, Penicillium* and *Ascobolus*.

Unit II: Basidiomycota, Allied fungi and Oomycota

- Basidiomycetes: Salient features (dikaryotization, clamp connection); development of Basidium, life histories of *Puccinia, Agaricus* and *Polyporus*.
- Deuteromycetes: Salient features with special reference to conidial fruit body types; Vegetative body and Reproduction in *Fusarium*, *Alternaria* and *Colletotrichum*.

Unit III: Symbiotic associations and applied Mycology

- Lichen: Classification, thallus organization, reproduction; ecological and economic significance.
- Mycorrhiza- Ectomycorrhiza, Endomycorrhiza and VAM fungi; Role of mycorrhizae and VAM in agriculture and forestry.
- Role of fungi in biotechnology; Application of fungi in food industry (Enlist application in Fermentation products, Baking, Organic acids, Enzymes, Mycoproteins production); Mushroom cultivation and spawn production (for Oyster and Button mushroom).

Unit IV: Phytopathology

- Plant Diseases: Definition; concepts of parasitism and saprophytism, Koch's postulate.
- Classification of plant diseases based on symptoms.
- Pathotoxins (HV toxin and Wild-fire toxin).
- Structural and biochemical defense mechanism of plants.
- Control of Plant diseases: Physical, chemical and biological methods.
- Symptoms, disease cycles and control measures of
  Bacterial diseases –Bacterial blight of rice, Citrus canker
  Viral diseases- Tobacco Mosaic viruses
  Fungal diseases- Late blight of potato, Brown spot of rice, Black stem rust of wheat, White rust of crucifer.

Practical –

Mycology -

- Study of the following genera: *Rhizopus, Ascobolus, Agaricus* (gill) and *Polyporus.*

- Identification of all the macroscopic and microscopic genera included in the theoretical syllabus. (It should also include *Alternaria* and *Fusarium* of Deuteromycetes).

Phytopathology -

- Study of the following diseases: White rust, Rust of wheat/*Justicia*, smut of wheat (or any member of Poaceae)
- Demonstration on isolation and sub-culturing of pathogen.
- Study of symptoms of: Brown spot of rice, Bacterial blight of rice, Citrus Canker; Vein clearing in Lady's finger, Late blight of potato, Rust of wheat from herbarium specimens.

[NB. Practicals will also include field study with specimen collection, preservation and their submission with proper documentation. It also includes temporary and where ever necessary permanent slide preparation and submission.]

Suggested Readings

1. Botany for degree students. Fungi. B. R. Vashistha, A. K. Sinha. V. R. Singha (Latest edition). S. Chand
2. College Botany Vol. –II. - Gangulee and Kar, New Central Book Agency, Kolkata.
3. Introduction to Fungi. Webster, J. Cambridge University Press.
4. Introduction to Fungi, Dubey, H. C. Vikas Publishing House.
5. Introduction to Mycology. Alexopoulas, C. J., Mims, C. W. and Blackwell Wiley. Bastern Limited, New Delhi.
6. Introductory Mycology. R. S. Mehrotra and Aneja, K. R. New Age International
7. Studies in Botany, Vol. I. - Mitra, Mitra, Choudhury. Moulik Library, Kolkata.
8. Text Book of Botany, Voli-1 and 2, By Hait, Ghosh and Bhattacharya, New Central Book Agency.
9. Text Book of Fungi, Sharma O.P. Tata McGraw Hill Publishing Co. Latyestedn.
10. Text Book of Fungi, Sharma, O. P. Tata Mc Graw Hill Publishing Co. Latest edn.
11. Plant Pathology. Agrios R. N. academic Press.
12. Plant Pathology, Mehrotra, R. S. Tata Mc Graw Hill Publishing Company. New Delhi
13. Diseases of Crop Plants in India. Rangaswamy, G. Prentice Hall India Pvt. Ltd. New Delhi
14. Plant Diseases. Singh, R. S. Oxford & IBH, New Delhi.
15. Pathogen and Plant Diseases. Pandey, B. P., S. Chand & Company Ltd. Rangaswamy, G. New Delhi.

Course name: Archegoniatae: Bryophytes, Pteridophytes, Gymnosperms

Course Code: BSCHBOTC202

Course Type: **Core**	Course Details: **CC-4**			L-T-P: **4-0-4**	
Credit: 6	Full Marks: 100	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**10**	20	**40**

Course Learning Outcomes:

On completion of this course, the students will be able to:

- Demonstrate an understanding of archegoniatae, Bryophytes, Pteridophytes and Gymnosperms
- Develop critical understanding on morphology, anatomy and reproduction of Bryophytes, Pteridophytes and Gymnosperms
- Understanding of plant evolution and their transition to land habitat.
- Demonstrate proficiency in the experimental techniques and methods of appropriate analysis of Bryophytes, Pteridophytes, Gymnosperms

Unit I: Introduction

- Unifying features of archegoniates; Transition to land habit; Alternation of generations and concept of sporophyte and gametophyte.

Unit II: Bryophytes

- Origin of Bryophytes; Habit and distribution; Broad outline of Classification according to Proskauer, (1957), Comparative study of Hepaticopsida, Anthocerotpoida and Bryopsida.
- Morphology, anatomy, reproduction and evolutionary trends in *Riccia*, *Marchantia*, *Pellia*, *Porella*, *Anthoceros*, *Sphagnum* and *Funaria*.
- Ecological and economic importance of bryophytes with special reference to *Sphagnum*.

Unit III: Pteridophytes

- Introduction to Palaeobotany – Important terminologies and definitions; Types of fossil on the basis of modes of preservation; Nomenclature, Conditions suitable for fossilization; Importance of fossils and their study; Stratigraphy – Law of superposition, Stratigraphic correlation and stratigraphic deduction based on megafossil and microfossil assemblages. Geological time scale and important events of plant life.
- Introduction to Pteridophyta – Concept of Vascular Cryptogams; stellar organization and its evolution; General features of Pteridophytes; Apogamy and apospory; Telome theory, Enation Theory.

- Outline of Pichi Sermolli (1977) system of classification of pteridophytes up to family.
- A comparative account of fossil members: Geological history and morphoanatomical features of *Rhynia, Psilophyton* and *Zosterophyllum*; *Lepidodendron (Lepidodendron, Lepidocarpon), Calamites (stem and strobilus-Calamostachys and Palaeostachya).*
- A comparative account of the living members: Distribution, Morphology and anatomy of vegetative structure and reproduction of *Psilotum. Lycopodium, Selaginella, Equisetum*: *Pteris* and *Marsilea.*

Unit IV: Gymnosperms

- General features, evolution of seed habit; outline classification as adopted by Stewart & Rothwell (1993); Economic importance of gymnosperms.
- General account of fossil members: Progymnospermopsida: *Archaeopteris*; Pteridospermales: *Lyginopteris* (*Crossotheca* male organ and *Lagenostoma* female organ); Glossopteridales: *Glossopteris* (*Vertebraria* root, *Araucarioxylon* trunk, *Glossopteris* leaf, *Glossotheca* male organ, *Denkania* female organ); Bennettitales: *Williamsonia sewardiana* reconstruction (*Bucklandia* stem, *Ptilophyllum* leaf, *Weltrichia* male organ, *Williamsonia* female organ).
- Morphoanatomical features and Comparative account of the life histories of living members - *Cycas, Pinus, Ginkgo* and *Gnetum*. Their distribution in India.

Practicals –

- Study of the gametophytic and sporophytic structures of the following genera: *Marchantia, Anthoceros and Funaria.*
- Study of external morphology and anatomical features of leaf, stem and reproductive parts of the following: *Lycopodium, Selaginella, Equisetum, Pteris* (leaflet) and *Marsilea* (Sporocarp).
- Study of the morphological and anatomical features of the following: *Cycas* (leaflet, rachis, microsporophyll) and *Pinus* (needle, stem, male cone).
- Macroscopic and microscopic identification of specimens of all extant genera included in the theoretical syllabus of Bryophytes, Pteridophytes and Gymnosperms.
- Study (including mode of preservation) of the following: *Lepidodendron,* (stem in T. S.), *Calamites* (stem in T. S.), *Bucklandia* (stem, specimen), *Glossopteris* (leaf, specimen), *Lyginopteris* (stem in T. S.),*Vertebraria*(root, specimen).

[NB. Practicals will also include field study with specimen collection, preservation and their submission with proper documentation. It also includes temporary and where ever necessary permanent slide submission.]

Suggested Readings

1. A Text Book of Botany: Lower Plants (2nd edition) Part-I: Bryophta. Singh, Pandey and Jain. 1999. Rastogi Publications. Merut.
2. A Text Book of Botany, Pandey, S. N., Trivedi, P. S. and Misra, S. P. 1989. VikasPublishing House Pvt. Ltd.
3. Bryophytes, a broad perspective. Puri, P. 1973. Atma Ram & Sons. New Delhi.
4. The structure and life of Bryophytes, Watson, E. V. Hutchinson University Library, London.
5. College Botany Vol. –II.- Gangulee and Kar, New Central Book Agency, Kolkata.
6. Cryptogamic Botany Vol. II. GM Smith,Bryophtes and Pteridophytes (2nd edition). Mc.Graw Hill Book Co. New York.
7. E. M. Gifford and A. S. Foster. 1988. Morphology and Evolution of Vascular Plants.
8. N. S. Parihar: An Introduction to Embryophyta Vol-II. Central Book. Allahabad.
9. Studies in Botany, Vol. I. - Mitra, Mitra, Choudhury. Moulik Library, Kolkata.
10. Text Book of Botany, Voli-1 and 2, By Hait, Ghosh and Bhattacharya, New Central Book Agency.
11. K. R. Sporne : The Morphology of Pteridophytes. B. S. Publications. Calcutta
12. P. C. Vasistha. 1980 Botany for degree student Pteridophyta. S. Chand & Company Pvt. Ltd.W. N. Stewart and G. N. Rothwall (recent edition). Palaeobotany and the evolution of Plants. Cambridge University Press.
13. Rashid. 1976. An Introduction to Pteridophyta. Vikas Publishing . New Delhi.
14. Pichi-Sermolli, R. E. R. 1959. In Vistas in Botany. Vol-I (edition. W. B. Turill).
15. S. SundarRajan. 1994. An introduction to Pteridophyta. New Age International Publishing Limited and Willey Eastern Ltd.
16. S. Sundararjan (Wiley Eastern) Introduction to Pteridophyta.
17. Mehra and Bir, Pteridophytic Flora of Darjeeling and Sikim Himalaya. Bishen Singh Mahendra Pal Singh.
18. K. Kubtzki (ed.) Vol-I, The Families & Genera of Vascular Plants Springer Pteridophyta & Gymnosperms 1990. Springer
19. Stewart, W. N. & G. W. Rothwell. 1993. Palaeobotany and Evolution of Plants. Cambridge University Press. 4. Taylor, T. N., E. L.
20. Taylor and M. Krings. 2009. Palaeobotany, the biology and evolution of fossil plants. Elsevier Inc.
21. Beck, C. B. 1988. Origin and evolution of gymnosperms. Columbia University Press.
22. Chamberlain, C. J. 1934. Gymnsoperms – structure and evolution. Chicago Univ. Press.
23. Sporne, K. R. 1974. Morphology of Gymnosperms. Hutchson Univ. Library, London.
24. Bhatnagar, S. P. & A. Moitra. 1996. Gymnosperms. New Age International Ltd., New-Delhi.

25. Biswas, C. & B. M. Johri. 1997. Gymnosoperms. Narosa Publishing House. New Delhi.

Semester – III

Course name: Anatomy of Angiosperms

Course Code: BSCHBOTC301

Course Type: **Core**	Course Details: **CC-5**			L-T-P: **4-0-4**	
Credit: 6	Full Marks: 100	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**10**	20	**40**

Course Learning Outcomes:

On completion of this course, the students will be able to:

- Develop an understanding of concepts and fundamentals of plant anatomy
- Examine the internal anatomy of plant systems and organs
- Develop critical understanding on the evolution of concept of organization of shoot and root apex.
- Analyze the composition of different parts of plants and their relationships
- Evaluate the adaptive and protective systems of plants

Unit I: Introduction to plant anatomy and plant body

- Cell wall: Structure, growth and thickenings; Adcrustation and incrustation; Pits and Plasmodesmata.
- Tissue: Definition and types (meristematic and permanent tissues); classification of simple and complex tissues; A general account of different types of simple and permanent tissues. Sclereids.
- Tissue system – Epidermal (multiple epidermis, bulliform cells, stomatal types, trichoblasts, glandular hairs), vascular (leaf gap, branch gap, types of vascular bundles) and ground tissue system (Genral features of cortex, pith and medullary rays), Stele types.

Unit II: Adaptive and Protective Systems

- Vascular bundles (types); Stele and its types; Root stem transition; mechanical tissue and their distribution in plant bodies (including principles of their distribution).

- General account on: Cuticle, Stomata, Hydathodes, Cavities, Laticifers, Kranz anatomy

Unit III: Apical meristems

- Evolution of concept of organization of shoot apex (Apical cell theory, Histogen theory, Tunica Corpus theory, continuing meristematic residue, cyto-histological zonation)
- Organization of root apex (Apical cell theory, Histogen theory, Korper-Kappe theory); Quiescent centre; Root cap.

Unit IV: Vascular Cambium and Wood

- Structure, function and seasonal activity of cambium; Secondary growth in root and stem. Anomalous secondary growth (General account); Sapwood and heartwood; Ring and diffuse porous wood; Early and late wood, tyloses; Dendrochronology. Development and composition of periderm, rhytidome and lenticels.

Practical

- Study of stomata through peal method.
- Staining techniques – simple and differential staining.
- Demonstration of the method of temporary and permanent slide preparation.
- Study of primary structure: Stem: monocot (Maize), dicot (Sunflower); Root: monocot(*Canna*), dicot (Chick pea).
- Microscopic study from permanent slides of: Bulliform cells, stomatal types, lenticels, raphides (acicular and sphaeraphides), cystolith, cavities and laticifers.
- Study of the anomalous structures of stems of the following genera: *Bignonia, Dracaena, Boerhaavia* and *Achyranthes.*
- Maceration of wood elements of *Cucurbita* and *Pinus* stem and their microscopic examination.

Suggested Readings

1. Any local/state/regional flora published by BSI or any other agency.
2. Cutter, E. G. 1978 Plant Anatomy Part I & II. Edward & Arnold
3. Dickison, W.C. (2000). Integrative Plant Anatomy. Harcourt Academic Press, USA.
4. Esau, K. 1966. Plant Anatomy. John Willey.
5. Evert, R.F. (2006) Esau's Plant Anatomy: Meristems, Cells, and Tissues of the Plant Body: Their Structure, Function and Development. John Wiley and Sons, Inc.
6. Fahn, 1982. Plant Anatomy. John Willey.
7. Fahn, A. (1974). Plant Anatomy. Pergmon Press, USA.
8. Mauseth, J.D. (1988). Plant Anatomy. The Benjammin/Cummings Publisher, USA.
9. P. Roy. Plant Anatomy, new Central Book Agency, Kolkata-700010.

Course name: Morphology and Reproductive Biology of Angiosperms

Course Code: BSCHBOTC302

Course Type: **Core**	Course Details: **CC-6**			L-T-P: **4-0-4**	
Credit: **6**	Full Marks: 100	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**10**	20	**40**

Course Learning Outcomes:

On completion of this course, the students will be able to:

- To know about different plants organ like root, stem and leaves and their importance.
- To learn about various plants parts, embryonic development, breeding activity and conservation techniques.
- Recall the history of reproductive biology of angiosperms & recognize the importance of genetic and molecular aspects of flower development
- Understand structure and functions of anther wall and pollen wall
- Evaluate the special structures of Ovule
- Solve Self-incompatibility in Pollination and fertilization & relate between Embryo, Endosperm and Seed
- Comprehend the causes of Polyembryony and apomixes with its classification
- To learn structure and function of pollen and its role in fertilization, forensic science, melissopalynology.

Unit I - Morphology of Angiosperm -

- Leaves: Types, phyllotaxy, modifications of leaves, stipules.
- Inflorescence: Types with examples.
- Flower – General characteristics, as a modified shoot; aestivation; placentation; floral formulae, floral diagram; adhesion and cohesion of floral parts.
- Fruits: Definition and types; Dispersal of fruits and seeds.
- Organization of orthotropous ovule, types of ovules.

Unit – II - Advance Morphology –

- Evolution and phylogeny of Inflorescence and Placentation types.

Unit III - Embryology -

- Prefertilization changes - Microsporogenesis and microgametogenesis, megasprogenesis and megagametogenesis (monosporic, bisporic and tetrasporic)
- Fertilization - Pollination: Types and contrivances. Mechanism of Fertilization (pollen germination, pollen tube growth, entry into the ovule and discharge and double fertilization); sporophytic and gametophytic self incompatibility (Concept of S-allele)
- Post-fertilization changes - Development of typical dicot embryo (Crucifer - type); Endosperm development (3 Types)

Unit IV - Palynology –

- Spore/pollen morphology with reference to polarity, size, shape, symmetry, aperture and sculpture.
- Importance of Palynology; Melissopalynology.

Practical -

Morphology –

- Morphological study of the plant organs included in the theoretical syllabus (No Submission is required)
- Spot Identification of various morphological specimens.

Reproductive biology -

- Microscopic examination of Pollen germination in Catharanthus roseus.
- Study of exine sculptures by temporary slide preparation in *Impatient balsamea*.

Suggested Readings

1. Bhojwani, S. S. and S. P. Bhatnagar. 1992. The Embryology of Angiosperms. Vikas Publ. House.
2. College Botany Vol. –II.- Gangulee and Kar, New Central Book Agency, Kolkata.
3. Maheshwari, P. 1960. An Introduction to the Embryology of Angiosperms. McGraw-Hill Publ. Co.
4. Plant Groups. (Recent Edition). H. Mukherjee. New Central Book Agency.
5. Sachdeva, S. K. 1990. Angiosperms, Morphology, Anatomy, Taxonomy, Evolution. Kalyani Publishers, New Delhi.
6. Sporne, K. R. 1974. The Morphology of Angiosperms: The structure and evolution of flowering plants. Hutchinson University Library. London.
7. Studies in Botany, Vol. I. - Mitra, Mitra, Choudhury. Moulik Library, Kolkata.
8. Text Book of Botany, Voli-1 and 2, Hait, Ghosh and Bhattacharya, New Central Book Agency.

Course name: Plant Systematics

Course Code: BSCHBOTC303

Course Type: **Core**	Course Details: **CC-7**			L-T-P: **4-0-4**	
Credit: **6**	Full Marks: 100	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**10**	20	**40**

Course Learning Outcomes:

On completion of this course, the students will be able to:

- Classify Plant systematics and recognize the importance of herbarium and Virtual herbarium
- Evaluate the Important herbaria and botanical gardens
- Interpret the rules of ICN in botanical nomenclature
- Assess terms and concepts related to Phylogenetic Systematics
- Generalize the characters of the families according to Bentham & Hooker's system of classification

Unit I: Significance of Plant systematics and Taxonomic hierarchy

- **Introduction to systematics**; Plant identification, Classification, Nomenclature. Evidences from palynology embryology, cytology, phytochemistry and molecular data. Field inventory; Importance of Herbarium; Important herbaria and botanical gardens of the world and India; Virtual herbarium; E-flora; Documentation: Flora, Monographs, Journals; Keys: intended (yolked) and bracketed keys.
- **Plant classification** - artifitial, natural and phylogenetic approach, concept of molecular chronometers, Basic concept of Numerical taxonomy (Definition of Operational Taxonomic Units (OTU), Phenon, Phenogram); Phenetics vs. Cladistics; Rankless system of phylogenetic systematic
- **Taxonomic Hierarchy**: Concept of taxa (family, genus, species); Categories and taxonomic hierarchy; Species concepts (biological, morphological, evolutionary).Modes of speciation. Problems with species concepts.

Unit II: Botanical Nomenclature and System of Classification

- Principles and rules (ICBN); Ranks and names; Typification, author citation, valid publication, rejection of names, principle of priority and its limitations; Names of hybrids.
- Outline of the system of classification – Linnaeus (1753), Bentham and Hooker (1862-83), Takhtajan (1997); Principles of Angiosperm Phylogeny Group (APG IV) classification.

Unit III: Biometrics, Numerical Taxonomy and Cladistics

- Characters; Variations; OTUs, character weighting and coding; Cluster analysis; Phenograms, cladograms (definitions and differences).

Unit IV: Phylogenetic Systematics

- Terms and concepts (primitive and advanced, homology and analogy, parallelism and convergence, monophyly, Paraphyly, polyphyly, clades, synapomorphy, symplesiomorphy, apomorphy, lineage sorting, serial homology etc).
- Origin and evolution of angiosperms; Co-evolution of angiosperms and animals; Methods of illustrating evolutionary relationship (phylogenetic tree, cladogram).

Unit V: Salient features of the following families with examples from common Indian species and economic importance. [Evolutionary trends need to be briefly discussed in case of families marked with astericks].

Dicotyledons: Magnoliaceae*, Malvaceae, Brassicaceae, Leguminosae, Euphorbiaceae, Apocynaceae, Asclepiadaceae, Solanaceae, Scrophulariaceae, Lamiaceae, Verbinaceae, Acanthaceae, Rubiaceae, Asteraceae (Compositae)*.

Monocotyledons: Alismataceae*, Liliaceae, Poaceae, Orchidaceae*.

Practical

- Study of vegetative and floral characters of the following families (Description, V.S.flower, section of ovary, floral diagram/s, floral formula/e and systematic position according to Bentham & Hooker's system of classification):
  Malvaceae, Brassicaceae, Leguminosae, Euphorbiaceae, Apocynaceae, Asclepiadaceae, Solanaceae, Scrophulariaceae, Lamiaceae, Verbinaceae, Acanthaceae, Rubiaceae, Asteraceae (Compositae)*, Liliaceae, Poaceae, Orchidaceae
  (Take at least one genus from each family)
- Field visit (local or outside depending on situation) –
- Mounting of a properly dried and pressed specimen of any 20 wild plants with Herbarium label (to be submitted in the record book).
- Construction of plant phylogenetic trees using various loci (rbcL, ITS, trnLetc) with various phylogenetic methods (Neibour Joining, Maximum Likelihood etc)

Suggested Readings

1. College Botany Vol. III. New Central Book Agency. Calcutta.
2. Datta, S. C. 1991. Systematic Botany. Wiley Eastern Ltd. New Delhi, Calcutta.
3. Good, R. Plant Geography. Oxford & IBH.

4. Judd, Campbell, Kellogg. Stevens. 2003. Phylogeny & Evolution of Vascular Plants. Sinaurer Associates Inc. Publishers Sunderland. Massachusetts. USA.
5. Lawrence, G. H. M. 1981. Taxonomy of Vascular Plants. Mc Milian New York.
6. Mitra, J. N. 1974. An Introduction to Systematic Botany and Ecology. The Wall Press.
7. Naik, V. N. Taxonomy of Angiosperms. Tata Mc. Graw Hill Publishers Co. 1981. New Delhi
8. Plant Groups. (Recent Edition). H. Mukherjee. New Central Book Agency.
9. Plant Systematics. Gurucharan Singh. 2005 (2nd Edition). Oxford & IBH.
10. Plant Systematics. Simpson. 2006. Elsivier. 11. S. K. Mukherjee. 1984.
11. Sachdeva, S. K. 1990. Angiosperms, Morphology, Anatomy, Taxonomy, Evolution. Kalyani Publishers, New Delhi.
12. Sporne, K. R. 1974. The Morphology of Angiosperms: The structure and evolution of flowering plants. Hutchinson University Library. London.
13. Stuessy T. F. Plant Taxonomy, The systematic evaluation of Comparative data. Columbia IUniv. Press. Second Edition.
14. Takhtajan, A. 2009. Flowering Plants, Springer.
15. Takhtajan, A. 1986. Diversity & Plant Distribution. Oliver & Boyd.

Semester – IV

Course name: Plant Ecology and Phytogeagraphy

Course Code: BSCHBOTC401

Course Type: **Core**	Course Details: **CC-8**			L-T-P: **4-0-4**	
Credit: **6**	Full Marks: 100	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**10**	20	**40**

Course Learning Outcomes:

On completion of this course, the students will be able to:

- Understand core concepts of biotic and abiotic
- Classify the soils on the basis of physical, chemical and biological components
- Analysis the phytogeography or phytogeographical division of India
- Evaluate energy sources of ecological system
- Assess the adaptation of plants in relation to light, temperature, water, wind and fire.
- Conduct experiments using skills appropriate to subdivisions

Unit I: Basic Principles of ecology and ecological factors -

Ecology: Definition, Basic concepts; Levels of organization, Concept of Autecology and Synecology. Abiotic and biotic Components and their interrelationships and dynamism, homeostasis.

Unit II: Ecological adaptations, Population ecology

Ecological adaptation: Morphological, anatomical and physiological adaptations of xerophytes, hydrophytes and halophytes.

Population ecology: Characteristics and population growth, population regulation, growth curves, life history strategies; *r* and *k* selection. Ecological Speciation.

Unit III: Plant Communities and Ecosystem

Community characteristics: analytical and synthetic; Concept of ecological amplitude; Habitat and niche; Ecotone and edge effect; Succession: processes, types (Hydrosere, Xerosere); climax concept. Primary vs Secondary succession.

Ecosystem: Structure; Processes; Trophic organization; Food chains and Food webs; Ecological pyramids. Ecosystems of India.

Unit IV: Functional Aspects of Ecosystem and Phytogeography

Principles and models of energy flow; Production and productivity; Ecological efficiencies; Biogeochemical cycles of carbon, nitrogen and phosphorus.

Biodiversity (hot spots, megadiversity zones, IUCN threatened species), conservation (*in-situ-, ex-situ* conservation and cryopreservation).

Pollution: Definition causes and remedies with respect to air, water and noise pollution.

Phytogeography: Principles; Continental drift; Theory of tolerance; Endemism; Brief description of major terrestrial biomes (one each from tropical, temperate & tundra); Phyto-geographical division of India (After Independence); Vegetation characteristic of Eastern Himalayas and Sunderbans.

Practical

- Comparison of bulk density, porosity and rate of infiltration of water in soils of three habitats.
- Determination of dissolved oxygen of water samples from polluted and unpolluted sources.
- Study of Ecological adaptations with respect to anatomy of: *Ipomoea aquatica* stem, Phyllode of *Acacia auriculoformis, Nerium* leaf and *Vanda* root
- Study of biotic interactions of the following: Stem parasite (*Cuscuta*), Root parasite (*Orobanche*) Epiphytes, Predation (Insectivorous plants).
- Determination of minimal quadrat size for the study of herbaceous vegetation in the college campus, by species area curve method (species to be listed).
- Quantitative analysis of herbaceous vegetation in the college campus for frequency and comparison with Raunkiaer's frequency distribution law.
- Quantitative analysis of herbaceous vegetation for density and abundance in the college campus.

Suggested Readings

1. Ambasht, R. S. A Text book of plant ecology. Students Friends Co. Varanasi.
2. Dash, M. C. Fundamentals of Ecology. Tata Mc. Graw Hil Publishing Company Ltd.
3. Good, R. Plant Geography. Oxford & IBH.
4. Kormondy, B. J. 1983. Concept of Ecology (Recent edition) Prentice Hall India Ltd. New Delhi.
5. Kuman, H. D. Modern Concept of ecology. Vikas Publications House New Delhi
6. Odum, E. P. fundamentals of Ecology (recent edition) W. B. Sunders & Co. Philadelphia.
7. Plant Ecology. R. Mishra. Oxford & IBH.
8. Sanjeev Pandey, Advance Botany, Volume-1, 2nd Edn, Pub. Books and Allied (P) Ltd. Kolkata.
9. Sharma, P. D. Geology and Environment (10th edition). Rastogi Publications. Meerut.
10. Sharma, p. D. Environmental Biology and Toxxicology (10th edition) Rastogi Publications. Meerut. Odum, E. P. Ecology. Hoit Reinhart and Winston Inc.
11. Treatise on Plant Ecology. K. N. Bhatia and k. K. Sharma. (Recent edition) Pradeep Publications Jalaandhar.
12. Takhtajan, A. 1986. Diversity & Plant Distribution. Oliver & Boyd.

Course name: Economic Botany and Pharmacognosy

Course Code: BSCHBOTC402

Course Type: **Core**	Course Details: **CC-9**			L-T-P: **4-0-4**	
Credit: **6**	Full Marks: 100	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**10**	20	**40**

Course Learning Outcomes:

On completion of this course, the students will be able to:

- Understand core concepts of Economic Botany and relate with environment, populations, communities, and ecosystems
- Develop critical understanding on the evolution of concept of organization of apex new crops/varieties, importance of germplasm diversity, issues related to access and ownership
- Develop a basic knowledge of taxonomic diversity and important families of useful plants
- Increase the awareness and appreciation of plants & plant products encountered in everyday life.
- Appreciate the diversity of plants and the plant products in human use.
- To know about medicinal properties and uses of plants by folklore and ayurveda system.
- Ability of conserve rare and threatened plant species both in in-vivo and in-vitro conditions.

Economic Botany –

Unit I – Utilization of Plant Wealth (fibre and Sugar; Timber, oil, pulse and biofuel)

- Morphology, origin, extraction and uses of Cotton and Sugarcane.
- Morphological nature of the economically important parts and their uses of the following plant products: Sal (wood), Mustard (oil), Pegion Pea (Pulse) and *Jatropha curcas* (Biodiesel).

Unit II – Utilization of Plant (Essential oil)

- General account, sources, chemical nature, uses and extraction of following essential oils - Eucalyptus, lemon grass, citronella, cinnamom, chamomile, clove, and rose.

Unit III – Introduction to Pharmacognosy

- Introduction; definition of drugs, folk medicine, active principles; Pharmacy, Pharmacognosy, Pharmacopoeia,drug adulteration (sophistication) and drug evaluation.

Unit IV – Utilization of plant wealth (Drug yielding plants)

- Study of the following drug plants (Diagnostic features, active principles and uses): *Rauwolfia serpentina* (root), *Adhatoda vasica* (leaf), *Strychnos nuxvomica* (seed), *Catharanthus roseus* (Whole plant), *Taxus* sp. (bark).

Practical –

Economic Botany –

- T.S. of potato tuber to show localization of starch grains,
- Qualitative test for starch using either rice/potato,
- Identification of jute fibre through maceration technique,
- Qualitative test for lipid in crushed seeds of mustard,
- Whole mount of cotton seed to show lint and fuzz fibres.

Pharmacognosy –

- Organoleptic and microscopic examination of following plant drugs to be supplied fresh and powdered form – *Adhatoda vasica* (leaf), *Strychnos* (seed), Zinger (rhizome).

Suggested Readings

1. Agarwal, V. S. & Ghosh, B. 1985. Drug Plants of India: root drugs. Kalyani Publishers.
2. C. K. Kokate; A. P. Purohit; S. B. Pokhale. Pharmacognosy, NiraliPrakashani.
3. Eames, A. J. and Mc Daniels, L. H. An Introduction of Plant Anatomy. Tata Mc. Graw Hill Company Limited.
4. Kochhar S. L. Economic Botany in the Tropics, Sec edition, MacMillan India Ltd.
5. Prasad R. L. Essentuials of Eco Botany. Medtec publication.
6. Sanjeev Pandey, Advance Botany, Volume-1, 2nd Edn, Pub. Books and Allied (P) Ltd. Kolkata.
7. Singh Pandey and Jain. Economic Botany. Rastogi Publication.
8. Tayler, V. E. 1988. Pharmacognosy.

Course name: Agronomy

Course Code: BSCHBOTC403

Course Type: **Core**	Course Details: **CC-10**			L-T-P: **4-0-4**	
Credit: **6**	Full Marks: 100	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**10**	20	**40**

Course Learning Outcomes:

On the completion of the course the students will be able to:

- Understand the concept of agronomy and sustainable agriculture.
- Analyze different aspects diversified agriculture and farm enterprises, production technology of vegetation and flowers.
- Examine the implications integrated farming system along with production economics and farm management
- Evaluate the IT communication and diffusion of agricultural innovation

Unit I: Principles of crop production –

Definition and scope of Agronomy, Classification of Crops on Different basis, General principles of Crop production : Climate, soil and its preparation, seed and seed sowing, post-sowing tillage, water management, nutrition, plant protection measures, harvesting, threshing and storage, Agroforestry system, Agriculture, extension management.

Unit II Fundamentals of soil science

Definition of Soil, Components of Soil and their role in agriculture, Physical properties of soil, and their significance, Chemical properties of soil, cation and anion exchange phenomenon and their importance in agriculture.

Unit III Agricultural Metereology

Different meteorological variables related to agriculture, Rainfall- Hydrologic cycle and its components, Types and forms of precipitation, Humidity, definition, windvane, Anemo-meter, Indian Agro Climatic Zones Elementary idea of weather forecasting, etc.

Unit III Agricultural management and cultivation of some important crops –

Soil and water management, Integrated pest management, Post-harvest technology and value addition, Production economics and farm management; Manures, Fertilizers, Agrochemicals and Weed management,

Cultivation and processing of the following crops: Rice, Wheat, Tea and Jute.

Practical

- Identification of soil types, soil texture, soil moisture, soil pH, Soil conductivity, organic and inorganic matter (C, NPK estimation by test kit).

- Identification of major soil fauna (particularly nematodes)
- Vermiculture and vermicomposting/ vermiwash (Visit a vermiculture farm or develop in the departmental farm house)
- Determination of seed viability by TTC test.

Suggested Readings

1. Craig C. Sheaffer and Kristine M. Moncada (2012). Introduction to Agronomy-Food crops and Environment (Second Edition).
2. George Acquaah (2004). Principles of Crop production.
3. Reddy S.R. (2017). Principles of Agronomy.

Semester – V

Course name: Plant Physiology and Metabolism

Course Code: BSCHBOTC501

Course Type: **Core**	Course Details: **CC-11**			L-T-P: **4-0-4**	
Credit: **6**	Full Marks: 100	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**10**	20	**40**

Course Learning Outcomes:

On completion of this course, the students will be able to;

- Understand Water relation of plants with respect to various physiological processes.
- Explain chemical properties and deficiency symptoms in plants
- Classify aerobic and anaerobic respiration
- Explain the significance of Photosynthesis and respiration
- Assess dormancy and germination in plants
- Students acquire the adequate knowledge of metabolism in plants.
- Explain the ATP-Synthesis
- To acquire adequate knowledge about translocation in plants, carbon dioxide concentrating mechanisms, growth regulators and flowering of plants.

Unit I: Water Potential and Other Potential Physiological Aspect of Plant

- Water Potential and its components, water absorption by roots, aquaporins, pathway of water movement, symplast, apoplast, transmembrane pathways, root pressure, guttation. Ascent of

sap–theories on Ascent of sap. Transpiration and factors affecting transpiration, antitranspirants; mechanism of stomatal movement – K^+-H^+ antiport theory, role of CO_2, sucrose and ABA and blue light response.

- Essential and beneficial elements; Macro and micronutrients; Hydroponics; Criteria for essentiality of elements; Mineral deficiency symptoms and roles of essential elements; Heavy metal toxicity on plants; Phytoremediation (basic concept).
- Soil as a nutrient reservoir, transport of ions across cell membrane, passive absorption and active absorption of ions, carrier mediated transport, uniport, co-transport, symport, antiport; Nernst equation.
- Experimental evidence in support of phloem as the site of sugar translocation; Source–sink relationship; Phloem loading and unloading, Pressure–Flow Model.

Unit II: Photosynthesis and Photorespiration

Photosynthesis: Definition, photosynthetic pigments, basic concept about mechanism of light-dependent and light independent reactions; C 3 -, C4 - and CAM pathways of CO_2 fixation; Photorespiration - definition, sites, mechanism and significance

Unit IV: Phytochrome, Phytohormone and Plant Cycle

- Definition and types, bioassay (auxin only), Chemical nature and physiological roles of: Auxin, Gibberellins, Cytokinin, Abscisic acid, Ethylene. General account of cell signaling and secondary messenger (cAMP and Calmodulin).
- Photoperiodism, flowering stimulus, physicochemical nature of phytochrome, role of phytochromes in flowering, florigen concept, vernalization;
- Seed germination - different phases of seed germination, seed dormancy (types, significance and breaking of seed dormancy).

Unit II: Metabolism

- Carbon Metabolism – Respiration, Respiratory quotient (RQ), Glycolysis, oxidative decarboxylation, Krebs cycle, electron transport system, oxidative phosphorylation and chemiosmotic system, Glyoxylate cycle, Gluconeogenesis.
- Nitrogen metabolism - nitrate assimilation, nitrogen fixing organisms (free living, symbiotic and associative diazotrophs), Mechanism of nitrogen fixation – both asymbiotic and symbiotic. Mechanism of nodule formation and concept of nod and nif genes. GS-GOGAT pathway for ammonia assimilation. Definition and examples of transamination, deamination and decarboxylation reactions of amino acids.
- Lipid Metabolism – β-oxidation of even carbon fatty acids (Palmitic acid).

Practical

Plant Physiology –

- Determination of osmotic potential of plant cell sap by plasmolytic method (using *Rhoeo* epidermal peel).
- Determination of amount of water absorption, retention and transpiration.
- Study of the effect of humidity and light on the rate of transpiration in excised twig/leaf.
- Study the effect of KNO_3 on stomatal opening.
- Determination of the effect of CO_2 concentration on the rate of photosynthesis using molar solution of bicarbonate and by measurement of volume of O_2 liberation.

Plant Metabolism

- Quantitative test – Quantitative estimation of sugar in an unknown sample with the help of known standards (DNS method); Quantitative estimation of protein in an unknown sample with the help of known standards (Lowry test); Concentration should be determined by plotting standard curve.
- Determination of respiratory substrate of germinating seeds of a carbohydrate, protein and oil rich seed by RQ method
- Determination of rate of respiration in different plant parts.

Suggested Readings

1. Conn, E. E. Stumpt, P. K. Bruening, G. and Doi, R. H Cutline of Biochemistry, John Wiley & Sons
2. Ghosh and Mukherjee. Plant Physiology. NCBA
3. Hopkins, W. G. – An Introduction to Plant Physiology, John Wiley & Sons Inc.
4. Lehninger, A. L.; Nelson, D. L. and Cox, M. M. – Principles of Biochemistry. Worth Publishers.
5. Morh, H. Schopfer, P. – Plant Physiology Springer Verlag.
6. Sanjeev Pandey, Advance Botany, Volume-1, 2nd Edn, Pub. Books and Allied (P) Ltd. Kolkata.
7. Salisbury, F. B. and Ross, C. W. – Plant Physiology. Wordsworth Publishing Company.
8. Srivastava, H. S. 1999.plant Physiology, Rastogi Publicaation, Meerut.
9. Stryer, L. – Biochemistry, John Wiley & Sons 4. Sarkar &Rakshit – Organic Chemistry.
10. Taiz, L. and Zeiger, E. – Plant Physiology. The Benjamin Cumming Publishing Company.
11. V. K. Jain. Fundamentals of Plant Physiology, S Chand Pub.

Course name: Cytology and Genetics

Course Code: BSCHBOTC501

Course Type: **Core**	Course Details: **CC-12**			L-T-P: **4-0-4**	
Credit: **6**	Full Marks: 100	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**10**	20	**40**

Course Learning Outcomes:

On completion of this course, the students will be able to:

- Have conceptual understanding of laws of inheritance, genetic basis of loci and alleles and their linkage.
- Comprehend the effect of chromosomal abnormalities in numerical as well as structural changes leading to genetic disorders.
- Develop critical understanding of chemical basis of genes and their interactions at population and evolutionary levels.
- Analyze the effect of mutations on gene functions and dosage.
- Examine the structure, function and replication of DNA.

Unit I: Principles of genetics and Biology of Inheritance

Mendelism: History; Mendel's Laws of inheritance; Chromosome theory of inheritance and linkage; Incomplete dominance and codominance; Interaction of Genes; Multiple alleles, Lethal alleles, Epistasis, Pleiotropy, Recessive and Dominant traits, Penetrance and Expressivity, Mendellian segregation and gene interaction: Numericals; Polygenic inheritance; Mitosis and Meiosis in plants, animal and human; Cell cycle and cell division.

Cell cycle, Role of Cyclins and Cdks, Cell cycle regulation (Checkpoints).

Unit II: Extra-nuclear Inheritance, Linkage, crossing over and chromosome mapping

Determining non-Mendelian Inheritance; Maternal effects and cytoplasmic inheritance; Chloroplast mutation: Variegation in Four O'clock plant; Mitochondrial mutations in yeast; Maternal effects-shell coiling in snail; Infective heredity- Kappa particles in *Paramecium.* Linkage and crossing over; Cytological basis of crossing over; Recombination frequency, two factor and three factor crosses; Interference and coincidence; Linkage and Gene mapping, and numericals based on gene mapping;

Unit III: Variation in Chromosome Number and Structure, Mutations

Chromosome morphology and Karyotype concept, Deletion, Duplication, Inversion, Translocation, Position effect; Euploidy, Aneuploidy and Amphiploidy and their implications, FISH and GISH in chromosome and genome identification. Types of mutations;

Molecular basis of Mutations; Induction of mutations and Mutagens – physical and chemical (Base analogs, deaminating, alkylating and intercalating agents); Detection of mutations: CLB method. Role of Transposons in mutation. DNA repair mechanisms.

Unit IV: Fine Structure of Gene, Gene Interaction, Population and Evolutionary Genetic

Evolution of Gene Concept - Classical vs molecular concepts of gene : One gene one character; One gene-one enzyme, one gene-one polypeptide hypothesis and beyond; Cistrans complementation test for functional allelism and gene as unit of function, mutation and recombination, non-coding RNA. Concept of sex determination and Sex chromosomes; Patterns of Sex determination in plants and animals (human, Drosophila and other animals); Sex-linked, sex-limited and sex-influenced characters; Dosage compensation. Allele frequencies, Genotype frequencies, Hardy-Weinberg Law, role of natural selection, mutation, genetic drift. Genetic variation and Speciation.

Practical

1. Study of Mitotic cell division and chromosome complements in *Allium cepa* root tips by aceto-orcein squash technique.
2. Study of Meiotic divisions in *Allium cepa* or *Rhoeo spathacea*/*R. discolor* by aceto-carmine staining technique. Determination of chiasma frequency in these plants.
3. Laboratory exercises in probability (coin tossing and dice throwing) and testing goodness of fit of Mendellian ratio by chi-square test.
4. Chromosome mapping using point test cross data.
5. Pedigree analysis for dominant and recessive autosomal and sex linked traits.
6. Incomplete dominance and gene interaction through seed ratios (9:7, 9:6:1, 13:3, 15:1, 12:3:1, 9:3:4).
7. Blood Typing: ABO groups & Rh factor (Only blood transfusion compatibility from chart)
8. Study of aneuploidy: Down's, Klinefelter's and Turner's syndromes (From photograph).
9. Photographs/Permanent Slides showing Translocation Ring, Laggards and Inversion Bridge.
10. Study of human genetic traits: Sickle cell anemia, Xeroderma Pigmentosum, Albinism, red-green Color blindness, Widow's peak, Rolling of tongue, Hitchhiker's thumb and Attached earlobe.

Suggested Readings

1. Cooper, G.M. and Hausman, R.E. (2009) The Cell: A Molecular Approach. 5th edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.
2. Genes – XI (Lewin)
3. 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.
4. Gardner, E.J., Simmons, M.J., Snustad, D.P. (1991). Principles of Genetics, John Wiley & sons, India. 8th edition.
5. Hardin, J., Becker, G., Skliensmith, L.J. (2012). Becker's World of the Cell, Pearson Education Inc. U.S.A. 8th edition.

6. Karp, G. (2010). Cell Biology, John Wiley & Sons, U.S.A. 6th edition.
7. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. Benjamin Cummings, U.S.A. 9th edition.
8. Molecular Biology of the Cell – Bruce Albert
9. Molecular Biology of the Gene – Watson
10. Piter J. Russell: I-Genetics: A Molecular Approach. 3rd edition.
11. Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics, John Wiley & Sons Inc., India. 5th edition.

Semester – VI

Course name: Molecular Biology

Course Code: BSCHBOTC601

Course Type: **Core**	Course Details: **CC-13**			L-T-P: **4-0-4**	
Credit: **6**	Full Marks: 100	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**10**	20	**40**

Course Learning Outcomes:

On completion of this course, the students will be able to;

- Analyse the structures and chemical properties of DNA and RNA through various historic experiments.
- Differentiate the main types of prokaryotes through their grouping abilities and their characteristic
- Evaluate the experiments establishing central dogma and genetic code.
- Gain an understanding of various steps in transcription, protein synthesis and protein modification.

Unit I: Nucleic Acids: Carriers of Genetic Information and Structure

Historical perspective; DNA as the carrier of genetic information (Griffith's, Hershey & Chase, Avery, McLeod & McCarty, Fraenkel-Conrat's experiments). DNA Structure: Miescher to Watson and Crick-historic perspective, DNA structure, Salient features of double helix, Types of DNA, Types of genetic material, denaturation and renaturation, cot curves; Organization of DNA- Prokaryotes, Viruses, Eukaryotes. RNA Structure Organelle DNA -- mitochondria and chloroplast DNA. The Nucleosome Chromatin structure- Euchromatin, Heterochromatin- Constitutive and Facultative heterochromatin.

Unit II: Central dogma and The replication of DNA

Chemistry of DNA synthesis (Kornberg's discovery); General principles – bidirectional, semi-conservative and semi discontinuous replication, RNA priming; Various models of DNA replication, including rolling circle, θ (theta) mode of replication, replication of linear ds-DNA, replication of the 5'end of linear chromosome; Enzymes involved in DNA replication. DNA proofreading. Key experiments establishing-The Central Dogma (Adaptor hypothesis and discovery of mRNA template), Central Dogma Reverse (RNA viruses etc.),

Unit III: Genetic code and transcription

Genetic code (deciphering & salient features) and wobble hypothesis. Transcription in prokaryotes and eukaryotes. Principles of transcriptional regulation; Concept of operon Prokaryotes: lac operon. Regulation of lactose metabolism and tryptophan synthesis in *E.coli.* Eukaryotes: transcription factors, heat shock proteins, steroids and peptide hormones; Gene silencing.

Unit IV: Processing and modification of RNA and translation

Split genes-concept of introns and exons, removal of introns, spliceosome machinery, splicing pathways, group I and group II intron splicing, alternative splicing eukaryotic mRNA processing(5' cap, 3' polyA tail); Ribozymes; RNA editing and mRNA transport.

Translation: Ribosome structure and assembly, mRNA; Charging of tRNA, aminoacyl tRNA synthetases; Various steps in protein synthesis, proteins involved in initiation, elongation and termination of polypeptides; Fidelity of translation; Inhibitors of protein synthesis; Post-translational modifications of proteins, Protein targeting.

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 (Messelson and Stahl's, Avery et al, Griffith's, Hershey & Chase's and Fraenkel & Conrat's experiments)
8. Study of the following through photographs: Assembly of Spliceosome machinery; Splicing mechanism in group I & group II introns; Ribozyme and Alternative Splicing.

Suggested Readings

1. 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.
2. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. Benjamin Cummings. U.S.A. 9th edition.
3. Russell, P. J. (2010). i-Genetics- A Molecular Approach. Benjamin Cummings, U.S.A. 3rd edition.
4. Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics. John Wiley and Sons Inc., U.S.A. 5th edition.
5. 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.

Course name: Plant Biotechnology and Genetic Engineering Course Code: BSCHBOTC602

Course Type: **Core**	Course Details: **CC-14**			L-T-P: **4-0-4**	
Credit: **6**	Full Marks: 100	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**10**	20	**40**

Course Learning Outcomes:

On the completion of the course the students will be able to

- Understand the core concepts and fundamentals of plant biotechnology and genetic engineering
- Develop their competency on different types of plant tissue culture
- Analyze the enzymes and vectors for genetic manipulations
- Examine gene cloning and evaluate different methods of gene transfer
- Critically analyze the major concerns and applications of transgenic technology
- To learn about gene cloning, recombinant DNA technology and bioinformatics includes recent biotechnological advancement related to genomics and proteomics.
- Acquire the knowledge about gene transfer and applications of biotechnology.
- Acquire the knowledge about tissue culture techniques, restriction digestion, isolation and electrophoresis of plasmid DNA.

Unit I: Plant Tissue Culture

Historical perspective; Formulation of nutrient media; Sterilization, role of vitamins and hormones; Totipotency; Organogenesis; Embryogenesis (somatic and zygotic); Organ culture, Embryo culture, Anther and triploid culture, Callus culture, Protoplast isolation, culture and fusion; Tissue culture applications including micropropagation, androgenesis, production of virus free plants, secondary metabolite production, haploids, triploids and hybrids and germplasm conservation, Cryopreservation and usages.

Unit II: Enzymes and Vectors for Genetic Manipulations

Restriction Endonucleases (History, Types I-IV and subtypes of II, Structures, biological role, Mechanism, and usages in cloning); Restriction Mapping (Linear and Circular); Ligases enzymes, Cloning Vectors: History, basic sequences of any vector, types of bacterial vectors (pUC18 and pUC19, pBR322, Ti plasmid, BAC); Yeast vector, viral vectors including Lambda phage, M13 phagemid, Cosmid, Shuttle vector; Eukaryotic Vectors (YAC).

Unit III: Gene Cloning and Methods of Gene Transfer

Basic concept of Gene cloning, advantages of gene cloning, Bacterial Transformation methods and selection of recombinant clones using various strategies, PCR- mediated gene cloning; Gene Construct; Plant transformation vector, T-DNA and viral vector, *Agrobacterium*-mediated Transformation protocols, molecular mechanism of T-DNA transfer, direct gene transfer method by Electroporation, Microinjection, Microprojectile bombardment ;Selection of transgenics– selectable marker and reporter genes (Luciferase, GUS, GFP), chloroplast transformation, transgene analysis, Mutant formation, Maker-free and novel selection strategies.

Unit IV: Major Concerns and Applications of Transgenic Technology

Transgenic technology and sustainable agriculture, Biosafety concerns with transgenic technology, History of transgenic development across the world, Major concerns with implementation of transgenic technology in India. Applications as Pest resistant (Bt-cotton); herbicide resistant plants (RoundUp Ready soybean); Transgenic crops with improved quality traits in major crops (Flavr Savr tomato, Golden rice); Improved horticultural varieties (Moondust carnations); Role of transgenics in bioremediation (Superbug)

Practical

- Preparation of liquid and solid MS medium.
- Demonstration of *in vitro* sterilization of seeds and germination in MS media containing petriplates.
- *in vitro* selection and inoculation methods using leaf and nodal explants of tobacco, *Datura*, *Brassica* etc.
- Callus formation in tobacco and rice using MS medium containing phytohormones.
- Study of anther, embryo and endosperm culture, micropropagation, somatic embryogenesis & artificial seeds through photographs.
- Isolation of protoplasts and protoplast culture using photographs
- Construction of restriction map of circular and linear DNA from the data provided.
- Study of methods of gene transfer through photographs: Agrobacterium-mediated,
- direct gene transfer by electroporation, microinjection, microprojectile bombardment.
- Study of steps of genetic engineering for production of Bt cotton, Golden rice, Flavr Savr tomato through photographs.
- Isolation of plasmid DNA.
- Restriction digestion and gel electrophoresis of plasmid DNA.

Suggested Readings

1. Brown T.A. (2010). Gene Cloning & DNA Analysis, An Introduction, 6th edition, Wiley-Blackwell.
2. Bhojwani, S.S. and Razdan, M.K., (1996). Plant Tissue Culture: Theory and Practice. Elsevier Science Amsterdam. The Netherlands.

3. Bhojwani, S.S. and Bhatnagar, S.P. (2011). The Embryology of Angiosperms. Vikas Publication House Pvt. Ltd., New Delhi. 5th edition.
4. Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington.
5. Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics. John Wiley and Sons, U.K.
6. Stewart, C.N. Jr. (2008). Plant Biotechnology & Genetics: Principles, Techniques and Applications. John Wiley & Sons Inc. U.S.A.

Discipline Specific Elective Course

Semester - V

Course Name: Analytical Techniques in Plant Sciences

Course Code: BSCHBOTDSE501

Course Type: **Core**	Course Details: **DSE-501**			L-T-P: **4-0-4**	
Credit: **6**	Full Marks: 100	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**10**	20	**40**

Course Learning Outcomes:

On completion of this course the students will be able to:

- Develop conceptual understanding of cell wall degradation enzymes and cell fractionation.
- Classify different types of chromatography techniques.
- Explain the principles of Light microscopy, compound microscopy, Fluorescence microscopy and confocal microscopy
- Apply suitable strategies in data collections and disseminating research findings.

Unit I: Cellular Fractionation and Separation Techniques

Good laboratory practices, Cell fractionation, Sedimentation of cellular particles, type of centrifugation: Differential and density gradient centrifugation, type of rotors, Svedberg equation, Ultracentrifugation and applications

Unit II: Characterization of Biomolecules

Principle; Paper chromatography; Column chromatography, TLC, GLC, HPLC, Ion exchange chromatography; Molecular sieve chromatography; Affinity chromatography.

Electrophoresis: AGE, PAGE, SDS-PAGE

Unit III: Visualization Molecules in Living Cells

Principles of microscopy; Light microscopy; compound microscopy, Fluorescence microscopy; Confocal microscopy; Use of fluorochromes. (a) Flow cytometry (FACS); (b) Applications of fluorescence microscopy: Chromosome banding, FISH, chromosome painting; (c) Transmission and Scanning electron microscopy – sample preparation for electron microscopy, cryofixation, negative staining, shadow casting, freeze fracture, freeze etching.

Unit IV: Radiobiology, Colorimetry and Spectroscopy

Use of radioisotopes in biological research, auto-radiography, pulse chase experiment, Autoradiography.

Basic principles of Colorimetry and Spectrophotometry (Beer-Lambert Law), Instrumentation, Comparison between Colorimeter and Spectrophotometer, application of Colorimeter and Spectrophotometer in biological research.

Practical

1. 1. Separation of amino acids by Course chromatography and identification of unknown sample.
2. Preparation of permanent slides (double staining) for microscopic studies of any plant tissue.
3. Demonstration of some Instruments: Centrifuge, Colorimeter/Spectrophotometer and Electrophoresis.

Suggested Readings

1. Plummer, D.T. (1996). An Introduction to Practical Biochemistry. 3rd edition. Tata McGraw-Hill Publishing Co. Ltd. New Delhi.

2. Ruzin, S.E. (1999). Plant Microtechnique and Microscopy, Oxford University Press, New York. U.S.A.

3. Ausubel, F., Brent, R., Kingston, R. E., Moore, D.D., Seidman, J.G., Smith, J.A., Struhl, K. (1995). Short Protocols in Molecular Biology. 3rd edition.

4. John Wiley & Sons.

5. Zar, J.H. (2012). Biostatistical Analysis. 4th edition. Pearson Publication. U.S.A.

Course Name: Bioinformatics

Course Code: BSCHBOTDSE502

Course Type: **Core**	Course Details: **DSE-502**			L-T-P: **4-0-4**	
Credit: **6**	Full Marks: 100	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical

		30	**10**	20	**40**

Course Learning Outcomes:

On completion of this course the students will be able to:

- Understand the concept of databases and use of different public domain for DNA and proteins sequence retrieval.
- Understand the concept of pairwise alignment of DNA sequences using algorithms.
- Explain the structure of proteins homology modeling approach using SWISS MODEL and SWISS-PDB.
- Reflect upon the role of various models in molecular evolution.
- Analyze the role of (QSAR) techniques in Drug Design.

Unit I - Introduction

Introduction to bioinformatics, over view and exploring and querying (search and retrieval) available bioinformatics resources NCBI, PUBMED, EBI, EMBL, gene bank etc.

Unit II – Homology Search and Pair-wise and Multiple Alignment

Pair wise alignment of protein and DNA sequences using algorithm software to deduce homology and interpretation of data. Database searches for homology using BLAST and FASTA and interpretation of the results to derive biological significance of the queried DNA/protein sequences.

Unit III – Protein Structure Prediction and Phylogenetic analyses

Prediction of structure of proteins by homology modeling approach using SWISSMODEL and SWISS-PDB. Models of molecular Evolution, Selection of best-fitting models, Methods of Phylogeny reconstruction: Phenetic vs. Cladistic, Neighbor Joining, UPGMA, Maximum Parsimony, Maximum Likelihood, Bayesian Inference, Software for Phylogenetic Analyses, Consistency of Molecular Phylogenetic Prediction.

Unit IV – Molecular Docking and Drug Design

Structural Bioinformatics in Drug Discovery, Quantitative structure-activity relationship (QSAR) techniques in Drug Design, Microbial genome applications, Crop improvement.

Practical

(Every topic can have multiple practical, a few for general guidance is given below)

1. Nucleic acid and protein databases.
2. Sequence retrieval from databases.
3. Sequence alignment.
4. Sequence homology and Gene annotation.
5. Construction of phylogenetic tree.

6. Brief idea about Molecular docking (Autodock-Vina)

Suggested Readings

1. Arthur M. Lesk. (2003). Introduction to Bioinformatics, Oxford University Press, Indian edition.
2. Des Higgins and Willie Taylor. (2000). Bioinformatics, Sequence, structure and databanks. A practical approach. Oxford University Press, Indian edition, Second impression, New Delhi.
3. Imtiaz Alam Khan. (2005). Elementary bioinformatics. Pharma Book Syndicate, Hyderabad.
4. Irfan Ali Khan and Attiya Khanum (eds.). (2005). Basic concepts of Bioinformatics, Ukaaz Publications, Hyderabad.
5. Irfan Ali Khan and Attiya Khanum (eds.). (2004). Introductory Bioinformatics. Ukaaz Publications, Hyderabad.
6. Krane Dan, E. and Raymer M.L. (2004). Fundamental concepts of Bioinformatics. Pearson education. New Delhi. Second Indian reprint.
7. Rastogi, S.C., Mediratta, N. and Rastogi. P. (2004). Bioinformatics, methods and applications, genomics, proteomics and drug discovery, Prentice hall of India, pvt. Ltd., New Delhi.
8. Baxevanis, A. D. and Ouellettee, B. F. F. (2002). Bioinformatics: A Practical Guide to the analysis of Genes and Proteins. (2nd Ed.), New York, John Wiley & Sons, Inc. Publications.
9. Attwood, T. K. and Parry-Smith, D. J. (2001). Introduction to Bioinformatics Delhi. Pearson Education (Singapore) Ptd. Ltd.

Course Name: Stress Biology

Course Code: BSCHBOTDSE503

Course Type: **Core**	Course Details: **DSE-503**		L-T-P: **4-0-4**
		CA Marks	ESE Marks

Credit: **6**	Full Marks: 100	Practical	Theoretical	Practical	Theoretical
		30	**10**	20	**40**

Course Learning Outcomes:

On completion of this course, students will be able to:

- Develop the understanding of concept of stress, stress factors and resistance mechanisms.
- Explain different types of stress with examples.
- Develop the ability for critical appraisal of various physiological mechanisms that protect the plant from environmental stress i.e. adaptation, avoidance and tolerance.
- Analyze the role of production and scavenging mechanisms

Unit I: Defining Plant Stress

Stress and stress factors, Resistance Mechanisms; Tolerance, Acclimation and avoidance.

Unit II: Abiotic and Biotic Stress Factors

Water stress; Salinity stress, High light stress; Temperature stress; Hypersensitive reaction; Pathogenesis– related (PR) proteins; Systemic acquired resistance; Mediation of insect and disease resistance by jasmonates. Signal transduction and various mechanisms of acquiring resistance.

Unit III: Stress Sensing Mechanisms in Plants

Signalling: Hormonal, Calcium modulation, Phospholipid signaling.

Unit IV: Developmental and Physiological Mechanisms that Protect Plants Against Environmental Stress

Adaptation in plants; Changes in root:shoot ratio; Aerenchynma development; Osmotic adjustment; Compatible solute production. **Reactive oxygen species:** Production and scavenging mechanisms of ROS. LEA (Late Embryogenesis Abundant Protein) in Abiotic Stress.

Practical

1. Determination of osmotic potential (*Rhaoeo* leaf epidermal peelings) and RWC (Relative water content) in Leaves (any plant).
2. Detection of stress related compatible solutes viz. proline by colorimeter/spectrophotometric method in a plant under salinity stress.
3. Measurement of root:shoot ratio, and total wet weight of a plant under salt/drought stress
4. Effect of salt/temperature stress on seed viability and germination.

Suggested Readings

1. Hopkins, W.G. and Huner, A. (2008). Introduction to Plant Physiology. 4th edition.John Wiley and Sons. U.S.A.
2. Taiz, L., Zeiger, E., MØller, I.M. and Murphy, A (2015). Plant Physiology and Development. 6th edition. Sinauer Associates Inc. USA.
3. Singh D.P. (2003).Stress Physiology. New Age International pvt. Ltd.

Course Name: Plant Breeding

Course Code: BSCHBOTDSE504

Course Type: **Core**	Course Details: **DSE-504**			L-T-P: **4-0-4**	
Credit: **6**	Full Marks: 100	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**10**	20	**40**

Course Learning Outcomes:

On completion of this course students will be able to:

- Develop conceptual understanding of plant genetic resources, plant breeding, gene bank and gene pool.
- Familiarize with genetic basis of heterosis.
- Classify Sexual and Asexual modes of reproduction.
- Explain monogenic and polygenic inheritance
- Reflect upon the role of various non- conventional methods used in crop improvement.

Unit I: General Introduction

Introduction, aims and objectives of plant breeding; Plant introduction, acclimatization and domestication.

Unit II: Methods of crop improvement

Selection methods: For self pollinated, cross pollinated and vegetatively propagated plants; Hybridization: For self, cross and vegetatively propagated plants – Procedure, advantages and limitations.

Unit III: Quantitative inheritance

Concept, mechanism, examples of inheritance of Kernel colour in wheat, Skin colour in human beings.Monogenic vs polygenic Inheritance.

Unit IV: Inbreeding depression, heterosis and Crop Improvement

History, genetic basis of inbreeding depression and heterosis; Applications.

Role of mutations (Radiation and CRIPSR technology); Polyploidy; Distant hybridization and role of biotechnology in crop improvement

Practical

1. Calculation of central tendency – mean, mode and median of a data obtained from natural population.
2. Normal distributon curve using a continuous variation (Data May be provided).
3. Chi square test of goodness of fit for Mendelian ratios.
4. Demonstration of Breeder's kit.

Suggested Readings

1. Chaudhari, H.K. (1984). Elementary Principles of Plant Breeding. Oxford – IBH. 2ndedition.

2. Das, L.D. Vijendra (2006) Plant Breeding. New Age International Publishers, New Delhi.

3. Sharma, J.R.(1994) : Principles and practices of Plant Breeding. Tata McGraw-Hill Publishing Company Ltd. , New Delhi

4. Singh, B.D. (2012). Plant Breeding: Principles and Methods. Kalyani Publishers. 9thedition.

5. Singh, Phundan (1996): Essentials of Plant Breeding. Kalyani Publishers, New Delhi-2.

Semester - VI

Course Name: Research Methodology

Course Code: BSCHBOTDSE601

Course Type: **Core**	Course Details: **DSE-601**		L-T-P: **4-0-4**
		CA Marks	ESE Marks

Credit: **6**	Full Marks: 100	Practical	Theoretical	Practical	Theoretical
		30	**10**	20	**40**

Course Learning Outcomes:

At the end of the course the students will be able to,

- Understand the concept of research and different types of research in the context of biology
- Develop laboratory experiment related skills.
- Develop competence on data collection and process of scientific documentation
- Analyze the ethical aspects of research
- Evaluate the different methods of scientific writing and reporting

Unit I: Basic Concepts of Research

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

Unit II: Data Collection and Documentation of Observations

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

Unit III: Overview of Biological Problems

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

Unit IV: Ethics and Good Practical's and Art of Scientific Writing

Authors, acknowledgements, reproducibility, plagiarism, Numbers, units, abbreviations and nomenclature used in scientific writing. Writing references. Power-point presentation. Poster presentation. Scientific writing and ethics, Introduction to copyright-academic misconduct/plagiarism.

Practical

- The art of imaging of samples through microphotography and field photography.
- Poster presentation on defined topics.
- Technical writing on topics assigned.
- Difference between Research Article, Review, Monograpgs etc.
- Curation of relevant scientific literature from Google Scholar

Suggested Readings

1. Dawson, C. (2002). Practical research methods. UBS Publishers, New Delhi.

2. Stapleton, P., Yondeowei, A., Mukanyange, J., Houten, H. (1995). Scientific writing for agricultural research scientists – a training reference manual. West Africa Rice Development Association, Hong Kong.

3. Ruzin, S. E. (1999). Plant microtechnique and microscopy. Oxford University Press, New York, U.S.A.

Course Name: Biostatistics

Course Code: BSCHBOTDSE602

Course Type: **Core**	Course Details: **DSE-602**			L-T-P: **4-0-4**	
Credit: **6**	Full Marks: 100	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**10**	20	**40**

Course Learning Outcomes:

At the end of the course the students will be able to,

- Comprehend the fundamental concepts related to descriptive and inferential biostatistics.
- Develop skills in data tabulation, its treatment, analysis, interpretation and graphical representation of data.
- Analyze the implications of inferential statistics in biology.
- Develop their competence in hypothesis testing and interpretation.

Unit I: Biostatistics

History of the field and connection with population genetics, levels of measurements, types of variables, precision vs accuracy.

Unit II: Data Summarization and Visualization

Types of variables, frequency tabulations (EFD, ERFD, ECD), various types of charts, error bars, scatterplots.

Unit III: Descriptive Statistics

Mean, median, mode, geometric mean - merits & demerits. Measures of dispersion - range, standard deviation, mean deviation, quartile deviation - merits and demerits; Co- efficient of variations.

Unit IV: Correlation, Regression and Statistical inference

Types of correlation, regression, simple regression equation, fitting prediction, similarities and dissimilarities of correlation and regression. Hypothesis testing and P values, Confidence Intervals, Student 't' test, chi square test, ANOVA.

Practical

1) Calculation of mean, standard deviation and standard error mean
2) Calculation of correlation coefficient and regression values.
3) Interpretation of a continuous variation by a binomial curve with a given value of mean and standard deviation.

[All Calculations and practical can be done using MS-excel]

Suggested Readings

1. Danniel, W.W.(1987). Biostatistics, New York, John Wiley Sons.
2. Sundarrao, P.S.S and Richards, J. Christian. An introduction to Biostatistics, 3rd edition. Medical College, Vellore
3. Selvin, S. (1991). Statistical Analysis of epidemiological data New York University Press
4. Campbell, R.C. (1998). Statistics for Biologists, Cambridge University Press.

Course Name: Natural Resource Management

Course Code: BSCHBOTDSE603

Course Type: **Core**	Course Details: **DSE-603**			L-T-P: **4-0-4**	
Credit: **6**	Full Marks: 100	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical

		30	**10**	20	**40**

Course Learning Outcomes:

At the end of the course the students will be able to,

- Understand the concept of different natural resources and their utilization.
- Critically analyze the sustainable utilization land, water, forest and energy resources.
- Evaluate the management strategies of different natural resources.
- Reflect upon the different national and international efforts in resource management and their conservation

Unit I: Natural Resources and Sustainable Utilization

Definition and types, concept, approaches (economic, ecological and socio-cultural) for sustainable utilization.

Unit II: Land, Water and Biological Resources

Utilization (agricultural, pastoral, horticultural, silvicultural); Soil degradation and management. Fresh water (rivers, lakes, groundwater, aquifers, watershed); Marine; Estuarine; Wetlands; Threats and management strategies. Biodiversity-definition and types; Significance; Threats; Management strategies; Bio- prospecting; IPR; Convention on Biological Diversity (CBD); National Biodiversity Action Plan).

Unit III: Forests and Energy

Definition, Cover and its significance (with special reference to India); Major and minor forest products; Depletion; Management. Renewable and non-renewable sources of energy

Unit IV: Contemporary Practices in Resource Management

EIA, GIS, Participatory Resource Appraisal, Ecological Footprint with emphasis on carbon footprint, Resource Accounting; Waste management. National and international efforts in resource management and conservation

Practical

1. Estimation of solid waste generated by a domestic system (biodegradable and nonbiodegradable) and its impact on land degradation.
2. Collection of data on forest cover of specific area (Using Satellite image).
3. Measurement of dominance of woody species by DBH (diameter at breast height) method.
4. Calculation and analysis of ecological footprint.

5. Ecological modelling (Theoretical idea).

Suggested Readings

1. Vasudevan, N. (2006). Essentials of Environmental Science. Narosa Publishing House, New Delhi.

2. Singh, J. S., Singh, S.P. and Gupta, S. (2006). Ecology, Environment and Resource Conservation. Anamaya Publications, New Delhi.

3. Rogers, P.P., Jalal, K.F. and Boyd, J.A. (2008). An Introduction to Sustainable Development. Prentice Hall of India Private Limited, New Delhi.

4. United States Government Accountability Office (2008) Natural Resource Management. Nova Science Publishers Inc, 10th Edition

5. Stacy Keach (2016) Natural Resources Management. Syrawood Publishing House

6. Rathor, V.S. and Rathor B. S. (2013) Management of Natural Resource for Sustainable Development. Daya Publishing House, New Delhi

Course Name: Horticultural Post-harvest

Course Code: BSCHBOTDSE604

Course Type: **Core**	Course Details: **DSE-604**		L-T-P: **4-0-4**	
Credit: **6**	Full Marks: 100	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**10**	20	**40**

Course Learning Outcomes:

At the end of the course the students will be able to,

- Understand the concept of different types of horticultural practices for value addition
- Visualize the post-harvest problems likely to be confronted
- Know the tricks of the trade and how to increase the longevity of the produce

Unit I: Horticultural Crops - Conservation and Management

- Scope and importance, Branches of horticulture; Role in rural economy. and employment generation; Importance in food and nutritional security; urban horticulture and ecotourism.

Unit II: Horticultural Practices

Types, classification (annuals, perennials, climbers and trees); Propagation Methods: asexual (grafting, cutting, layering, budding), sexual (seed propagation), Bonsai Production;

Unit III– Ornamental plants, fruits and vegetables, Medicinal and Aromatic plants

- Identification and salient features of some ornamental plants [rose, marigold, tuberose], Ornamental flowering trees (Gulmohar, Lagerstroemia and areca palms).
- Description of plants and their economic products; Management and marketing of vegetable (Potato and Brinjal) and fruit crops (Mango and Banana).
- Cultivation, processing and marketing of products of major medicinal plants (Senna, Ashwagandga, Amla, Vetiver, Aloe vera).

Unit IV: Post-harvest Technology

- Importance and overview of post -harvest handling; Principles and methods of preservation and processing : Methods of minimizing loses during storage and transportation; Harvesting and handling of fruits, cut flowers, vegetables, herbs, storage tissues and organs.
- Food processing: canning, fruit juice beverages, pickles, jam, jellies, candies, Food additives, labeling; Food irradiation and food safety.
- Post-harvest diseases and losses by insects: Types of diseases, Source of infection, Factors affecting disease development, Prevention techniques for post -harvest losses, Storage techniques, Biorational approaches; Value addition.

Practical:

1. Methods of Vegetative propagation – Cuttings, grafting, gooting and layering.
2. Disease Management – Integrated Pest Management practices (A field study).
3. Field visits to gardens, standing crop sites, nurseries, vegetable gardens and horticultural fields at IARI or other suitable locations.(Optional)
4. Extraction / hydro-distillation of essential oil of *Ocimum, Geranium* etc.
5. Identification of major conditions responsible for early decay of produce.
6. Identification of pathogenic and non-pathogenic reasons of produce spoilage during storage
7. Cold storage techniques for fruits and vegetables
8. Visit to some nearby cold-storage facility (Optional)

Suggested Readings

1. Chakraverty, A., Majumdar, A.S., Raghavan, G.S.V. and Ramaswamy, H.S. (2003). Handbook of Postharvest Technology: Cereals, Fruits, Vegetables, Tea and Spices. Marcel Dekker Inc, NY.

2. Wills, R and Golding, J. (2016). Postharvest :an introduction to the physiology and handling of fruits and vegetables. UNSW Press.

3. Wills, R.B.H., Glasson, W.B. and Mc. Graham, D. (2007). Postharvest: an introduction to the physiology and handling of fruits, vegetables and Ornamentals., CABI, pp 227
4. Ramaswamy, H. (2015). Post-harvest Technologies of Fruits and Vegetables. DEStech Publications, Inc.. Pp 311
5. Mathur, G.K., Rathore, N.S. and Chasta, S.S (2012). Post-Harvest Management and Processing of Fruits and Vegetables. The Energy and Resource Institute. pp 250

SEC- Skill Enhancement Course -

Semester - III

Course name: Biofertilizers

Course code – BSCHBOTSEC301

Course Type: **Core**	Course Details: **SEC-301**			L-T-P: **4-0-0**	
Credit: **4**	Full Marks: 100	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		-	**10**	-	**40**

Course Learning Outcomes:

On the completion of this course, the students will be able to;

- Develop their understanding on the concept of bio-fertilizer
- Identify the different forms of biofertilizers and their uses
- Compose the Green manuring and organic fertilizers
- Develop the integrated management for better crop production by using both nitrogenous and phosphate bio fertilizers and vesicular arbuscular mycorrhizal (VAM).
- Interpret and explain the components, patterns, and processes of bacteria for growth in crop production

Unit-1:

General account about the microbes used as biofertilizer, Rhizobium – isolation, identification, mass production, Commercialization; Actinorrhizal symbiosis.

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

Unit -2:

General idea about Plant growth promoting rhizobacteria (PGPR) and Phosphate solubilizing bacteria (PSB) . PGPR traits; Stress hormone Ethylene and PGPR.

Unit- 3:

Cyanobacteria (blue green algae) and Azolla as biofertilizer; Blue green algae and Azolla production; blue green algae and *Azolla* in rice cultivation.

Unit -4:

Mycorrhizal association, types of mycorrhizal association, taxonomy, occurrence and distribution; VAM fungi, and their influence on growth and yield of crop plants. (6 lectures)

Organic farming – Green manuring and organic fertilizers; Organic Compost and Vermicompost - production and application.

Suggested Readings -

1. Dubey, R.C., 2005 A Text book of Biotechnology S.Chand & Co, New Delhi.
2. Kumaresan, V. 2005, Biotechnology, Saras Publications, New Delhi.
3. John Jothi Prakash, E. 2004. Outlines of Plant Biotechnology. Emkay Publication, New Delhi.
4. Sathe, T.V. 2004 Vermiculture and Organic Farming. Daya publishers.
5. Subha Rao, N.S. 2000, Soil Microbiology, Oxford & IBH Publishers, New Delhi.
6. Vayas,S.C, Vayas, S. and Modi, H.A. 1998 Bio-fertilizers and organic Farming Akta Prakashan, Nadiad

Course name: Ethnobotany

Course code – BSCHBOTSEC302

Course Type: **Core**	Course Details: **SEC-302**		L-T-P: **4-0-0**
		CA Marks	ESE Marks

Credit: **4**	Full Marks: 100	Practical	Theoretical	Practical	Theoretical
		-	**10**	**-**	**40**

Course Learning Outcomes:

On completion of this course, the students will be able to:

- Conceptualize ethnobotany as an interdisciplinary science
- Restate the established methodology of ethnobotany studies
- Categories various indigenous ethnic groups and their environmental practices.
- Understand the legalities associated with ethnobotany.

Unit 1:

Major and minor ethnic groups or Tribals of India, and their life styles. Plants used by the tribals: a) Food plants b) intoxicants and beverages c) Resins and oils

Unit 2:

Methodology of Ethnobotanical studies a) Field work b) Herbarium c) Ancient Literature, d) Archaeological findings e) temples and sacred places.

Unit 3:

Role of ethnobotany in modern Medicine; Significance of the following plants in ethno botanical practices (along with their habitat and morphology) a) *Azadiractha indica* b) *Ocimum sanctum* c) *Aloe vera*. d) *Eclipta alba* e) *Phyllanthus niruri* f) *Emblica officinalis* g) *Centella asiatica* h) *Saraca indica*. Role of ethnobotany in modern medicine with special example *Rauvolfia sepentina, Taxus brevifolia, Artemisia vulgaris, Withania somnifera*.

Unit 4:

Ethnobotany and legal aspects - Ethnobotany as a tool to protect interests of ethnic groups. Sharing of wealth concept with few examples from India. Biopiracy, Intellectual Property Rights and Traditional Knowledge.

Suggested Readings

1) S.K. Jain, Manual of Ethnobotany, Scientific Publishers, Jodhpur, 1995.

2) S.K. Jain (ed.) Glimpses of Indian. Ethnobotny, Oxford and I B H, New Delhi – 1981

3) Lone et al,. Palaeoethnobotany

4) S.K. Jain (ed.) 1989. Methods and approaches in ethnobotany. Society of ethnobotanists, Lucknow, India.

5) S.K. Jain, 1990. Contributions of Indian ethnobotny.Scientific publishers, Jodhpur.

6) Colton C.M. 1997. Ethnobotany – Principles and applications. John Wiley and sons – Chichester

7) Rama Ro, N and A.N. Henry (1996). The Ethnobotany of Eastern Ghats in Andhra Pradesh, India.Botanical Survey of India. Howrah.

8) Rajiv K. Sinha – Ethnobotany The Renaissance of Traditional Herbal Medicine – INA –SHREE Publishers, Jaipur-1996

9) Faulks, P.J. 1958.An introduction to Ethnobotany, Moredale pub. Ltd. 84

Semester - IV

Course name: Plant Diversity and Human welfare

Course code – BSCHBOTSEC401

Course Type: **Core**	Course Details: **SEC-401**			L-T-P: **4-0-0**	
Credit: **4**	Full Marks: 100	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		-	**10**	**-**	**40**

Course Learning Outcomes:

On completion of this course, the students will be able to:

- Develop understanding of the concept and scope of plant biodiversity
- Identify the causes and implications of loss of biodiversity
- Apply skills to manage plant biodiversity
- Utilize various strategies for the conservation of biodiversity
- Conceptualize the role of plants in human welfare with special reference to India

Unit -1: **- Plant diversity and its scope**

Plant diversity and its scope- Genetic diversity, Species diversity, Plant diversity at the ecosystem level, Agrobiodiversity and cultivated plant taxa. Values and uses of Biodiversity: Ethical and aesthetic values.

Unit -2: **Loss of Biodiversity**

Loss of Biodiversity: Loss of genetic diversity, Loss of species diversity, Loss of ecosystem diversity, Loss of agrobiodiversity, Projected scenario for biodiversity loss.

Unit -3:

Management of Plant Biodiversity: Organizations associated with biodiversity management-Methodology for execution-IUCN, UNEP, UNESCO, WWF, NBPGR; Biodiversity legislation and conservation.

Unit-4:

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. Importance of forestry their utilization and commercial aspects; Avenue trees; Ornamental plants of India; Alcoholic beverages; Fruits and nuts; Wood and its uses; their commercial importance.

Suggested Readings -

1. Krishnamurthy, K.V. (2004). An Advanced Text Book of Biodiversity – Principles and Practices.Oxford and IBH Publications Co. Pvt. Ltd. New Delhi
2. Singh, J.S., Singh, S.P. and Gupta, S. (2006). Ecology Environment and Resource Conservation. Anamaya Publications, New Delhi, India.
3. Reddy, K.V. and Veeraiah, S. (2010). Biodiversity and Plant Resources. Aavishkar publication, New Delhi.
4. Heywood, V. H. and Watson, R. T. (1995). Global biodiversity and Assessment. Cambridge University Press.

Course name: Mushroom culture technology

Course code – BSCHBOTSEC402

Course Type: **Core**	Course Details: **SEC-402**			L-T-P: **4-0-0**	
Credit: **4**	Full Marks: 100	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		-	**10**	-	**40**

Course Learning Outcomes:

On completion of this course, the students will be able to:

- Recall various types and categories of mushrooms.
- Demonstrate various types of mushroom cultivating technologies.
- Examine various types of food technologies associated with mushroom industry.
- Value the economic factors associated with mushroom cultivation
- Device new methods and strategies to contribute to mushroom production.

Unit 1:

Introduction and history. Types of edible mushrooms available in India - *Volvariella volvacea*, *Pleurotus citrinopileatus*, *Agaricus bisporus*; Nutritional and medicinal value of edible mushrooms; Poisonous mushrooms.

Unit 2:

Methods of cultivation of edible mushrooms (Oyster, Button and Paddy straw mushrooms). Diseases of Mushroom fungi and methods of remedy. Methods of Mushroom span production. Equipments and Tools required for mushroom as well as spawn production.

Unit 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.

Unit 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.

Suggested Readings

1. Marimuthu, T. Krishnamoorthy, A.S. Sivaprakasam, K. and Jayarajan. R (1991) Oyster Mushrooms, Department of Plant Pathology, Tamil Nadu Agricultural University, Coimbatore.

2. Swaminathan, M. (1990) Food and Nutrition. Bappco, The Bangalore Printing and Publishing Co. Ltd., No. 88, Mysore Road, Bangalore - 560018.

3. Tewari, Pankaj Kapoor, S.C., (1988). Mushroom cultivation, Mittal Publications, Delhi.

4. Nita Bahl (1984-1988) Hand book of Mushrooms, II Edition, Vol. I & Vol. II.