COURSES OFFERED BY DEPARTMENT OF BOTANY

Category-I

Botany (H) Courses for Undergraduate Programme of study with Botany as a Single Core Discipline

DISCIPLINE SPECIFIC CORE COURSE – 1: Plant Diversity and Evolution

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Plant Diversity and Evolution **BOT-DSC-1**	**4**	**2**	**0**	**2**	10+2 from any recognized Board with Biology/Biotechnology	**Nil**

Learning Objective:

- To make students aware about the diversity of plants and microbes present on the planet and their relationships with each other in light of evolution.

Learning outcomes

By studying this course students will gain basic knowledge on:

- the diversity and general characteristics of plants and microbes.
- various groups of plants and their evolutionary relationships.
- basic principles and concepts of evolution that contribute to plant diversity.

SYLLABUS OF BOT-DSC-1

Unit1: Origin of life **Weeks: 1.5**

Principles and concepts of evolution, Tree of Life, and classification (upto six kingdoms)

Unit2: Bacteria **Week: 01**

General characteristic features, cell structure, asexual reproduction and modes of gene ransfer (conjugation, transformation and transduction), brief introduction to Archaebacteria.

Unit3: Viruses **Week: 01**

General characteristic features, replication, RNA virus (structure of TMV), DNA virus (structure of T-phage), Lytic and Lysogenic life cycle (Lambda phage).

Unit4: Algae **Weeks: 1.5**

General characteristic features, cell structure, range of thallus, methods of reproduction and evolutionary classification (only upto groups). Brief account of *Spirogyra*, *Sargassum*.

Unit5: Fungi **Weeks: 02**

General characteristic features, reproduction and broad classification. Myxomycetes and their similarities with fungi, plants and animals, Brief account of *Rhizopus*, *Agaricus*. Introduction to lichens.

Unit6: Bryophytes **Weeks: 02**

General characteristic features and reproduction, adaptation to land habit, broad classification, evolutionary trends in Bryophytes. Brief account of *Marchantia*, and *Funaria*.

Unit7: Pteridophytes **Weeks: 02**

General characteristic features and reproduction, broad classification, evolutionary trends in Pteridophytes, affinities with Bryophytes. Brief account of *Adiantum*, *Selaginella*.

Unit8: Gymnosperms **Weeks: 02**

General characteristic features and reproduction, broad classification, evolutionary trends in Gymnosperm, affinities with Pteridophytes. Brief account of *Gnetum*, *Ephedra*.

Unit9: Angiosperms **Weeks: 02**

General characteristic features and reproduction, Concept of natural, artificial and phylogenetic system of classification. Affinities with Gymnosperms.

Practical component:

1. To study structure of TMV and Bacteriophage (electron micrographs/models). **(Week: 01)**
2. To study morphology of *Volvox*, *Oedogonium*, *Chara*, *Fucus* and *Polysiphonia* (Temporary preparation/specimens/slides). **(Weeks: 02)**
3. To study *Rhizopus*, *Penicillium*, *Alternaria* (Temporary preparations), symptoms of rust of wheat, white rust of crucifer (specimen). **(Weeks: 02)**
4. To study *Marchantia* (morphology, WM of rhizoids and scales), *Anthoceros* (morphology), *Sphagnum* (morphology, WM of leaf), *Funaria* (morphology WM of rhizoid and leaf). **(Weeks: 02)**
5. To study *Selaginella* (morphology, WM of strobilus and spores), *Equisetum* (morphology, WM of spores), *Pteris* (morphology, tease mount of sporangia and spores). **(Weeks: 02)**
6. To study *Cycas* (morphology, leaf, leaflet anatomy, coralloid root, bulbils, megasporophyll and microsporophyll); *Pinus* (morphology of dwarf shoot, needle anatomy, male and female cones, WM pollen grains). **(Weeks: 02)**
7. To study variation in leaf venations in dicots and monocots (at least two specimens each). **(Weeks: 02)**
8. To study the types of inflorescences in angiosperms (through specimens). **(Week: 01)**
9. To study the types of fruits in angiosperms (through specimens). **(Week: 01)**

Essential/recommended readings:

- Campbell, N.A., Reece,J.B. (2008) Biology, 8th edition, Pearson Benjamin Cummings, San Francisco.
- Evert, R. F., Eichhorn,S.E. (2012).Raven Biology of Plants, 8th edition, New York, NY: W.H.Freeman and Company.
- Bhatnagar, S.P., Moitra, A. (1996).Gymnosperms. New Delhi, Delhi, New Age International (P) Ltd. Publishers.
- Kumar, H.D. (1999). Introductory Phycology, 2nd edition .Delhi, Delhi, Affiliated East-

West. Press Pvt. Ltd.

- Pelczar, M. J. (2001). Microbiology, 5th edition. NewDelhi, Delhi:TataMcGraw-HillCo.
- Puri,P. (1985). Bryophytes. New Delhi, Delhi, Atma Ram and Sons.
- Sethi, I.K. and Walia, S.K. (2018). Textbook of Fungi and Their Allies. (2nd Edition), Medtech Publishers, Delhi.
- Tortora,G.J., Funke, B.R., Case, C.L. (2007). Microbiology. San Francisco, U.S.A, Pearson Benjamin Cummings.
- Vashishta, P.C., Sinha, A.K., Kumar, A. (2010). Pteridophyta. New Delhi, Delhi, S.Chand & Co Ltd.
- Singh, G. (2019) Plant Systematics-An Integrated Approach. 4th edition. CRC Press, Taylor and Francis Group.
- Blackmore, S., Crane, P. (2019) How Plants Work–Form, Diversity, Survival, Princeton University Press; Illustrated edition.
- Ingrouille, M., Eddie, B. (2006) Plants: Evolution and Diversity. Cambridge University Press.

Suggestive readings:

- Parihar, N.S. (1991). An Introduction to Embryophyta. Vol.II. Pteridophytes. Prayagraj: U.P.: Central Book Depot.
- Singh,V., Pandey,P.C., Jain,D.K. (2001).A Text Book of Botany. Meerut, UP: Rastogi and Co.
- Webster, J., Weber, R. (2007). Introduction to Fungi. Cambridge, Cambridge University Press.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – 2: Cell Biology: Organelles and Biomolecules

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Cell Biology: Organelles and Biomolecules **BOT-DSC-2**	**4**	**2**	**0**	**2**	10+2 from any recognized Board with Biology/Biotechnology	**Nil**

Learning Objectives:

- To study the Cell as a structural and functional unit of life.
- To study the various types of biomolecules (proteins, carbohydrates, lipids and nucleic acids) and their roles in cell structure and function.
- To study the structures of different organelles and their role in fundamental metabolic processes of a cell.

Learning outcomes

By studying this course, students will gain basic knowledge on:

- The relationships between the properties of biomolecules, their cellular activities and biological functions.
- Physico-chemical composition of organelles and their functional organization.

SYLLABUS OF BOT-DSC-2

Unit 1: Biomolecules **Weeks: 05**

Types of chemical bonds and their biological significance. Structure and biological roles of carbohydrates, lipids, proteins and nucleic acids. ATP: structure and its role as an energy currency molecule.

Unit 2: The Cell **Week: 01**

Cell as a unit of structure and function; Characteristics of prokaryotic and eukaryotic cells; Origin of eukaryotic cell (Endosymbiotic theory).

Unit 3: Cell Wall and Plasma Membrane **Weeks: 1.5**

Chemistry, structure and function of Plant Cell Wall. Singer and Nicolson's fluid mosaic model of cell membrane.

Unit 4: Cell Organelles: Structure and function of the following Organelles

Weeks: 5.5

Nucleus: Structure and function (nuclear envelope, nuclear pore complex, nuclear lamina); types of chromatin; nucleolus.

Chloroplast and Mitochondria: Structural organization; Function; Semi- autonomous nature of mitochondria and chloroplast.

Endomembrane system: Endoplasmic Reticulum – Structure and function of RER and SER, protein folding, processing in ER, export of proteins and lipids; Golgi Apparatus - Organization, protein glycosylation, protein sorting and export from Golgi Apparatus. Introduction to post-translational modifications.

Peroxisome and Lysosomes: Structure and function.

Cytoskeleton: Role and structure of microtubules, microfilaments, intermediary filament and motor proteins.

Unit 5: Cell division **Weeks: 02**

Eukaryotic cell cycle, mitosis and meiosis; regulation of cell cycle.

Practicals:

1. Study of cell and its organelles with the help of electron micrographs and otherdigital resources. **(Weeks: 02)**
2. Study of plant cell structure with the help of epidermal peel mount of

Allium/*Rhoeo*/*Crinum*. **(Week: 01)**

3. Microchemical tests for carbohydrates (reducing, non-reducing sugars and starch), lipids and proteins. **(Weeks: 02)**
4. Separation of chloroplast pigments by paper chromatography/ Thin Layer Chromatography. **(Weeks: 02)**
5. Separation of amino acids by paper chromatography. **(Weeks: 02)**
6. Study the effect of organic solvent and temperature on membrane permeability. **(Weeks: 02)**
7. Demonstration of the phenomenon of protoplasmic streaming in *Hydrilla* leaf. **(Weeks: 01)**
8. Demonstration of the phenomenon of plasmolysis and deplasmolysis. **(Week: 01)**
9. Demonstration of separation of biomolecules by dialysis. **(Week: 02)**

Essential/recommended Readings:

- Hardin, J. and Lodolce, J.P. (2022). Becker's World of The cell, 10th edition, Pearson
- Berg, J.M., Tymoczko, J.L., Stryer, L. (2011). *Biochemistry*. New York, NY: W. H. Freeman and Company.
- Campbell, N. A. (2020). Biology: A Global Approach, 12th Edition, Pearson
- Campbell, P.N., Smith, A.D. (2011). *Biochemistry Illustrated*, 4th edition.London, UK: Churchill Livingstone.

Suggested readings:

- Cooper, G.M., Hausman, R.E. (2019). The Cell: A Molecular Approach, 7thedition. Sinauer/OUP.
- Iwasa, J, Marshall , W. (2020). Karps's Cell Biology, 9th edition, New Jersey,U.S.A.: John Wiley & Sons.
- Majumdar, R., Sisodia, R. (2019). Laboratory Manual of Cell Biology, withreference to Plant Cells. New Delhi, Delhi: Prestige Publication.
- Nelson, D.L., Cox, M.M. (2021). Lehninger Principles of Biochemistry, 8thedition. New

York, NY: W.H. Freeman and Company.

- Raven, F.H., Evert, R.F., Eichhorn, S.E. (1992). Biology of Plants. New York,NY: W.H.Freeman and Company.
- Tymoczko, J.L., Berg, J.M., Stryer, L. (2012). Biochemistry: A short course, 2ndedition. New York, NY: W.H. Freeman and Company.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – 3: Basic Laboratory and Field Skills in Plant Biology

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Basic Laboratory and Field Skills in Plant Biology **BOT-DSC-3**	**4**	**2**	**0**	**2**	10+2 from any recognized Board with Biology/ Biotechnology	**Nil**

Learning Objectives

The course will help students to:

- Learn fundamental skills important for performing laboratory and field experiments

Learning outcomes

This course will be able to demonstrate basic knowledge and understanding of:

- Good laboratory practices, management of laboratory waste, understanding hazards and risks to ensure a safe laboratory environment.
- Basics of measurements, units and common mathematical calculations, sampling and data collection.
- Operation and maintenance of basic laboratory instruments
- Presentation, analysis of data and interpretation of results.

SYLLABUS OF BOT-DSC-3

Unit 1: Lab safety and good lab practices **Weeks: 02**

General laboratory safety, good laboratory practices, biosafety measures (first-aid practices to be followed in case of burn, acid spills and injury), safety symbols, lab safety equipments (fire extinguisher, fume hood, safety glasses), classes of laboratory chemicals, maintenance and handling of chemicals (Labels, Quality - LR/ AR/ Molecular biology grade/ HPLC grade/Tissue culture grade; Expiry date; Precautions for use), Disinfectants, Biocontainment, Disposal of hazardous chemicals, radioactive and biological waste, Laboratory waste management.

Unit 2: Use and maintenance of Laboratory equipment **Weeks: 02**

Weighing balance (Top loading and Analytical), pH meter (calibration and use), magnetic stirrer, pipettes and micropipettes, autoclave, laminar airflow, BOD incubator, incubator shaker, micrometer, haemocytometer, spectrophotometer, Agarose gel electrophoresis unit,SDS PAGE unit, centrifuge, distillation unit, conductivity meter, Lux meter.

Unit 3: Microscopy, sample and slide preparation **Weeks: 2.5**

Microscopes (Dissecting, Compound and Electron microscopes), Fixation and Preservation (for light and electron microscopy); staining, mounting; basic introduction to other types of microscopes (Confocal, Fluorescence)

Unit 4: Measurements and calculations **Week: 01**

Units of measurements and conversion from one unit to another, measurement of volumes of liquids, Weighing, calculations: scientific notations, powers, logarithm and fractions.

Unit 5: Solutions and Buffers **Week: 01**

Molarity, Molality, Normality, percent solution, stock solution, standard solution, dilution, dilution series, pH, acids and bases, buffers - phosphate, Tris- acetate, Tris-Cl and Citrate buffer.

Unit 6: Basic culturing techniques **Weeks: 1.5**

Basic culture media (LB, YEB, MS)- liquid and solid, Culture techniques: plating

(streak, spread & pour), replica plating, serial dilution.

Unit 7: Data collection, statistical analysis and interpretation Weeks: 02

Fundamentals of data collection, data types - primary and secondary, methods of data collection, sample, sampling methods - merits and demerits, technical and biological replicates, classification - tabulation and presentation of data, Descriptive statistics - Mean, Mode, Median, Variance, Standard Deviation, Standard error, Coefficient of Variation, difference between sample mean and population mean.

Unit 8: Basic computer skills for biology Weeks: 02

MS-Word, PowerPoint, Excel, introduction to biological databases.

Unit 9: Field Skills Week: 01

Identification, collection, cataloguing and preservation of plant specimens, Herbarium and Museum.

Practical component:

1. Preparation of solutions- molar, molal, normal, percentage, stock, standard andserial dilution **(Week: 01)**
2. Determining pH of solutions (pH paper, Universal indicator, pH meter) andpreparation of buffers (Phosphate, Tris-Cl, Electrophoresis buffers - TBE/TAE) **(Week: 01)**
3. Working of instruments -light microscope, autoclave, laminar air flow, spectrophotometer, centrifuge, gel electrophoresis unit (Agarose & Poly acrylamide). **(Week: 01)**
4. Temporary peel mount slide preparation and staining (safranin and acetocarmine). **(Week: 01)**
5. Calculate cell size using micrometer. **(Week: 01)**
6. Calculate number of cells (pollen/spores) using haemocytometer. **(Week: 01)**
7. Preparation of LB medium, growth and maintenance of bacterial cultures (liquid -serial dilution method; and semi-solid cultures - streak, spread and pour plates)

(Weeks: 02)

8. Isolation of genomic DNA from *E. coli* and plant leaf material, Agarose gel electrophoresis **(Weeks: 02)**
9. Calculation of mean, mode, median, standard deviation using data set (collectedfrom experiments 5 and 6). **(Week: 01)**
10. Using software to draw tables, graphs and calculating descriptive statistics(Microsoft Excel) **(Week: 02)**
11. Laboratory safety equipment (Fire extinguisher, Fume hood, safety glasses) **(Week: 01)**
12. Mounting of a properly dried and processed plant specimen with herbarium label. **(Week: 01)**

Essential/recommended Readings:

- Evert, R. F., Eichhorn, S. E., Perry, J.B. (2012). Laboratory Topics in Botany. W.H. Freeman and Company.
- Mesh, M.S., Kebede-Westhead, E. (2012). Essential Laboratory Skills for Biosciences. John Wiley & Sons, Ltd.
- Mu, P., Plummer, D. T. (2001). Introduction to practical biochemistry. Tata McGraw-Hill Education.
- Mann, S. P. (2016). Introductory Statistics, 9th edition. Hoboken, NJ, John Wiley and Sons Inc.
- Danniel, W.W. (1987). Biostatistics. New York, NY: John Wiley Sons.
- Jones, A.M., Reed, R., Weyers, J. (2016). Practical Skills in Biology, 6th Edition, Pearson
- Bisen, P.S. (2014). Laboratory Protocols in Applied Life Sciences, 1st edition. CRC Press.

Suggested readings:

- Zar, Z. H. (2010). Biostatistical Analysis, 5th edition, Pearson Prentice Hall, New Jersey, USA.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

GENERIC ELECTIVES (BOT-GE-1)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Plant Diversity and Human Welfare **BOT-GE-1**	**4**	**2**	**0**	**2**	**-**	**Nil**

Learning Objectives

Build awareness about the different groups of plants and their roles in supportinghuman life.

Learning outcomes

After studying this course, the student will gain knowledge about:

- the diversity of various groups of plants, their characteristics and identification.
- different phytogeographic zones in India.
- the basic principles of conservation of Biodiversity and Sustainable DevelopmentGoals (SDG).
- the role of plants in human welfare.

SYLLABUS OF BOT-GE-1

Unit 1: Understanding biodiversity **Weeks: 03**

Understanding biodiversity - definition of key terms; plant diversity in India; assigning value to plant diversity; economic and ecological importance of Algae, Bryophytes, Pteridophytes and Gymnosperms; insights into flowering plant diversity with special focus on agrobiodiversity.

Unit 2: Crop diversity **Weeks: 04**

Crop diversity in various phytogeographic regions in India and their traditional importance as food (including cereals, pulses, oil crops, spices, beverages, fruits and nuts, vegetables, condiments), medicines (Ashwagandha and Sarpagandha) and adornments.

Unit 3: Role of forests **Weeks: 03**

Forests, woodlands, and vegetation stands: diversity and their importance in ecological, aesthetic, and overall well-being; social dimensions of plant diversity; commercial value and utilization of plant wealth.

Unit 4: Cash Crops **Weeks: 2.5**

Crops of high economic value (tobacco, sugarcane, cotton, basmati rice, sandalwood, saffron); Petro crops: the future industry (*Jatropha* sp., corn and sugarcane).

Unit 5: Conservation of biodiversity **Weeks: 1.5**

Conservation of biodiversity using community driven conservation strategies, sustainable utilization keeping Sustainable Development Goals (SDGs) in mind, Innovative approaches and traditional methods of biodiversity utilization and waste minimization during product formation.

Unit 6: Policy issues in conservation of Biodiversity **Week: 01**

National and International initiatives and programmes/schemes focusing on Plant Diversity and human welfare (Tribal Rights Bill, Convention on Biological Diversity (CBD), International Union for Conservation of Nature (IUCN), Protection of Plant Varieties and Farmers' Rights Authority (PPVFRA).

Practicals:

1. To study local plant diversity (common Algae, Bryophytes, Pteridophytes, Gymnosperms (any two of each) in and around the campus; and understand their ecological and economic importance. **(Weeks: 02)**
2. Microchemical tests for carbohydrates, proteins and oils. **(Weeks: 02)**

3. To study (any three) commonly found tree species in the vicinity and understandtheir role in human welfare. **(Weeks: 02)**
4. To prepare an inventory of common medicinal plants in your campus (identify to the family level, list their uses in Indian System of Medicines) **(Weeks: 02)**
5. To visit the local parks and list the trees planted. Also assess some for their dustpollution mitigation capacity using standard procedures. **(Weeks: 02)**
6. Industrial visit to see how the drugs are extracted from plants (report to besubmitted for evaluation). **(Weeks: 02)**

Essential/recommended readings:

- Bilgrami, K. S. (1998). Phytodiversification and Human Welfare: Dedicated toLate Prof. KS Bilgrami, FNA (1933-96). MD Publications Pvt. Ltd.
- Utting, P. (2013). Trees, People and Power. Routledge.
- Manoharachary, C., Nagaraju, D. (2016). Medicinal plants for human health andwelfare. Ann. Phytomed, *5*(1), 24-34.

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Suggestive reading:

- Myers, N. (2019). A wealth of wild species: storehouse for human welfare.Routledge

GENERIC ELECTIVES (BOT-GE-2)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Biofertilizers BOT-GE-2	**4**	**2**	**0**	**2**	**-**	**Nil**

Learning Objectives

The Learning Objectives of this course are as follows:

- To develop an understanding of biological systems used as fertilizers and build skills in handling microbial inoculants.
- To understand the optimum conditions for growth and multiplication of usefulmicrobes such as *Rhizobium*, cyanobacteria, mycorrhizae, *Azotobacter* etc.
- To understand the role of microbes in mineral cycling and nutrition of plants.
- To gain expertise in various methods of decomposition of biodegradable waste,conversion into compost and apply this knowledge and skill in their daily life.

Learning outcomes

On successful completion of this course, a student will be able to:

- visualize and identify different types of microorganisms with a compound microscope.
- understand the classification of microorganisms according to their shape/ structurefor morphological identification. Prepare and sterilize different types of culture media.
- isolate of microorganisms from the environmental samples and culture in aseptic conditions.

SYLLABUS OF BOT-BOT-GE-2

Unit 1: Introduction **Weeks: 3.5**

Introduction to microbial inoculants or biofertilizers, macro and micro-nutrition of plants, chemical fertilizers versus biofertilizers; Methods and steps in mass multiplication of biofertilizers: stock culture, broth culture, growth medium, fermentation, blending with the carrier, packaging, and quality check, ISI standard specification for biofertilizers; scope of biofertilizers in India.

Unit 2: Microbial Inoculants **Weeks: 04**

Study of important microbial inoculants: *Rhizobium*, *Azospirillum*, *Azotobacter*, Actinorhizae; Characteristics, isolation, identification, and crop response.

Unit 3: Role of Cyanobacteria **Week: 01**

Role of Cyanobacteria (blue-green algae) in rice cultivation; *Azolla* and *Anabaena azollae* association, nitrogen fixation, and factors affecting growth.

Unit 4: Mycorrhizal association **Weeks: 04**

Types of mycorrhizal association, taxonomy, occurrence and distribution; Role of Arbuscular mycorrhizal fungi in phosphorus nutrition, growth and yield of crop plants;AMF – methods in isolation (wet sieving and decanting), identification (morphologicaland molecular methods). Methods of inoculum production (Pot culture and root culture).

Unit 5: Organic farming **Weeks: 2.5**

Introduction to organic farming, recycling of biodegradable municipal (domestic), agricultural and industrial waste; green manuring, bio-composting, vermicomposting and their field application.

Practicals:

1. Study of *Rhizobium* from root nodules of leguminous plants by Gram stainingmethod. **(Week: 01)**
2. Observation of arbuscular mycorrhizal fungi from plant roots. **(Weeks: 02)**
3. Isolation of arbuscular mycorrhizal spores from rhizosphere soil. **(Week: 01)**
4. Isolation of *Anabaena* from *Azolla* leaf. **(Week: 01)**
5. Study of Earthworm, *Azolla*, AMF: Arbuscules-vesicles through specimen / digital resources. **(Week: 01)**
6. Study of Biocontrol methods and their application -Pheromone trap, *Trichoderma*, *Pseudomonas*, Neem etc. through digital resources. **(Week: 01)**
7. Rapid test for pH, $NO3^{-}$, $SO4^{2-}$, Cl^{-} and organic matter of different composts. **(Weeks: 02)**
8. Projects on any one of the following topics: *Rhizobium* technology, AMF technology, Organic farming, Bio composting, Vermicomposting, *Azolla* culture etc. (The design of the project should be such that it includes a continuous work of at least 6 weeks and a dissertation submission). **(Weeks: 06)**

Essential/recommended readings:

1. Kumaresan, V. (2005). Biotechnology. New Delhi, Delhi: Saras Publication.
2. Sathe, T.V. (2004). Vermiculture and Organic Farming. New Delhi, Delhi: Dayapublishers.
3. Subha Rao, N.S. (2020). Soil Microbiology, 5th edn. New Delhi, Delhi: Oxford &IBH Publishers.
4. Reeta Khosla (2017). Biofertilizers and Biocontrol Agents for Organic Farming, Kojo Press

Suggestive readings:

1. *Azotobacter* - Isolation and characterization - https://youtu.be/1Z1VhgJ2h6U
2. *Rhizobium* - Identification and characterization - https://youtu.be/jELlo-pMvc4.
3. 3-Days Online Workshop On Arbuscular Mycorrhizal Fungi - Biodiversity,

Taxonomy and Propagation 19-2 (2022-01-20 at 02_27 GMT-8) - https://youtu.be/LKzK4IuSRc4.

4. Vayas, S.C, Vayas, S., Modi, H.A. (1998). Bio-fertilizers and organic Farming. Nadiad, Gujarat: Akta Prakashan.

GENERIC ELECTIVE (BOT-GE-3)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Protected Agriculture – Hydroponics and Organic Cultivation **BOT-GE-3**	**4**	**2**	**0**	**2**	**-**	**None**

Learning Objectives

The Learning Objectives of this course are as follows:

- To provide knowledge and expertise of various aspects of hydroponics, aquaponics and organic cultivation to students.
- To make students economically self-reliant by growing and marketing organic herbs, vegetables, microgreens and fruits.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Students will develop a thorough understanding of the concepts of Hydroponics, Aquaponics and Organic farming.
- Students will be trained in establishing hydroponic facility.
- Students will learn the development of various organic products such as biopesticides, biofertilizers and bio-0rganic growth promoters.
- Students will understand various government policies in marketing of hydroponic and organic produce.
- Students will understand Good Agricultural Practices associated with protected agriculture.

SYLLABUS OF BOT-GE-3

Unit 1: Introduction to Protected Agriculture **Week: 01**

Types of Protected Agriculture (hydroponics, aquaponics and organic farming), definition, history, terminology, importance and advantages over traditional agriculture, limitations and challenges.

Unit 2: Plant Growth Requirements and Media formulations **Weeks: 2.5**

Physical parameters - light (quality and quantity) artificial light, light balancers; pH, conductivity, salinity (Dissolved Oxygen-DO, Total Dissolved Solid - TDS) and temperature; Chemical parameters- mineral nutrient requirements, deficiencies, toxicities, growth regulators (auxins, gibberellins, cytokinins and abscisic acids); Growth media- types, properties, uses, nutrient formulae, preparation of solutions, solid Media and nutrient film.

Unit 3: Hydroponic growing systems **Weeks: 3.5**

Basic concepts and designs (closed and open systems techniques Nutrient Film Technique (NFT), Deep Water Culture (DWC), Dutch Bucket and other small-scale systems), systems layout. Strengths and weaknesses of various systems, site considerations, componentry, nutrient delivery, pumping

Unit 4: Hydroponics associated pest and diseases **Weeks: 03**

Hydroponics associated pest - mites, thrips, whiteflies, leaf miners; Identification and management of diseases -bacterial, fungal and viral diseases; safety practices (Good Agricultural Practices (GAP) and Integrated Pest Management (IPM).

Unit 5: Organic farming and its management **Weeks: 03**

Organic farming and associated management practices (nutritional requirements, pest,diseases, weeds); use of biofertilizers, biopesticides, bioherbicides, biocontrol agents (plant growth promoting rhizobacteria (PGPR), pheromone trapping, *Trichoderma*, *Pseudomonas*, neem oil, garlic etc.) in management.

Unit 6: Marketing and Policies **Weeks: 02**

Marketing of the produce and government institutes and policies related to protected farming (hydroponics and organic farming).

Practicals:

1. Study of various instruments used in hydroponics. **(Week: 01)**
2. Preparation of growth media for hydroponics. **(Week: 01)**
3. Estimation of NPK, DO, TDS, pH of growing media. **(Week: 01)**
4. Demonstration of different irrigation techniques in hydroponics. **(Week: 01)**
5. Demonstration of construction of a sustainable hydroponic unit. **(Weeks: 02)**
6. Perform rapid tests for estimation of NPK in different soil samples (samples from at least three different sites). **(Week: 01)**
7. Bulk density and porosity of soilless media e.g. coco-peat, perlite, vermiculite,expanded clay, rockwool (any two media). **(Week: 01)**
8. Demonstration of growing a leafy vegetable/fruity vegetable/ medicinal herb/aromatic plant in Hydroponics solution. **(Weeks: 02)**
9. Study of traditional organic inputs and formulation of biofertilizer. **(Weeks: 02)**
10. Preparation of biopesticides, plant health promoters like *Panchgavya, Beejamrut* etc.

    (Week: 02)
11. Field visit to organic farm/hydroponic farm and submission of visit report. **(Week: 01)**

Essential/recommended readings:

1. Schwarz, M. (1995). Soilless Culture Management. Advanced Series in Agricultural Sciences, vol. 24. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-79093-5_2.
2. Hasan, M., Sabir, N., Singh, A.K., Singh, M.C., Patel, N., Khanna, M., Rai, T., Pragnya, P. (2018). Hydroponics Technology for Horticultural Crops, Tech.

Bull.TB-ICN 188/2018. Publ. by I.A.R.I., New Delhi-110012 INDIA.

3. Misra S., Misra S., Misra R.L. (2017). Soilless Crop production. Daya PublishingHouse, Astral International (P) Ltd., New Delhi.
4. Palaniappan S. P., Annadurai K. (2018). Organic Farming: Theory & Practice.Scientific Publisher.
5. Goddek, S., Joyce, A., Kotzen, B., Burnell, G.M. (2019). Aquaponics Food Production Systems. Springer, Cham.

Suggestive readings:

1. Jones, J. B. (2014). Complete Guide for Growing Plants Hydroponically. CRCPress.
2. Vayas, S.C, Vayas, S., Modi, H.A. (1998). Bio-fertilizers and organic Farming.Akta Prakashan, Nadiad.

GENERIC ELECTIVES (BOT-GE-4)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Basic Laboratory and Field Skills in Plant Biology and Allied Sciences **BOT-GE-4**	**4**	**2**	**0**	**2**	**-**	**Nil**

Learning Objectives

The Learning Objectives of this course are as follows:

To learn fundamental skills important for performing laboratory and fieldexperiments.

Learning outcomes

After completion of this course the student will learn:

- Good Lab Practices, management of laboratory waste, understanding hazards andrisks to ensure a safe laboratory environment.
- Basics of measurements, units and common mathematical calculations, samplingand data collection.
- Handling and maintenance of instruments
- Presentation, analysis and interpretation of results.

SYLLABUS OF BOT-GE-4

Unit 1: Lab safety and good lab practices **Weeks: 02**

General laboratory safety, good laboratory practices, biosafety measures (first-aid practicesto be followed in case of burn, acid and injury), safety symbols, lab safety

equipment (Fireextinguisher, fume hood, safety glasses), classes of laboratory chemicals, maintenance andhandling of chemicals (Labels, Quality - LR/ AR/ Molecular biology grade/ HPLC grade/Tissue culture grade; Expiry date; Precautions for use), Disinfectants, Biocontainment, Disposal of hazardous chemicals, radioactive and biological waste, Laboratory waste management

Unit 2: Use and maintenance of Laboratory equipment **Weeks: 02**

Weighing balance (Top loading and Analytical), pH meter (calibration and use), magnetic stirrer, pipettes, autoclave, laminar airflow, BOD incubator, incubator shaker, micrometer, haemocytometer, spectrophotometer, Agarose gel electrophoresisunit, SDS PAGE unit, centrifuge, distillation unit, conductivity meter, Lux meter.

Unit 3: Microscopy, sample and slide preparation **Weeks: 2.5**

Microscopes (Dissecting, compound, electron microscope), Fixation and Preservation (for light and electron microscopy); staining, mounting; basic introduction to other types of microscopes (confocal, fluorescence)

Unit 4: Measurements and calculations **Week: 01**

Units of measurements and conversion from one unit to another, measurement of volumes of liquids, Weighing, calculations: scientific notations, powers, logarithmand fractions

Unit 5: Solutions and Buffers **Week: 01**

Molarity, Molality, Normality, percent solution, stock solution, standard solution, dilution, dilution series, pH, acid and bases, buffers- Phosphate, Tris- acetate, Tris-Cl and Citrate buffer

Unit 6: Basic culturing techniques **Weeks: 1.5**

Basic culture media (LB, YEB, MS)- Liquid and solid, Culture techniques : plating (streak, spread & pour),replica plating , serial dilution

Unit 7: Data collection, statistical analysis and interpretation **Weeks: 02**

Fundamentals of data collection, data types - primary and secondary, methods of data collection, sample, sampling methods - merits and demerits, technical and biological replicates, classification - tabulation and presentation of data, Descriptive statistics - Mean, mode, median, Variance, Standard Deviation, Standard error, Coefficient of Variation, difference between sample and population mean.

Unit 8: Basic computer skills for biology **Weeks: 02**

MS- Word, PowerPoint, Excel, introduction to biological databases

Unit 9: Field Skills **Week: 01**

Identification, collection, cataloguing and preservation of plant specimens, Herbarium and Museum

Practicals:

1. Preparation of solutions - molar, molal, normal, percentage, stock, standard and serial dilution **(Week: 01)**
2. Determining pH of solutions (pH paper, Universal indicator, pH meter) and preparation of buffers (Phosphate, Tris-Cl, Electrophoresis buffers- TBE/TAE) **(Week: 01)**
3. Working of instruments - light microscope, autoclave, laminar air flow, spectrophotometer, centrifuge, gel electrophoresis unit (Agarose & Poly acrylamide gels) **(Week: 02)**
4. Temporary peel mount slide preparation and staining (safranin and acetocarmine). **(Week: 01)**
5. Calculate cell size using micrometer. **(Week: 01)**
6. To calculate number of cells per unit volume (usingpollen/spores) using haemocytometer **(Week: 01)**
7. Preparation of LB medium, growth and maintenance of bacterial cultures (liquid -serial dilution method; and semi-solid cultures - streak, spread and

pour plates) **(Weeks:02)**

8. Isolation of genomic DNA from *E. coli* and plant leaf material, Agarose gelelectrophoresis. **(Weeks: 02)**
9. Calculation of mean, mode, median, standard deviation using data set (collected from experiments 5 and 6) **(Week: 01)**
10. Using software to draw tables, graphs and calculating descriptive statistics (Microsoft Excel) **(Week: 01)**
11. Laboratory safety equipment (Fire extinguisher, Fume hood, safety glasses) **(Week: 01)**
12. Mounting of a properly dried and processed plant specimen with herbarium label **(Week: 01)**

Essential/recommended readings:

- Evert, R. F., Eichhorn, S. E., Perry, J.B. (2012). Laboratory Topics in Botany.

W.H. Freeman and Company.

- Mesh, M.S., Kebede-Westhead, E. (2012). Essential Laboratory Skills for Biosciences. John Wiley & Sons, Ltd.
- Mu, P., Plummer, D. T. (2001). Introduction to practical biochemistry. Tata McGraw-Hill Education.
- Mann, S. P. (2016). Introductory Statistics, 9th edition. Hoboken, NJ, John Wileyand Sons Inc.
- Danniel, W.W. (1987). Biostatistics. New York, NY: John Wiley Sons.
- Jones, A., Reed, R.,Weyers, J. (2016) Practical Skills in Biology, 6th Edition,Pearson.
- Bisen, P.S. (2014). Laboratory Protocols in Applied Life Sciences (1st edition).CRC Press.

Suggestive readings:

- Zar, Z. H. (2010). Biostatistical Analysis, 5th edition, Pearson Prentice Hall, NewJersey, USA.

GENERIC ELECTIVES (BOT-GE-5)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Green Belt Development and Urban Management for Smart Cities **BOT-GE-5**	**4**	**2**	**0**	**2**	**-**	**Nil**

Learning Objectives

The Learning Objectives of this course are as follows:

- To make students aware about Green Belt Development, which is a major step in the development of a sustainable ecosystem, particularly under the Smart Cities Program for urban development (Government of India).
- To introduce students with one of the key green skill development programs under the Skill India mission by the Government of India.
- To acquaint students with various methods and techniques used in development ofgreen infrastructure for smart cities

Learning outcomes

After completion of this course, students will:

- become familiar with green skills that contribute to preserving or restoring the environment for a sustainable future that protect ecosystems and biodiversity, reduce energy and minimize waste and pollution.
- understand the role of green belt in capturing the transient emissions, prevent soil erosion and degradation, containing water run- offs and recharging ground water, attenuate noise generated and improve the aesthetics.

- be well trained (knowledge & skills) to contribute to Green SectorSkill program.

SYLLABUS OF BOT-GE-5

Unit 1: Introduction **Week: 01**

Definition, History and Concept of Green Belt; Aesthetics and Importance; Recommended Guidelines for green belt development for industries; Advantages and Applications.

Unit 2: Pollution and Carbon emission **Weeks: 02**

Type and various source of Emissions; Methods of estimation and monitoring of pollutants; Mechanism of deposition; Regulatory standards for major pollutants.

Unit 3: Plant-Pollutant Interaction **Weeks: 02**

Methods of sampling and screening local flora, Native and Exotic Plants, Various indicators (Morphological, Anatomical, Physiological and Biochemical) for selection of pollution mitigating plants; Sensitive/indicator, Resistant/ Tolerant Plant Speciesfor different pollutants (air, water, land and sound). Factors effecting plant regeneration and growth.

Unit 4: Structural and Functional Aspects of Green Belt **Weeks: 03**

Methods of Planting and Propagation, Various approaches for green belt development, Theoretical Models; Site specific ecological requirements, parameters involved that affect landscape design, Methods to evaluate the effectiveness of green belt. Various tools for assessment and monitoring of green belt (GIS and Remote Sensing)

Unit 5: Green Belt for Mitigating Climate change **Weeks: 02**

Objectives of UNFCCC for mitigating greenhouses gases in urban sectors, Green Finance and Green Infrastructure development, Methods to evaluate total carbon sequestered; Carbon stocks and credits.

Unit 6: Waste water treatment through constructed wetlands **Weeks: 03**

Introduction: Wetlands values and functions, natural and constructed wetlands for wastewater treatments; Life forms in wetlands: microbes and vegetation in wetlands, plants adapted to pollutants and flooding, Role of macrophytes in constructed wetlands; physical and chemical characteristics of freshwater wetlands, constructed wetlands: types, role and management including key parameters for assessment.

Unit 7: Economics of Green Infrastructure **Weeks: 02**

Understanding of key plants for green economy - NFTP (Non-Forest timber products), biodiesel plants, herbal garden; Evaluating the cost and benefits of green belt development with type studies, Environmental accounting, Ecosystem services and constituents of wellbeing. Environmental Impact Assessment

Practicals:

1. Methods of Vegetation Sampling and calculation of importance value index. **(Weeks: 02)**
2. Measuring Tree Height and Cover to estimate green cover of an area. **(Weeks: 03)**
3. Estimation of total carbon of an area. **(Weeks: 02)**
4. Methods for selection of plants according to pollutant load in air and water (includes field survey) **(Weeks: 02)**
5. Open Sources Software for mapping the GPS points and generating a cover map. **(Weeks: 02)**
6. Measurement of Dissolved Oxygen (DO) from treated waste water. **(Weeks: 02)**
7. Measurement of BOD and TDS from intake and treated pond. **(Weeks: 02)**

Essential/recommended readings:

- Vesilind, P. A., Peirce, J. J., Weiner, R., (1998). Environmental Pollution andControl Netherlands: Elsevier Science.

- Burnwal, K., Jagwani, D. (2013). Air Pollution Abatement through Trees & GreenBelt Development. LAP Lambert Academic Publishing.
- CPCB (2000). Guidelines for Green Belt development, CPCB, MoEF, GoI, NewDelhi.
- Zhou, S. W. W., Zhou, S. W. W. (2020). Carbon Management for a SustainableEnvironment. Germany: Springer International Publishing.
- Yunus, M., Singh, N. *de* Kok, L.J. (2013). Environmental Stress: Indication, Mitigation and Eco-conservation.Netherlands: Springer Netherlands
- Acar, S., Yeldan, A.E. (2019). Handbook of Green EconomicsNetherlands: Elsevier Science.
- Stefanakis, A., (2018). Constructed Wetlands for Industrial Wastewater TreatmentUnited Kingdom, Wiley.
- Kröpfelová, L., Vymazal, J., Kröpfelová, L., Vymazal, J. (2008). Wastewater Treatment in ConstructedWetlands with Horizontal Sub-Surface Flow. Czechia: Springer Netherlands.

Suggestive readings:

- Amati, M. (2016). Urban Green Belts in the Twenty-first Century (Urban Planning and Environment) 1st Edition. Routledge publishers

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Nomenclature of certificate/diploma/degrees:

- ✓ After securing 44 credits (from semester I and II), by completing one year of study of the UG honours Programme with Botany as a single core discipline, if a student exits after following due procedure, he or she shall be awarded **Undergraduate Certificate in Botany.**

- ✓ After securing 88 credits (from semester I, II, III & IV), by completing two years of study of the UG honours Programme with Botany as a single core discipline, if a student exits after following due procedure, he or she shall be awarded **Diploma in Botany.**

- ✓ After securing 132 credits (from semester I to VI), by completing three years of study of the UG honours Programme with Botany as a single core discipline, if a student exits after following due procedure, he or she shall be awarded **Bachelor of Science (Honours) in Botany.**

- ✓ After securing 176 credits (from semester I to VIII), by completing four years of study of the UG honours Programme with Botany as a single core discipline and writes dissertation, the student shall be awarded **Bachelor of Science (Honours with Research) in Botany.**

- ✓ After securing 176 credits (from semester I to VIII), by completing four years of study of the UG honours Programme with Botany as a single core discipline and engages in Academic Project/Entrepreneurship, the student shall be awarded **Bachelor of Science (Honours with Academic Project/Entrepreneurship) in Botany.**

COURSES OFFERED BY DEPARTMENT OF BOTANY

Category-I

Botany (H) Courses for Undergraduate Programme of study with Botany as a Single Core Discipline

DISCIPLINE SPECIFIC CORE COURSE – 4: Microbiology and Plant-Microbe Interactions

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Microbiology and Plant-Microbe Interactions **BOT-DSC-4**	**4**	**2**	**0**	**2**	Nil	Nil

Learning Objective:

- To impart basic understanding about the microbial world and their interactions with plants.

Learning Outcomes:

- Understanding microbes and their roles and applications.
- Understanding about modes of reproduction of Viruses, Archaebacteria, Eubacteria
- Understand plant-microbe interaction

SYLLABUS OF BOT-DSC-4

Unit 1: Introduction **Week: 01**

Microbial world, Growth and nutrition of microbes with reference to nutritional media.

Unit 2: Viruses **Weeks: 3.5**

Discovery; Physicochemical and biological characteristics; Classification (Baltimore); General structure with special reference to viroids and prions, DNA and RNA viruses; General account and mechanism of replication, lytic and lysogenic cycle; General account of viral diseases of plants (mosaic and vein clearing disease).

Unit 3: Bacteria **Weeks: 4.5**

Discovery, General characteristics; Types - Archaebacteria, Eubacteria, Wall less forms (Mycoplasma, Phytoplasma and Spheroplasts); Cell structure; Nutritional types; Reproduction - vegetative, asexual and recombination (conjugation, transformation and transduction); General account of bacterial diseases of plants (Citrus canker, Angular leaf spots of cotton).

Unit 4: Applied Microbiology **Weeks: 02**

Economic importance of viruses with reference to vaccine production, role in research, medicine and diagnostics and agriculture. Economic importance of bacteria with reference to their role in agriculture and industry (fermentation and medicine).

Unit 5: Plant-Microbe interactions **Weeks: 04**

General account of Plant-microbe interactions; Plant growth promoting rhizobacteria (PGPR); Mechanism of nitrogen fixation by Cyanobacteria and Rhizobia; Types of mycorrhizal association with plants; Ectomycorrhiza and Endomycorrhiza and their effects on plant growth.

Practicals:

1. Study of Viruses: Electron micrographs / Models - T-Bacteriophage and TMV; specimens/digital resources/ Line drawings of Lytic and Lysogenic Cycle. **(Weeks: 02)**
2. Study of Bacteria: Electron micrographs of bacteria; Types of Bacteria from temporary/permanent slides. Endospore, Binary fission, Conjugation, Root nodule through specimens/digital resources. **(Weeks: 02)**
3. Study of Plant Growth Promoting Rhizobacteria (PGPR) through specimens/digital resources (at least three). **(Week: 01)**
4. Gram staining to differentiate between Gram-positive and Gram-negative bacteria. **(Weeks: 02)**
5. Study of *Rhizobium* from root nodules of a leguminous plant. **(Weeks: 02)**
6. Isolation of *Anabaena* from *Azolla* leaves. **(Weeks: 02)**
7. Histochemical staining to observe Arbuscular Mycorrhizal Fungi (AMF) colonization in roots. **(Weeks: 02)**
8. Study of bacterial diseases (Citrus canker, Angular leaf spots of cotton) and viral diseases of plants (mosaic and vein clearing disease) through specimens/digital resources. **(Weeks: 02)**

Suggested Readings:

1. Pelczar, M.J. (2001). Microbiology, 5th edition. New Delhi, Delhi, Tata McGrawHill Co.
2. Tortora, G.J., Funke, B.R., Case, C.L. (2016). Microbiology: An Introduction, Indian

edition, Pearson India Education Services Pvt. Limited, Noida, India

3. Prescott, L.M., Harley J.P., Klein D. A. (2005). Microbiology, 6th edition: McGraw Hill, New Delhi.
4. Gupta, R., Chugh, G. (2022). Plants, Microbes and Diseases 1st Edition, I.K. International Pvt. Ltd., Delhi.
5. Subba Rao, N.S. (2000). Soil Microbiology, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi

Additional Resources:

1. Talaro, K.P., Talaro, A. (2006). Foundations in Microbiology. McGraw Hill, New Delhi

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – 5: Plant Resources and Economic Botany

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Plant Resources and Economic Botany **BOT-DSC-5**	**4**	**2**	**0**	**2**	**Nil**	**Nil**

Learning Objectives

The course will help students gain knowledge on:

- the economic importance of diverse plant species and train them in identifying plants of economic importance through field visit/s, live plant specimens, herbarium specimens and digital resources.
- the different plant parts and plant products such as food, fibers, medicines, oils and others).
- the processing of various plant resources and train them to identify and analyse nutrients using simple microchemical tests.

Learning outcomes:

- This course would provide students with information about the economic importance and products derived from plants and their roles in our daily lives.
- Students will learn to perform microchemical tests to study the presence of various components.
- Students will explore the regional diversity in food crops and other plants and their ethnobotanical importance.

SYLLABUS OF BOT-DSC-5

Unit 1: Introduction and Origin of Cultivated Plants **Week: 01**

Importance of Plant Resources; Vavilov's concept for the Origin of cultivated plants; Centres of Origin (Primary and Secondary); Centres of diversity, Harlan's concept of gene pools; Plant Genetic Resources and their conservation.

Unit 2: Cereals **Weeks: 02**

Wheats (Origin, Evolution of Wheats (tetra- & hexaploid), Morphology, Production, and Economic Importance of Hexaploid Wheat); Rice (Origin-Monophyletic and Polyphyletic, Production, Morphology, Comparison between *indica* and *japonica* Rice, Parboiling, Economic Importance); Other cereals: Maize, Barley, Oats, Millets (jowar, bajra, ragi) and Pseudocereals.

Unit 3: Legumes **Weeks: 1.5**

General account (Nutritive Value of Pulses, Protein Malnutrition, Lathyrism, Favism, Ecological Importance); Chick pea and Pigeon pea (Production, Morphology and Economic Importance); Other Legumes: Lentil, Cluster Bean, Lathyrus, Beans, Pea, Cowpea, Fodder legumes and Green manure crops.

Unit 4: Sugars and Starches **Weeks: 1.5**

Sugarcane (Morphology, Ratooning, Nobilization, Products and By-products); Potato (Morphology, Tuber Anatomy, Seed Tubers vs True Potato Seeds and Economic uses).

Unit 5: Spices, Condiments & Flavourings **Weeks: 1.5**

General Account (Spices, Condiments, Culinary Herbs and Essences, with examples), Importance of Spices, Clove (Morphology, Anatomy of part used and Economic Importance) and Black Pepper (Morphology, Anatomy of part used and Economic Importance). Other examples: Ginger, Turmeric, Cinnamon, Saffron, Cardamom, Chillies & Pepper, Fennel, Coriander, Cumin, Vanilla, Nutmeg.

Unit 6: Beverages **Week: 01**

Types of Beverages (Alcoholic and Non-Alcoholic) with examples; Tea and coffee (Morphology, Chemistry, Processing and Economic Importance)

Unit 7: Fibres and Fibre-yielding plants **Weeks: 1.5**

Classification of Fibres based upon their Origin (surface fibres, bast fibres, and leaf fibres, with examples); Jute (morphology, extraction and economic importance), Cotton (*Gossypium* species, morphology, processing and economic importance) Comparison between Jute and Cotton fibers. Other examples: Flax, Hemp and Coconut.

Unit 8: Oil-Yielding Plants **Weeks: 1.5**

Fatty Oils and Essential Oils, Comparison between Fatty Oils and Essential Oils; Fatty Oils (Classification with examples, keeping quality), Groundnut (Morphology and Economic Importance); Essential Oils (General characteristics, Methods of Extraction and Economic Importance, with examples). Other examples: Rapeseed & Mustard (canola), Coconut, Olive, Castor, Cottonseed, Sesame, Soybean, Linseed.

Unit 9: Medicinal and Drug-Yielding Plants **Week: 01**

Brief Account of Therapeutic Drugs with Examples; Morphology, Chemical Constituents, Economic Importance of *Cinchona, Rauwolfia, Digitalis.*

Unit 10: Fumigatory & Masticatory **Week: 01**

Tobacco **(**Morphology, species - *Nicotiana tabacum* & *N. rustica*), Processing, Products, Economic Importance and Health Hazards), *Cannabis*, *Papaver* (Morphology, Chemical constituents, Economic importance)

Unit 11: Rubber **Week: 0.5**

Para Rubber - *Hevea brasiliensis* (Morphology, Tapping of latex, Processing, Products and Economic Importance)

Unit 12: Fruits & Nuts **Week: 0.5**

Tropical & Temperate; *Citrus*, Mango, Banana, Apple, Pineapple, Papaya; Nuts: Cashew, Walnut, Almond & Pistachio.

Unit 13: Vegetables **Week: 0.5**

Common examples of root crops, leafy vegetables (herbage), fruit seed vegetables.

Practicals:

1. **Cereals**: Wheat (habit sketch, L.S/T.S. grain, W.M. starch grains, microchemical tests), Rice (habit sketch, study of paddy and grain, W.M. starch grains, microchemical tests). Millets - Pearl Millet, Finger Millet and Pseudocereals - Amaranth, Quinoa (specimens/digital resources and grains) **(Weeks: 02)**
2. **Legumes**: Chickpea, Pigeonpea (habit, fruit, seed structure, micro-chemical tests). **(Week: 01)**
3. **Sugars and Starches**: Sugarcane (habit sketch, products and by-products, Cane juice-microchemical tests); Potato (habit sketch, tuber morphology, T.S. tuber to show

localization of starch grains, W.M. starch grains, microchemical tests). **(Week: 01)**

4. **Spices**: Clove, Black pepper (habit and sections-L.S./T.S.), Saffron, Fennel (specimen/digital resources) **(Week: 01)**
5. **Beverages**: Tea (plant specimen, tea leaves), Coffee (plant specimen, beans) **(Week: 01)**
6. **Fibres**: Jute (specimens/digital resources of *Corchorus capsularis* and *C. olitorious*, T.S. stem, test for cellulose and lignin on section of stem and fibre). Cotton (specimen, W.M. seed to show lint and fuzz; W.M. fibre and test for cellulose) **(Weeks: 02)**
7. **Oil-Yielding Plants**: Fatty Oils: Groundnut (h abit-specimen, fruit, seeds, microchemical Tests)' Coconut (habit-photograph, fruit, T.S. nut), Mustard - (habit-specimen, fruit, seeds); Essential Oils: habit sketch of Rose, Jasmine, Vetiver, Sandalwood and *Eucalyptus* (specimens/photographs)
   (Weeks: 02)
8. **Drug-Yielding plants:** Habit - Fever Bark Tree, Poppy, Foxglove and Cannabis (Specimens/ Photographs) **(Weeks: 02)**
9. **Tobacco:** *Nicotiana tabacum* and *N. rustica* (specimens/photographs), Tobacco Products **(Week: 01)**
10. **Rubber:** Para Rubber-Habit, Tapping of latex (Specimen/photograph), Rubber Products **(Week: 01)**
11. **Petro-crops:** *Saccharum officinarum* , *Jatropha* sp. **(Week: 01)**

Suggested Readings:

1. Kochhar, S.L. (2012). Economic Botany in Tropics. New Delhi, India: MacMillan & Co.
2. Kochhar, S.L. (2016). Economic Botany – A Comprehensive Study, 5th Edition. New Delhi, India: Cambridge University Press.
3. Wickens, G.E. (2001). Economic Botany: Principles & Practices. The Netherlands: Kluwer Academic Publishers.
4. Chrispeels, M.J., Sadava, D.E. (1994). Plants. Genes and Agriculture. Jones & Bartlett-Publishers.
5. Berg L. (2008). Introductory Botany: Plants, People, And The Environment, Thomson Brooks/Cole.
6. Cook F.E.M. (1995). Economic Botany: Data Collection Standard Royal Botanic Garden, Kew, Richmond.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – 6: Plant Systematics

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Plant Systematics **BOT-DSC-6**	**4**	**2**	**0**	**2**	**Nil**	**Nil**

Learning Objectives:

- The course will help students gain knowledge about the basics of plant systematics and its interrelationships with allied subject areas

Learning outcomes

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

- understand technical terminology used in plant taxonomy
- apply the terminologies to describe, identify and classify flowering plants
- search and analyse taxonomic information from internet-based scientific databases and other resources
- interpret and evaluate the concept of species and evolutionary processes in angiosperms
- comprehend and compare various systems of classifications
- recognise diversity in local/regional flora
- appreciate the significance and application of systematics in science and welfare of society

SYLLABUS OF BOT-DSC-6

Unit 1: Introduction **Week: 01**

Identification, Classification (types) and Nomenclature, Phylogeny; Major contributions - Parasara, Charaka, Theophrastus, Bauhin, Tournefort, Linnaeus, Adanson, de Candolle, Bessey, Hutchinson, Takhtajan, Bremer, MW Chase

Unit 2: Resources in Plant Identification **Week: 01**

Literature (Floras, Manuals, *Icones*, Monographs, Revisions, Journals, e-resources); Herbaria and Botanical gardens (in brief).

Unit 3: Systematics - An Interdisciplinary Science **Weeks: 02**

Relevance of palynology, cytology, phytochemistry and molecular data (cp.DNA, mt.DNA, nuclear DNA, PCR amplification, sequence data analysis); three examples from each with emphasis on application in resolving taxonomic problems - details of techniques to be excluded)

Unit 4: Botanical Nomenclature **Weeks: 2.5**

Principles and rules (ICN); Ranks and names; Principle of priority and its limitations; Concept of 'Type', Author citation, Valid publication, Rejection of names, Nomenclature of hybrids

Unit 5: Systems of Classification **Weeks: 03**

Taxonomic hierarchy; Concept of species (morphological, biological and evolutionary); Classification systems - Bentham and Hooker (up to series), Engler and Prantl (up to sub-class) and Angiosperm Phylogeny Group (APG) classification (major clades).

Unit 6: Approaches in Systematics **Weeks: 03**

Terms and concepts (primitive and advanced, homology and analogy, parallelism and convergence, monophyly, paraphyly, polyphyly, clades and grades).

Phenetics - Principles, Methodology, Characters; Selection of OTUs, Character weighing and Coding; Cluster analysis; Phenogram.

Cladistics - Principles, Methodology, Characters; Selection of EUs, Character weighing and Coding; Cluster analysis; Cladogram

Unit 7: Evolution of Angiosperms **Weeks: 2.5**

Concept of a primitive flower (Euanthial theory and Pseudanthial theory); Basal Living Angiosperms; Herbaceous origin; Coevolution of angiosperms with animals.

Practicals:

1. Field trip/ Visit to any herbaria/ Botanical Garden. **(Week: 01)**
2. To prepare at least five herbarium specimens and identify them using available resources (Literature, herbaria, e-resources, taxonomic keys) and classify up to family level

(according to Bentham and Hooker's classification and compare it with APG IV System in the field notebook). **(Weeks: 02)**

3. Description of taxa using semi-technical terms and identification of the families according to Bentham and Hooker's classification and compare the placement of family with APG IV System (Only placement of family according to APG IV system to be mentioned) **(Weeks: 12)**

Note: Any **twelve** families from the following list to be studied with **at least two** specimens (**or one** where limitations exist).

List of Suggested Families (*mandatory)

Acanthaceae, Amaranthaceae, *Apiaceae, Apocynaceae, *Asteraceae, *Brassicaceae, *Euphorbiaceae, *Fabaceae, *Lamiaceae, Liliaceae, *Malvaceae, Moraceae, *Poaceae, *Ranunculaceae, *Solanaceae

Suggested Readings:

1. Simpson, M. G. (2019). Plant systematics. 3rd Edition, Academic press.
2. Singh, G. (2019). Plant Systematics- An Integrated Approach. 4th edition. CRC Press, Taylor and Francis Group.
3. Stuessy, T.F. (2009). Plant Taxonomy: The Systematic Evaluation of Comparative Data, 2nd edition, Columbia University Press.
4. Taylor, D.V., Hickey, L.J. (1997). Flowering Plants: Origin, Evolution and Phylogeny. CBS Publishers & Distributors, New Delhi.
5. Pandey, A. K., Kasana, S. (2021). *Plant Systematics*. 2nd Edition. CRC Press Taylor and Francis Group
6. http://www.mobot.org/MOBOT/research/APweb/
7. Maheshwari, J. K. (1963). The flora of Delhi. Council of Scientific & Industrial Research.
8. Maheshwari, J. K. (1966). Illustrations to the Flora of Delhi. Council of Scientific & Industrial Research.
9. Harris, J. G., Harris, M. W. (2001). Plant Identification Terminology: An Illustrated Glossary. Spring Lake, Utah: Spring Lake Pub. Spring Lake, Utah.
10. Radford, A. E. (1974). Vascular plant systematics. Harper & Row Publishers, New York, London.
11. Judd, W.S., Campbell, L.S., Kellogg, E.A., Stevens, P.F., Donoghue, M.J. (2016). Plant Systematics: A Phylogenetic Approach. 4th edition. Sunderland, MA: Sinauer Associates.

Additional Resources:

1. The Angiosperm Phylogeny Group, Chase, M. W., Christenhusz, M. J.M., Fay, M. F.,

Byng, J. W., Judd, W. S., Soltis, D.E. Mabberley, D. J., Sennikov, A. N., Soltis, P. S., Stevens, P. F. (2016). An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants*:* APG IV. Botanical journal of the Linnean Society 181 (1): 1–20.

2. Soltis, D. E., Bell, C. D., Kim, S., Soltis, P. S. (2008). Origin and early evolution of angiosperms. Annals of the New York Academy of Sciences 1133: 3-25.
3. Scutt, C. P. (2021). The origin of angiosperms. In Evolutionary developmental biology: a reference guide. Cham: Springer International Publishing.
4. https://www.mobot.org/MOBOT/research/APweb/treeapweb2s.gif
5. https://www.digitalatlasofancientlife.org
6. http://apps.kew.org/herbcat/navigator.do
7. https://efloraofindia.com/
8. https://powo.science.kew.org/
9. Page, R.D.M., Holmes, E.C. (1998). Molecular Evolution: A phylogenetic approach. Blackwell Publishing Ltd.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

COMMON POOL OF GENERIC ELECTIVES (BOT-GE)

GENERIC ELECTIVES (BOT-GE-6)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Ethnobotany **BOT-GE-6**	**4**	**2**	**0**	**2**	**Nil**	**Nil**

Learning Objective:

- To have the knowledge of the plants used by the local communities, tribals, ethnic groups, their nutritive and medicinal value.

Learning Outcomes:

- After studying this course the student will have an understanding of the value and usefulness of the natural products and their efficient use by the local communities as food and medicine and their conservation practices.

SYLLABUS OF BOT-GE-6

Unit 1: Introduction to Ethnobotany and Basic Taxonomy **Weeks: 03**

Introduction, concept, scope and objectives; Ethnobotany as an interdisciplinary science; The relevance of ethnobotany in the present context; Major and minor ethnic groups or tribes of India, and their lifestyles; Plants used by the indigenous societies: a) Food plants, b) Medicinal plants, c) intoxicants and beverages, d) Resins and oils and miscellaneous uses.

Unit 2: Applied Ethnobotany **Weeks: 3.5**

Role of ethnobotany in modern Medicine, Medico-ethnobotanical sources in India; Significance of the following plants in ethnobotanical practices (along with their habitat and morphology): a) *Azadirachta indica*, b) *Ocimum sanctum*, c) *Vitex negundo*, d) *Gloriosa superba*, e) *Tribulus terrestris*, f) *Pongamia pinnata*, g) *Cassia auriculata*, h) *Indigofera tinctoria*.

Unit 3: The Ecology of Ethnobotany **Weeks: 3.5**

Ethnobotany—Spirits, Lore, Material Cultures, Folk Magic, Narcotics, Stimulants; Nutritional Ethnobotany – Agriculture, foraging and wild foods; Linguistic Ethnobotany—Botanical

Classification and Ethics; Medicinal Ethnobotany and Ethnopharmacology; Ethnoveterinary knowledge.

Unit 4: Research Methods in Ethnobotany **Weeks: 03**

Etic and Emic Perspectives: a) Field work; b) Herbarium; c) Ancient Literature and oral traditions; d) Archaeological finding inferences; e) Religious and sacred places.

Unit 5: Protecting Knowledge **Weeks: 02**

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; databases and knowledge resource (Traditional Knowledge Digital Library); Case studies of traditional medicines leading to development of modern pharmaceutical products (use of *Trichopus zeylanicus* by Kani tribe and *Artemesia* sp. for malaria cure).

Practicals:

1. Collection, identification and preparation of herbarium of three ethno-botanically important plants with appropriate references. **(Week: 02)**
2. Preparation of crude extract of ethnobotanically important plants with appropriate references (any method to be used). **(Weeks: 04)**
3. Project work-documentation, literature survey, and collection of information on ethno-botanically useful plants from traditional healers). (**Weeks: 09)**

Suggested Readings:

1. Jain, S.K. (2010). Manual of Ethnobotany. Rajasthan: Scientific Publishers.
2. Martin, G.J. (1995). Ethnobotany: A Methods Manual. Chapman Hall
3. Cunningham, A.B. (2001). Applied Ethnobotany: People, Wild Plant Use and Conservation. Earthscan, London.
4. Young, K.J. (2007). Ethnobotany. Infobase Publishing, New York.
5. Schmidt, B.M., Cheng, D.M.K. (Eds.) (2017). Ethnobotany: A Phytochemical Perspective. John Wiley & Sons Ltd. Chichester, UK.
6. Research papers from various Scientific Journals for case studies**.**

GENERIC ELECTIVES (BOT-GE-7)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Viewing and Capturing Diversity in Nature **BOT-GE-7**	**4**	**2**	**0**	**2**	**Nil**	**Nil**

Learning Objectives

- A comprehensive introduction to photography, including aesthetics and technique.
- An opportunity to rethink the environment in which they live through the medium of pictures.
- Build familiarity with digital camera and smartphone photography.
- A working knowledge of digital image processing
- An opportunity to use nature photography in your business and career prospects.
- To enhance appreciation for the tremendous beauty inherent in plants and gardens/ nature.

Learning Outcomes

On successful completion of this course, a student will be able to:

- understand the digital camera or smartphone camera functions.
- use different photographic equipment to enhance their photographic skills.
- know about the photographic variables with weather and season.
- exploit their photographic work in various professions and for entrepreneurship development.

SYLLABUS OF BOT-GE-7

Unit 1: Basics of Photography and Videography **Weeks: 05**

History and development of digital photography; Introduction to lenses and camera; Definitions (Megapixel, Magnification, Resolving Power, Zoom feature, contrast and brightness of image); Types of lenses, analog camera, Digital camera, SLR camera, imaging system in camera; Role of lighting, depth of field, focal length, colour and contrast in photography; types of photography and techniques; working of camera: exposure, shutter speed and aperture; Understanding Image: Types of shots: distance, angle and movement; Digital

image basics: image format, resolution, aspect ratio, Pixels, DPI and PPI, composition and aesthetics; rules and guidelines.

Unit 2: Diversity of Nature: Colours and Landscape **Weeks: 05**

Importance of plants as natural products; General characteristic features of various plant life forms (Single celled, colonial forms, filamentous forms and multicellular and complex forms); General account of diverse landscaping patterns based on different geographical locations, plant adaptations and ecological interactions; role of plant pigments (diverse forms of alga, leaf coloration, floral pigments) in aesthetic appeal.

Unit 3: Diversity around us - A magnified view **Weeks: 2.5**

Principles of Microscopy: Dissection and compound microscope, scanning electron microscope. importance of sample preparation for microscopy, staining techniques, micrometry.

Unit 4: Photographic visualisation of Nature **Weeks: 2.5**

Sensitization of Biodiversity conservation; Thematic depiction of nature in Art galleries; Eco-tourism: a general account; role of photography in Eco-tourism and ecological discourse.

Practicals:

1. To study the parts of a digital camera. **(Week: 01)**
2. To study the principle and working of digital camera/ smartphone camera. **(Week: 01)**
3. Working and handling of light microscopes (Dissection and Compound). **(Week: 01)**
4. Study of plant forms through microscopic lens (Single celled, colonial forms, filamentous forms, multicellular and complex forms). **(Week: 01)**
5. To study techniques of capturing shots (using light and lenses effectively, macro and micro photography, wide angle and close-ups). **(Week: 01)**
6. Study of plant adaptations through photographs (Aquatic and desert plants). **(Week: 01)**
7. To capture and understand the Ecological Interactions. **(Week: 01)**
8. Identification of different plant life forms through online available tools/ search engines. **(Week: 01)**
9. Outdoor/ Campus Photography: Plants, Environment, Landscapes and cityscape, Mushrooms. **(Week: 01)**
10. Project Work: To make a portfolio of diverse landscaping patterns/ selected theme through outdoor visits. **(Weeks: 06)**

Suggested Readings:

1. Ang., T. (2008). Fundamentals of modern Photography. London, Mitchell.
2. Patterson, F. (1999). The Art of Seeing. Key Porter Books.

3. Fitzharris, T. (2011). Landscape Photography. Firefly Books.
4. Kelby, S. (2012). The digital photography book. Peachpit Press.
5. Langford, M., Fox, A., Smith, R.S. (2013). Langford basic photography: the guide for serious photographers. Amsterdam: Focal Press/Elsevier.
6. Peterson, B. (2016). Understanding exposure: how to shoot great photographs with any camera. AmPhoto Books.
7. Karp, G. (2010). Cell Biology, 6th edition. New Jersey, U.S.A.: John Wiley & Sons.

Additional Resources:

1. Sharma, P.D. (2010.) Ecology and Environment. Meerut, UP. Rastogi Publications.
2. Wilson, K., Walker, J. (2018). Principles and Techniques of Biochemistry and Molecular Biology, Cambridge University Press.

GENERIC ELECTIVES (BOT-GE-8)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Agricultural Botany and Weed Science **BOT-GE-8**	**4**	**2**	**0**	**2**	**Nil**	**Nil**

Learning Objectives:

To gain the knowledge on:

- the conditions required for seed germination
- growth hormones, plant development and flowering conditions
- weeds and the methods to control weeds

Learning Outcomes:

After completion of this course the students would be able to understand:

- how is the quality of seeds judged and how are the suitable conditions for the seed germination created.
- how are the growth, flowering and fruiting in plants managed through the applications of hormones.
- how are weeds managed in commercial crops.

SYLLABUS OF BOT-GE-8

Unit 1: Seed Physiology **Weeks: 02**

Seed dormancy types, factors, mechanism and methods for breaking dormancy, seed viability, seed vigour and seed germination.

Unit 2: Physiology of Crop Growth and Yield **Weeks: 2.5**

Growth, methods of growth analysis, factors affecting growth, concept of phytotronics and fertilizers (Nitrogen, Phosphorus, biofertilizers).

Unit 3: Regulation of Growth and Development **Weeks: 02**

Role of hormones in plant growth and development; growth retardants.

Unit 4: Reproductive Physiology and Senescence **Weeks: 03**

Physiology of flowering; Photoperiodism; Vernalization; Physiology of fruit ripening, senescence and regulation of senescence.

Unit 5: Biology of Weeds **Weeks: 02**

Ecology of weeds, competition, reproduction of weeds; Allelopathy and Invasive Plants.

Unit 6: Crop Management Practices **Weeks: 3.5**

Mechanical, Cultural, Biological and Chemical Weed control; Some obnoxious weeds and their management, Integrated pest management (IPM).

Practicals:

1. To study the effect of ethylene on shelf life of cut flowers/ To study the effect of cytokinin on leaf senescence. **(Weeks: 02)**
2. To test the viability of weed seeds. **(Weeks: 03)**
3. To study the allelopathic effects of weeds on germination of crop seeds. **(Weeks: 03)**
4. To study the effect of herbicides on seed germination and seedling growth of weeds. **(Weeks: 03)**
5. Determination of pH and analysis of a soil sample for carbonates, chlorides, sulphates, organic matter and base deficiency by rapid field tests. **(Week: 01)**
6. To perform the qualitative test for Nitrogen (NH^{4+}, NO^{3-}, urea) in a fertilizer and the soil sample. **(Week: 01)**
7. Demonstration / photographs for the mechanisms used in herbicide application. **(Week: 01)**
8. Field trip to a crop land to study weeds. **(Week: 01)**
9. Submission of any two properly dried and mounted weed specimens with the herbarium label.

Suggested Readings:

1. Ashton, F. M., Monaco, T. J. (2002). Weed Science: Principles and Practices. New Jersey, U.S.: John Wiley and Sons. Inc.
2. Hopkins, W. G., Huner, N. P. A. (2009). Introduction to Plant Physiology, 4th edition. New Delhi, Delhi: Wiley India Pvt. Ltd.
3. Taiz, L., Zeiger, E., Moller, I. M., Murphy, A. (2018). Plant Physiology and Development International 6th edition. New York, NY: Oxford University Press, Sinauer Associates.
4. Mandal, R.C. (1990). Weeds, weedicides and weed control: Principle and Practice. New Delhi, Delhi: Agro Botanical Publishers.

5. Rao, V. S. (1999). Principles of Weed Science. Oxford and IBH Publishers, New Delhi.
6. Subramanian, S. (2017). All about weed control. New Delhi, Delhi: Kalayani publishers.

GENERIC ELECTIVES (BOT-GE-9)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Intelligent Systems in Plants **BOT-GE-9**	**4**	**2**	**0**	**2**	**Nil**	**Nil**

Learning Objectives

- The course aims to lay the foundations on plant intelligence and develops understanding of the intelligent adaptively variable behaviour of plants.

Learning outcomes

- The students will be learning the concepts of intelligence, distinction between development and intelligent behaviour and morphological /adaptive strategies employed by plants to survive.

SYLLABUS OF BOT-GE-9

Unit 1: Introduction **Weeks: 02**

An Introduction to Plant Structure (Morphological and Anatomical details); compartmentalization

Unit 2: Plants and Intelligence **Weeks: 1.5**

Introduction to Plant Intelligence and Memory - Historical Perspective

Unit 3: Sensory Biology **Weeks: 02**

Cell to cell communication, Self-recognition, Recognition of Neighbours and Relatives.

Unit 4: Learning in Plants **Weeks: 03**

Habituation learning; Learning by association (Rhizosphere and Mycorrhizae); Adaptive Intelligence (Hydrophytes, Xerophytes, Parasites, Carnivorous plants, Thermogenic plants); Response to water, heat, salt and cold stress; Mechanical and chemical defence against predators with special reference to secondary metabolites.

Unit 5: Intelligent Behaviour of Plants **Weeks: 6.5**

A Guided tour to Plant Movements (Tropic Movements, Movement towards gravity, light, tracking sun movements, prey driven movements, liberation movements); Intelligent response to minerals and light (Seed germination, root cap, response of shoot, leaf morphology and anatomy); Unique pollination and seed dispersal mechanisms; Osmosis; Short and long-distance transport of water and food; Metabolic redundancy; Life Cycle Signaling in response to external stimuli (Reactive Oxygen Species, peptides, receptors, hormones).

Practicals:

1. Study the structure of plant cell using temporary mount. **(Week: 01)**
2. Study of the cell as an osmotic system (Plasmolysis and Deplasmolysis). **(Week: 01)**
3. Demonstration of the phenomenon of protoplasmic streaming in *Hydrilla* leaf. **(Week: 01)**
4. Extraction and qualitative analysis of alkaloids, flavonoids, tannins and phenols. **(Weeks: 02)**
5. To study the phenomenon of seed germination (effect of light). **(Week: 02)**
6. To study light sensitivity and etiolation vs. de-etiolation. **(Week: 01)**
7. Morphology and orientation of chloroplasts in leaves growing in light and dark, plasmodesmata connections and plasma membrane receptors. (through photographs or other digital resources). **(Week: 01)**
8. Estimation of total photosynthetic pigments. **(Week: 01)**
9. Study of (a) Root cap (b) Trichomes: non-glandular and glandular (c) Leaf Morphology and Anatomy (d) pulvinus anatomy in *Mimosa pudica* (e) Specialised motor tissue at the base of monocot leaves. **(Weeks: 02)**
10. (a) Study of morphological and anatomical adaptations of hydrophytes, xerophytes.
    (b). Study of biotic interactions of the following: Stem parasite (*Cuscuta*), Root parasite (*Orobanche*), Epiphytes, Predation (Insectivorous plants). **(Weeks: 02)**
11. Pollination types (selected) and associated seed dispersal mechanisms. **(Week: 01)**

Suggested Readings:

1. Mauseth, J.D. (1988). Plant Anatomy. The Benjammin/Cummings Publisher, USA.
2. Evert, RF., Eichhorn, S.E. (2012). Raven Biology of Plants, 8th edition, New York, NY: W.H. Freeman and Company.
3. Koller, D. (2011). The Restless Plant. Edited by Elizabeth Van Volkenburgh, Haward University Press, Cambridge, Massachusetts, and London, England.
4. Crang, R., Lyons-Sobaski, S., Wise, R. (2018) Plant Anatomy- A Concept based approach to the structure of seed plants, Springer Nature, Switzerland.

Additional Resources:

Trewavas A. (2017). The foundations of plant intelligence. Interface Focus 7: 20160098. http://dx.doi.org/10.1098/rsfs.2016.0098

GENERIC ELECTIVES (BOT-GE-10)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Informatics and Statistics for Biology and Allied Sciences **BOT-GE-10**	**4**	**2**	**0**	**2**	**Nil**	**Nil**

Learning Objectives:

- To build an understanding *in silico*/computational approaches in various aspects of understanding biology and biological research.
- To build analytical skills and integrate the principles of statistical analyses for robust interpretation of biological observations.

Learning outcomes

The student will understand:

- the basics of bioinformatics and develop awareness of the interdisciplinary nature of this field.
- learn about biological databases, sequence retrieval, alignment, and phylogenetic analysis using various tools.
- understand the basic concept of sampling methods, data classification, presentation and statistical analysis.

SYLLABUS OF BOT-GE-10

Unit 1: Introduction to Bioinformatics **Weeks: 1.5**

Historical background; Aims and scope; bioinformatics in Genomics, Transcriptomics, Proteomics, Metabolomics, Systems biology and drug discovery; Applications and Limitations in bioinformatics.

Unit 2: Biological databases **Weeks: 02**

Introduction to biological databases - Primary, secondary and composite databases; Study of following databases: NCBI (GenBank, PubChem, PubMed and its tools (BLAST)); introduction to EMBL, DDBJ, UniProt, PDB and KEGG.

Unit 3: Basic concepts of Sequence alignment **Weeks: 02**

Similarity, identity and homology. Concepts of alignment (gaps and penalty); Alignment – pairwise and multiple sequence alignments

Unit 4: Molecular Phylogeny **Weeks: 02**

Introduction to Molecular Phylogeny, methods of construction of phylogenetic trees: maximum parsimony (MP), maximum likelihood (ML) and distance (Neighbour-joining) methods.

Unit 5: Biostatistics **Week: 01**

Biostatistics – definition, Basics of descriptive and inferential statistics; Limitations and applications of biostatistics.

Unit 6: Data types and presentation **Weeks: 1.5**

Primary and secondary data; Sampling methods (in brief); tabulation and presentation of data.

Unit 7: Descriptive Statistics **Weeks: 02**

Measures of central tendency - mean, median, and mode; Measures of dispersion - range, standard deviation, and standard error.

Unit 8: Correlation and Regression **Weeks: 1.5**

Types and methods of correlation; Introduction to simple regression equation; similarities and dissimilarities between correlation and regression.

Unit 9: Statistical inference **Weeks: 1.5**

Hypothesis – (simple hypothesis), student's t test, chi-square test.

(Note: Numerical based questions of unit 7, 8 and 9 should be covered only in practical)

Practicals:

1. Biological databases (NCBI, EMBL, UniProt, PDB) **(Week: 02)**
2. Literature retrieval from PubMed. **(Week: 01)**
3. Sequence retrieval (protein and gene) from NCBI (formats - FASTA, GenBank and GenPept formats). **(Week: 02)**
4. Protein Structure retrieval from PDB (in pdb format) and visualisation by viewing tools (Ras Mol/ J mol/Mol*/Swiss 3D Viewer/Pymol). **(Week: 02)**
5. Multiple sequence alignment (MEGA/ Clustal omega). **(Week: 02)**
6. Construction of phylogenetic tree (PHYLIP/ MEGA/ Clustal omega). **(Week: 02)**
7. Making of Bar diagrams, Pie chart, Histogram, Frequency polygon, Cumulative frequency curve (any four) in the given data set using Microsoft Excel. **(Week: 01)**
8. Calculation of mean, mode, median, standard deviation and standard error (through

manual calculation and using Microsoft Excel) (use only ungrouped data). **(Week: 01)**

9. Calculation of correlation coefficient values by Karl Pearson's /Spearman Rank methods (through manual calculation and using Microsoft Excel). **(Week: 01)**
10. Student's t-test (using Microsoft Excel only), chi square test (Manual and using Microsoft Excel). **(Week: 01)**

Suggested readings:

1. Ghosh, Z., Mallick, B. (2008). *Bioinformatics – Principles and Applications*, 1st edition. New Delhi, Delhi: Oxford University Press.
2. Baxevanis, A.D., Ouellette, B.F., John (2005). *Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins*, 3rd edition. New Jersey, U.S.: Wiley & Sons, Inc.
3. Roy, D. (2009). *Bioinformatics*, 1st edition. New Delhi, Delhi: Narosa Publishing House.
4. Andreas, D., Baxevanis, B.F., Francis, Ouellette. (2004). *Bioinformatics: A practical guide to the analysis of genes and proteins*, 3rd edition. New Jersey, U.S.: John Wiley and Sons.
5. Khan, I.A., Khanum, A. (2004). Fundamentals of Biostatistics, 5th edition. Hyderabad: Ukaaz publications.
6. Campbell, R.C. (1998). Statistics for Biologists. Cambridge, U.S.A.: Cambridge University Press

Additional Resources:

1. Pevsner, J. (2009). Bioinformatics and Functional Genomics, 2nd edition. New Jersey, U.S.: Wiley Blackwell.
2. Xiong, J. (2006). Essential Bioinformatics, 1st edition. Cambridge, U.K.: Cambridge University Press.
3. Mount, D.W. (2004). Bioinformatics: Sequence and Genome analysis 2nd edition, Cold Spring Harbor Laboratory Press, USA.
4. Zar, J.H. (2012). Biostatistical Analysis, 4th edition. London, London: Pearson Publication.
5. Pandey, M. (2015). Biostatistics Basic and Advanced. New Delhi, Delhi: M V Learning.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Nomenclature of certificate/diploma/degrees:

- ✓ After securing 44 credits (from semester I and II), by completing one year of study of the UG honours Programme with Botany as a single core discipline, if a student exits after following due procedure, he or she shall be awarded an Undergraduate **Certificate in Botany.**

- ✓ After securing 88 credits (from semester I, II, III & IV), by completing two years of study of the UG honours Programme with Botany as a single core discipline, if a student exits after following due procedure, he or she shall be awarded a **Diploma in Botany.**

- ✓ After securing 132 credits (from semester I to VI), by completing three years of study of the UG honours Programme with Botany as a single core discipline, if a student exits after following due procedure, he or she shall be awarded a **Degree in Bachelor of Science (Honours) in Botany.**

- ✓ After securing 176 credits (from semester I to VIII), by completing four years of study of the UG honours Programme with Botany as a single core discipline and writing dissertation, the student shall be awarded a **Degree in Bachelor of Science (Honours with Research) in Botany.**

- ✓ After securing 176 credits (from semester I to VIII), by completing four years of study of the UG honours Programme with Botany as a single core discipline and engages in Academic Project/Entrepreneurship, the student shall be awarded a **Degree in Bachelor of Science (Honours with Academic Project/Entrepreneurship) in Botany.**

COURSES OFFERED BY DEPARTMENT OF BOTANY

Category II

Botany Courses for Undergraduate Programme of study with Botany as one of the Core Disciplines
(B.Sc. Programmes with Botany as Major discipline)

DISCIPLINE SPECIFIC CORE COURSE (BOT-LS-DSC-1): Plant Diversity and Systematics

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Plant Diversity and Systematics **BOT-LS-DSC-1**	**4**	**2**	**0**	**2**	10+2 from any recognized Board with Biology/ Biotechnology	**Nil**

Learning Objective

- To make students aware about the diversity of plants and microbes present on the planet and how are they possibly related to each other in light of evolution

Learning Outcomes:

This course will be able to impart basic knowledge in understanding of:

- the diversity of the plants and microbes
- the possible relationship between each group
- their general characteristics
- they will be able to identify various groups of plants

SYLLABUS OF BOT-LS-DSC-1

Unit 1: Diversity of Life **Week: 0.5**

Classifying the diversity of life: Domains of Life –Eubacteria, Archaea and

Eukaryotes.

Unit 2: Microbes **Weeks: 02**

Viruses: General account; Replication, Lytic and Lysogenic cycle; Bacteria: structure, Wall-less forms (L-forms, Mycoplasma), asexual reproduction and genetic recombination.

Unit 3: Algae **Weeks: 1.5**

Brief introduction of major classes Blue green, Green, Brown and Red algae. Diagnostic features of identification; morphology, reproduction and classification with special reference to *Nostoc*, *Volvox*, and *Spirogyra*.

Unit 4: Fungi **Weeks: 1.5**

Diagnostic features of identification; morphology, reproduction and classification with special reference to *Rhizopus, Penicillium and Agaricus*; Lichens (a general account).

Unit 5: Bryophytes, Pteridophytes and Gymnosperm **Weeks: 03**

Characteristic features of identification, Morphology and reproduction of Bryophytes. Pteridophytes and Gymnosperms, with special reference to *Marchantia*, *Funaria*, *Pteris* and *Pinus* (only morphology).

Unit 6: Angiosperms **Week: 01**

Diagnostic features, Structure of flower, types of inflorescence

Unit 7: Systematics **Week: 0.5**

Aims, fundamental components of systematics description, identification, nomenclature, phylogeny, biosystematics**.**

Unit 8: Systematics in Practices **Weeks: 3.5**

Taxonomic Hierarchy- Concept of taxa and categories; Botanical Nomenclature- principles and rules; Type method; Author citation; Valid publication; Rejection of names, Principle of priority and its limitations; Names of hybrids and cultivars.

Unit 9: Systems of classification **Weeks: 1.5**

Classification: Artificial, Natural and Phylogenetic. An outline of Bentham and Hooker's (up to series only) and Engler and Prantl's (up to Subclasses) systems of classification and their merits and Demerits. APG System.

Practicals:

1. **Viruses:** EM of TMV and Bacteriophage, Specimens of virus infected plants (any two). **(Week: 01)**
2. **Bacteria:** EM of a bacterium, types through permanent slides/photographs, specimens of infected plants (any two). **(Week: 01)**
3. **Algae:** Study of vegetative and reproductive structures of (a) *Nostoc* (b) *Volvox* (c) *Spirogyra* through temporary preparations and permanent slides. **(Week: 01)**
4. **Fungi:** Study of vegetative and reproductive structures of (a) *Rhizopus*, (b) *Penicillium*, and (c) *Agaricus* through temporary preparations and permanent slides/specimens/photographs. **(Week: 01)**
5. **Lichens:** Crustose, Foliose and Fruticose (specimens/photographs). **(Week: 01)**
6. **Bryophytes:** Study of (a) *Marchantia* morphology of thallus, W.M. rhizoids and scales, V.S. thallus through gemma cup, W.M. gemmae (all temporary slides), V.S. antheridiophore, archegoniophore, L.S. sporophyte (all permanent slides), (b) *Funaria*: detailed study and classification from W.M. rhizoids, operculum, peristome, spores and permanent slides of archegonia, antheridia and capsule. **(Weeks: 02)**
7. **Pteridophytes:** Study of *Pteris:* T. S. of Rachis, V.S. of Sporophyll and W.M. of sporangium. **(Week: 01)**
8. **Gymnosperms:** Study of *Pinus* morphology of long & dwarf shoot, male and female cones (specimens) and T.S. of needle (permanent slides only). **(Week: 01)**
9. **Herbarium technique** (Mounting of a properly dried and pressed specimen of any wild plant on the herbarium sheet with complete herbarium label). **(Week: 01)**
10. Taxonomic study of characters of 1 plant from each of the following families (any four): Malvaceae, Solanaceae, Asteraceae, Fabaceace, and Liliaceae. **(Weeks: 05)**

Suggested Readings:

1. Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996). *Introductory Mycology*, 4th edition. Singapore, John Wiley and Sons (Asia).
2. Kumar, H.D. (1999). Introductory Phycology, 2nd edition. Delhi, Delhi: Affiliated East-West. Press Pvt. Ltd.
3. Bhatnagar, S.P., Moitra, A. (1996). Gymnosperms. New Delhi, Delhi: New Age

International (P) Ltd Publishers.

4. Parihar, N.S. (1991). An introduction to Embryophyta. Vol. I. Bryophyta. Prayagraj: U.P.: Central Book Depot.
5. Pelczar, M.J. (2001). Microbiology, 5th edition. New Delhi, Delhi: Tata McGraw-Hill Co.
6. Tortora, G.J., Funke, B.R., Case. C.L. (2007). Microbiology. San Francisco, U.S.A: Pearson Benjamin Cummings.
7. Raven, P.H., Evert, RF., Eichhorn, S.E. (1999). Biology of Plants. New York, NY: W.H.Freeman and Company Worth Publishers.
8. Sethi, I.K. and Walia, S.K. (2018). Text book of Fungi and Their Allies. (2nd Edition), Medtech Publishers, Delhi.
9. Vashishta, P.C., Sinha, A.K., Kumar, A. (2010). Pteridophyta. New Delhi, Delhi: S. Chand & Co Ltd.
10. Singh, G. (2012). Plant Systematics: Theory and Practice, 3rd edition. Oxford and IBH Pvt.Ltd. New Delhi.
11. Simpson, M.G. (2010). Plant Systematics. Elsevier Academic Press, San Diego, CA, U.S.A.
12. Raven, F.H., Evert, R. F., Eichhorn, S.E. (1992). Biology of Plants. W.H. Freeman and Company. New York, NY.
13. Gupta R. 2011 (Ed.) Plant Taxonomy: past, present, and future. New Delhi: The Energy and resources Institute (TERI).
14. Walter S. Judd, et.al. 2015 Plant Systematics: A Phylogenetic Approach 4th Edition Sinauer Associates , Oxford University Press.USA .

http://www.mobot.org/MOBOT/research/APweb/. (for APG IV classification).

GENERIC ELECTIVES (BOT-GE-1)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Plant Diversity and Human Welfare **BOT-GE-1**	**4**	**2**	**0**	**2**	**-**	**Nil**

Learning Objectives

Build awareness about the different groups of plants and their roles in supportinghuman life.

Learning outcomes

After studying this course, the student will gain knowledge about:

- the diversity of various groups of plants, their characteristics and identification.
- different phytogeographic zones in India.
- the basic principles of conservation of Biodiversity and Sustainable DevelopmentGoals (SDG).
- the role of plants in human welfare.

SYLLABUS OF BOT-GE-1

Unit 1: Understanding biodiversity **Weeks: 03**

Understanding biodiversity - definition of key terms; plant diversity in India; assigning value to plant diversity; economic and ecological importance of Algae, Bryophytes, Pteridophytes and Gymnosperms; insights into flowering plant diversity with special focus on agrobiodiversity.

Unit 2: Crop diversity **Weeks: 04**

Crop diversity in various phytogeographic regions in India and their traditional importance as food (including cereals, pulses, oil crops, spices, beverages, fruits and nuts, vegetables, condiments), medicines (Ashwagandha and Sarpagandha) and adornments.

Unit 3: Role of forests **Weeks: 03**

Forests, woodlands, and vegetation stands: diversity and their importance in ecological, aesthetic, and overall well-being; social dimensions of plant diversity; commercial value and utilization of plant wealth.

Unit 4: Cash Crops **Weeks: 2.5**

Crops of high economic value (tobacco, sugarcane, cotton, basmati rice, sandalwood, saffron); Petro crops: the future industry (*Jatropha* sp., corn and sugarcane).

Unit 5: Conservation of biodiversity **Weeks: 1.5**

Conservation of biodiversity using community driven conservation strategies, sustainable utilization keeping Sustainable Development Goals (SDGs) in mind, Innovative approaches and traditional methods of biodiversity utilization and waste minimization during product formation.

Unit 6: Policy issues in conservation of Biodiversity **Week: 01**

National and International initiatives and programmes/schemes focusing on Plant Diversity and human welfare (Tribal Rights Bill, Convention on Biological Diversity (CBD), International Union for Conservation of Nature (IUCN), Protection of Plant Varieties and Farmers' Rights Authority (PPVFRA).

Practicals:

1. To study local plant diversity (common Algae, Bryophytes, Pteridophytes, Gymnosperms (any two of each) in and around the campus; and understand their ecological and economic importance. **(Weeks: 02)**
2. Microchemical tests for carbohydrates, proteins and oils. **(Weeks: 02)**

3. To study (any three) commonly found tree species in the vicinity and understandtheir role in human welfare. **(Weeks: 02)**
4. To prepare an inventory of common medicinal plants in your campus (identify to the family level, list their uses in Indian System of Medicines) **(Weeks: 02)**
5. To visit the local parks and list the trees planted. Also assess some for their dustpollution mitigation capacity using standard procedures. **(Weeks: 02)**
6. Industrial visit to see how the drugs are extracted from plants (report to besubmitted for evaluation). **(Weeks: 02)**

Essential/recommended readings:

- Bilgrami, K. S. (1998). Phytodiversification and Human Welfare: Dedicated toLate Prof. KS Bilgrami, FNA (1933-96). MD Publications Pvt. Ltd.
- Utting, P. (2013). Trees, People and Power. Routledge.
- Manoharachary, C., Nagaraju, D. (2016). Medicinal plants for human health andwelfare. Ann. Phytomed, *5*(1), 24-34.

.

Suggestive reading:

- Myers, N. (2019). A wealth of wild species: storehouse for human welfare.Routledge

GENERIC ELECTIVES (BOT-GE-2)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Biofertilizers BOT-GE-2	**4**	**2**	**0**	**2**	**-**	**Nil**

Learning Objectives

The Learning Objectives of this course are as follows:

- To develop an understanding of biological systems used as fertilizers and build skills in handling microbial inoculants.
- To understand the optimum conditions for growth and multiplication of usefulmicrobes such as *Rhizobium*, cyanobacteria, mycorrhizae, *Azotobacter* etc.
- To understand the role of microbes in mineral cycling and nutrition of plants.
- To gain expertise in various methods of decomposition of biodegradable waste,conversion into compost and apply this knowledge and skill in their daily life.

Learning outcomes

On successful completion of this course, a student will be able to:

- visualize and identify different types of microorganisms with a compound microscope.
- understand the classification of microorganisms according to their shape/ structurefor morphological identification. Prepare and sterilize different types of culture media.
- isolate of microorganisms from the environmental samples and culture in aseptic conditions.

SYLLABUS OF BOT-BOT-GE-2

Unit 1: Introduction **Weeks: 3.5**

Introduction to microbial inoculants or biofertilizers, macro and micro-nutrition of plants, chemical fertilizers versus biofertilizers; Methods and steps in mass multiplication of biofertilizers: stock culture, broth culture, growth medium, fermentation, blending with the carrier, packaging, and quality check, ISI standard specification for biofertilizers; scope of biofertilizers in India.

Unit 2: Microbial Inoculants **Weeks: 04**

Study of important microbial inoculants: *Rhizobium*, *Azospirillum*, *Azotobacter*, Actinorhizae; Characteristics, isolation, identification, and crop response.

Unit 3: Role of Cyanobacteria **Week: 01**

Role of Cyanobacteria (blue-green algae) in rice cultivation; *Azolla* and *Anabaena azollae* association, nitrogen fixation, and factors affecting growth.

Unit 4: Mycorrhizal association **Weeks: 04**

Types of mycorrhizal association, taxonomy, occurrence and distribution; Role of Arbuscular mycorrhizal fungi in phosphorus nutrition, growth and yield of crop plants;AMF – methods in isolation (wet sieving and decanting), identification (morphologicaland molecular methods). Methods of inoculum production (Pot culture and root culture).

Unit 5: Organic farming **Weeks: 2.5**

Introduction to organic farming, recycling of biodegradable municipal (domestic), agricultural and industrial waste; green manuring, bio-composting, vermicomposting and their field application.

Practicals:

1. Study of *Rhizobium* from root nodules of leguminous plants by Gram

stainingmethod. **(Week: 01)**

2. Observation of arbuscular mycorrhizal fungi from plant roots. **(Weeks: 02)**
3. Isolation of arbuscular mycorrhizal spores from rhizosphere soil. **(Week: 01)**
4. Isolation of *Anabaena* from *Azolla* leaf. **(Week: 01)**
5. Study of Earthworm, *Azolla*, AMF: Arbuscules-vesicles through specimen / digital resources. **(Week: 01)**
6. Study of Biocontrol methods and their application -Pheromone trap, *Trichoderma*, *Pseudomonas*, Neem etc. through digital resources. **(Week: 01)**
7. Rapid test for pH, $NO3^{-}$, $SO4^{2-}$, Cl^{-} and organic matter of different composts. **(Weeks: 02)**
8. Projects on any one of the following topics: *Rhizobium* technology, AMF technology, Organic farming, Bio composting, Vermicomposting, *Azolla* culture etc. (The design of the project should be such that it includes a continuous work of at least 6 weeks and a dissertation submission). **(Weeks: 06)**

Essential/recommended readings:

1. Kumaresan, V. (2005). Biotechnology. New Delhi, Delhi: Saras Publication.
2. Sathe, T.V. (2004). Vermiculture and Organic Farming. New Delhi, Delhi: Dayapublishers.
3. Subha Rao, N.S. (2020). Soil Microbiology, 5th edn. New Delhi, Delhi: Oxford &IBH Publishers.
4. Reeta Khosla (2017). Biofertilizers and Biocontrol Agents for Organic Farming, Kojo Press

Suggestive readings:

1. *Azotobacter* - Isolation and characterization - https://youtu.be/1Z1VhgJ2h6U
2. *Rhizobium* - Identification and characterization - https://youtu.be/jELlo-pMvc4.
3. 3-Days Online Workshop On Arbuscular Mycorrhizal Fungi - Biodiversity, Taxonomy and Propagation 19-2 (2022-01-20 at 02_27 GMT-8) - https://youtu.be/LKzK4IuSRc4.
4. Vayas, S.C, Vayas, S., Modi, H.A. (1998). Bio-fertilizers and organic Farming. Nadiad, Gujarat: Akta Prakashan.

GENERIC ELECTIVE (BOT-GE-3)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Protected Agriculture – Hydroponics and Organic Cultivation **BOT-GE-3**	**4**	**2**	**0**	**2**	**-**	**None**

Learning Objectives

The Learning Objectives of this course are as follows:

- To provide knowledge and expertise of various aspects of hydroponics, aquaponics and organic cultivation to students.
- To make students economically self-reliant by growing and marketing organic herbs, vegetables, microgreens and fruits.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Students will develop a thorough understanding of the concepts of Hydroponics, Aquaponics and Organic farming.
- Students will be trained in establishing hydroponic facility.
- Students will learn the development of various organic products such as biopesticides, biofertilizers and bio-0rganic growth promoters.
- Students will understand various government policies in marketing of hydroponic and organic produce.
- Students will understand Good Agricultural Practices associated with protected agriculture.

SYLLABUS OF BOT-GE-3

Unit 1: Introduction to Protected Agriculture **Week: 01**

Types of Protected Agriculture (hydroponics, aquaponics and organic farming), definition, history, terminology, importance and advantages over traditional agriculture, limitations and challenges.

Unit 2: Plant Growth Requirements and Media formulations **Weeks: 2.5**

Physical parameters - light (quality and quantity) artificial light, light balancers; pH, conductivity, salinity (Dissolved Oxygen-DO, Total Dissolved Solid - TDS) and temperature; Chemical parameters- mineral nutrient requirements, deficiencies, toxicities, growth regulators (auxins, gibberellins, cytokinins and abscisic acids); Growth media- types, properties, uses, nutrient formulae, preparation of solutions, solid Media and nutrient film.

Unit 3: Hydroponic growing systems **Weeks: 3.5**

Basic concepts and designs (closed and open systems techniques Nutrient Film Technique (NFT), Deep Water Culture (DWC), Dutch Bucket and other small-scale systems), systems layout. Strengths and weaknesses of various systems, site considerations, componentry, nutrient delivery, pumping

Unit 4: Hydroponics associated pest and diseases **Weeks: 03**

Hydroponics associated pest - mites, thrips, whiteflies, leaf miners; Identification and management of diseases -bacterial, fungal and viral diseases; safety practices (Good Agricultural Practices (GAP) and Integrated Pest Management (IPM).

Unit 5: Organic farming and its management **Weeks: 03**

Organic farming and associated management practices (nutritional requirements, pest,diseases, weeds); use of biofertilizers, biopesticides, bioherbicides, biocontrol agents (plant growth promoting rhizobacteria (PGPR), pheromone trapping, *Trichoderma*, *Pseudomonas*, neem oil, garlic etc.) in management.

Unit 6: Marketing and Policies **Weeks: 02**

Marketing of the produce and government institutes and policies related to protected farming (hydroponics and organic farming).

Practicals:

1. Study of various instruments used in hydroponics. **(Week: 01)**
2. Preparation of growth media for hydroponics. **(Week: 01)**
3. Estimation of NPK, DO, TDS, pH of growing media. **(Week: 01)**
4. Demonstration of different irrigation techniques in hydroponics. **(Week: 01)**
5. Demonstration of construction of a sustainable hydroponic unit. **(Weeks: 02)**
6. Perform rapid tests for estimation of NPK in different soil samples (samples from at least three different sites). **(Week: 01)**
7. Bulk density and porosity of soilless media e.g. coco-peat, perlite, vermiculite,expanded clay, rockwool (any two media). **(Week: 01)**
8. Demonstration of growing a leafy vegetable/fruity vegetable/ medicinal herb/aromatic plant in Hydroponics solution. **(Weeks: 02)**
9. Study of traditional organic inputs and formulation of biofertilizer. **(Weeks: 02)**
10. Preparation of biopesticides, plant health promoters like *Panchgavya, Beejamrut* etc.

    (Week: 02)
11. Field visit to organic farm/hydroponic farm and submission of visit report. **(Week: 01)**

Essential/recommended readings:

1. Schwarz, M. (1995). Soilless Culture Management. Advanced Series in Agricultural Sciences, vol. 24. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-79093-5_2.
2. Hasan, M., Sabir, N., Singh, A.K., Singh, M.C., Patel, N., Khanna, M., Rai, T., Pragnya, P. (2018). Hydroponics Technology for Horticultural Crops, Tech. Bull.TB-ICN 188/2018. Publ. by I.A.R.I., New Delhi-110012 INDIA.

3. Misra S., Misra S., Misra R.L. (2017). Soilless Crop production. Daya PublishingHouse, Astral International (P) Ltd., New Delhi.
4. Palaniappan S. P., Annadurai K. (2018). Organic Farming: Theory & Practice.Scientific Publisher.
5. Goddek, S., Joyce, A., Kotzen, B., Burnell, G.M. (2019). Aquaponics Food Production Systems. Springer, Cham.

Suggestive readings:

1. Jones, J. B. (2014). Complete Guide for Growing Plants Hydroponically. CRCPress.
2. Vayas, S.C, Vayas, S., Modi, H.A. (1998). Bio-fertilizers and organic Farming.Akta Prakashan, Nadiad.

GENERIC ELECTIVES (BOT-GE-4)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Basic Laboratory and Field Skills in Plant Biology and Allied Sciences **BOT-GE-4**	**4**	**2**	**0**	**2**	**-**	**Nil**

Learning Objectives

The Learning Objectives of this course are as follows:

To learn fundamental skills important for performing laboratory and fieldexperiments.

Learning outcomes

After completion of this course the student will learn:

- Good Lab Practices, management of laboratory waste, understanding hazards andrisks to ensure a safe laboratory environment.
- Basics of measurements, units and common mathematical calculations, samplingand data collection.
- Handling and maintenance of instruments
- Presentation, analysis and interpretation of results.

SYLLABUS OF BOT-GE-4

Unit 1: Lab safety and good lab practices **Weeks: 02**

General laboratory safety, good laboratory practices, biosafety measures (first-aid practicesto be followed in case of burn, acid and injury), safety symbols, lab safety

equipment (Fireextinguisher, fume hood, safety glasses), classes of laboratory chemicals, maintenance andhandling of chemicals (Labels, Quality - LR/ AR/ Molecular biology grade/ HPLC grade/Tissue culture grade; Expiry date; Precautions for use), Disinfectants, Biocontainment, Disposal of hazardous chemicals, radioactive and biological waste, Laboratory waste management

Unit 2: Use and maintenance of Laboratory equipment **Weeks: 02**

Weighing balance (Top loading and Analytical), pH meter (calibration and use), magnetic stirrer, pipettes, autoclave, laminar airflow, BOD incubator, incubator shaker, micrometer, haemocytometer, spectrophotometer, Agarose gel electrophoresisunit, SDS PAGE unit, centrifuge, distillation unit, conductivity meter, Lux meter.

Unit 3: Microscopy, sample and slide preparation **Weeks: 2.5**

Microscopes (Dissecting, compound, electron microscope), Fixation and Preservation (for light and electron microscopy); staining, mounting; basic introduction to other types of microscopes (confocal, fluorescence)

Unit 4: Measurements and calculations **Week: 01**

Units of measurements and conversion from one unit to another, measurement of volumes of liquids, Weighing, calculations: scientific notations, powers, logarithmand fractions

Unit 5: Solutions and Buffers **Week: 01**

Molarity, Molality, Normality, percent solution, stock solution, standard solution, dilution, dilution series, pH, acid and bases, buffers- Phosphate, Tris- acetate, Tris-Cl and Citrate buffer

Unit 6: Basic culturing techniques **Weeks: 1.5**

Basic culture media (LB, YEB, MS)- Liquid and solid, Culture techniques : plating (streak, spread & pour),replica plating , serial dilution

Unit 7: Data collection, statistical analysis and interpretation **Weeks: 02**

Fundamentals of data collection, data types - primary and secondary, methods of data collection, sample, sampling methods - merits and demerits, technical and biological replicates, classification - tabulation and presentation of data, Descriptive statistics - Mean, mode, median, Variance, Standard Deviation, Standard error, Coefficient of Variation, difference between sample and population mean.

Unit 8: Basic computer skills for biology **Weeks: 02**

MS- Word, PowerPoint, Excel, introduction to biological databases

Unit 9: Field Skills **Week: 01**

Identification, collection, cataloguing and preservation of plant specimens, Herbarium and Museum

Practicals:

1. Preparation of solutions - molar, molal, normal, percentage, stock, standard and serial dilution **(Week: 01)**
2. Determining pH of solutions (pH paper, Universal indicator, pH meter) and preparation of buffers (Phosphate, Tris-Cl, Electrophoresis buffers-TBE/TAE) **(Week: 01)**
3. Working of instruments - light microscope, autoclave, laminar air flow, spectrophotometer, centrifuge, gel electrophoresis unit (Agarose & Poly acrylamide gels) **(Week: 02)**
4. Temporary peel mount slide preparation and staining (safranin and acetocarmine). **(Week: 01)**
5. Calculate cell size using micrometer. **(Week: 01)**
6. To calculate number of cells per unit volume (usingpollen/spores) using haemocytometer **(Week: 01)**
7. Preparation of LB medium, growth and maintenance of bacterial cultures (liquid -serial dilution method; and semi-solid cultures - streak, spread and

pour plates) **(Weeks:02)**

8. Isolation of genomic DNA from *E. coli* and plant leaf material, Agarose gel electrophoresis. **(Weeks: 02)**
9. Calculation of mean, mode, median, standard deviation using data set (collected from experiments 5 and 6) **(Week: 01)**
10. Using software to draw tables, graphs and calculating descriptive statistics (Microsoft Excel) **(Week: 01)**
11. Laboratory safety equipment (Fire extinguisher, Fume hood, safety glasses) **(Week: 01)**
12. Mounting of a properly dried and processed plant specimen with herbarium label **(Week: 01)**

Essential/recommended readings:

- Evert, R. F., Eichhorn, S. E., Perry, J.B. (2012). Laboratory Topics in Botany.

W.H. Freeman and Company.

- Mesh, M.S., Kebede-Westhead, E. (2012). Essential Laboratory Skills for Biosciences. John Wiley & Sons, Ltd.
- Mu, P., Plummer, D. T. (2001). Introduction to practical biochemistry. Tata McGraw-Hill Education.
- Mann, S. P. (2016). Introductory Statistics, 9th edition. Hoboken, NJ, John Wileyand Sons Inc.
- Danniel, W.W. (1987). Biostatistics. New York, NY: John Wiley Sons.
- Jones, A., Reed, R.,Weyers, J. (2016) Practical Skills in Biology, 6th Edition,Pearson.
- Bisen, P.S. (2014). Laboratory Protocols in Applied Life Sciences (1st edition).CRC Press.

Suggestive readings:

- Zar, Z. H. (2010). Biostatistical Analysis, 5th edition, Pearson Prentice Hall, NewJersey, USA.

GENERIC ELECTIVES (BOT-GE-5)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Green Belt Development and Urban Management for Smart Cities **BOT-GE-5**	**4**	**2**	**0**	**2**	**-**	**Nil**

Learning Objectives

The Learning Objectives of this course are as follows:

- To make students aware about Green Belt Development, which is a major step in the development of a sustainable ecosystem, particularly under the Smart Cities Program for urban development (Government of India).
- To introduce students with one of the key green skill development programs under the Skill India mission by the Government of India.
- To acquaint students with various methods and techniques used in development ofgreen infrastructure for smart cities

Learning outcomes

After completion of this course, students will:

- become familiar with green skills that contribute to preserving or restoring the environment for a sustainable future that protect ecosystems and biodiversity, reduce energy and minimize waste and pollution.
- understand the role of green belt in capturing the transient emissions, prevent soil erosion and degradation, containing water run- offs and recharging ground water, attenuate noise generated and improve the aesthetics.

- be well trained (knowledge & skills) to contribute to Green SectorSkill program.

SYLLABUS OF BOT-GE-5

Unit 1: Introduction **Week: 01**

Definition, History and Concept of Green Belt; Aesthetics and Importance; Recommended Guidelines for green belt development for industries; Advantages and Applications.

Unit 2: Pollution and Carbon emission **Weeks: 02**

Type and various source of Emissions; Methods of estimation and monitoring of pollutants; Mechanism of deposition; Regulatory standards for major pollutants.

Unit 3: Plant-Pollutant Interaction **Weeks: 02**

Methods of sampling and screening local flora, Native and Exotic Plants, Various indicators (Morphological, Anatomical, Physiological and Biochemical) for selection of pollution mitigating plants; Sensitive/indicator, Resistant/ Tolerant Plant Speciesfor different pollutants (air, water, land and sound). Factors effecting plant regeneration and growth.

Unit 4: Structural and Functional Aspects of Green Belt **Weeks: 03**

Methods of Planting and Propagation, Various approaches for green belt development, Theoretical Models; Site specific ecological requirements, parameters involved that affect landscape design, Methods to evaluate the effectiveness of green belt. Various tools for assessment and monitoring of green belt (GIS and Remote Sensing)

Unit 5: Green Belt for Mitigating Climate change **Weeks: 02**

Objectives of UNFCCC for mitigating greenhouses gases in urban sectors, Green Finance and Green Infrastructure development, Methods to evaluate total carbon sequestered; Carbon stocks and credits.

Unit 6: Waste water treatment through constructed wetlands **Weeks: 03**

Introduction: Wetlands values and functions, natural and constructed wetlands for wastewater treatments; Life forms in wetlands: microbes and vegetation in wetlands, plants adapted to pollutants and flooding, Role of macrophytes in constructed wetlands; physical and chemical characteristics of freshwater wetlands, constructed wetlands: types, role and management including key parameters for assessment.

Unit 7: Economics of Green Infrastructure **Weeks: 02**

Understanding of key plants for green economy - NFTP (Non-Forest timber products), biodiesel plants, herbal garden; Evaluating the cost and benefits of green belt development with type studies, Environmental accounting, Ecosystem services and constituents of wellbeing. Environmental Impact Assessment

Practicals:

1. Methods of Vegetation Sampling and calculation of importance value index. **(Weeks: 02)**
2. Measuring Tree Height and Cover to estimate green cover of an area. **(Weeks: 03)**
3. Estimation of total carbon of an area. **(Weeks: 02)**
4. Methods for selection of plants according to pollutant load in air and water (includes field survey) **(Weeks: 02)**
5. Open Sources Software for mapping the GPS points and generating a cover map. **(Weeks: 02)**
6. Measurement of Dissolved Oxygen (DO) from treated waste water. **(Weeks: 02)**
7. Measurement of BOD and TDS from intake and treated pond. **(Weeks: 02)**

Essential/recommended readings:

- Vesilind, P. A., Peirce, J. J., Weiner, R., (1998). Environmental Pollution andControl Netherlands: Elsevier Science.

- Burnwal, K., Jagwani, D. (2013). Air Pollution Abatement through Trees & GreenBelt Development. LAP Lambert Academic Publishing.
- CPCB (2000). Guidelines for Green Belt development, CPCB, MoEF, GoI, NewDelhi.
- Zhou, S. W. W., Zhou, S. W. W. (2020). Carbon Management for a SustainableEnvironment. Germany: Springer International Publishing.
- Yunus, M., Singh, N. *de* Kok, L.J. (2013). Environmental Stress: Indication, Mitigation and Eco-conservation.Netherlands: Springer Netherlands
- Acar, S., Yeldan, A.E. (2019). Handbook of Green EconomicsNetherlands: Elsevier Science.
- Stefanakis, A., (2018). Constructed Wetlands for Industrial Wastewater TreatmentUnited Kingdom, Wiley.
- Kröpfelová, L., Vymazal, J., Kröpfelová, L., Vymazal, J. (2008). Wastewater Treatment in ConstructedWetlands with Horizontal Sub-Surface Flow. Czechia: Springer Netherlands.

Suggestive readings:

- Amati, M. (2016). Urban Green Belts in the Twenty-first Century (Urban Planning and Environment) 1st Edition. Routledge publishers

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Nomenclature of certificate/diploma/degrees:

- ✓ After securing 44 credits (from semester I and II), by completing one year of study of the UG honours Programme with Botany as a single core discipline, if a student exits after following due procedure, he or she shall be awarded **Undergraduate Certificate in Botany.**

- ✓ After securing 88 credits (from semester I, II, III & IV), by completing two years of study of the UG honours Programme with Botany as a single core discipline, if a student exits after following due procedure, he or she shall be awarded **Diploma in Botany.**

- ✓ After securing 132 credits (from semester I to VI), by completing three years of study of the UG honours Programme with Botany as a single core discipline, if a student exits after following due procedure, he or she shall be awarded **Bachelor of Science (Honours) in Botany.**

- ✓ After securing 176 credits (from semester I to VIII), by completing four years of study of the UG honours Programme with Botany as a single core discipline and writes dissertation, the student shall be awarded **Bachelor of Science (Honours with Research) in Botany.**

- ✓ After securing 176 credits (from semester I to VIII), by completing four years of study of the UG honours Programme with Botany as a single core discipline and engages in Academic Project/Entrepreneurship, the student shall be awarded **Bachelor of Science (Honours with Academic Project/Entrepreneurship) in Botany.**

COURSES OFFERED BY DEPARTMENT OF BOTANY

Category II

Botany Courses for Undergraduate Programme of study with Botany as one of the Core Disciplines
(B.Sc. Programmes with Botany as Major discipline)

DISCIPLINE SPECIFIC CORE COURSE – 4: Genetics and Molecular Biology

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Genetics and Molecular Biology **BOT-LS-DSC-4**	**4**	**2**	**0**	**2**	**Nil**	**Nil**

Learning Objective

- To apprise students with the basic principles of Genetics and Molecular Biology and its applications in living systems

Learning Outcomes

Students would be able to:

- understand the fundamentals of Mendelian inheritance and non-Mendelian inheritance.
- describe the concepts of linkage and crossing over and their usage in constructing genetic maps.
- gain knowledge about chromosomal aberrations and mutations.
- become familiar with structure and function of nucleic acids with reference to replication, transcription and translation.
- understand the mechanisms of gene regulation.

SYLLABUS OF BOT-LS-DSC-4

Unit 1: Mendelian genetics and extrachromosomal inheritance **Weeks: 03**

Mendel's principles of inheritance; chromosomal theory of inheritance; incomplete dominance and codominance; multiple allelism; lethal alleles (dominant and recessive lethals); deviations

of Mendelian dihybrid ratio (Epistatic interactions-dominant, recessive, duplicate dominant, duplicate recessive, duplicate gene interaction, dominant- ecessive); polygenic inheritance; numericals based on above; extrachromosomal inheritance (Chloroplast inheritance: variegation in Four O` clock plant; Mitochondrial inheritance: petite mutants in yeast); Maternal effect (shell coiling in snails).

Unit 2: Structure & Function of the gene **Week: 01**

Classical and molecular concept of gene - Benzer's cis-trans complementation analyses & fine map of rII locus in phage, Central Dogma.

Unit 3: Linkage, crossing over and chromosome mapping **Weeks: 1.5**

Discovery; linkage and crossing over; recombination frequency: two factor crosses; sex linkage (eye color in *Drosophila*; colour blindness and haemophilia in humans).

Unit 4: Variation in chromosome number and structure **Weeks: 1.5**

Haploidy, polyploidy, autopolyploidy (examples: banana, watermelon), allopolyploidy (ancestry of wheat) and aneuploidy (Down's, Turner's and Klinefelter's syndromes); Deletion; Duplication (Bar eye in *Drosophila*); Inversion (paracentric and pericentric); Translocation (*Rhoeo, Oenothera;* Robertsonian translocation, Familial Down Syndrome and cancer).

Unit 5: DNA structure and replication **Weeks: 1.5**

Discovery of DNA; Watson and Crick model of DNA- structure; semiconservative replication (Meselson & Stahl experiment); DNA replication mechanism in *E. coli* (semi-discontinuous mode and Y-fork).

Unit 6: Mutations **Weeks: 1.5**

History; mutation types with examples [spontaneous and induced; somatic and germinal; biochemical mutations; point mutations (base substitutions): transition and transversion; deletion and frameshift mutations), missense and nonsense mutations]; Molecular basis of mutation; Mutagens - physical (UV and X-rays), chemical mutagens [Base analogues, deaminating, alkylating and intercalating agents] and Transposons.

Unit 7: Gene expression **Weeks: 03**

Genetic code; Structure and types of RNA; Transcription and Translation in Prokaryotes; Transcription, RNA processing and Translation in Eukaryotes.

Unit 8: Regulation of gene expression **Weeks: 02**

Prokaryotes Inducible and repressible systems, negative and positive control of lactose operon and tryptophan operon. **Eukaryotes -** Transcriptional gene silencing - Role of chromatin, DNA methylation, histone modifications; cis-acting elements (promoters & enhancers/silencers), trans-acting factors; Post-transcriptional gene regulation (RNA interference/ PTGS), role of small RNAs, Epigenetics.

Practicals:

1. To study mitosis in *Allium cepa* through squash preparation of root tips. **(Week: 01)**
2. To study meiosis in *Allium cepa* through smear preparation of anthers. **(Weeks: 02)**
3. To study incomplete dominance and deviations of Mendelian dihybrid ratio (12:3:1, 9:3:4, 9:7, 15:1, 13:3) through seed samples. **(Weeks: 02)**
4. Human Genetics: a) Study of autosomal & sex-linked dominant & recessive inheritance through pedigree analyses. b) ABO blood group testing using kits, c) To study the syndromes (Down's, Klinefelter's, and Turner's) through karyotypes **(Weeks: 03)**
5. To study chromosomal aberrations: reciprocal translocation through squash preparations of *Rhoeo* anthers. Complex translocation ring, quadrivalents, lagging chromosomes, dicentric/inversion bridge through permanent slides. **(Weeks: 02)**
6. To prepare LB medium, inoculate and maintain (spread plate, streak plate, pour plate & serial dilution methods) *E. coli* cultures. **(Weeks: 02)**
7. To isolate genomic DNA from cauliflower and *E.coli*. Visualise using agarose gel electrophoresis. **(Weeks: 02)**
8. To estimate DNA by diphenylamine method. **(Week: 01)**

Suggested Readings:

1. Gardner, E.J., Simmons, M.J., Snustad, D.P. (1991). Principles of Genetics, 8th edition. New Delhi, Delhi: John Wiley & sons.
2. Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., Doebley, J. (2020). Introduction to Genetic Analysis, 12th edition. New York, NY: W.H. Freeman and Co.
3. Klug, W.S., Cummings, M.R., Spencer, C.A. (2020). Concepts of Genetics, 12th edition. San Francisco, California: Benjamin Cummings.

Additional Resources:

1. Russell, P. J. (2010). Genetics- A Molecular Approach. 3rd Edition. Benjamin Cummings
2. Snustad, D.P., Simmons, M.J. (2016). Principles of Genetics, 7th Edition. New Delhi, Delhi: John Wiley & sons
3. Pierce, B. A. (2020). Genetics: A Conceptual Approach Seventh Edition, Macmillan

COMMON POOL OF GENERIC ELECTIVES (BOT-GE)

GENERIC ELECTIVES (BOT-GE-6)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Ethnobotany **BOT-GE-6**	**4**	**2**	**0**	**2**	**Nil**	**Nil**

Learning Objective:

- To have the knowledge of the plants used by the local communities, tribals, ethnic groups, their nutritive and medicinal value.

Learning Outcomes:

- After studying this course the student will have an understanding of the value and usefulness of the natural products and their efficient use by the local communities as food and medicine and their conservation practices.

SYLLABUS OF BOT-GE-6

Unit 1: Introduction to Ethnobotany and Basic Taxonomy **Weeks: 03**

Introduction, concept, scope and objectives; Ethnobotany as an interdisciplinary science; The relevance of ethnobotany in the present context; Major and minor ethnic groups or tribes of India, and their lifestyles; Plants used by the indigenous societies: a) Food plants, b) Medicinal plants, c) intoxicants and beverages, d) Resins and oils and miscellaneous uses.

Unit 2: Applied Ethnobotany **Weeks: 3.5**

Role of ethnobotany in modern Medicine, Medico-ethnobotanical sources in India; Significance of the following plants in ethnobotanical practices (along with their habitat and morphology): a) *Azadirachta indica*, b) *Ocimum sanctum*, c) *Vitex negundo*, d) *Gloriosa superba*, e) *Tribulus terrestris*, f) *Pongamia pinnata*, g) *Cassia auriculata*, h) *Indigofera tinctoria*.

Unit 3: The Ecology of Ethnobotany **Weeks: 3.5**

Ethnobotany—Spirits, Lore, Material Cultures, Folk Magic, Narcotics, Stimulants; Nutritional Ethnobotany – Agriculture, foraging and wild foods; Linguistic Ethnobotany—Botanical

Classification and Ethics; Medicinal Ethnobotany and Ethnopharmacology; Ethnoveterinary knowledge.

Unit 4: Research Methods in Ethnobotany **Weeks: 03**

Etic and Emic Perspectives: a) Field work; b) Herbarium; c) Ancient Literature and oral traditions; d) Archaeological finding inferences; e) Religious and sacred places.

Unit 5: Protecting Knowledge **Weeks: 02**

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; databases and knowledge resource (Traditional Knowledge Digital Library); Case studies of traditional medicines leading to development of modern pharmaceutical products (use of *Trichopus zeylanicus* by Kani tribe and *Artemesia* sp. for malaria cure).

Practicals:

1. Collection, identification and preparation of herbarium of three ethno-botanically important plants with appropriate references. **(Week: 02)**
2. Preparation of crude extract of ethnobotanically important plants with appropriate references (any method to be used). **(Weeks: 04)**
3. Project work-documentation, literature survey, and collection of information on ethno-botanically useful plants from traditional healers). (**Weeks: 09)**

Suggested Readings:

1. Jain, S.K. (2010). Manual of Ethnobotany. Rajasthan: Scientific Publishers.
2. Martin, G.J. (1995). Ethnobotany: A Methods Manual. Chapman Hall
3. Cunningham, A.B. (2001). Applied Ethnobotany: People, Wild Plant Use and Conservation. Earthscan, London.
4. Young, K.J. (2007). Ethnobotany. Infobase Publishing, New York.
5. Schmidt, B.M., Cheng, D.M.K. (Eds.) (2017). Ethnobotany: A Phytochemical Perspective. John Wiley & Sons Ltd. Chichester, UK.
6. Research papers from various Scientific Journals for case studies**.**

GENERIC ELECTIVES (BOT-GE-7)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Viewing and Capturing Diversity in Nature **BOT-GE-7**	**4**	**2**	**0**	**2**	**Nil**	**Nil**

Learning Objectives

- A comprehensive introduction to photography, including aesthetics and technique.
- An opportunity to rethink the environment in which they live through the medium of pictures.
- Build familiarity with digital camera and smartphone photography.
- A working knowledge of digital image processing
- An opportunity to use nature photography in your business and career prospects.
- To enhance appreciation for the tremendous beauty inherent in plants and gardens/ nature.

Learning Outcomes

On successful completion of this course, a student will be able to:

- understand the digital camera or smartphone camera functions.
- use different photographic equipment to enhance their photographic skills.
- know about the photographic variables with weather and season.
- exploit their photographic work in various professions and for entrepreneurship development.

SYLLABUS OF BOT-GE-7

Unit 1: Basics of Photography and Videography **Weeks: 05**

History and development of digital photography; Introduction to lenses and camera; Definitions (Megapixel, Magnification, Resolving Power, Zoom feature, contrast and brightness of image); Types of lenses, analog camera, Digital camera, SLR camera, imaging system in camera; Role of lighting, depth of field, focal length, colour and contrast in photography; types of photography and techniques; working of camera: exposure, shutter speed and aperture; Understanding Image: Types of shots: distance, angle and movement; Digital

image basics: image format, resolution, aspect ratio, Pixels, DPI and PPI, composition and aesthetics; rules and guidelines.

Unit 2: Diversity of Nature: Colours and Landscape **Weeks: 05**

Importance of plants as natural products; General characteristic features of various plant life forms (Single celled, colonial forms, filamentous forms and multicellular and complex forms); General account of diverse landscaping patterns based on different geographical locations, plant adaptations and ecological interactions; role of plant pigments (diverse forms of alga, leaf coloration, floral pigments) in aesthetic appeal.

Unit 3: Diversity around us - A magnified view **Weeks: 2.5**

Principles of Microscopy: Dissection and compound microscope, scanning electron microscope. importance of sample preparation for microscopy, staining techniques, micrometry.

Unit 4: Photographic visualisation of Nature **Weeks: 2.5**

Sensitization of Biodiversity conservation; Thematic depiction of nature in Art galleries; Eco-tourism: a general account; role of photography in Eco-tourism and ecological discourse.

Practicals:

1. To study the parts of a digital camera. **(Week: 01)**
2. To study the principle and working of digital camera/ smartphone camera. **(Week: 01)**
3. Working and handling of light microscopes (Dissection and Compound). **(Week: 01)**
4. Study of plant forms through microscopic lens (Single celled, colonial forms, filamentous forms, multicellular and complex forms). **(Week: 01)**
5. To study techniques of capturing shots (using light and lenses effectively, macro and micro photography, wide angle and close-ups). **(Week: 01)**
6. Study of plant adaptations through photographs (Aquatic and desert plants). **(Week: 01)**
7. To capture and understand the Ecological Interactions. **(Week: 01)**
8. Identification of different plant life forms through online available tools/ search engines. **(Week: 01)**
9. Outdoor/ Campus Photography: Plants, Environment, Landscapes and cityscape, Mushrooms. **(Week: 01)**
10. Project Work: To make a portfolio of diverse landscaping patterns/ selected theme through outdoor visits. **(Weeks: 06)**

Suggested Readings:

1. Ang., T. (2008). Fundamentals of modern Photography. London, Mitchell.
2. Patterson, F. (1999). The Art of Seeing. Key Porter Books.

3. Fitzharris, T. (2011). Landscape Photography. Firefly Books.
4. Kelby, S. (2012). The digital photography book. Peachpit Press.
5. Langford, M., Fox, A., Smith, R.S. (2013). Langford basic photography: the guide for serious photographers. Amsterdam: Focal Press/Elsevier.
6. Peterson, B. (2016). Understanding exposure: how to shoot great photographs with any camera. AmPhoto Books.
7. Karp, G. (2010). Cell Biology, 6th edition. New Jersey, U.S.A.: John Wiley & Sons.

Additional Resources:

1. Sharma, P.D. (2010.) Ecology and Environment. Meerut, UP. Rastogi Publications.
2. Wilson, K., Walker, J. (2018). Principles and Techniques of Biochemistry and Molecular Biology, Cambridge University Press.

GENERIC ELECTIVES (BOT-GE-8)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Agricultural Botany and Weed Science **BOT-GE-8**	**4**	**2**	**0**	**2**	**Nil**	**Nil**

Learning Objectives:

To gain the knowledge on:

- the conditions required for seed germination
- growth hormones, plant development and flowering conditions
- weeds and the methods to control weeds

Learning Outcomes:

After completion of this course the students would be able to understand:

- how is the quality of seeds judged and how are the suitable conditions for the seed germination created.
- how are the growth, flowering and fruiting in plants managed through the applications of hormones.
- how are weeds managed in commercial crops.

SYLLABUS OF BOT-GE-8

Unit 1: Seed Physiology **Weeks: 02**

Seed dormancy types, factors, mechanism and methods for breaking dormancy, seed viability, seed vigour and seed germination.

Unit 2: Physiology of Crop Growth and Yield **Weeks: 2.5**

Growth, methods of growth analysis, factors affecting growth, concept of phytotronics and fertilizers (Nitrogen, Phosphorus, biofertilizers).

Unit 3: Regulation of Growth and Development **Weeks: 02**

Role of hormones in plant growth and development; growth retardants.

Unit 4: Reproductive Physiology and Senescence **Weeks: 03**

Physiology of flowering; Photoperiodism; Vernalization; Physiology of fruit ripening, senescence and regulation of senescence.

Unit 5: Biology of Weeds **Weeks: 02**

Ecology of weeds, competition, reproduction of weeds; Allelopathy and Invasive Plants.

Unit 6: Crop Management Practices **Weeks: 3.5**

Mechanical, Cultural, Biological and Chemical Weed control; Some obnoxious weeds and their management, Integrated pest management (IPM).

Practicals:

1. To study the effect of ethylene on shelf life of cut flowers/ To study the effect of cytokinin on leaf senescence. **(Weeks: 02)**
2. To test the viability of weed seeds. **(Weeks: 03)**
3. To study the allelopathic effects of weeds on germination of crop seeds. **(Weeks: 03)**
4. To study the effect of herbicides on seed germination and seedling growth of weeds. **(Weeks: 03)**
5. Determination of pH and analysis of a soil sample for carbonates, chlorides, sulphates, organic matter and base deficiency by rapid field tests. **(Week: 01)**
6. To perform the qualitative test for Nitrogen (NH^{4+}, NO^{3-}, urea) in a fertilizer and the soil sample. **(Week: 01)**
7. Demonstration / photographs for the mechanisms used in herbicide application. **(Week: 01)**
8. Field trip to a crop land to study weeds. **(Week: 01)**
9. Submission of any two properly dried and mounted weed specimens with the herbarium label.

Suggested Readings:

1. Ashton, F. M., Monaco, T. J. (2002). Weed Science: Principles and Practices. New Jersey, U.S.: John Wiley and Sons. Inc.
2. Hopkins, W. G., Huner, N. P. A. (2009). Introduction to Plant Physiology, 4th edition. New Delhi, Delhi: Wiley India Pvt. Ltd.
3. Taiz, L., Zeiger, E., Moller, I. M., Murphy, A. (2018). Plant Physiology and Development International 6th edition. New York, NY: Oxford University Press, Sinauer Associates.
4. Mandal, R.C. (1990). Weeds, weedicides and weed control: Principle and Practice. New Delhi, Delhi: Agro Botanical Publishers.

5. Rao, V. S. (1999). Principles of Weed Science. Oxford and IBH Publishers, New Delhi.
6. Subramanian, S. (2017). All about weed control. New Delhi, Delhi: Kalayani publishers.

GENERIC ELECTIVES (BOT-GE-9)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Intelligent Systems in Plants **BOT-GE-9**	**4**	**2**	**0**	**2**	**Nil**	**Nil**

Learning Objectives

- The course aims to lay the foundations on plant intelligence and develops understanding of the intelligent adaptively variable behaviour of plants.

Learning outcomes

- The students will be learning the concepts of intelligence, distinction between development and intelligent behaviour and morphological /adaptive strategies employed by plants to survive.

SYLLABUS OF BOT-GE-9

Unit 1: Introduction **Weeks: 02**

An Introduction to Plant Structure (Morphological and Anatomical details); compartmentalization

Unit 2: Plants and Intelligence **Weeks: 1.5**

Introduction to Plant Intelligence and Memory - Historical Perspective

Unit 3: Sensory Biology **Weeks: 02**

Cell to cell communication, Self-recognition, Recognition of Neighbours and Relatives.

Unit 4: Learning in Plants **Weeks: 03**

Habituation learning; Learning by association (Rhizosphere and Mycorrhizae); Adaptive Intelligence (Hydrophytes, Xerophytes, Parasites, Carnivorous plants, Thermogenic plants); Response to water, heat, salt and cold stress; Mechanical and chemical defence against predators with special reference to secondary metabolites.

Unit 5: Intelligent Behaviour of Plants **Weeks: 6.5**

A Guided tour to Plant Movements (Tropic Movements, Movement towards gravity, light, tracking sun movements, prey driven movements, liberation movements); Intelligent response to minerals and light (Seed germination, root cap, response of shoot, leaf morphology and anatomy); Unique pollination and seed dispersal mechanisms; Osmosis; Short and long-distance transport of water and food; Metabolic redundancy; Life Cycle Signaling in response to external stimuli (Reactive Oxygen Species, peptides, receptors, hormones).

Practicals:

1. Study the structure of plant cell using temporary mount. **(Week: 01)**
2. Study of the cell as an osmotic system (Plasmolysis and Deplasmolysis). **(Week: 01)**
3. Demonstration of the phenomenon of protoplasmic streaming in *Hydrilla* leaf. **(Week: 01)**
4. Extraction and qualitative analysis of alkaloids, flavonoids, tannins and phenols. **(Weeks: 02)**
5. To study the phenomenon of seed germination (effect of light). **(Week: 02)**
6. To study light sensitivity and etiolation vs. de-etiolation. **(Week: 01)**
7. Morphology and orientation of chloroplasts in leaves growing in light and dark, plasmodesmata connections and plasma membrane receptors. (through photographs or other digital resources). **(Week: 01)**
8. Estimation of total photosynthetic pigments. **(Week: 01)**
9. Study of (a) Root cap (b) Trichomes: non-glandular and glandular (c) Leaf Morphology and Anatomy (d) pulvinus anatomy in *Mimosa pudica* (e) Specialised motor tissue at the base of monocot leaves. **(Weeks: 02)**
10. (a) Study of morphological and anatomical adaptations of hydrophytes, xerophytes.
    (b). Study of biotic interactions of the following: Stem parasite (*Cuscuta*), Root parasite (*Orobanche*), Epiphytes, Predation (Insectivorous plants). **(Weeks: 02)**
11. Pollination types (selected) and associated seed dispersal mechanisms. **(Week: 01)**

Suggested Readings:

1. Mauseth, J.D. (1988). Plant Anatomy. The Benjammin/Cummings Publisher, USA.
2. Evert, RF., Eichhorn, S.E. (2012). Raven Biology of Plants, 8th edition, New York, NY: W.H. Freeman and Company.
3. Koller, D. (2011). The Restless Plant. Edited by Elizabeth Van Volkenburgh, Haward University Press, Cambridge, Massachusetts, and London, England.
4. Crang, R., Lyons-Sobaski, S., Wise, R. (2018) Plant Anatomy- A Concept based approach to the structure of seed plants, Springer Nature, Switzerland.

Additional Resources:

Trewavas A. (2017). The foundations of plant intelligence. Interface Focus 7: 20160098. http://dx.doi.org/10.1098/rsfs.2016.0098

GENERIC ELECTIVES (BOT-GE-10)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Informatics and Statistics for Biology and Allied Sciences **BOT-GE-10**	**4**	**2**	**0**	**2**	**Nil**	**Nil**

Learning Objectives:

- To build an understanding *in silico*/computational approaches in various aspects of understanding biology and biological research.
- To build analytical skills and integrate the principles of statistical analyses for robust interpretation of biological observations.

Learning outcomes

The student will understand:

- the basics of bioinformatics and develop awareness of the interdisciplinary nature of this field.
- learn about biological databases, sequence retrieval, alignment, and phylogenetic analysis using various tools.
- understand the basic concept of sampling methods, data classification, presentation and statistical analysis.

SYLLABUS OF BOT-GE-10

Unit 1: Introduction to Bioinformatics **Weeks: 1.5**

Historical background; Aims and scope; bioinformatics in Genomics, Transcriptomics, Proteomics, Metabolomics, Systems biology and drug discovery; Applications and Limitations in bioinformatics.

Unit 2: Biological databases **Weeks: 02**

Introduction to biological databases - Primary, secondary and composite databases; Study of following databases: NCBI (GenBank, PubChem, PubMed and its tools (BLAST)); introduction to EMBL, DDBJ, UniProt, PDB and KEGG.

Unit 3: Basic concepts of Sequence alignment **Weeks: 02**

Similarity, identity and homology. Concepts of alignment (gaps and penalty); Alignment – pairwise and multiple sequence alignments

Unit 4: Molecular Phylogeny **Weeks: 02**

Introduction to Molecular Phylogeny, methods of construction of phylogenetic trees: maximum parsimony (MP), maximum likelihood (ML) and distance (Neighbour-joining) methods.

Unit 5: Biostatistics **Week: 01**

Biostatistics – definition, Basics of descriptive and inferential statistics; Limitations and applications of biostatistics.

Unit 6: Data types and presentation **Weeks: 1.5**

Primary and secondary data; Sampling methods (in brief); tabulation and presentation of data.

Unit 7: Descriptive Statistics **Weeks: 02**

Measures of central tendency - mean, median, and mode; Measures of dispersion - range, standard deviation, and standard error.

Unit 8: Correlation and Regression **Weeks: 1.5**

Types and methods of correlation; Introduction to simple regression equation; similarities and dissimilarities between correlation and regression.

Unit 9: Statistical inference **Weeks: 1.5**

Hypothesis – (simple hypothesis), student's t test, chi-square test.

(Note: Numerical based questions of unit 7, 8 and 9 should be covered only in practical)

Practicals:

1. Biological databases (NCBI, EMBL, UniProt, PDB) **(Week: 02)**
2. Literature retrieval from PubMed. **(Week: 01)**
3. Sequence retrieval (protein and gene) from NCBI (formats - FASTA, GenBank and GenPept formats). **(Week: 02)**
4. Protein Structure retrieval from PDB (in pdb format) and visualisation by viewing tools (Ras Mol/ J mol/Mol*/Swiss 3D Viewer/Pymol). **(Week: 02)**
5. Multiple sequence alignment (MEGA/ Clustal omega). **(Week: 02)**
6. Construction of phylogenetic tree (PHYLIP/ MEGA/ Clustal omega). **(Week: 02)**
7. Making of Bar diagrams, Pie chart, Histogram, Frequency polygon, Cumulative frequency curve (any four) in the given data set using Microsoft Excel. **(Week: 01)**
8. Calculation of mean, mode, median, standard deviation and standard error (through

manual calculation and using Microsoft Excel) (use only ungrouped data). **(Week: 01)**

9. Calculation of correlation coefficient values by Karl Pearson's /Spearman Rank methods (through manual calculation and using Microsoft Excel). **(Week: 01)**
10. Student's t-test (using Microsoft Excel only), chi square test (Manual and using Microsoft Excel). **(Week: 01)**

Suggested readings:

1. Ghosh, Z., Mallick, B. (2008). *Bioinformatics – Principles and Applications*, 1st edition. New Delhi, Delhi: Oxford University Press.
2. Baxevanis, A.D., Ouellette, B.F., John (2005). *Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins*, 3rd edition. New Jersey, U.S.: Wiley & Sons, Inc.
3. Roy, D. (2009). *Bioinformatics*, 1st edition. New Delhi, Delhi: Narosa Publishing House.
4. Andreas, D., Baxevanis, B.F., Francis, Ouellette. (2004). *Bioinformatics: A practical guide to the analysis of genes and proteins*, 3rd edition. New Jersey, U.S.: John Wiley and Sons.
5. Khan, I.A., Khanum, A. (2004). Fundamentals of Biostatistics, 5th edition. Hyderabad: Ukaaz publications.
6. Campbell, R.C. (1998). Statistics for Biologists. Cambridge, U.S.A.: Cambridge University Press

Additional Resources:

1. Pevsner, J. (2009). Bioinformatics and Functional Genomics, 2nd edition. New Jersey, U.S.: Wiley Blackwell.
2. Xiong, J. (2006). Essential Bioinformatics, 1st edition. Cambridge, U.K.: Cambridge University Press.
3. Mount, D.W. (2004). Bioinformatics: Sequence and Genome analysis 2nd edition, Cold Spring Harbor Laboratory Press, USA.
4. Zar, J.H. (2012). Biostatistical Analysis, 4th edition. London, London: Pearson Publication.
5. Pandey, M. (2015). Biostatistics Basic and Advanced. New Delhi, Delhi: M V Learning.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Index
Department of Botany
SEMESTER -III

COURSES OFFERED BY DEPARTMENT OF BOTANY

Category-I

Botany (H) Courses for Undergraduate Programme of study with Botany as a Single Core Discipline

DISCIPLINE SPECIFIC CORE COURSE - 7: Phycology - The World of Algae

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Phycology - The World of Algae DSC-7	4	**2**	**0**	**2**	Class XII pass	Nil

Learning Objective:

To provide students with in-depth knowledge of the unique group of algae that are the primary photosynthetic organisms.

Learning Outcomes:

By studying this course students will gain basic knowledge on algae, with reference to:

- the diversity and general characteristics.
- distinguishing features of taxa belonging to different families.
- the various ecological and economic benefits.

Unit 1: Introduction to Algal World **6 hours**

Relevance of studying algae – Industrial (food, feed, fodder), Environmental (climate change, biofuel, acidification of oceans), Evolutionary (range of thallus organization); General characteristics; Ecology, diversity and distribution; Range of thallus organization; Cell structure; Criteria for classification (cell wall, pigment system, reserve food, flagella); Reproduction and life cycle patterns; Classification by Fritsch; Evolutionary classification of Lee (only up to groups); Significant contributions of eminent Phycologists.

Unit 2: Cyanophyceae (Blue-Green Algae) **3 hours**

General characteristics; Occurrence; Cell structure; Heterocyst (structure and function); Morphology, reproduction and life-cycle of *Nostoc*, economic importance.

Unit 3: Chlorophyceae (Green Algae) **6 hours**

General characteristics; Occurrence; Cell structure; Morphology, reproduction and life-cycle of *Chlamydomonas, Volvox*, *Chlorella, Ulva*, *Oedogonium*, *Coleochaete*; *Chara*; Structure and evolutionary significance of *Prochloron*, economic importance.

Unit 4: Xanthophyceae (Yellow-Green Algae) 2 hours
General characteristics; Occurrence; Morphology, reproduction, and life-cycle of *Vaucheria*, economic importance.

Unit 5: Bacillariophyceae (Diatoms) and Dinophyceae (Dinoflagellates) 3 hours

General characteristics, Occurrence, morphology, unique features**,** economic importance.

Unit 6: Phaeophyceae (Brown Algae) 4 hours
General characteristics; Occurrence; Morphology, reproduction, and life-cycle of *Ectocarpus* and *Sargassum*, economic importance.

Unit 7: Rhodophyceae (Red Algae) 4 hours
General characteristics; Occurrence; Morphology, reproduction, and life-cycle of *Gracilaria*, economic importance.

Unit 8: Recent advances in algal studies 2 hours
Model systems and their applications in genetic, molecular and evolutionary studies.

Practicals 60 hours

1. Study of algal diversity in different habitats through botanical excursion and submission of digital catalogue/report of various species observed.
2. ***Nostoc***: Study of vegetative, reproductive structures from temporary mounts and permanent slides; Ultrastructure of Heterocyst through Electron Micrographs.
3. ***Chlorella***: Study of vegetative, reproductive structures from temporary mounts. Study of ultrastructure through Electron Micrographs.
4. ***Volvox***: Study of vegetative, reproductive structures from temporary mounts and permanent slides.
5. ***Oedogonium***: Study of vegetative, reproductive structures from temporary mounts and permanent slides.
6. ***Coleochaete***: Study of vegetative, reproductive structures from temporary mounts and permanent slides.
7. ***Chara***: Study of vegetative, reproductive structures from temporary mounts, specimens and permanent slides.
8. ***Vaucheria***: Study of vegetative, reproductive structures from temporary mounts and permanent slides.
9. **Diatoms** and **Dinoflagellates**: Study vegetative, reproductive structures of at least two taxa from water bodies.
10. ***Ectocarpus***: Study of vegetative, reproductive structures from temporary mounts and permanent slides.
11. ***Sargassum***: Study of vegetative, reproductive structures from temporary mounts, specimens and permanent slides.

12. ***Polysiphonia/ Gracilaria***: Study of vegetative, reproductive structures from temporary mounts and permanent slides.

Suggested Readings:

1. Bold, H.C. and Wynne, M.J. (1985). Introduction to the Algae: Structure and Reproduction, 2nd edition. Prentice-Hall International INC.
2. Kumar, H.D. (1999). Introductory Phycology, 2nd edition. Affiliated East-West Press, New Delhi.
3. Lee, R.E. (2018). Phycology, 4th edition: Cambridge University Press, Cambridge.
4. Sahoo, D. and Seckbach, J. (2015). The Algae World. Springer, Dordrecht.
5. Sahoo, D. (2000).Farming the Ocean: Seaweed Cultivation and Utilization. Aravali Book International, New Delhi.

Additional Resources:

1. Van den Hoek, C., Mann, D.G., Jahans H.M. (1995). Algae: An Introduction to Phycology. Cambridge University Press.
2. Sharma, O.P. (2011). Algae. Tata Mc Graw Hill Education Private Limited, New Delhi.
3. Smith, G.M. (1955). Cryptogamic Botany. Vol.1.Algae and Fungi. McGraw-Hill Book Company, New York.
4. Vashishta, B.R., Singh, V.P. and Sinha, A.K. (2012). Botany for Degree Students: Algae. S Chand Publishing, New Delhi.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – 8: Bryophytes, Pteridophytes and Gymnosperms

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Bryophytes, Pteridophytes and Gymnosperms DSC – 8	**4**	**2**	**0**	**2**	Class XII pass	**Nil**

Learning Objectives:

- Provide a deep understanding of morphology, anatomy, reproduction and developmental biology of these unique groups of non-flowering plants.
- Enhance understanding of diversity, economic value, taxonomy in representative members of phylogenetically important groups.

Learning Outcomes:

At the end of this course students will be able to:

- identify and describe the group of plants that have given rise to land habit and the flowering plants.
- comprehend various phenological stages of the plants belonging to the sub-groups – bryophytes, pteridophytes and gymnosperms.

Unit 1: Bryophytes **9 hours**

Origin of bryophytes through green algal ancestor; Morphology and Reproduction of *Marchantia*, *Anthoceros* and *Funaria* with fertilization & spore dispersal mechanism (excluding developmental stages). Progressive sterilization of sporogenous tissue; Ecological and economic importance of bryophytes with special reference to *Sphagnum*.

Unit 2: Pteridophytes **9 hours**

Fossil pteridophytes (*Rhynia*). Morphology and Reproduction *of Selaginella*, *Equisetum* and *Pteris* (excluding developmental stages). Apogamy and apospory; Heterospory and seed habit; Stelar evolution. Economic importance.

Unit 3: Gymnosperms **9 hours**

Morphology, Sstem anatomy (significance of transfusion tissue) and Reproduction of *Cycas*, *Pinus* and *Gnetum*(excluding developmental stages and secondary growth). Economic importance.

Unit 4: Recent Advances **3 hours**

Model systems (*Physcomitrella*, *Ceratopteris*, *Ephedra*) and their applications in genetic, molecular and evolutionary studies.

Practicals: **60 hours**

1. *Riccia* – Morphology: Vegetative and reproductive structures (Specimen).

2. *Marchantia* - Morphology; V.S. of thallus through Gemma cup, whole mount of Gemmae (temporary slides); V.S. of Vegetative thallus, Antheridiophore, Archegoniophore, L.S. of Sporophyte (permanent slides).

3. *Pellia* - Morphological details through specimens/permanent slides; L.S. Sporophyte (permanent slide).

4. *Porella* - Vegetative Morphological details through specimens/permanent slides.

5. *Anthoceros* – Morphology; Dissection of sporophyte (to show stomata, spores, pseudoelaters, columella) (temporary slide), V.S. of thallus (permanent slide).

6. *Funaria* - Morphology; T.S. Stem (temporary and permanent slides both); Sporophyte: operculum, peristome, spores (temporary slides); Antheridial and archegonial heads, L.S. of capsule, W.M. of protonema (Permanent slides).

5. *Psilotum* – Morphology (specimen); T.S. of rhizome, stem and synangium (permanent slides).

6. *Selaginella* – Morphology (specimen); W.M. of leaf with ligule, T.S. of stem, L.S. of strobilus, W.M. of microsporophyll, megasporophyll (temporary slides); T.S. of rhizophore (permanent slide).

7. *Equisetum* – Morphology (specimen), T.S. of internode, L.S. of strobilus, T.S. of strobilus, W.M. of sporangiophore, W.M. of spores (wet and dry) (temporary slide).

8. *Pteris* - Morphology, T.S. of rachis, V.S. of sporophyll (temporary slides), T.S. of rhizome, W.M. of prothallus with sex organs and young sporophyte (permanent slide).

9. *Cycas* – Morphology, T.S. of coralloid root, T.S. of rachis, V.S. of leaflet, V.S. of microsporophyll, W.M. of spores (temporary slides); T.S. of stem, T.S. of root, L.S. of ovule (permanent slide).

10. *Pinus* - Morphology, T.S. of Needle, L.S. and T.S. of male cone, W.M. of microsporophyll (temporary slides); T.S. of stem, R.L.S. and T.L.S. of stem, L.S. of female cone (permanent slide).

11. *Gnetum* - Morphology (stem, male & female cones); T.S. of stem, L.S. of ovule (permanent slide).

12. Botanical Excursion and submission of digital catalogue/report of various species observed.

Suggested readings:

1. Bhatnagar, S.P., Moitra, A. (2023). Gymnosperms. 2nd edition, New Delhi, Delhi: New Age International (P) Ltd Publishers.
2. Kaur I.D., Uniyal P.L. (2019). Text Book of Gymnosperms. New Delhi, Delhi: Daya Publishing House.
3. Kaur I.D., Uniyal P.L. (2019). Text Book of Bryophytes. New Delhi, Delhi: Daya Publishing House.
4. Kaur I.D. (2023). Text Book of Pteridophytes. New Delhi, Delhi: Daya Publishing House.
5. Parihar, N.S. (2019). An Introduction to Embryophyta. Vol. II: Pteridophyta. Surjeet Publications.

Additional Resources:

1. Campbell, N.A., Reece J.B., Urry L.A., Cain M.L., Wasserman S.A., Minorsky P.V., Jackson, R.B. (2020). Biology. San Francisco, SF: Pearson Benjamin Cummings.
2. Raven, P.H., Johnson, G.B., Losos, J.B., Singer, S.R., (latest edition). Biology. New Delhi, Delhi: Tata McGraw Hill.
3. Singh, H. (1978). Embryology of Gymnosperms. Berlin, Germany. GebruderBorntraeger.
4. Vashishta, P.C., Sinha, A.K., Kumar, A. (2022). Botany For Degree Students Pteridophyta, New Delhi, Delhi: S. Chand Publication. Delhi, India.
5. Vashistha, B.R., Sinha, A.K., Kumar, A. (2010). Botany For Degree Students, Bryophyta. New Delhi, Delhi: S Chand Publication.
6. Parihar, N.S. (1965). An Introduction to Embryophyta. Vol. I: Bryophyta. Allahabad, UP: Central Book Depot.
7. Puri, P. (1973). Bryophytes. New Delhi, Delhi, Atma Ram and Sons.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – 9: Genetics and Plant Breeding

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Genetics & Plant Breeding **DSC-9**	**4**	**2**	**0**	**2**	Class XII pass	**Nil**

Learning Objectives:

- To apprise students with the basic principles of Genetics
- To enhance the applications of genetics in plant breeding and agriculture.

Learning Outcomes:

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

- understand the fundamentals of Mendelian inheritance and its deviation in gene interactions.
- describe the concepts of linkage and crossing over and their usage in constructing gene maps.
- become familiar with pedigree analysis.
- learn about principles of population genetics
- gain knowledge about gene mutations and inherited disorders
- learn about various plant breeding techniques / methods

Unit 1. Mendelian Genetics **6 hours**

Mendelism: History; Principles of inheritance, deviations (Incomplete dominance and co-dominance); Chromosome theory of inheritance; Multiple allelism; lethal alleles; Epistasis; Pleiotropy; Penetrance and expressivity; Polygenic inheritance; brief introduction to sex determination.

Unit 2. Extra-Nuclear Inheritance **4 hours**

Chloroplast and mitochondrial genomes; Chloroplast Inheritance: Variegation in Four O` clock plant; Mitochondrial inheritance in yeast; Maternal effect (Shell coiling in Snails).

Unit 3. Linkage, crossing over and chromosome mapping **5 hours**

Linkage and crossing over, Cytological basis of crossing over (Creighton and McClintock experiment in Maize); three factor crosses; interference and coincidence; Sex linkage (*Drosophila*)

Unit 4. Variation in Chromosome number and structure **4 hours**

Deletion; Duplication; Inversion; Translocation; Euploidy and aneuploidy (In Brief).

Unit 5. Mutations **4 hours**

Mutation types; Muller's CIB method, Molecular basis of mutations; Chemical mutagens (Base analogs, deaminating, hydroxylating, alkylating and intercalating agents) and Physical mutagens (Ionising and Non ionising radiations); Transposable genetic elements and their significance (Basic concept).

Unit 6. Population and evolutionary genetics **3 hours**

Hardy Weinberg law (Allele frequencies, genotype frequencies); speciation (modes of speciation and genetics of speciation).

Unit 7. Plant Breeding **4 hours**

Plant breeding- Principle and Practices, domestication and plant introduction (primary and secondary introduction), selection and its types: pure line selection, mass selection and clonal selection; hybridizations (inter-specific and intra-specific), heterosis and its significance.

Practicals: **60 hours**

1. To study meiosis in *Allium cepa* through squash preparation of anthers.
2. To study mitosis in *Allium cepa* through squash preparation of root tips.
3. To understand the deviations of Mendelian dihybrid ratios (12:3:1, 9:3:4, 9:7, 15:1, 13:3, 9:6:1) involved using the seed mixture given. Genetic ratio to be calculated using Chi square analysis.

4. Human Genetics:
   a) Study of autosomal & sex-linked dominant & recessive inheritance through pedigree analyses.
   b) ABO blood group testing using kits,
   c) To study the syndromes (Down's, Klinefelter's, Turner's, Edward's & Patau) through karyotypes
5. To calculate allelic and genotypic frequencies of human dominant and recessive traits using Hardy- Weinberg's principle.
6. To study Xeroderma pigmentosum, Sickle cell anaemia, albinism, haemophilia and colour blindness (Ishihara charts may be used to study colour blindness)
7. To study chromosomal aberrations:
   a) Quadrivalents, lagging chromosomes, dicentric/inversion bridge through photographs/permanent slides
   b) Reciprocal translocation through squash preparations of *Rhoeo* anthers.

8. Demonstration of basic methods of plant breeding (hybridizations): Emasculation, bagging and tagging using available plant material in pots/gardens/field.

Suggested Readings:

1. Gardner, E.J., Simmons, M.J., Snustad, D.P. (1991). Principles of Genetics, 8th edition. New Delhi, Delhi: John Wiley & sons.
2. Griffiths, A.J.F., Doebley,J., Peichel, C, Wassarman D (2020). Introduction to Genetic Analysis, 12th edition. New York, NY: W.H. Freeman and Co.
3. Klug, W.S., Cummings, M.R., Spencer, C.A. (2020). Concepts of Genetics, 12th edition. San Francisco, California: Benjamin Cummings.
4. Pierce, B. A. (2020). Genetics: A Conceptual Approach, 7th Edition, Macmillan

5. Campbell, N.A., Reece J.B., Urry L.A., Cain M.L., Wasserman S.A., Minorsky P.V., Jackson, R.B. (2020). Biology. San Francisco, SF: Pearson Benjamin Cummings.
6. Singh, B.D., (2022). Plant Breeding: Principles and Methods. New Delhi, Medtech Publishers

Additional Resources:

1. Russell, P. J. (2010). Genetics- A Molecular Approach. 3rd Edition. Benjamin Cummings
2. Snustad, D.P., Simmons, M.J. (2016). Principles of Genetics, 7th Edition. New Delhi, Delhi: John Wiley & sons
3. Hartl, D.L., Ruvolo, M. (2019). Genetics: Analysis of Genes and Genomes, 9th edition, Jones and Bartlett Learning.
4. Singh, B. D. (2023). Fundamentals of Genetics, 6th edition. MedTech.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE (DSE -1): Evolutionary Biology of Plants

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Evolutionary Biology of Plants **DSE-1**	**4**	**2**	**0**	**2**	Class XII pass	**Nil**

Learning Objectives:

- This course builds on the fundamental points introduced in the core course on Plant Diversity and Evolution and presents a synthesis of various theories, concepts, evidence and methods to study evolution.

Learning Outcomes:

At the end of this course the students will be able to:

- understand the essential theories in evolution
- differentiate between micro and macroevolution and the forces shaping evolution
- construct phylogenetic trees based on morphological and molecular data
- understand evolution of life.

Unit 1: Historical Perspective of Eevolutionary Cconcepts **4 hours**

Pre-Darwinian ideas, Lamarckism, Darwinism, Post-Darwinian era – Modern synthetic theory, Neo-Darwinism

Unit 2: Origin of Life **3 hours**

Chemogeny – An overview of pre-biotic conditions and events; experimental proofs to abiotic origin of micro- and macro-molecules. Current concept of chemogeny – RNA first hypothesis. Biogeny – Cellular evolution based on proto-cell models (coacervates and proteinoid micro-spheres). Evolution of eukaryotes from pprokaryotes

Unit 3: Evidences of Evolution **4 hours**

Paleobiological– Concept of Stratigraphy and geological timescale; fossil study
Anatomical & Embryological – Vestigial organs; homologous and analogous organs (concept of parallelism and convergence in evolution)
Taxonomic –Transitional forms/evolutionary intermediates, living fossils
Phylogenetic – morphology, protein (Cytochrome C) and gene (Globin gene family) based

Unit 4: Microevolution and Macroevolution **8 hours**

Hardy Weinberg equilibrium; Founder effect, Natural and artificial selection. Levels of selection.

Inferring phylogenies- Gene trees, species trees; Patterns of evolutionary change; Adaptive radiation, Evolution and development (evo-devo); Biodiversity- Estimating changes in biodiversity; Taxonomic diversity through the Phanerozoic era.

Unit 5. Forces of Evolution **3 hours**

Mutation, Geneflow, Selection, Genetic Drift, Co-adaptation and co-evolution, Anthropogenic activities, Extinction (in brief)- Periodic and Mass-scale – Causes and events.

Unit 6. Speciation **4 hours**

Species concept, Modes of speciation – Allopatric; sympatric; peripatric; Patterns of speciation – Anagenesis and Cladogenesis; Phyletic gradualism and Punctuated eequilibrium (Quantum evolution); Basis of speciation – Isolating mechanisms.

Unit 7. Evolution of Land Plants **4 hours**

Origin of land plants – Terrestrial algae and Bryophytes; alternation of generations. Early vascular plants – Stelar evolution; Sporangium evolution; seed habit and evolution of seed. Angiosperms – Phylogeny of major groups.

Practicals **60 hours**

1. Study of different types of fossils, connecting links/transitional forms and Living fossils (Specimens/slides/photographs)
2. Sampling of quantitative characters (continuous and discontinuous) in a population(height, weight, number of nodes etc)
3. Study of adaptive strategies (colouration, co-adaptation and co-evolution); (Specimens/photographs)
4. Calculations of genotypic, phenotypic and allelic frequencies from the data provided
5. Simulation experiments using coloured beads/playing cards to understand the effects of Selection and Genetic drift on gene frequencies
6. To study and interpret Phylogenetic trees (reading and using trees) - minimum of three examples.

Suggested Readings:

1. Campbell, N.A., Reece J.B., Urry L.A., Cain M.L., Wasserman S.A., Minorsky P.V., Jackson, R.B. (2020). Biology. San Francisco, SF: Pearson Benjamin Cummings.
2. Ridley, M. (2004). Evolution. III Edn. Blackwell Pub., Oxford.
3. Hall, B. K., Hallgrimson, B. (2008) Strickberger's Evolution. IV Edn. Jones and Barlett.
4. Zimmer, C., Emlen, D. J. (2013). Evolution: Making Sense of Life. Roberts & Co.
5. Futuyma, D. (1998). Evolutionary Biology. III Edn. Sinauer Assoc. Inc.
6. Barton, Briggs, Eisen, Goldstein and Patel. (2007). Evolution. Cold Spring Harbor Laboratory Press.
7. Nei, M., Kumar S. (2000). Molecular Evolution and Phylogenetics. Oxford University Press, New York.
8. Futuyma, J. D., Kirkpatrick, M. (2017). Evolution, 4th Ed. Sinauer, Sunderland, MA: Sinauer Associates.

DISCIPLINE SPECIFIC ELECTIVE COURSE (DSE -2): Biostatistics & Bioinformatics for Plant Sciences

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical / Practice		
Biostatistics & Bioinformatics for Plant Sciences **DSE-2**	**4**	**2**	**0**	**2**	Class XII pass	**Nil**

Learning Objective:

- To train students in using computational and mathematical tools to solve biological problems.

Learning Outcomes:

At the end of this course students will be able to:

- use the various online databases and resources for accessing biological data.
- use the different methods of alignment of DNA, RNA and protein sequences and interpret the significance of the same.
- understand the descriptive and inferential statistical tests for interpretation of experimental data.

Unit 1- Introduction to Bioinformatics **3 hours**

Historical background; Aims and scope; Bioinformatics in Genomics, Transcriptomics, Proteomics, Metabolomics; Applications of bioinformatics in crop improvement

Unit 2- Biological databases **4 hours**

Introduction to biological databases - Primary, secondary and composite databases. Study of following databases: NCBI (GenBank, PubChem, PubMed and its tools (only BLAST)), introduction to UniProt, PDB, PlantPepDB.

Unit 3- Basic concepts of Sequence alignment **4 hours**

Similarity, identity and homology. Concepts of alignment (gaps and penalty); Alignment – pairwise and multiple sequence alignments

Unit 4- Molecular Phylogeny **4 hours**

Introduction, methods of construction of phylogenetic trees: maximum parsimony (MP), maximum likelihood (ML) and distance (Neighbour-joining) methods.

Unit 5- Introduction to Biostatistics **2 hours**

Definition, Basics of descriptive and inferential statistics; Limitations and applications.

Unit 6- Data and sampling methods **3 hours**

Primary and secondary data; Sampling methods (in brief); tabulation and presentation of data.

Unit 7- Measures and deviations of central tendencies 4 hours
Dispersion - range, standard deviation, mean deviation, standard error, skewness and kurtosis, quartile deviation –merits and demerits; Coefficient of variation.

Unit 8-Correlation and Regression 3 hours
Correlation - types and methods of correlation (I. E. Karl Pearson and Spearman Rank method), Introduction to simple regression equation; similarities and dissimilarities between correlation and regression.

Unit 9- Statistical tests 3 hours
Statistical inference - hypothesis – (simple hypothesis), student's t test, chi-square test.

(Note: Numerical based questions of unit 7, 8 and 9 should be covered only in practical)

Practicals 60 hours

1. Biological databases (NCBI, UniProt, PlantPepDB)
2. Literature retrieval from PubMed
3. Sequence retrieval (protein and gene) from NCBI (formats - FASTA, GenBank and GenPept formats)
4. Protein Structure retrieval from PDB (in pdb format) and visualization by viewing tools (Ras Mol/ J mol/Mol*/Swiss 3D Viewer/Pymol)
5. Multiple sequence alignment (MEGA/Clustal omega)
6. Construction of phylogenetic tree (PHYLIP/ MEGA/ Clustal omega).
7. Calculation of standard deviation and coefficient of variation through manual calculation and using Microsoft Excel, using only ungrouped data)
8. Calculation of correlation coefficient values by Karl Pearson's /Spearman Rank methods (through manual calculation and using Microsoft Excel)
9. Student's t-test (using Microsoft Excel), chi square test (Manual and using Microsoft Excel)

Suggested Readings:

1. Ghosh, Z., Mallick, B. (2008). Bioinformatics – *Principles and Applications*, 1st edition. New Delhi, Delhi: Oxford University Press.
2. Baxevanis, A.D., Ouellette, B.F., John (2005). Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, 3rd edition. New Jersey, U.S.: Wiley & Sons, Inc.
3. Roy, D. (2009). Bioinformatics, 1st edition. New Delhi, Delhi: Narosa Publishing House.
4. Zar, J.H. (2012). Biostatistical Analysis, 4th edition. London, London: Pearson Publication.
5. Campbell, R.C. (1998). Statistics for Biologists. Cambridge, U.S.A.: Cambridge University Press

Additional Resources:

1. Pevsner J. (2009). Bioinformatics and Functional Genomics, 2nd edition. New Jersey, U.S.: Wiley Blackwell.

2. Xiong J. (2006). Essential Bioinformatics,1st edition. Cambridge, U.K.: Cambridge University Press.
3. Mount, D.W. (2004). Bioinformatics: Sequence and Genome analysis 2nd edition, Cold Spring Harbor Laboratory Press, USA.
4. Pandey, M. (2015). Biostatistics Basic and Advanced. New Delhi, Delhi: M V Learning.
5. Khan, I.A., Khanum, A., Khan S., (2020). Fundamentals of Biostatistics, 6th edition. Ukaaz Publications, Hyderabad, India.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Category II

Botany Courses for Undergraduate Programme of study with Botany as one of the Core Disciplines
(B.Sc. Programmes with Botany as Major discipline)

DISCIPLINE SPECIFIC CORE COURSE (DSC-.....): Plant Cell and Developmental Biology

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Plant Cell and Developmental Biology DSC-.....	**4**	**2**	**0**	**2**	Class XII pass	**Nil**

Learning objectives:
To understand the basics of plant cell structure, development, growth and organisation of plant body.

Learning outcomes:
On completion of the course, the students will

- become familiar with the structure and functions of various components of plant cell
- understand the processes of cell growth and its regulation
- comprehend the structure, organization and functions of various tissues of the plant organs
- get acquainted with the reproductive processes in the life cycle of angiosperms
- appreciate the interactions between the developmental pathways resulting in the differentiation of plant body
- recognise the importance of plant developmental biology in the improvement and conservation of plants

Unit 1. Introduction to Plant Cell: structure and function 5 hour
Cell as the basic unit of life; differences between plant and animal cell, prokaryotic and eukaryotic cell; Cell Theory.
Structure and functions of cell wall; cell membrane; cell organelles- nucleus, chloroplast, mitochondria, dictyosomes, endoplasmic reticulum, microbodies, cytoskeleton.

Unit 2: **Cell growth** **3 hours**

Cell cycle, regulation (in brief) and significance; mitosis and meiosis; cytokinesis.

Unit 3. **Polarity in plant growth** **3 hours**

Plant body as a bipolar structure; apical, basal and radial patterns of body plan; growth through primary and secondary meristems; organisation of shoot and root apices.

Unit 4. **Differentiation of tissues: vegetative organs** **6 hours**

Structure and functions of tissues (simple and complex); structure of stem, root, and leaf (dicot and monocot); principles of organ differentiation: role of transcription factors in cell, tissue, organ identity and development, cell fate determination by position, and cell-cell signalling; hormones involved in organ differentiation (very briefly).

Unit 5. Differentiation of tissues: reproductive organs **6 hours**

Anther, microsporogenesis and microgametogenesis, general structure of pollen grains and male gametes, male germ unit; ovule, megasporogenesis (monosporic, bisporic, tetrasporic) and megagametogenesis (Polygonum type), ultrastructure and significance of female germ unit; Flower development (ABC model).

Unit 6. Pollination and Fertilization **3 hours**

Pollination types, agents and adaptation; pollen germination; path of pollen tube in pistil; double fertilization

Unit 7. **Development of Embryo and Seed** **4 hours**

Endosperm types, functions; development of embryo from zygote, establishment of apical-basal and radial organisation; development of seed, modes of seed dispersal.

Practicals

1. Study of plant cell - through peel mount (*Tradescantia*, or any other); whole mount (*Hydrilla*) - cytoplasmic streaming.
2. Study of cell components - nucleus (Feulgen/acetocarmine staining); mitochondria (Janus green B staining); cell wall (PAS staining).
3. To study mitotic index. (pictures or permanent slides -24h-period or under different temperatures/environmental conditions may be used).
4. Study tissues and organs structure through temporary preparations of macerated material and sections - T.S. of dicot stem- *Helianthus/ Cucurbita*, *Hydrilla/ Nympaea petiole, Casuarina,* stem with secondary growth - *Helianthus, Salvadora/ Bignonia;* T.S. of monocot stem - *Zea mays*, *Dracaena;* T.S. of dicot root with and without secondary growth- *Cicer*, monocot root - *Zea mays*, V.S. of dicot leaf- *Vernonia/Hamelia*etc., *Nerium, Hydrilla;* V.S. of monocot leaf- *Zea mays, Triticum/Dracaena/Crinum;* peel mountstostudy epidermal structures - types of stomata, trichomes, laticifers; Shoot apex and root apex through micrographs.
5. Study Reproductive structures (i) Anther - T.S. of anther of any large flower like *Datura/ Hamelia/ Kigelia*); whole mounts of pollen grains; ii) pollen development through micrographs of T.S. anther at different stages of development (with secretory, amoeboid tapetum); (iii) types of ovule through permanent slides/specimens/ micrographs; (iv) Polygonum type of embryo sac development through micrographs; (v) ultrastructure of egg apparatus and central cell through micrographs.
6. Study (i) pollen viability (TTC/FDA); (ii) pollen germination; (iii) growth of pollen tube in cleared pistil.

7. Study (i) dicot and monocot embryo development (through permanent slides); (ii) structure of seed (L.S. of seed)

Suggested Readings:

1. Beck, C.B. (2010). An Introduction to Plant Structure and Development. Second edition. Cambridge University Press, Cambridge, UK.
2. Dickison, W.C. (2000). Integrative Plant Anatomy. Harcourt Academic Press, USA
3. Fahn, A. (1974). Plant Anatomy. Pergamon Press, USA
4. Mauseth, J.D. (1988). Plant Anatomy. The Benjammin/Cummings Publisher, USA
5. Esau, K. (1977). Anatomy of Seed Plants. John Wiley & Sons, Inc., Delhi.
6. Taiz, L., Zeiger, E., Moller, I.M., Murphy, A. (2015). Plant Physiology. 6th edition. Sinauer Associates, Sunderland. USA.
7. Hopkins, W.G., Huner, N.P.A. (2009). Introduction to Plant Physiology. Fourth edition, John Wiley & Sons, Inc. USA.
8. Bhojwani, S.S., Bhatnagar, S.P., Dantu, P.K. (2015). The Embryology of Angiosperms, 6th edition. New Delhi, Delhi: Vikas Publishing House.
9. Johri, B.M. (1984). Embryology of Angiosperms. Netherlands: Springer-Verlag.
10. Raghavan, V. (2000). Developmental Biology of Flowering plants. Netherlands: Springer.
11. Shivanna, K.R. (2003). Pollen Biology and Biotechnology. New Delhi, Delhi: Oxford and IBH Publishing Co. Pvt. Ltd.

Additional Resources:

1. Cutler, D.F., Botha, T., Stevenson, D.W. (2007). Plant Anatomy - An Applied Aspect. Blackwell Publishing, USA
2. Bahadur, B. Rajam, M.V., Sahijram, L., Krishnamurthy, K.V. (2015). Plant Biology and Biotechnology. Volume 1: Plant Diversity, Organization, Function and Improvement. Springer (India) Pvt. Ltd. New Delhi, Heidelberg, New York, Dordrecht, London.
3. Shivanna, K.R., Tandon, R. (2014). Reproductive Ecology of Flowering Plants: A Manual. Springer (India) Pvt. Ltd. New Delhi, Heidelberg, New York, Dordrecht, London
4. Moza M. K., Bhatnagar A.K. (2007). Plant reproductive biology studies crucial for conservation. Current Science 92:1907.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Category III:

B.Sc. programme in Applied Life Sciences with Agrochemicals and Pest Management Botany (H) Courses for Undergraduate Programme of study with Botany as a Single Core Discipline

DISCIPLINE SPECIFIC CORE COURSE (DSC 03)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the core course			Eligibility criteria	Pre-requisite of the course (If any)
		Lecture	Tutorial	Practical/ Practice		
Genetics and Molecular Biology ALSBOTDSC03	**4**	**2**	**0**	**2**	**XII pass with Science with Biology/ Biotechnology**	**NIL**

Learning Objectives:

The learning objectives of this course are as follows:

- To understand the basic concept of Mendelian genetics and comprehensive study of Mendelian extensions.
- To provide adequate knowledge about Linkage, Crossing over and Mutations.
- To provide brief knowledge of population and evolutionary genetics.
- To impart detailed understanding about the structureof nucleic acids and their types. .
- To understand key events of Molecular biology comprising mechanism of DNA Replication, Transcription and Translation in Prokaryotes and Eukaryotes.
- To give comprehensive explanation of Transcriptional Regulation with examples of lac operon and tryptophan operon in prokaryotic as well as eukaryotic organisms along with the key concept of Gene Silencing.

Learning Outcomes:

By studying this course, students will be able to:

- Analyse the basic concepts of Mendelian genetics and its extension, Linkage and Crossing over, Mutations and population genetics.

- Explicate the mechanism of replication, transcription, translation in prokaryotes and eukaryotes.
- Comprehend the mechanism of gene regulation and gene silencing.

Unit 1: Mendelian Genetics and Extensions (3 Hours)

Mendel's work on transmission of traits, Co-dominance, Incomplete dominance, Multiple alleles, Lethal Genes, Epistasis, Pleiotropy, Polygenic inheritance, Pedigree analysis.

Unit 2: Extra-chromosomal Inheritance (2 Hours)

Cytoplasmic inheritance: Chloroplast variegation in Four 'O clock plant, Kappa particles in *Paramecium*, Maternal effect-shell coiling pattern in snail.

Unit 3: Linkage, Crossing over and Chromosomal Mapping (3 Hours)

Linkage and crossing over, Recombination mapping - two point and three points.

Unit 4: Mutations (3 Hours)

Chromosomal mutations, Deletion, Duplication, Inversion, Translocation, Aneuploidy and Polyploidy, Gene mutations.

Unit 5: Population and Evolutionary Genetics (2 Hours)

Allelic frequencies, Genotypic frequencies, Gene pool, Hardy-Weinberg Law.

Unit 6: The Genetic Material: DNA and RNA (4 Hours)

DNA structure: Salient features of double helix, Types of DNA, DNA denaturation and renaturation, Nucleosome, Chromatin structure- Euchromatin, Heterochromatin (Constitutive and Facultative), RNA structure and its types.

Unit 7: Replication of DNA (3 Hours)

Mechanism of prokaryotic DNA replication, Chemistry of DNA synthesis, Enzymes and proteins involved in DNA replication, Comparison of replication in prokaryotes and eukaryotes.

Unit 8: Transcription and Processing of RNA (4 Hours)

Mechanism of transcription in prokaryotes and eukaryotes, Split genes: concept of introns and exons, Removal of introns, Spliceosome machinery group I & group II intron splicing, alternative splicing, eukaryotic mRNA processing (5' cap, 3' poly A tail).

Unit 9: Translation (3 Hours)

Mechanism of translation in prokaryotes and eukaryotes: initiation, elongation and termination of polypeptides,Proteins and enzymes involved in translation.

Unit 10: Regulation of transcription in prokaryotes and eukaryotes (3 Hours)

Prokaryotes: Regulation of lactose metabolism and tryptophan synthesis in *E. coli*, Eukaryotes: Transcription factors, Heat shock proteins, Gene silencing.

PRACTICAL (Credit: 02)

(Laboratory practical- 15 classes of 4 hours each)

1. To study Mendelian and Non- Mendelian gene interaction ratios (9:7, 9:6:1, 13:3, 15:1, 12:3:1, 9:3:4) through seeds.
2. To study linkage, recombination, gene mapping using marker-based data from *Drosophila*.

3. Karyotype and Idiogram preparation through photographs.
4. PTC testing in a population and calculation of allelic and genotypic frequencies.
5. Study of abnormal human karyotype and pedigrees.
6. Isolation of genomic DNA from Cauliflower curd.
7. Qualitative analysis of DNA using gel electrophoresis.
8. Estimation of DNA by Diphenylamine method.
9. Separation of nucleotide bases by paper chromatography.
10. Purity and quantitative estimation of isolated DNA by UV-VIS spectrophotometer.
11. Study of Molecular techniques: PCR, Southern, Northern and Western Blotting and PAGE.

Essential/ Recommended readings:

1. Snustad D.P. and Simmon M.J. (2012) *Genetics* 6 th Ed., John Wiley & Sons. (Singapore)
2. PierceB.A, (2012) *Genetics - A Conceptual Approach*, 4 th Ed., W.H. Freeman & Co. (New York)
3. Griffiths A.J.F., Wessler S. R, Carroll S. B and Doebley J. (2010) *An Introduction to Genetic Analysis*, 10th Ed., W.H. Freeman & Company (New York).
4. Watson J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R. (2007) *Molecular Biology of the Gene*, 6th Ed. Pearson Benjamin Cummings, CSHL Press, New York, U.S.A.

Suggestive readings:

1. Klug, W.S., Cummings, M.R. and Spencer, C.A. (2009)*Concepts of Genetics*. 9th Ed. Benjamin Cummings. U.S.A.
2. Russell, P. J. (2010) *Genetics- A Molecular Approach*. 3rd Ed. Benjamin Cummings, U.S.A.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE (DSE01)

Course title & Code	Credits	Credit distribution of the core course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Ecology, Conservation and Restoration ALS BOT DSE 01	4	2	0	2	XII pass with Science with Biology/ Biotechnology	NIL

Learning Objectives:

- To develop a scientific understanding of the diverse aspects of ecology.
- To familiarize students with the interactions between the organisms and their physical environment.
- To understand various attributes of populations and communities with the help of theoretical concepts and field studies.
- To make students understand various factors that lead to variations among populations of a species.
- To familiarize students about the concepts of conservation and restoration.

Learning Outcomes:

By studying this course,students will be able to:

- Gain knowledge aboutthebasic concepts of ecology.
- Comprehend the characteristics of the community, ecosystem development and climax theories.
- Explicate the relationship of evolution of various species and their environment.
- Analyse the basic field studies including data collection and its interpretation.
- Explicate the Conservation and Restoration methods.

Unit 1: Introduction to Ecology (3 Hours)

Autecology and Synecology, Laws of limiting factors, Study of physical factors: Temperature and Light.

Unit 2: Population (4 Hours)

Unitary and Modular populations, Unique and group attributes of population: density, natality, mortality, Life tables, Fecundity table, Survivorship curves, Intraspecific population regulation: density-dependent and independent factors.

Unit 3: Species Interactions (5 Hours)

Types of species interactions, Interspecific competition: Lotka-Volterra model of competition, Gause's Principle, Niche concept, Predation, Predator defence mechanisms.

Unit 4: Community (4 Hours)

Community characteristics: species richness, dominance, diversity, abundance, guilds, ecotone and edge effect, Ecological succession with examples and types.

Unit 5: Ecosystem (5 Hours)

Types of Ecosystems: terrestrial and aquatic ecosystems, Vertical stratification in tropical forest, Food chain: detritus and grazing food chains, linear and Y-shaped food chains, Food web, Energy flow through the ecosystem: Ecological pyramids and Ecological efficiencies, Biogeochemical cycles: Nitrogen cycle.

Unit 6: Conservation (5 Hours)

Ecology in wildlife conservation and management: In-situ conservation (Biosphere Reserves, National Parks, Wildlife Sanctuaries), Ex-situ conservation (botanical gardens, gene banks, seed and seedling banks, DNA banks),Principles of Environmental impact assessment.

Unit 7: Restoration (4 Hours)

Restoration ecology: Afforestation, Social forestry, Agro-forestry, Joint Forest management, Role of remote sensing in management of natural resources.

PRACTICAL (Credit: 02)

(Laboratory practical- 15 classes of 4 hours each)

1. Study of life tables and plotting of survivorship curves of different types from hypothetical/real data.
2. Determination of population density and abundance in a natural or a hypothetical community by quadrat method.
3. Quantitative analysis of herbaceous vegetation in the college campus and comparison with Raunkiaer's Frequency distribution law.
4. Study of morphological features of hydrophytes and xerophytes in the ecosystems.
5. Measurement of temperature, turbidity/penetration of light and pH of any two water samples.
6. Comparison of Dissolved oxygen content in different water samples using Winkler's titration method.
7. Comparison of organic carbon of two soil samples using Walkley and Black's rapid titration method.
8. Comparison of CO_2 and alkalinity in two different water samples.
9. Estimation of Total Dissolved Solids (TDS) in water samples.
10. Perform Rapid field tests to detect the presence of Carbonates, Nitrate, Sulphate, Chloride, Organic matter and Base deficiency in two soil samples.
11. A visit to a National Park/Biodiversity Park/Wildlife Sanctuary/Urban Forest.

Essential/Recommended readings:

1. Sharma, P.D. (2012). *Ecology and Environment*. Rastogi Publications.
2. Singh J.S., Singh S.P., and Gupta S. R. (2014) *Ecology, Environment Science and Conservation*. S. Chand and Company Limited.
3. Odum, E.P. and Barrett G. W. (2004) *Fundamentals of Ecology*. Indian Edition (5th)Brooks/Cole Publishers.

Suggestive readings:

1. Smith T. M. and Smith R. L. (2015). *Elements of Ecology*. 9th International Edition, Publisher: Benjamin Cummings.
2. Saha G.K. and Mazumdar S. (2020) *Wildlife Biology*, An Indian Perspective. Publisher: PHI Learning Private Limited

3. Futuyma, Douglas and Mark, Kirkpatrick (2017). *Evolutionary Biology* (3rd Edition), Oxford University Press

Category IV:

B.Sc. Biological Sciences (Hons)for Undergraduate Programme of study with Botany as a Single Core Discipline

DISCIPLINE SPECIFIC CORE COURSE –9 :

Course title & Code	Credits	Credit distribution of the core course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Functional Ecology (BS-DSC303)	4	2	-----	2	Class XII pass with Biology and chemistry, as one of the papers in Class XII	Nil

Learning Objectives

• To understand the basic concepts in ecology and levels of organization in an ecosystem
• Obtain a basic understanding of the various aspects of a 'population' and interactions among individuals of the same as well as different species.
• To understand the structure and functions of the community and its processes.
• To comprehend the components of an ecosystem, energy flow and nutrient cycling.
• To appreciate the applied aspects required in restoration of degraded ecosystems.
• To understand trade-offs in life history characteristics of organisms and various behaviors shownby organisms.

Learning outcomes
By the end of the course, the student will be able to:
• To comprehend the principles and applications of ecology and ecosystem.
• Know about the importance of ecosystem in general and the effects of changes inecosystem.
• Understand the techniques used for the quantitative and qualitative estimation of bioticand abiotic components of an ecosystem.
• Gain knowledge about the density, frequency and diversity of species in an ecosystem.
• Understand about key interactions between organisms like competition , predation ,parasitism etc.
• Participate in citizen science initiatives from an ecological perspective

DISCIPLINE SPECIFIC CORE COURSE –9 :26
SYLLABUS OF DSC-9
Theory
Unit 1: Introduction to Ecology 1.5 weeks
History of ecology, Autecology and synecology, levels of Organisation, Laws of limiting

factors (Liebig's law of minimum, Shelford's law of tolerance), ecological range (Eury and Steno).

Unit 2: Population Ecology 6 weeks

Population: Unitary and Modular populations; Metapopulation: Density, natality, mortality, life tables, fecundity tables, survivorship curves, sex ratio, age pyramids, dispersal and dispersion; carrying capacity, population dynamics (exponential and logistic growth equation and patterns), r and K selection, density-dependent and independent population regulation; Niche concept, Population interactions: Positive and negative interactions; Competition, Gause's Principle for competition with laboratory and field examples, Lotka-Volterra equation for predation.

Unit 3: Community Ecology 4 weeks

Community structure: Dominance, diversity, species richness, abundance, stratification; Diversity indices; Ecotone and edge effect; Community dynamics (succession): Primary and secondary succession, Succession on a bare rock. Climax: monoclimax and polyclimax concepts (preclimax, postclimax, disclimax etc.). Concept of keystone, indicator and flagship species with plant and animal examples.

Unit 4: Ecosystem Ecology 3.5 weeks

Concept, components, and types of ecosystems (example of Pond ecosystem in detail showing abiotic and biotic components), BOD, eutrophication. Energy flow (Grazing and Detritus food chain), linear and Y-shaped energy flow model, black box model, food web. Ecological pyramids and Ecological efficiencies.

PRACTICALS CREDITS: 2 Total weeks: 15

1. To understand the principle and working of ecological instruments such as Anemometer, Hygrometer, Luxmeter, Rain gauge, turbidity meter, pH meter, Soil thermometer, MinMax thermometer.
2. To study biotic interactions using specimens/ photographs/ permanent slides of Parasitic angiosperms, Saprophytic angiosperms, root nodules, velamen roots, lichens , corals .
3. To study plant-microbe interactions by preparing temporary stained mounts of VAM fungi / mycorrhizal roots/ root nodules.
4. Mark recapture method for determining population density of animals
5. To determine a minimal quadrat area for sampling
6. To determine density, frequency and abundance of herbaceous vegetation by quadrat method
7. To estimate dissolved oxygen content of a given water sample using Winkler's method.
8. Plotting of survivorship curves from hypothetical life table data.27

REFERENCES

1. Barrick, M., Odum, E. P., Barrett, G. W., (2005) Fundamentals of Ecology.5th Edition. Cengage Learning.
2. Smith, T. M..& Smith, R. L.(2012). Elements of Ecology 8th Edition. Pearson.
3. Ricklefs, R. E., & Miller, G. L., (2000) Ecology, 4th Edition W.H. Freeman.
4. Sharma, P. D. (2017). Ecology and Environment.13th Edition. Meerut: Rastogi Publications.

MOOCs

1. 'Ecology: Ecosystem Dynamics and Conservation from American Museum of Natural History on Coursera https://www.classcentral.com/course/coursera-

ecology- ecosystem-dynamics-andconservation-10618

2. https://alison.com/course/diploma-in-ecology-studies
3. https://swayam.gov.in/ Any ecology based online course that may be available during the semester, depending on its relevance to the present syllabus28

DISCIPLINE SPECIFIC Elective –DSE-1 :

Course title & Code	Credits	Credit distribution of the core course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Medicinal and Ethnobotany (BS-DSE-1)	**4**	**2**	**-----**	**2**	**Class XII pass with Biology and NA chemistry, as one of the papers in Class XII**	**Nil**

Learning Objectives:

Plants are imperative to mankind with almost all plants known to possess medicinal values. There is an increased emphasis on indigenous system of medicine which has lent prime focus on medicinal plants. Keeping the therapeutic importance of medicinal plants in mind this course is designed to provide education and training on diverse perspectives of medicinal plants. The course also offers comprehensive knowledge about understanding the difference between ancient wisdom and themodern system of medicine.

Learning Outcomes:

On successful completion of the course, a student will:

• Be able to identify the common medicinal plants in their vicinity.

• Learn about the traditional healing sciences namely Ayurveda, Siddha and Unani, which have been used since the ancient times.

• Appreciate the importance of conservation strategies for medicinal plants.

• Be able to understand the importance of medicinal plants, significance of ethnobotany, role of ethnic groups in the conservation of medicinal plants.

Course Contents - Theory

Unit 1: History, Scope and Importance of Medicinal Plants No. of weeks 5

Introduction to indigenous systems of medicines- Ayurveda, Unani and Siddha system of medicine)- Ayurveda: History, origin, Panchamahabhutas, Saptadhatu and Tridosha concepts, Siddha: Origin of Siddha medicinal systems, Basis of Siddha system. Unani: History, concept: Umoor-e- tabiya. Plants used in Ayurveda, Siddha and Unani medicine with special reference to Carum carvi, Plantago ovata, Allium sativum, Asparagus racemosus, Vitis vinifera, Linum usitatissimum, Amaranthus paniculatus. Polyherbal formulations (with special reference to Safi, Chyawanprash, Trifala, Swalin, Amukkara Choorna, Gandhak rasayana). Natural

products – Compounds responsible for biological activity of medicinal plants: their biology, and pharmacology (Curcumin, Vinblastine, Vincristine, Ecliptine, Cinchonine, Azadirachtin, Artemisinin).

Unit 2: Conservation of Endangered and Endemic Medicinal Plants No. of weeks: 4

Definition: endemic and endangered medicinal plants, Red list criteria; In situ conservation: Biosphere reserves, sacred groves, National Parks; Ex situ conservation: Botanical Gardens, herbal gardens, Ethnomedicinal plant gardens. Germplasm conservation, cryopreservation (Cryo banks and DNA banks), Role of NBPGR and JNTBGRI in conservation of plants, Propagation of Medicinal Plants: In vitro and In vivo strategies. Adulteration of Herbal drugs. Organoleptic, microscopic and phytochemical evaluation of plant drugs.

Unit 3: Ethnobotany and Folk Medicines No. of weeks: 6

Introduction, concept, scope and objectives; Ethnobotany in India: Methods to study ethnobotany; Folk medicines of ethnobotany, Role of ethnobotany in modern medicine with special reference to *Rauvolfia serpentina*, *Trichopus zeylanicus*, *Artemisia, Withania*. Major and minor ethnic groups of India and their lifestyles. Application of natural products to certain diseases- Jaundice, cardiac, infertility, diabetics, blood pressure and skin diseases. Role of ethnic groups in conservation of plant genetic resources; Brief account of biopiracy and IPR.

PRACTICAL
Credit: 2 Total weeks: 15

1. Identification of any ten common medicinal plants in the surrounding area and study their characteristic features.
2. Collection, identification and preparation of herbarium of any five medicinal plants.
3. Extraction and qualitative estimation of active principle compounds (alkaloids, tannins, saponins and flavanoids) from any four medicinal plants. (*Aloe vera, Ocimum* sp, *Azadirachta , Catharanthus, Adhatoda, Withania*)
4. Study of components and medicinal uses of common polyherbal formulations used in the traditional system of medicine (Ayurveda, Unani and Siddha).
5. Study of organoleptic, macroscopic and microscopic parameters of any two medicinal plants.
6. To compare the total phenolic content of few locally available medicinal plants
7. Field trip: Industries/Institutes/herbal garden/ medicinal gardens/ nurseries/tribal museum.
8. e-presentations (System of medicine, Conservation strategies, propagation of medicinal plants, folk medicines, application of natural products to certain diseases listed in the syllabus)

Essential readings:

1. Abdin, M. Z. and Abrol, Y. P., (2006). Traditional Systems of Medicine. Narosa Publishing House, New Delhi.
2. Kumar, S., (2018). Ethnobotany. Kojo press, New Delhi.
3. Purohit and Vyas, (2008). Medicinal Plant Cultivation: A Scientific Approach, Agrobios.
4. Trivedi, P. C. (2006). Medicinal Plants: Ethnobotanical Approach. Agrobios.

Additional Readigs

1. Colton, C. M., (1997). Ethnobotany: Principles and Applications. John Wiley and Sons.

2. Jain, S. K., (1990). Contributions to Indian Ethnobotany. Scientific publishers, Jodhpur.
3. Jain, S. K., (1995). Manual of Ethnobotany. Scientific Publishers, Jodhpur.

COMMON POOL OF GENERIC ELECTIVES (GE)

GENERIC ELECTIVES (GE-11): Industrial and Environmental Microbiology

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical / Practice		
Industrial and Environmental Microbiology **GE-11**	4	2	0	2	Class XII pass	Nil

Learning Objectives:

- To introduce students to understand the uses of microbes in industry: concepts, principles, scope and applications.
- To introduce students to the role of microbes in the environment: concepts, principles, scope and application.

Learning Outcomes:

Upon successful completion of the course, students will be able to:

- understand how microorganisms are involved in the manufacture of industrial products.
- know about design of bioreactors, factors affecting growth and production of bioproducts.
- understand the rationale in medium formulation & design for microbial fermentation, sterilization of medium and air.
- comprehend the different types of fermentation processes and the underlying principles in upstream and down- stream processing.
- learn the occurrence, abundance, distributionandrole of microorganisms in the environment.Also, learn different methods for microbial isolation and detection from different habitats.
- understand the basic principles of environmental microbiology and their application in waste water treatment, bioremediation and role of microbes in agriculture.

Unit 1: Introduction **4 hours**

Scope and importance of microbes in Industry and Environment (Institutes of microbial research). Bioremediation. Distribution and isolation of microbes in the air, soil and water.

Unit 2: Bioreactors/ Fermenters and Fermentation process **4 hours**

Solid-state and liquid state (stationary and submerged) fermentations; batch and continuous fermentations; components of a typical bioreactor, types of bioreactors.

Unit 3: Microbial production of industrial importance **12 hours**

Microorganisms generally regarded as safe (GRAS), types of media, conditions necessary for the growth and production of industrially important products, downstream processing and uses; filtration, centrifugation, cell disruption, solvent extraction, precipitation and ultrafiltration, lyophilization, spray drying.

Production of enzyme (amylase); organic acid (citric acid); alcohol (ethanol); antibiotic (penicillin).

Unit 4: Enzyme immobilization **3 hours**

Definition, Methods of immobilization, their advantages and applications, large scale production and application of penicillin acylase.

Unit 5: Microbial flora of water **4 hours**

Microorganisms as indicators of water quality: coliform and faecal coliform; role of microbes in sewage and waste water treatment system.

Unit 6: Microbes and agriculture **3 hours**

Legume root nodule symbiosis, Mycorrhizae, Arbuscular Mycorrhiza Fungi (AMF) and its importance in agriculture.

Practicals: **60 hours**

1. Principle and functioning of instruments in microbiological laboratory (autoclave, laminar flow, incubator, fermenters).
2. Sterilization methods: Wet and dry methods, membrane filters, chemicals.
3. Preparation of different culture media (Potato dextrose agar/Czapek-Dox agar, Luria Bertani) for isolation of microorganisms from soil using serial dilution agar plating method and study of aero-microflora.
4. Culturing techniques: Streak plate method, pour plate method and spread plate method.
5. To study the ability of microorganisms to hydrolyse casein/ starch.
6. Production of alcohol using sugar/ jaggery.
7. Observation of AMF colonization in plant roots.
8. A visit to any educational institute/ industry to understand the uses of microbes for industrial applications and a report to be submitted for the same.

Suggested Readings:

1. Pelczar, M.J. Jr., Chan E.C. S., Krieg, N.R. (2010). Microbiology: An application based approach. New Delhi, Delhi: McGraw Hill Education Pvt. Ltd., Delhi.
2. Reed, G. (2004). Prescott and Dunn's Industrial Microbiology. 4thEdition , CBS Publishers and Distributors Pvt. Ltd.
3. Willey, J.M. (2023). Prescott's Microbiology, 12th edition, McGrew Hill.
4. Tortora, G.J., Funke, B.R., Case. C.L. (2007). Microbiology. 9th edition, San Francisco, SF: Pearson Benjamin Cummings.
5. Stanbury, P.F., Whitaker, A., Hall, S.J. (2017). Principles of Fermentation Technology. Amsterdam, NDL: Elsevier Publication
6. Patel, A.H. (2008). Industrial Microbiology, Bangalore, India: McMillan India Limited
7. Mohapatra. P.K. (2008). Textbook of Environmental Microbiology New Delhi, Delhi, I.K. International Publishing House Pvt. Ltd.
8. Bertrand, Jean-Claude, Caumette, P. Lebaron, P, Matheron, R., Normand, P., Sime Ngando, T. (2015). Environmental Microbiology: Fundamentals and Applications. Amsterdam, Netherlands, Springer.
9. Casida, J.R. (2019). Industrial Microbiology, 2nd Edition, New Age International Publishers, New Delhi.
10. Atlas, R.M., Bartha, R. (2009). Microbial Ecology: Fundamentals and Applications., Pearson, San Francisco
11. Sharma, P.D. (2005). Environmental Microbiology. Meerut, UP: Alpha Science International, Ltd.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

GENERIC ELECTIVES (GE-12)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Environmental Biotechnology & Management **GE-12**	**4**	**2**	**0**	**2**	Class XII pass	**Nil**

Learning Objectives:

The course aims to build awareness of:

- various global and regional environmental concerns due to natural causes and/or human activities.
- different types of pollution and their impacts on the environment.
- existing and emerging technologies that are important in the area of environmental biotechnology to fulfill Sustainable Development Goals.

Learning Outcomes:

After completion of course the student will be able to:

- demonstrate awareness about emerging concerns such as climate change, waste management; biodegradation of xenobiotic compounds; bioremediation, etc.
- relate applications of biotechnology for alleviating the environmental concerns
- appreciate the scientific, ethical and/or social issues
- understand the national and international legislations, policies and role of public participation in Environmental Protection

Unit 1: Environment **5 hours**

Basic concepts and issues, global environmental problems - ozone layer depletion, UV-B, greenhouse effect and acid rain due to anthropogenic activities, their impact and biotechnological approaches for management. Fate of pollutants in the environment, Bioconcentration, Biomagnification.

Unit 2: Microbiology of waste water treatment 7 hours

Aerobic process - activated sludge, oxidation ponds, trickling filter. Anaerobic process - anaerobic digestion, anaerobic filters, up-flow anaerobic sludge blanket reactors. Treatment schemes for waste waters of dairy and sugar industries.

Unit 3: Xenobiotic compounds7 hours

Organic (Bio degradation of petroleum products and pesticides) and inorganic (metals, phosphates, nitrates). Bioremediation of xenobiotics in environment - ecological consideration, Bioaccumulation and Biosorption of metals

Unit 4: Treatment of toxic compounds: Role of immobilized cells/enzymes, microbial remediation 5 hours

Biopesticides, bioreactors, bioleaching, biomining, biosensors, biotechniques for air pollution abatement and odour control. Bioindicators and Bioprospecting

Unit 5: International Legislations, Policies for Environmental Protection 3 hours
Stockholm Conference (1972) and its declaration, WCED (1983) and Brundtland Report (1987), Rio Earth Summit-UNCED (1992) and its declaration, Montreal Protocol - 1987, Kyoto Protocol- 1997. Environmental ethics

Unit 6: National Legislations, Policies for Pollution Management 3 hours
Water Pollution (Prevention and Control) Act-1974, Air Pollution (Prevention and Control) Act-1981, National Environmental Policy - 2006, Central and State Pollution Control Boards: Constitution and power.

Practicals: 60 hours

1. To determine the pH and total hardness of water samples collected from different places (polluted and non-polluted sites)
2. To determine the salinity of water samples (polluted and non-polluted sites)
3. To determine the dissolved oxygen of two water samples.
4. To determine the alkalinity of water samples.
5. To determine the pH and rapid field test of soil samples (Chloride, Nitrate, and Sulphate).
6. To study microbessuspended in air and water samples.
7. A visit to any educational institute/ industry to understand the uses of microbes in environmental management and a report to be submitted for the same.

Suggested Readings:

1. De, A. K. (2022). Environmental Chemistry, 10th Edition, New Delhi. New Age International Pvt. Limited
2. Dennis, A., Seal, K.J., Gaylarde, C.C. (2004). Introduction to Biodeterioration, Cambridge University Press
3. Ahmed, N., Qureshi, F.M., Khan, O.Y. (2006). Industrial and Environmental Biotechnology, Horizon Press
4. Rochelle, P.A. (2001). Environmental Molecular Biology, Horizon Press.
5. Jadhav, H.V., Bhosale, V.M. (2015). Environmental Protection and Laws, Himalaya publishing House Pvt Ltd.
6. Trivedi, P. C. (2006). Biodiversity Assessment and Conservation, Agrobios Publ.
7. Rana, S.V.S. (2015). Environmental Biotechnology, Rastogi Publications, India.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

GENERIC ELECTIVES (GE-13): Plant Biotechnology

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical / Practice		
Plant Biotechnology **GE-13**	**4**	**2**	**0**	**2**	Class XII pass	**Nil**

Learning Objective

To give students knowledge of techniques used in plant biotechnology and its applications.

Learning Outcomes:

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

- understand the basic concepts, principles, and methods in plant biotechnology.
- will be able to explain the usage of the acquired knowledge in biotechnological, pharmaceutical, medical, ecological, and agricultural applications.

Unit 1: Introduction and Scope of Plant Biotechnology **2 hours**

Historical perspective, Current paradigms in plant biotechnology, GM crops, International/National institutions

Unit 2: Plant Tissue Culture **10 hours**

Plasticity and Totipotency of plant cells – why and how do plants grow from a single cell; Nutrient media and role of vitamins and hormones. Regeneration of plants in the laboratory: Direct and indirect organogenesis, somatic embryogenesis; Brief account of micropropagation, haploids, triploids and cybrids and their applications; artificial seeds

Unit 3:Cloning and transformation techniques **10 hours**

What is cloning?; Restriction and modifying enzymes, plasmids as cloning vehicles, Transformation of bacterial cells, selection of transformants and clones – antibiotic selection, blue-white selection; How do we make transgenic plants: *Agrobacterium*-mediated transformation, Direct gene transfer by Electroporation, Microinjection, Microprojectile bombardment. Selection of transgenic plants - selectable marker and reporter genes (Luciferase, GUS, GFP).

Unit 4: Applications **8 hours**

Applications of transgenic plants in enhancing crop productivity: Pest resistant (Bt-cotton, Bt Brinjal) and herbicide resistant plants (Round Up Ready soybean); Transgenic crops with improved quality traits (FlavrSavr tomato, Golden rice);

Improved horticultural varieties (Moondust carnations); Role of transgenics in bioremediation (Superbug), Edible vaccines; Genetically engineered products - Human Growth Hormone and Humulin; Transgenic plants and their role in understanding plant biology, Biosafety regulations for transgenic plants.

Practicals **60 hours**

1. a. Preparation of Murashige & Skoog's (MS) medium.
   b. Demonstration of in vitro sterilization and inoculation methods using leaf and nodal explants of *Nicotiana* / *Datura / Brassica*.
2. Study anther, embryo, endosperm culture, micropropagation and somatic embryogenesis (photographs/slides).
3. Study isolation of protoplasts and production of artificial seeds.
4. Study methods of gene transfer: A*grobacterium*-mediated, direct gene transfer by electroporation, microinjection, microprojectile bombardment (through digital resources).
5. Study various steps of genetic engineering for production of *Bt*cotton, Golden rice, Flavr Savr tomato.
6. Plasmid and genomic DNA isolation, Restriction digestion and agarose gel electrophoresis of DNA.
7. Visit to a plant tissue culture / Biotechnology laboratory and to submit a field report.

Suggested Readings:

1. Bhojwani, S.S., Bhatnagar, S.P. (2015). The Embryology of Angiosperms, 6th edition. New Delhi, Delhi: Vikas Publication House Pvt. Ltd.
2. Bhojwani, S.S., Razdan, M.K., (1996). Plant Tissue Culture: Theory and Practice. Amsterdam, Netherlands: Elsevier Science.
3. Newmann, Karl-Hermann (2020). Plant Cell and Tissue Culture: A Tool in Biotechnology, 2nd Edition {Springer}
4. Glick, B.R., Pasternak, J.J. (2022). Molecular Biotechnology Principles and Applications of Recombinant DNA, 6th Edition. Washington, U.S.: ASM Press.
5. Stewart, C.N. Jr. (2016). Plant Biotechnology and Genetics: Principles, Techniques and Applications, 2nd Edition. New Jearsey, U.S.: John Wiley & Sons Inc.

Additional Resources:

1. Razdan, M. K. (2019). Introduction to Plant Tissue Culture, 3rd Edition {CBS / Oxford & IBH}
2. Singh, B. D. (2022). Plant Biotechnology, Delhi, Medtech

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

GENERIC ELECTIVES (GE-14): Plant Tissue Culture

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Plant Tissue Culture **GE-14**	4	**2**	**0**	2	Class XII pass	**Nil**

Learning Objectives

To give students knowledge of techniques used in plant tissue culture and its applications.

Learning Outcomes

The successful students will be able to:

- learn the basic concepts, principles and processes in plant cell and tissue culture.
- understand the use of tissue culture techniques in plant improvement.
- apply the concepts and principles of plant cell and tissue culture in biotechnological and agricultural fields.
- become an entrepreneur by establishing their own plant tissue culture lab.

Unit 1 Introduction **3 hours**

Historical perspective, Important contributions of Haberlandt, White, Reinert & Steward, Murashige, Skoog, Cocking, Guha & Maheshwari, Morrel & Martin.
Terminologies: Cell culture,organ culture, explant, callus, totipotency, plasticity, regeneration, somaclonal variants.

Unit 2 Types and composition of Media **4 hours**

Role of nutrients, vitamins, hormones and supplements in nutrient medium. Composition of MS and White medium.

Unit 3 Techniques of Plant Tissue Culture **4 hours**

Collection of plant material, sterilization of tissue (maintenance of aseptic conditions by use of autoclave and laminar flow chamber), filter sterilization, inoculation.

Unit 4 Protoplast culture **5 hours**

Protoplast isolation (mechanical and enzymatic), culture, purification (viability test) and fusion (spontaneous, induced), selection of fused protoplasts, applications.

Unit 5Micropropagation **5 hours**

Selection of plant material and suitable explant, methodology, plant regeneration pathways-somatic embryogenesis, organogenesis, difference between somatic and zygotic embryos.

Unit 6 Tissue culture applications **9 hours**

Anther culture, Production of haploids, triploids and cybrids, artificial seeds (production & advantages), embryo rescue, virus elimination, secondary metabolite production; Cryopreservation; Germplasm conservation. Novel sources of variation.

Practicals **60 hours**

l. To study the equipment used in tissue culture: autoclave and laminar air flow chamber.
2. Preparation of Murashige & Skoog's (MS) medium.
3. Demonstration of sterilization and inoculation methods using leaf and nodal explants of tobacco, carrot, *Datura*, *Brassica* etc. (any two).
4. Study of anther, embryo and endosperm culture.
5. Study of micropropagation, somatic embryogenesis & artificial seeds.
6. Isolation of protoplasts.
7. Visit to a plant tissue culture laboratory and submission of field report.

Suggested Readings:

1. Bhojwani, S.S. (1990). Plant Tissue Culture: Applications and Limitations {Elsevier}
2. Bhojwani, S.S, Bhatnagar, S.P. (2015). The Embryology of Angiosperms, 6th edition. New Delhi, Delhi: Vikas Publication House Pvt. Ltd.
3. Bhojwani, S. S. and Dantu, P. K. (2013). Plant Tissue Culture: An Introductory Text Springer
4. Bhojwani, S. S. and Razdan, M. K. (1996). Plant Tissue Culture: Theory and Practice, Revised Edition, Elsevier
5. Newmann, Karl-Hermann (2020). Plant Cell and Tissue Culture: A Tool in Biotechnology, 2nd Edition Springer

Additional Resources:

1. Park, Sunghun (2021). Plant Tissue Culture: Techniques and Experiments, 4th Edition Elsevier
2. Razdan, M. K. (2019). Introduction to Plant Tissue Culture, 3rd Edition CBS / Oxford & IBH
3. Smith, R. H. (2013). Plant Tissue Culture: Techniques and Experiments, 3rd Edition {Elsevier}
4. Stewart, C. Neal (2016). Plant Biotechnology and Genetics, 2nd Edition Wiley-Blackwell
5. Trigiano, R. N. (2011). Plant Tissue Culture, Development, and Biotechnology CRC Press

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GENERIC ELECTIVES (GE-15): Inheritance in Biology

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Inheritance in Biology **GE-15**	**4**	**2**	**0**	2	Class XII pass	**Nil**

Learning Objectives:

- Mendelian and non-Mendelian inheritance: How is genetic information transferred across generations?
- Genetic defects in humans: Causes, inheritance and diagnostics
- Mutations: Types and agents
- DNA fingerprinting: DNA as a tool for establishing unique identity

Learning Outcomes:

Students will get familiarized with the concepts and principles of inheritance, sex determination, causal agents of genetic changes (mutations) and defects (congenital diseases) in humans. The course will also enable students to learn how genetic information is used to detect diseases and also to establish unique identity of an individual.

Section A: Information transfer across generations: Transmission Genetics

Unit 1: Chromosomal Inheritance **7 hours**

Principles of Mendelian inheritance; Chromosomal theory of inheritance, Incomplete dominance and co- dominance; Multiple allelism; lethal alleles; Epistasis; Pleiotropy; Penetrance and expressivity; Polygenic inheritance; Linkage and crossing over.

Unit2: Extra-chromosomal Inheritance: **4 hours**

Chloroplast Inheritance: Variegation in Four O` clock plant; Mitochondrial inheritance: petite mutants in yeast; Maternal effect- shell coiling in snails.

Section B: Male or Female? What determines the gender of the offspring?

Unit 3: Sex determination **3 hours**

Mechanism of sex determination in Insects (*Drosophila*), Plants (*Melandrium, Coccinia*)and humans (Sex determination regions/genes-TDF, SRY and Testicular feminisation), Dosage compensation in humans.

Section C: Human Genetics

Unit 4: Genetic defects-Structural **3 hours**

Autosomal and sex linked, congenital defects: Hemophilia, Thalassemia, Sickle cell anemia, Phenylketonuria, Cystic fibrosis, pedigree analysis

Unit 5: Genetic Defects-Variation in Chromosome number **3 hours**

Syndromes associated with chromosomal abnormalities: Down, Turner, Klinefelter, Edward and Patau.

Section D: Molecular Genetics

Unit 6: Heritable changes (mutations) and their causes **3 hours**

Physical and chemical mutagens, Transposable genetic elements and their role in mutations.

Unit 7: Diagnostics for human genetic disorders **3 hours**

Molecular, chromosomal and biochemical testing

Unit 8: DNA fingerprinting as molecular signatures- applications **4 hours**

Forensics (case studies), Paternity testing, unique identity establishment, conservation, finding adulterants in food/drugs.

Practicals **60 hours**

1. To understand the genetic interaction involved using the given seed mixture. Genetic ratios to be calculated using Chi square analysis.
2. Pedigree analysis (Sex linked dominant and recessive; autosomal dominant and recessive)
3. To study/list human dominant and recessive traits and to observe the listed physical traits among the students present in the class. Analyse the results.
4. To study the syndrome through photographs (Klinefelter, Turner, Downs /Patau/Edwards)
5. To demonstrate variation in the ability to taste PTC (Phenylthiocarbamide) in a given population.
6. Chromosomal and gene mutations: Complex translocation ring, quadrivalents, lagging chromosomes, dicentric/inversion bridge, sickle cell anaemia, xeroderma pigmentosum
7. To study sex chromosomes in *Drosophila, Melandrium, Coccinia* and human through photographs.

Suggested Readings:

1. Gardner, E.J., Simmons, M.J., Snustad, D.P. (1991). Principles of Genetics, 8th edition. New Delhi, Delhi: John Wiley & sons.
2. Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., Doebley, J. (2020). Introduction to Genetic Analysis, 12th edition. New York, NY: W.H. Freeman and Co.
3. Klug, W.S., Cummings, M.R., Spencer, C.A. (2020). Concepts of Genetics, 12th edition. San Francisco, California: Benjamin Cummings.
4. Campbell, N.A., Urry,L.A., Cain, M.L., Wasserman,S.A., Minorsky, P.V., Reece, J.B. (2020). Biology, 12th Edition. Harlow,England : Pearson

Additional Resources:

1. Hartl, D.L., Ruvolo, M. (2019). Genetics: Analysis of Genes and Genomes, 9th edition. New Delhi, Delhi: Jones and Bartlett Learning.

2. Snustad, D.P., Simmons, M.J. (2019). Principles of Genetics, 67th edition. New Delhi, Delhi: John Wiley & sons.
3. Singh, B. D. (2023). Fundamentals of Genetics, 6th edition. MedTech.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.