UNIVERSITY OF DELHI

CNC-II/093/1(22)/2022-23/212
Dated: 06.10.2022

N O T I F I C A T I O N

Sub: Amendment to Ordinance V

[E.C Resolution No. 18-1-3 dated 18.08.2022]

Following addition be made to Appendix-II-A to the Ordinance V (2-A) of the Ordinances of the University;

Add the following:

Syllabi of Semester-I of the following departments under Faculty of Science based on Under Graduate Curriculum Framework -2022 to be implemented from the Academic Year 2022-23.

FACULTY OF SCIENCE

DEPARTMENT OF BOTANY

BSc. (Hons.) Botany
Category-I

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	**DSC-1**	**2**	0	**2**	10+2 from any recognized Board with Biology & Candidates must appear in CUET in the following subject combination: **Physics+ Chemistry+ Biology/Biotechnology**	**Nil**

Learning Objectives

The Learning Objectives of this course are as follows:

- 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

The Learning Outcomes of this course are as follows:

By studying this course students will gain basic knowledge on

- The diversity of plants and microbes
- Their general characteristics
- Various groups of plants and their evolutionary relationships
- Basic principles and concepts of evolution that contribute to plant diversity

SYLLABUS OF DSC-1

Unit1: Origin of life **Hours: 6**

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

Unit2: Bacteria **Hours: 4**

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

Unit3: Viruses **Hours: 4**

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

Unit4: Algae **Hours: 6**

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

Unit5: Fungi **Hours: 8**

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 **Hours: 8**

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

Unit7: Pteridophytes **Hours: 8**

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

Unit8: Gymnosperms **Hours: 8**

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

Unit9: Angiosperms **Hours: 8**

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

Practical component (60 Hours)

1. To study structure of TMV and Bacteriophage (electronmicrographs/models). (**01)**
2. To study morphology of *Volvox*, *Oedogonium*, *Chara*, *Fucus* and *Polysiphonia* (Temporary preparation/specimens/slides). (02)
3. To study *Rhizopus*, *Penicillium*, *Alternaria* (Temporary preparations), symptoms of rust of wheat, white rust of crucifer (specimen). (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). (02)
5. To study *Selaginella* (morphology, WM of strobilus and spores), *Equisetum* (morphology, WM of spores), *Pteris* (morphology, tease mount of sporangia and spores). (03)
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). (02)
7. To study variation in leaf venations in dicots and monocots (at least two specimens each). (01)
8. To study the types of inflorescences in angiosperms (through specimens).(01)
9. To study the types of fruits in angiosperms (through specimens). (01)

Essential/recommended readings

- Campbell,N.A.,Reece,J.B.(2008.)Biology,8thedition,PearsonBenjaminCummings,San Francisco.
- Evert,RF.,Eichhorn,S.E.(2012).RavenBiologyofPlants,8thedition, NewYork,NY: W.H.Freeman and Company.
- Bhatnagar,S.P.,Moitra,A.(1996).Gymnosperms.NewDelhi,Delhi:NewAgeInternational(P)

Ltd Publishers.

- Kumar,H.D.(1999).IntroductoryPhycology,2ndedition.Delhi,Delhi:AffiliatedEast-West. Press Pvt. Ltd.
- Pelczar,M.J.(2001).Microbiology,5thedition.NewDelhi,Delhi:TataMcGraw-HillCo.
- Puri,P.(1985).Bryophytes.NewDelhi,Delhi,AtmaRam andSons.
- Sethi,I.K.andWalia,S.K.(2018).TextbookofFungiandTheirAllies.(2ndEdition),Medtech Publishers, Delhi.
- Tortora,G.J.,Funke,B.R.,Case.C.L.(2007).Microbiology.SanFrancisco,U.S.A:Pearson Benjamin Cummings.
- Vashishta,P.C.,Sinha,A.K.,Kumar,A.(2010).Pteridophyta.NewDelhi,Delhi:S.Chand &Co Ltd.
- Singh,G.(2019)PlantSystematics-AnIntegratedApproach.4th edition.CRCPress,TaylorandFrancisGroup.
- Blackmore,S.,Crane,P.(2019)HowPlantsWork–Form,Diversity,Survival,PrincetonUniversity Press; Illustrated edition
- Ingrouille,M.,Eddie,B.(2006)Plants:EvolutionandDiversity.CambridgeUniversityPress.

Suggestive readings

- Parihar,N.S.(1991).AnIntroductiontoEmbryophyta.Vol.II.Pteridophytes.Prayagraj:U.P.: CentralBook Depot.
- Singh,V.,Pandey,P.C.,Jain,D.K.(2001).ATextBookofBotany.Meerut,UP:Rastogiand Co.
- Webster,J.,Weber,R.(2007).IntroductiontoFungi.Cambridge,CambridgeUniversityPress.

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

CREDIT DI STRIBUTION, E LIGIBILITY AND PRE-REQUISITES O F TH E COURSE

Course t itle & Code	Credits	Credit di stribution o f t he course			Eligibility criteria	Pre-requisite of t he course (if any)
		Lecture	Tutorial	Practical/ Practice		
Cell Biology: Organelles and Biomolecules	DSC-2	**2**	0	**2**	10+2 from any recognized Board with Biology & Candidates must appear in CUET in the following subject combination: **Physics+Chemistry+ Biology/ Biotechnology**	**Nil**

Learning Objectives

The Learning Objectives of this course are as follows:

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

Learning outcomes

The Learning Outcomes of this course are as follows:

By studying this course students will gain basic knowledge on

- The relationships between the properties of macromolecules, their cellularactivities and biological functions.
- Physico-chemical composition of organelles and their functional organization.
- Basic principles and concepts of evolution that contribute to plant diversity.

SYLLABUS OF DSC-2

Unit 1: Biomolecules **Hours: 10**

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 **Hours: 04**

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 **Hours: 06**

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

Hours: 11

Nucleus: Structure and function (nuclear envelope, nuclear pore complex, nuclear lamina); types of chromatins; 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 **Hours: 08**

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

Practical component (60 Hours):

1. Study of cell and its organelles with the help of electron micrographs and other digital resources. (02)
2. Study of plant cell structure with the help of epidermal peel mount of *Allium*/*Rhoeo*/*Crinum*. (01)
3. Microchemical tests for carbohydrates (reducing, non-reducing sugars and starch), lipids and proteins. (02)
4. Separation of chloroplast pigments by paper chromatography/ Thin Layer Chromatography. (01)
5. Separation of amino acids by paper chromatography. (01)
6. Study the effect of organic solvent and temperature on membrane permeability. 02
7. Demonstration of the phenomenon of protoplasmic streaming in *Hydrilla* leaf. (01)
8. Demonstration of the phenomenon of plasmolysis and deplasmolysis. (01)
9. Demonstration of separation of biomolecules by dialysis. (01)

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:

1. Cooper, G.M., Hausman, R.E. (2019). The Cell: A Molecular Approach, 7th edition. Sinauer/OUP.
2. Iwasa, J, Marshall , W. (2020). Karps's Cell Biology, 9th edition, New Jersey, U.S.A.: John Wiley & Sons.
3. Majumdar, R., Sisodia, R. (2019). Laboratory Manual of Cell Biology, with reference to Plant Cells. New Delhi, Delhi: Prestige Publication.
4. Nelson, D.L., Cox, M.M. (2021). Lehninger Principles of Biochemistry, 8th edition. New York, NY: W.H. Freeman and Company.
5. Reven, F.H., Evert, R.F., Eichhorn, S.E. (1992). Biology of Plants. New York, NY: W.H.Freeman and Company.
6. Tymoczko, J.L., Berg, J.M., Stryer, L. (2012). Biochemistry: A short course, 2nd edition. New York, NY: W.H.Freeman and Company.

Note: Examination scheme and modes 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

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	**DSC-3**	**2**	**0**	**2**	10+2 from any recognized Board with Biology & Candidates must appear in CUET in the following subject combination: **Physics+ Chemistry+ Biology/ Biotechnology**	**Nil**

Learning Objectives

The course will help students gain knowledge about:

- 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 instruments
- Presentation, analysis of data and interpretation of results.

SYLLABUS OF DSC-3

Unit 1: Lab safety and good lab practices **Hours: 08**

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; 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 **Hours: 08**

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 **Hours: 05**

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 **Hours: 04**

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 **Hours: 04**

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 **Hours: 06**

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 **Hours: 08**

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 **Hours: 08**

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

Unit 9: Field Skills **Hours: 04**

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

Practical component (60 Hours):

1. Preparation of solutions- molar, molal, normal, percentage, stock, standard and serial dilution (01)
2. Determining pH of solutions (pH paper, Universal indicator, pH meter) and preparation of buffers (Phosphate, Tris-Cl, Electrophoresis buffers - TBE/TAE) (01)
3. Working of instruments -light microscope, autoclave, laminar air flow, spectrophotometer, centrifuge, gel electrophoresis unit (Agarose & Poly acrylamide). (01)
4. Temporary peel mount slide preparation and staining (safranin and acetocarmine). (01)
5. Calculate cell size using micrometer. (01)
6. Calculate number of cells (pollen/spores) using haemocytometer. (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) (02)
8. Isolation of genomic DNA from *E. coli* and plant leaf material, Agarose gel electrophoresis (01)
9. Calculation of mean, mode, median, standard deviation using data set (collected from experiments 5,6). (01)
10. Using software to draw tables, graphs and calculating descriptive statistics (Microsoft Excel (01)
11. Laboratory safety equipment (Fire extinguisher, Fume hood, safety glasses) (01)
12. Mounting of a properly dried and processed plant specimen with herbarium label. (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 modes hall be as prescribed by the Examination Branch, University of Delhi, from time to time.

COMMON POOL OF GENERIC ELECTIVES (GE) COURSES
Offered by Department of Botany
Category-IV

GENERIC ELECTIVES (GE-1)

Credit distribution, Eligibility and Pre-requisites of the Course

Course t itle & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Plant Diversity and Human Welfare	4	2	0	2	12th Pass	NIL

Learning Objectives

The Learning Objectives of this course are as follows:
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 GE-1

Unit 1: Understanding biodiversity

Hours: 06

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

Hours: 08

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

Hours: 06

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

Hours: 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

Hours: 3

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

Hours: 02

National and International initiatives and programmes/schemes focussing 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: (60 Hours)

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.

2. Microchemical tests for carbohydrates, proteins and oils.
3. To study (any three) commonly found tree species in the vicinity and understandtheir role in human welfare.
4. To prepare an inventory of common medicinal plants in your campus (identify tothe family level, list their uses in Indian System of Medicines)
5. To visit the local parks and list the trees planted. Also assess some for their dust pollution mitigation capacity using standard procedures.
6. Industrial visit to see how the drugs are extracted from plants (report to be submitted for evaluation).

Essential/recommended readings

1. Bilgrami, K. S. (1998). Phytodiversification and Human Welfare: Dedicated toLate Prof. KS Bilgrami, FNA (1933-96). MD Publications Pvt. Ltd.
2. Utting, P. (2013). Trees, People and Power. Routledge.
3. Manoharachary, C., Nagaraju, D. (2016). Medicinal plants for human health and welfare. 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 (GE-2)

Credit distribution, Eligibility and Pre-requisites of the Course

Course t itle & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite o f the course
		Lecture	Tutorial	Practical/ Practice		
Biofertilizers	4	2		2	12th Pass	**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 useful microbes 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/ structure for morphological identification. Prepare and sterilize different types of culture media.
- isolate of microorganisms from the environmental samples and culture in aseptic conditions.

SYLLABUS OF GE-2

Unit 1: Introduction

Hours: 7

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

Hours: 08

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

Unit 3: Role of Cyanobacteria

Hours: 02

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

Unit 4: Mycorrhizal association

Hours: 08

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 (morphological and molecular methods). Methods of inoculum production (Pot culture and root culture).

Unit 5: Organic farming

Hours: 5

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

Practicals: (60 Hours)

1. Study of *Rhizobium* from root nodules of leguminous plants by Gram staining method. **Hours: 01**

2. Observation of arbuscular mycorrhizal fungi from plant roots. **Hours: 02**

3. Isolation of arbuscular mycorrhizal spores from rhizosphere soil. **Hours: 01**

4. Isolation of *Anabaena* from *Azolla* leaf. **Hours: 01**

5. Study of Earthworm, *Azolla*, AMF: Arbuscules-vesicles through specimen / digital resources. **Hours: 01**

6. Study of Biocontrol methods and their application -Pheromone trap, *Trichoderma*, *Pseudomonas*, Neem etc. through digital resources. **Hours: 01**

7. Rapid test for pH, $NO3^{-}$, $SO4^{2-}$, Cl^{-} and organic matter of different composts. **Hours: 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 Hours and a dissertation submission). **Hours:06**

Essential/recommended readings

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

Suggestive readings

- *Azotobacter* - Isolation and characterization - https://youtu.be/1Z1VhgJ2h6U
- *Rhizobium* - Identification and characterization - https://youtu.be/jELlo-pMvc4.
- 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.
- Vayas, S.C, Vayas, S., Modi, H.A. (1998). Bio-fertilizers and organic Farming. Nadiad, Gujarat: Akta Prakashan.

GENERIC ELECTIVES (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	4	2		2	12th Pass	**Nil**

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 the 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 concept 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 biogrowth promoters.
- Students will understand various government policies in marketing of hydroponicand organic produce.
- Understand Good Agricultural Practices associated with protected agriculture.

SYLLABUS OF GE-3

Unit 1: Introduction to Protected Agriculture

Hours: 02

Protected Agriculture types (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

Hours: 5

Physical parameters - light (quality and quantity) artificial light, light balancers; pH, conductivity, salinity (Dissolved Oxygen-DO, Total Dissolved Solid - TDS) andtemperature; 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

Hours: 7

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

Hours: 06

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

Hours: 06

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

Hours: 04

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

Practicals: (60 Hours)

1. Study of various instruments used in hydroponics.
2. Preparation of growth media for hydroponics.
3. Estimation of NPK, DO, TDS, pH of growing media
4. Demonstration of different irrigation techniques in hydroponics.
5. Demonstration of construction of a sustainable hydroponic unit.
6. Perform rapid tests for estimation of NPK in different soil samples (at leastthree).
7. Bulk density and porosity of soilless media e.g. coco-peat, perlite, vermiculite, expanded clay, rockwool (any two media).

8. Demonstration of growing a leafy vegetable/fruity vegetable/ medicinal herb/aromatic plant in Hydroponics solution.
9. Study of traditional organic inputs and formulation of biofertilizer.
10. Preparation of biopesticides, plant health promoters like *Panchgavya, Beejamrut* etc. Field visit to organic farm/hydroponic farm and submission of visit report.

Essential/recommended readings

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

Suggestive readings

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

GENERIC ELECTIVES (GE-4)

Credit distribution, Eligibility and Pre-requisites of the Course

Course t itle & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite o f the course
		Lecture	Tutorial	Practical/ Practice		
Basic Laboratory and Field Skills in Plant Biology	4	2		2	12th Pass	**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 GE-4

Unit 1: Lab safety and good lab practices

Hours: 04

General laboratory safety, good laboratory practices, biosafety measures (first-aid practices to be followed in case of burn, acid and injury), safety symbols, lab safety equipments (Fireextinguisher, fume hood, safety glasses), classes of laboratory chemicals, maintenance and handling of chemicals (Labels, Quality - LR/ AR/ Molecular biology grade/ HPLC 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 equipments

Hours: 04

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 electrophoresis unit, SDS PAGE unit, centrifuge, distillation unit, conductivity meter, Lux meter.

Unit 3: Microscopy, sample and slide preparation:

Hours: 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

Hours: 02

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

Hours: 02

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

Hours: 03

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

Hours: 04

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

Hours: 04

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

Unit 9: Field Skills

Hours: 02

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

Practicals: (60 Hours)

1. Preparation of solution- molar, molal, normal, percentage, stock, standard andserial dilution
2. Determining pH of solutions (pH paper, Universal indicator, pH meter) andpreparation of buffers (Phosphate, Tris-Cl, Electrophoresis buffers- TBE/TAE)
3. Working of instruments - light microscope, autoclave, laminar air flow, spectrophotometer, centrifuge, gel electrophoresis unit (Agarose & Poly acrylamide gels)
4. Temporary peel mount slide preparation and staining (safranin and acetocarmine).
5. Calculate cell size using micrometer.
6. To calculate number of cells using haemocytometer per unit volume (using pollen/spores)
7. Preparation of LB medium, growth and maintenance of bacterial cultures (liquid -serial dilution method; and semi-solid cultures - streak, spread and pour plates)
8. Isolation of genomic DNA from *E. coli* and plant leaf material, Agarose gel electrophoresis.
9. Calculation of mean, mode, median, standard deviation using data set (collectedfrom experiments 5,6.
10. Using software to draw tables, graphs and calculating descriptive statistics(Microsoft Excel)
11. Laboratory safety equipments (Fire extinguisher, Fume hood, safety glasses)
12. Mounting of a properly dried and processed plant specimen with herbarium label

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. TataMcGraw-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, New Jersey, USA.

GENERIC ELECTIVES (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	4	2		2	12th Pass	**Nil**

Learning Objectives

The Learning Objectives of this course are as follows:

- Green Belt Development 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 of green infrastructure for smart cities

Learning outcomes

Students will gain as the:

- Course familiarizes students 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.
- This course will help students 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 the noise generated and improve the aesthetics.

- Students would be well trained (knowledge & skills) to contribute to Green Sector Skill program.

SYLLABUS OF GE-5

Unit 1: Introduction

Hours: 02

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

Hours: 04

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

Hours: 04

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 Species for different pollutants (air, water, land and sound). Factors effecting plant regeneration and growth.

Unit 4: Structural and Functional Aspects of Green Belt

Hours: 06

Methods of Planting and Propagation, Various approaches for green belt development, Theoretical Models; Site specific ecological requirements, parameters involved that effect 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

Hours: 04

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

Hours: 06

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

Hours: 04

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: (60 Hours)

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

Suggested Readings:

- Vesilind, P. A., Peirce, J. J., Weiner, R., (1998). Environmental Pollution and Control Netherlands: Elsevier Science.
- Burnwal, K., Jagwani, D. (2013). Air Pollution Abatement through Trees & Green Belt Development. LAP Lambert Academic Publishing.

- CPCB (2000). Guidelines for Green Belt development, CPCB, MoEF, GoI, New Delhi.
- Zhou, S. W. W., Zhou, S. W. W. (2020). Carbon Management for a Sustainable Environment. 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 Economics Netherlands: Elsevier Science.
- Stefanakis, A., (2018). Constructed Wetlands for Industrial Wastewater Treatment United Kingdom, Wiley.
- Kröpfelová, L., Vymazal, J., Kröpfelová, L., Vymazal, J. (2008). Wastewater Treatment in Constructed Wetlands 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.