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

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.

SEMESTER II

COMMON POOL OF GENERIC ELECTIVES (GE) COURSES OFFERED BY THE DEPARTMENT of 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
		Lecture	Tutorial	Practical/ Practice		
Ethnobotany	04	2	0	2	12th Pass	NIL

Learning Objectives

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

Learning outcomes

After studying this course the student will gain knowledge about:

- Students would have an understanding of the treasure, 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 GE-6

Unit 1: Introduction to Ethnobotany and Basic Taxonomy **06 Hours**

Introduction, concept, scope and objectives; Ethnobotany as an interdisciplinary science, databases and knowledge resource (Traditional Knowledge Digital Library), The relevance of ethnobotany in the present context; Major and minor ethnic groups or Tribals of India, and their life styles, 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 **07 Weeks**

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) *Azadiractha 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 **07 Hours**

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

13

Ethnobotany—Botanical Classification and Ethics; Medicinal Ethnobotany and Ethnopharmacology; Ethnoveterinary knowledge

Unit 4: Research Methods in Ethnobotany **06 Hours**

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 **04 Hours**

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; Case studies of traditional medicines leading to development of modern pharmaceutical products (use of *Trichopus zeylanicus* by kanhi tribe and Artemesia sp. for malaria cure)

Practicals: **60 Hours**

- Collection, identification and preparation of herbarium of three ethno-botanically important plants with appropriate references
- Preparation of crude extract of ethno-botanically important plants with appropriate references (any method to be used)
- Project work-documentation, literature survey, and collection of information on ethno-botanically useful plants from traditional healers)

Suggested Readings:

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

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

14

GENERIC ELECTIVES (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	**4**	**2**	0	2	12th Pass	**Nil**

Learning Objectives

The Learning Objectives of this course are as follows:

- To provide students a comprehensive introduction to photography, including both aesthetic and technique.
- To get students to rethink the environment in which they live through the medium of pictures.
- To become thoroughly familiar with digital camera and smartphone photography technology.
- To develop a working knowledge of digital image modification,
- To understand the importance and use Nature photography in your business and career prospects.
- To enhance appreciation for the tremendous beauty inherent in plants and gardens.

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 GE-7

Unit 1: Basics of Photography and Videography **10 Hours**

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 10 Hours

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 05 Hours

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

Unit 4: Photographic visualisation of Nature 05 Hours

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: 60 Hours

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

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

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

GENERIC ELECTIVES (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	**4**	**2**	**0**	2	12th Pass	**Nil**

Objectives: To gain the knowledge on

- Requirement of the conditions 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?

Unit 1: Seed Physiology **04 Hours**

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 **05 Hours**

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

Unit 3: Regulation of Growth and Development **04 Hours**

Role of hormones in plant growth and development, growth retardant.

Unit 4: Reproductive Physiology and Senescence **06 Hours**

Physiology of flowering, Photoperiodism, vernalization, physiology of fruit ripening, senescence and regulation of senescence.

Unit 5: Biology of Weeds **04 Hours**

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

Unit 6: Crop Management Practices **07 Hours**

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

Practicals: (60 hours)

1. To study the effect of ethylene on shelf life of cut flowers./ To study the effect of cytokinin on leaf senescence.
2. To test the viability of weed seeds.
3. To study the allelopathic effects of weeds on germination of crop seeds.
4. To study the effect of herbicides on seed germination and seedling growth of weeds.
5. Determination of pH and analysis of a soil sample for carbonates, chlorides, sulphates, organic matter and base deficiency by rapid field tests.
6. To perform the qualitative test for Nitrogen (NH^{4+}, NO^{3-}, urea) in a fertilizer and the soil sample.
7. Demonstration / photographs for the mechanisms used in herbicide application.
8. Field trip to a crop land to study weeds.
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 (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	04	2	**0**	2	12th Pass	**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 Learning Outcomes of this course are as follows:

- 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 GE-09

Unit 1: Introduction **04 Hours**
An Introduction to Plant Structure (Morphological and Anatomical details), compartmentalization

Unit 2: Plants and Intelligence **03 Hours**
Introduction to Plant Intelligence and Memory - Historical Perspective

Unit 3: Sensory Biology **04 Hours**
Cell to cell communication, Self-recognition, Recognition of Neighbours and Relatives.

Unit 4: Learning in Plants **06 Hours**
Habituation learning, Learning by association (Rhizosphere and Mycorrhizae), Adaptive Intelligence (Hydrophytes, Xerophytes, Parasites, Carnivorous plants, Thermogenic plants), Response to water, heat, salt, cold stress. Mechanical and chemical defence against predators with special reference to secondary metabolites.

Unit 5: Intelligent Behaviour of Plants **13 Hours**
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:(60 hours)

1. Study the structure of plant cell using temporary mount
2. Study of the cell as an osmotic system (Plasmolysis and Deplasmolysis).
3. Demonstration of the phenomenon of protoplasmic streaming in *Hydrilla* leaf.
4. Extraction and qualitative analysis of alkaloids, flavonoids, tannins and phenols.
5. To study the phenomenon of seed germination (effect of light).
6. To study light sensitivity and etiolation vs. de-etiolation.
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)
8. Estimation of total photosynthetic pigments.
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
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).
11. Pollination types (selected) and associated seed dispersal mechanisms

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 (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	**4**	2	0	2	**12th Pass**	**Nil**

Learning Objectives

The Learning Objectives of this course are as follows:

- 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 GE-10

Unit 1: Introduction to Bioinformatics 03 Hours

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 04 Hours

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 04 Hours

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

Unit 4: Molecular Phylogeny 04 Hours

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

Unit 5: Biostatistics 02 Hours

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

Unit 6: Data types and presentation 03 Hours

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

Unit 7: Descriptive Statistics 04 Hours

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

Unit 8: Correlation and Regression 03 Hours

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

Unit 9: Statistical inference 03 Hours

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, EMBL, UniProt, PDB)
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. Making of Bar diagrams, Pie chart, Histogram, Frequency polygon, Cumulative frequency curve (any four) in the given data set using Microsoft Excel
8. Calculation of mean, mode, median, standard deviation and standard error (through manual calculation and using Microsoft Excel) (use only ungrouped data)
9. Calculation of correlation coefficient values by Karl Pearson's /Spearman Rank methods (through manual calculation and using Microsoft Excel)
10. Student's t-test (using Microsoft Excel only), 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. 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.

SEMESTER III

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 compounds 7 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

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

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.

COMMON POOL OF GENERIC ELECTIVES (BOTANY)

SEMESTER-IV

GENERIC ELECTIVE (BOT-GE-16)

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 Health & Disease Diagnostics BOT-GE-16	4	2	0	2	Class XII pass with Biology/ Biotechnology	**Nil**

Learning Objectives:

- understand the challenges and importance of plant pathogen diagnosis
- understand methods for reducing/minimizing risk of the spread of pathogens and pests.
- understand principles and tools for early warning systems to protect plant health.

Learning Outcomes:

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

- diagnose the cause of a plant disease and identify the causal agent
- select appropriate methods and strategy for control and mitigate spread.

Unit 1: Introduction to Plant Diseases **04 Hours**

Definition; History of Plant Pathology, Concept and basic components of disease; Causes and classification of diseases; Disease cycle; Significance of plant diseases.

Unit 2: Plant Disease Diagnosis **06 Hours**

Koch's Postulates; Plant disease symptoms and types (Necrosis, Hypertrophy and Hyperplasia, Hypoplasia); General symptoms of viral, bacterial and fungal plant diseases; Methods of plant disease diagnosis- Histochemical, Serological and PCR techniques.

Unit 3: Plant Disease Epidemiology **05 Hours**

Epidemics and factors affecting the development of epidemics; Epidemic assessment and Disease forecasting; Tools of epidemiology geographic information system (GIS), Global Positioning System (GPS), Geostatistics, Remote sensing.

Unit 4: Plant Diseases **11 hours**

Causal organism, symptoms, disease cycle and management of the plant disease caused by bacteria, virus and fungi: Tobacco Mosaic, Yellow Vein mosaic of Bhendi, Citrus Canker, Angular leaf spot of Cotton, White rust of crucifers, Late & early blight of potato, Rust of wheat, Smut of Cereals.

Unit 5: Management of Plant Diseases **04 Hours**

Concept of integrated disease management (IDM); strategies for IDM- regulatory, cultural, physical, chemical and biological.

Practicals **60 hours**

1. Preparation of Fungal Medium (Potato Dextrose Agar | Czapek Dox), Study of Instruments (Laminar Air flow, Autoclave, Incubator) & sterilization techniques.
2. Isolation pathogen from an infected plant sample.
3. Symptoms of Citrus canker and Angular leaf spot of Cotton through specimens / photograph.
4. Powdery mildew of pea: Symptoms and study of asexual and sexual stage of causal organism (*Erysiphe polygoni*) with the help of temporary tease /section/permanent slides.
5. Symptoms of Tobacco Mosaic Virus and Yellow Vein Mosaic of Bhinde through specimens / photographs.
6. White Rust of Crucifers - Symptoms and study of asexual and sexual stages of *Albugo candida* from tease /section/permanent slides.
7. Late blight of potato. Symptoms
8. Early blight of potato - Symptoms and study of asexual stage of *Alternaria solani* through temporary tease mounts
9. Black stem rust of wheat: Symptoms on both wheat and barberry. Types of spores of *Puccinia gormenistritici* wheat and barberry by temporary tease/section mount /permanent slides.
10. Symptoms of Loose and covered smuts of barley.

Suggested Readings:

1. Cooke, B.M., Jones, D.G., Kaye, B. (2007) The Epidemiology of Plant Diseases, 2nd ed. Springer.
2. Madden, L.V., Hughes, G. and Bosch, F van den (2017). The Study of Plant Disease Epidemics, APS Publications.
3. Sethi, I.K. and Walia, S.K. (2018). Text book of Fungi and their Allies. (2nd Edition), Medtech Publishers, Delhi.
4. Sharma, P.D. (2014*).* Plant Pathology. Rastogi Publications, Meerut.
5. Singh R.S. (2018*).* Plant Diseases. 10th Edition Medtech, New De

Additional Resources:

1. Agrios G.N. (2005*).* Plant Pathology. 5th Edition, Elsevier.
2. Gupta, V.K. and Sharma, R.C. (2020) Integrated Disease Management and Plant Health, Scientific Publishers, India
3. Kapoor, A.S. and Banyal, D.K. (2012). Plant Disease Epidemiology and Management, AbeBooks.

GENERIC ELECTIVE (BOT-GE-17)

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 Monitoring and Ecosystem Restoration BOT-GE-17	4	2	0	2	Class XII pass with science	**Nil**

Learning Objectives:

- The course will train students on methods for conducting environmental monitoring protocols.
- It will provide experiential learning in conducting quality check experiments on soil, water and air.
- The course will develop understanding on different aspects of ecosystem restoration and processes through monitoring system.

Learning Outcomes:

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

- understand the problem of environmental degradation
- assessment of quantitative and qualitative parameters used in environmental monitoring of air, soil and water.
- understand the strategies and methods for ecosystem restoration, including physico-chemical and biological indicators.
- understand degraded and restored sites through field visits.

Unit 1: Introduction **03 Hours**

Ecosystem degradation, Magnitude/ Scale of degradation (National and Global Scenario); influence of climate change in Ecosystem degradation (extreme and erratic natural events)

Unit 2: Factors of environmental degradation **03 Hours**

Factors responsible for degradation of soil, water, air and loss of biodiversity; natural and anthropogenic-forest fires, landslides, floods, deforestation, overgrazing, soil erosion, mining, landfills, etc.

Unit 3: Ecosystem Restoration **06 Hours**

Definition; UN decade on Ecosystem Restoration; Bradshaw's Concept: Restoration, Rehabilitation and Reclamation (replacement); Role of Sustainable Development Goals (SDGs)., REDD+, Joint Forest Management; Relevance for people, nature and climate.

Unit 4: Environment Monitoring **09 Hours**

Indicators of land degradation: Soil- alkalinity, salinity, organic carbon and soil health; Water- pH, Hardness, BOD, COD and Heavy metals content; Air- PM 10 , PM 2.5 , SO_2 , NOx, ozone), Air Quality Index (AQI); Bioindicators/ Biomonitors (plants, animals and microbes).

Unit 5: Role of Plants and Microbes in Ecosystem Restoration **09 Hours**

Brief account of remediation technologies: bioremediation, phytoremediation (phytoextraction, rhizofiltration, phytovolatilization, phytostabilization etc); Role of associations of Grasses-AMF, Legumes-Rhizobium in restoring degraded land/ mined out areas; Role of macrophytes in wetland restoration; Role of green spaces including parklands and avenue plantations in amelioration of air quality.

Practicals **60 hours**

1. Field visit to degraded ecosystem/ natural ecosystem/restored ecosystem.
2. Analyze the soil and water samples from polluted and unpolluted sites for their pH
3. Analyze carbonates, chlorides, nitrates, sulphates, organic matter and base deficiency by rapid field tests in soil samples from degraded and healthy sites.
4. Determine the organic matter in soil samples by Walkley and Black's rapid titration method.
5. Determine the dissolved oxygen of water samples of polluted and nonpolluted sites by Winkler's method.
6. Determine the BOD and COD content of water samples of polluted and nonpolluted sites.
7. To collect, collate and analyze Air Quality Index (AQI) data, Water Quality data of various locations from DPCC/CPCB website collected from real-time monitoring stations.
8. Study of bioindicators (plant, animal and microbes).

Suggested Readings:

1. Bagyaraj, D.J. and Jamaluddin (2016) Microbes for Restoration of Degraded Ecosystems, New India Publishing Agency
2. Majumdar R., Kashyap R (2020). Practical Manual of Ecology and Environmental Science, Prestige
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.
5. Smith, T. M., Smith, R. L. (2012). Elements of Ecology 8th Edition. Pearson.

Additional Resources:

1. Central Pollution Control Board (CPCB) Air and Water: https://cpcb.nic.in/real-time-data/
2. Managing Ecosystems in The Context of Climate Change Mitigation: A review of current knowledge and recommendations to support ecosystem-based mitigation actions that look beyond terrestrial forests https://www.cbd.int/doc/publications/cbd-ts-86-en.pdf
3. National Clean Air Programme (NCAP) 2018. https://moef.gov.in/wp-content/uploads/2019/05/NCAP_Report.pdf
4. Real Time Ambient Air Quality Data (DPCC). https://www.dpccairdata.com/dpccairdata/display/index.php
5. Restoration for People, Nature and Climate, https://wedocs.unep.org/bitstream/handle/20.500.11822/36251/ERPNC.pdf
6. Champion, H. G., and S. K. Seth. A revised classification of forest types of India. Manager Publication, Government of India, Delhi (1968).

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

POOL OF GENERIC ELECTIVES

GENERIC ELECTIVE (BOT-GE-18)

SEMESTER-V

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		
Genetic Engineering Technologies & Applications BOT-GE-18	4	2	0	2	Class XII pass with Science	**Nil**

Learning Objectives:

- To illustrate the use of modern techniques for the manipulation and analysis of DNA sequences
9. To understand the applications of recombinant DNA technology for the generation of commercial biotechnological products of diverse usage.
10. To gain knowledge about biosafety and ethical concerns associated with recombinant DNA technology.
11. To train students in strategizing research topics employing genetic engineering techniques.

Learning Outcomes: At the end of this course students would be able to:

- understand methods and techniques involved in manipulation and analysis of nucleic acids, gene cloning and creation of genetically modified organisms (GMOs).
- understand the commercial application of rDNA technology in research, agriculture and human health
- comprehend biosafety and ethical issues associated with rDNA technology

Unit 1: Introduction **01 Hours**

Introduction to rDNA technology and gene cloning.

Unit 2: Enzymes and Vectors in genetic engineering **07 Hours**

Restriction endonucleases, exonucleases, polymerases, RNAses, kinases, ligases; Plasmids (pBR322, pUC18, pUC19); Lambda based vectors and derivatives (Insertion vectors, replacement vectors, cosmids, phagemids); Artificial Chromosomes (YACs, BACs); Bacterial transformation, strategies for selection and screening (α complementation, antibiotic resistance); Plant Transformation vectors (Ti plasmid), Protein Expression Vectors for use in *E. coli*; introduction to marker and reporter genes (GUS, GFP).

Unit 2: Gene transfer methods **04 Hours**

Agrobacterium mediated transformation, Electroporation, Microinjection, Particle Bombardment, PEG mediated

Unit 3: DNA libraries construction and screening **04 Hours**

Procedures for construction of genomic and cDNA libraries, screening methods for locating the desired gene (Replica plating, Complementation screening, heterologous gene probe-based hybridizations)

Unit 4: PCR, nucleic acid hybridization and DNA sequencing **08 Hours**

PCR technique and its applications, RT-PCR, qPCR, Hybridization based assays (Southern and Northern blotting), Sanger's di-deoxy chain termination method of sequencing – gel-based electrophoresis (semi-automated) and capillary-based gel electrophoresis (automated sequencing).

Unit 5: Applications of rDNA technology **06 Hours**

Applications in basic research (identify, map, clone, and sequence genes and to determine their functions); applications in agriculture (biotic and abiotic stress tolerant transgenic plants, improved Nitrogen fixation, and plant growth); applications in human health (Disease diagnosis (heritable diseases and acquired infectious diseases) and therapeutics (production of recombinant vaccines, protein therapies: production of Insulin, Interferons, and human growth hormone). Human genome project and sequencing of plant genomes by taking *Arabidopsis* genome as an example. Safety and Ethical Issues related to rDNA research.

Practicals **60 hours**

- Isolation of genomic/plasmid DNA from bacteria.
- Quantification of extracted DNA by DPA (Diphenylamine) method.
- Restriction digestion and AGE (Agarose gel electrophoresis) of DNA.
- Restricting Mapping of linear and circular DNA.
- Study of direct and indirect gene transfer methods by photographs: Electroporation, Microinjection and Particle Bombardment, Ti-plasmid mediated gene transfer.
- Demonstration of techniques by photographs: PCR, RT-PCR, qPCR, Southern and Northern blotting and hybridization.
- Study of applications of rDNA technology by photographs: recombinant insulin, interferon and human growth hormone, Bt Cotton, Golden rice, and Flavr Savr tomato.
- Demonstration of working of equipments used in rDNA technology: Thermocycler, Laminar air flow cabinet, Autoclave, Incubator shaker, Refrigerated centrifuge.

Suggested Readings:

11. M. R. Green, J. Sambrook. Molecular Cloning: A Laboratory Manual (Cold Spring Harbor, ed. 4, 2012).

12. M. Wink. An Introduction to Molecular Biotechnology: Molecular Fundamentals, Methods and Applications in Modern Biotechnology (Wiley, ed. 2, 2011).
13. Glick, B.R., & Patten C. (2022). Molecular Biotechnology: Principles and Applications. 6thedn. Washington, U.S.: ASM Press.
14. Snustad, D.P.,Simmons, M.J. (2019). Principles of Genetics, 7th edition. Chichester, England: John Wiley and Sons.
15. Brown, T. A. 2020. Gene Cloning & DNA Analysis: An Introduction. 8thedn. UK: Wiley Blackwell.
16. Primrose, S. B., Twyman, R. (2009). Principles of gene manipulation and genomics. Wiley. com.
17. Howe, C. J. (2007). Gene cloning and manipulation. Cambridge University Press.

Additional Resources:

1. M. M. Burell. (1993) Enzymes of Molecular Biology, Humana Press.
2. H.M. Eun. (1996) Enzymology: Primer for Recombinant DNA Technology, Academic Press.
3. S. B. Primrose, R. Twyman. (2006) Principles of Gene Manipulation and Genomics (Wiley-Blackwell, ed. 7).

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

GENERIC ELECTIVE (BOT-GE-19)

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		
Fundamentals of Molecular Biology **BOT-GE-19**	4	2	0	2	Class XII pass with Science	**Nil**

Learning Objectives:

5. To gain the knowledge of structure and functions of DNA and RNA

Learning Outcomes:

Students would have understanding of

9. understanding of nucleic acid, organization of DNA in prokaryotes and Eukaryotes, DNA replication mechanism, genetic code and transcription process.
10. Processing and modification of RNA and translation process, function and regulation of expression.

Unit 1: Nucleic Acids as genetic material **02 Hours**

Discovery of Nuclein by Fredrich Miescher; Experiments by Griffith, Hershey and Chase, Avery, McLeod and McCarty and Fraenkel Conrat.

Unit 2: Structure of Nucleic acids- the blueprint of Life **04 Hours**

Building blocks of nucleic acid: Ribose sugar, Purine, Pyrimidine, phosphate; Watson and Crick's model of DNA, DNA types (A,B,Z type), Comparison of RNA structure and types (tRNA, mRNA and rRNA); nucleosome- chromatin structure; Euchromatin and heterochromatin.

Unit 4: Central Dogma of Life **04 Hours**

Concept of Central dogma; Salient features of genetic code, deciphering the genetic code (Contribution of Nirenberg, Matthei and Ochoa, H.G. Khorana).

Unit 3: Replication **05 Hours**

Semi-conservative mode of DNA replication; replication of linear and circular DNA (Theta and Rolling circle model); mechanism and role of key enzymes in replication; role of telomerase enzyme in eukaryotic DNA replication; reverse transcription.

Unit 5: Transcription **05 Hours**

Comparative account of transcription in Prokaryotes and eukaryotes; post-transcriptional processing of pre-mRNA in eukaryotes (3', 5' end modifications and general mechanism of splicing involving spliceosomes).

Unit 6: Translation **05 Hours**

Comparative account of prokaryotic and eukaryotic ribosome structure and translation; inhibitors of protein synthesis (antibiotics).

Unit 7: Gene regulation **05 Hours**

Gene regulation in Prokaryotes- Operon concept: inducible and repressible operon; regulation of lactose (lac) and tryptophan (trp) in *Escherichia coli*; attenuation regulation.

Practicals **60 hours**

6. DNA isolation from cauliflower head by spooling method.
7. Study experiments establishing nucleic acid as genetic material: Griffith's, Avery et al, Hershey & Chase's and Fraenkel Conrat's experiments (through photographs)
8. Study DNA packaging (photographs/paper models).
9. Study modes of DNA replication: Meselson and Stahl's experiment, Rolling circle and Theta model of replication and semi-discontinuous, semi conservative replication (photographs).
10. Study structure of tRNA, prokaryotic RNA polymerase and eukaryotic RNA polymerase II (photographs/paper models).
11. Study RNA modification: Assembly of Spliceosome machinery, Splicing mechanism in group I & group II introns (photographs/paper models).
12. Study gene regulation mechanism in prokaryotes: lactose (lac) operon and tryptophan (trp) operon (photographs).
13. Finding the Tm of different DNA samples from the photographs of DNA melting profile provided. Problem solving for calculating the GC content.

Suggested Readings:

- Cooper, G.M., Hausman, R.E. (2009). The Cell: A Molecular Approach, 5th edition. Washington, D.C.: ASM Press & Sunderland, Sinauer Associates, MA.
- Karp, G. (2010). Cell Biology, 6th edition. New Jersey, U.S.A.: John Wiley & Sons
- Snustad, D.P., Simmons, M.J. (2012). Principles of Genetics, 6th Edition. New Delhi, Delhi: John Wiley & Sons
- Klug, W.S., Cummings, M.R., Spencer, C.A. (2012). Concepts of Genetics, 10th edition. San Francisco, California: Benjamin Cummings

Additional Resources:

6. Hardin, J. and Lodolce, J.P. (2021). Becker's World of the cell, 10th edition, Pearson

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

GENERIC ELECTIVE (BOT-GE-20)

SEMESTER-VI

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		
Genomics, Proteomics and Metabolomics **BOT-GE-20**	4	2	0	2	Class XII Pass with Science	**Nil**

Learning Objectives:

22. Build the concepts of genomics, proteomics and metabolomics.
23. Understand the role of model organisms in genomics studies
24. Familiarization of tools used in genomics and proteomics.

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

7. understand the implications of genomic, transcriptomic, proteomic and metabolomic studies in an organism.
8. assimilate logic and reasoning behind choice of model organisms for genomics study.

Unit 1: Introduction to genomics **02 Hours**

Recapitulating basics of prokaryotic and eukaryotic genomes; basic concept of structural and functional genomics.

Unit 2: Model organisms in genomics **02 Hours**

Features of important model organisms used in genomics study (*Escherichia coli*, *Saccharomyces cerevisiae*, *Caenorhabditis elegans*, *Arabidopsis thaliana*)

Unit 3: Sequencing strategies **04 Hours**

Sequencing: basic principle-Sanger's method; classical approaches for sequencing large genomes (whole genome shot gun method viz. WGS, clone by clone sequencing); Next generation sequencing (NGS) ; Concept of third generation sequencing

Unit 4: Genome sequencing Projects **04 Hours**

Human genome project (brief history and significance); *Arabidopsis* genome project; rice genome project; applications of genomics in agriculture and human health

Unit 5: Transcriptomics **03 Hours**

Concept: EST sequencing; Gene expression studies by Microarrays and RNAseq.

Unit 6: Introduction to proteins and proteomics **06 Hours**

Proteins as structural and functional unit of life; basics concept of protein structure (primary, secondary, tertiary, and quaternary), peptide bonds; brief introduction of major post-translational modifications (phosphorylation, glycosylation); introduction to enzymes; introduction to proteomics and its applications.

Unit 7: Tools for proteome analysis **05 Hours**

Separation and isolation of proteins from plant tissue; purification of proteins by chromatographic techniques (column chromatography, ion exchange and affinity chromatography); separation of total cellular proteins by electrophoresis: SDS-PAGE, western blotting and ELISA.

Unit 8: Metabolomics **04 Hours**

Concept of metabolomics; classes of metabolites (primary and secondary metabolites in plants); Experimental methods and instruments used in metabolomics- HPLC, GC; applications of metabolomics.

Practicals **60 hours**

- Genomic DNA extraction from cauliflower heads
- Select 10 different organisms (5 prokaryotic and 5 eukaryotic) whose genomes have been completely sequenced and categorize them based on taxonomy, find their genome size and locate the database where their genome sequence is hosted.
- Demonstration of gene expression studies through photographs: microarrays and RNA seq.
- Demonstration of Sanger's DNA sequencing principle.
- Interpretation and reading of DNA sequence chromatograms.
- Experiment to demonstrate activity of Amylase.
- Estimation of protein concentration through Lowry's methods/Bradford assay.
- Demonstration of separation of proteins using SDS-PAGE (demonstration).
- Study of proteins by Western blotting technique (digital resources/demonstration).
- Demonstration of ELISA through kit.

Suggested readings:

15. Brown, T. A. (2020). Gene Cloning & DNA Analysis: An Introduction. 8thedn. UK: Wiley Blackwell.
16. Glick, B.R., Patten C. (2022). Molecular Biotechnology: Principles and Applications. 6thedn. Washington, U.S.: ASM Press.
17. 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.
18. Liebler, D.C. (2002). Introduction to Proteomics: Tools for New Biology, Humana Press.
19. Primrose, S. B. Twyman, R.M. (2006). Principles of Gene Manipulation and Genomics. 7thedn. Victoria, Australia: Blackwell Publishing.
20. Twyman R. (2013) Principles of Proteomics, Taylor & Francis Books.
21. Watson J.D. (2017) Molecular Biology of the Gene. Pearson publishers.

22. Westermeier, R., Naven, T., Hopker, H.R. (2008). Proteomics in Practice: A guide to successful experimental design, 2nd edition, Wiley Blackwell.
23. Wood, P.L., (2021) Metabolomics. Springer Protocols.

Additional resources:

- Banks, K (2022) Introduction to Proteomics. Larsen & Keller Education
- Campbell, A.M. and Heyer, L.J (2006). Discovering Genomics, Proteomics and Bioinformatics, Pearson publishers.
- Bhattacharya, S.K. (2019) Metabolomics: Methods & Protocols. Springer Protocols/Humana Press

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