Bachelor of Life Science (Program)

SEMESTER VII

UNIVERSITY OF DELHI

COURSES OFFERED BY DEPARTMENT OF BOTANY FOR SEMESTER-VII

Under UGCF-2022 based on NEP-2020

(Effective from Academic Year 2022-23)

Department of Botany

Courses offered in B.Sc. Life Science Semester VII with Botany as Major Discipline (course contents)

SEMESTER –VII

(Under UGCF-2022 based on NEP-2020)

DISCIPLINE SPECIFIC COURSE (DSC-07)

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 **LS-DSC-BOT-07**	**4**	**2**	**0**	**2**	Sem VI	**Nil**

COURSE 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

THEORY: 30 HOURS

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 and Treatment of toxic compounds, Role of immobilized cells/enzymes, microbial remediation (12 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, Biopesticides, bioreactors, bioleaching, biomining, biosensors, biotechniques for air pollution abatement and odour control. Bioindicators and Bioprospecting.

Unit 4: International Legislations, Policies for Pollution Management and Environmental Protection (6 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, 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 Delh i. 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.

DISCIPLINE SPECIFIC ELECTIVE COURSE -08: Research Methodology **CREDIT**

DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
RESEARCH METHODOLOGY BOT-DSE -08	4	**2**	**0**	**2**	Semester VI	Nil

COURSE LEARNING OBJECTIVE:

This course offers overview of Research Methodology including quantitative and qualitative research in basic as well as applied aspects of Biological Sciences. It is designed to provide hands-on experience with collection, analysis and interpretation of data and also writing a report/thesis. Moreover, this course focusses on developing the skills necessary for pursuing a career in research. The students will be motivated to learn scientific investigation to solve problems, test hypothesis, develop or invent new products for the benefit of society.

COURSE LEARNING OUTCOME:

After completing this course, the students should be able to:

- describe basic concepts of research and its methodologies
- identify appropriate research topics and propose hypothesis
- perform literature review using library (print) and internet (online) resources
- design experiments/surveys
- collect, analyze and interpret data with appropriate software tools, represent data in tables/figures and draw conclusion
- write scientific report/ review/ thesis and prepare seminar/ conference presentations
- understand the methods of citation and referencing styles, check plagiarism and get insight of intellectual property rights

THEORY: 30 Hours

Unit 1: Basic Concepts of Research (4 Hours)

Objectives, Research Methods vs Methodology, Types of Research-Quantitative vs Qualitative, Analytical vs Descriptive, Basic vs Applied, Field Research, Search engines, Literature-review and its consolidation

Unit 2: Research Design, Data Collection and Analysis (12 Hours)

Conceptualization a research problem, Developing a research model, Validation of the proposed model with standard procedures and attributes, Experimental design, and implementation, Observation and Data acquisition, Methods of data collection, Data quality check, Processing and Analysis Strategies; Data presentation (Tables and Figures), Interpretation

Unit 3: Ethical Issues (4 Hours)
Intellectual Property Rights, Copy Right, Plagiarism, Commercialization and Royalty

Unit 4: Report Writing (10 Hours)
Technical Research writing (Dissertation/ Reports/Research/Review papers), Citations, Acknowledgements, Research Grants/ Fellowships, Bibliography

PRACTICALS: 60 Hours

1. Search engines, Literature survey, identification of gap areas
2. Presentation of collated literature
3. Experimental layout, execution, observation
4. Data analysis, using softwares, tables and figures
5. Writing a report/research paper/dissertation/summary
6. Preparation of bibliography in different formats as per journal's requirements
7. Usage of software tools for checking plagiarism

Assessment Methods:
Submission and presentation of thesis/Dissertation followed by viva-voce

SUGGESTED READINGS:

1. Coley, S.M. and Scheinberg, C.A. (1990). "Proposal writing". Stage Publications.
2. Stapleton, P., Yondeowei, A., Mukanyange, J., Houten, H. (1995). Scientific writing for agricultural research scientists – a training reference manual. West Africa Rice Development Association, Hong Kong.
3. Wadhera, B.L. (2002). Law Relating to Patents, Trade Marks, Copyright Designs and Geographical Indications, Universal Law publishing.
4. Dawson, C. (2002). Practical research methods. UBS Publishers, New Delhi.
5. Anthony, M, Graziano, A.M. and Raulin, M.L. (2009). Research Methods: A Process of Inquiry, Allyn and Bacon.
6. Kothari, C.R. (2014). Research Methodology: Methods and Techniques, 2nd edition, New Age International (P) Ltd.,
7. Walliman, N. (2011). Research Methods- The Basics. Taylor and Francis, London, New York, USA.
8. Cresswell, J.W. (2014). Research Design: Qualitative, Quantitative, and Mixed Methods Approaches (4th edition). SAGE Publications Inc.
9. Rao, G.N. (2018). Biostatistics & Research Methodology. Pharmamed Press.
10. Gary J. Burkholder, G.J., Cox, K.A., Crawford, L.M. Hitchcock, J.H. (2019). Research Design and Methods: An Applied Guide for the Scholar-Practitioner. SAGE Publications, Inc.
11. Mukherjee, S.P. (2019). A Guide to Research Methodology: An Overview of Research Problems, Tasks and Methods. CRC Press
12. Flick, U. (2020). Introducing Research Methodology: Thinking Your Way Through Your Research Project. SAGE Publications Ltd.

DISCIPLINE SPECIFIC ELECTIVE COURSE - 09: Biodiversity Informatics

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Biodiversity Informatics **BOT-DSE-09**	4	**2**	**0**	**2**	Semester VI	Nil

COURSE LEARNING OBJECTIVES: To introduce students to an integrated area of study where concepts learnt under different courses in previous semesters are to be utilised. The field of Biodiversity informatics integrates information on systematics, ecosystems to curate, analyse and develop an information management system to provide sound scientific bases for policy decisions.

LEARNING OUTCOMES:

- **Assess** knowledge on basic principles of Ecology, Conservation, Restoration, Biodiversity, Genetics, Molecular biology.
- Applications of Remote Sensing and Geographical Information System as well as Informatics.
- Provide an opportunity to learn principles of Data Capture systems, basic elements of digitisation of Biological data, some key elements of Information Science along with creation/ curation of Biological Databases (collection, storage & retrieval)
- Emphasise the importance of field collection, maintenance of herbaria & specimen collections.
- Introduce relevant National and International Biodiversity Laws.

THEORY: 30 Hours

Unit 1. History of Biodiversity Informatics and Informatics Resources (08 Hours)

I. Global & National movements for conservation, institutions (including National Biodiversity Authority of India, NBPGR and others) and other non-Governmental organisations (NGO s) and networks involved in biodiversity informatics.

II. National & International efforts in Conservation, databases GBIF, IUCN categorized-endangered, threatened, vulnerable species.

III. Red data book and related documentation.

IV. Categories of Biodiversity informatics databases and tools based on target life cycle step : data planning and collection, data quality and fitness, data description, data preservation and publication,

data discovery and integration, computational modeling and analysis.(few databases example can be chosen to explain the steps - BRAHMS, Genbank, Catalog of Life, DataOne, GBIF, BioCollections)

Unit 2. Understanding Biodiversity and Measuring/Estimating Biodiversity (11 Hours)

i. Recapitulating Basic principles of Ecology & Biodiversity - Geological Time scale and evolution of life forms, Five major extinctions, Ecosystems & Ecosystems diversity: biomes, mangroves, coral reefs, wetlands and terrestrial diversity. Biodiversity Hotspots & factors of endemism.
ii. Levels of Biodiversity: Community diversity (alpha, beta and gamma biodiversity), Gradients of Biodiversity (latitudinal, insular).
iii. Magnitude of biodiversity (Global and Indian data). Introduction to Diversity Indices (Simpson, Shannon) and estimation of Species diversity: richness and evenness, loss of species.
iv. Metagenomics, use of ancient DNA (aDNA) for estimation of biodiversity loss.
v. Estimating Threats to natural Biodiversity: Habitat loss and fragmentation
vi. Disturbance and pollution; Introduction of exotic species; Human intervention and Biodiversity loss; Consequences of monotypic agricultural practice
vii. Global Environmental changes, land and water use changes ; Impacts of Climate Change on Biological systems.

Unit 3 – Methods In Biodiversity Informatics (05 Hours)

i. Remote Sensing/ Geographical Information Systems and its applications.
ii. Data capture – citizen science, uploading information on portals (e.g. www.indiabiodiversityportal.org).
iii. Key parameters for conservation (populations reproductive ecology)
iv. Essential management practices in in-situ and ex-situ Biodiversity Management :
    a. Management of - Biosphere reserves, National Parks, Sanctuaries, Sacred groves etc.
    b. Management of Botanical gardens, Zoological gardens, Gene banks, Pollen, seed and seedling banks, tissue culture and DNA banks etc.

Unit 4. Applications of Biodiversity Informatics (06 Hours)

i. Modeling Ecosystems & Predictions, conservation plans for species/taxa/ecosystem.
ii. Definitions and concepts of system, sub-system, variables and parameters, systems analysis, modeling and simulation ((Lotka-Voltera model).
iii. Legal issues in Biodiversity Management & Conservation; Rules for exchange of genetic materials; Case studies -National & International. (This is important for IPR perspective, gives the student and faculty options for assignments/ assessments, case studies
iv. Legal issues in Biodiversity Management & Conservation; Rules for exchange of genetic materials; Case studies -National & International.
v. Designing & implementing ecological restorations.

PRACTICALS: **(60 hours)**

1. Measurement of species diversity (calculation of Diversity Indices - from data collected on plant species in different areas of the campus.
2. Use of molecular markers for estimating biodiversity (DNA Barcoding).
   (simple case studies and wherever possible experiments can be performed to teach the concept).
3. Blast analyses of selected DNA sequences from the International Gene Banks.
4. Introduction to simulations based on various environmental models.
5. Applications of RS/GIS techniques for species distribution models.
6. **Experiential Learning Module**: Visit to Biodiversity Parks, study the management and species diversity, based on that prepare a proposal for enhancement/ creation of local Biodiversity Park/Community outreach activities and other attributes.

SUGGESTED READINGS:

1. Groom MJ, Meffe GK, Carroll CR (2006) Principles of Conservation Biology, 3rd edition, Sinauer Associates.
2. Tandon U, Parasaran M, Luthra S (2018) Biodiversity : Law, Policy and Governance, Routledge, India
3. Wilson, Edward O., 1993, Diversity of Life. Harvard University Press, Cambridge, MA.
4. Wheater CP, Bell JR, Cook PA (2011) Practical field Ecology: A Project guide, Wiley-Blackwell
5. IUCN RED DATA BOOK - https://portals.iucn.org/library/node/16746
6. http://biodiversity-informatics-training.org/bi-curriculum/
7. https://www.tdwg.org/standards/
8. https://methodsblog.com/2015/05/26/beta_diversity/

ADDITIONAL RESOURCES:

1. Saha, G.K. and Mazumdar, S. (2017). Wildlife Biology: An Indian Perspective. PHI learning Pvt. Ltd. ISBN: 8120353137, 978-812035313
2. Sinclair, A.R.E., Fryxell, J.M. and Caughley,G. (2006). Wildlife Ecology, Conservation and Management. Wiley-Blackwell, Oxford, UK.
3. Singh, S.K. (2005). Text Book of Wildlife Management. IBDC, Lucknow.
4. Banerjee, K. (2002). Biodiversity Conservation in Managed and Protected Areas. Agrobios, India.
5. Sharma, B.D. (1999). Indian Wildlife Resources Ecology and Development. Daya Publishing House, Delhi.
6. www.indiabiodiversityportal.org
7. Magurran,A.E. 2013. Measuring Biological Diversity, John Wiley.
9. Primack, R.B. (1998). Essentials of Conservation Biology. Sinauer Associates, Inc. Sunderland, MA.
10. Rachel Carson (1962) A Silent Spring, Houghton Mifflin Company .

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DISCIPLINE SPECIFIC ELECTIVE COURSE - 10: 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 **BOT-DSE-10**	4	**2**	**0**	2	Semester VI	**Nil**

COURSE 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 principles and processes in plant cell and tissue culture.
- Understand the use of tissue culture techniques in plant improvement, resource generation and conservation.
- 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 to have mass propagation of commercially important plants.

THEORY: 30 Hours

Unit 1 Introduction (3 hours)

Historical perspective, important contributions of Haberlandt, White, Reinert & Steward, Murashige, Skoog, Cocking, Guha & Maheshwari, Morrel & Martin. Terminologies: Cell and organ culture, explant, callus, totipotency, plasticity, regeneration, somaclonal variants.

Unit 2 Types and composition of Media and Techniques of Plant Tissue Culture (8 hours)

Role of nutrients, vitamins, hormones and supplements in nutrient medium. Composition of MS and White medium. Collection of plant material, sterilization of tissue (maintenance of aseptic conditions by use of autoclave and laminar flow chamber), filter sterilization, inoculation.

Unit 3: Micropropagation and Protoplast culture (10 hours)

Selection of plant material and suitable explant, methodology, plant regeneration pathways-somatic embryogenesis, organogenesis, difference between somatic and zygotic embryos. Protoplast isolation

(mechanical and enzymatic), culture, purification (viability test) and fusion (spontaneous, induced), selection of fused protoplasts, applications.

Unit 4: Tissue culture applications (**9 hours)**

Anther culture, Production of haploids, triploids and cybrids, artificial seeds (production & advantages), embryo rescue, virus elimination, secondary metabolite production; Cryopreservation; Germplasm conservation. Novel sources of variation.

PRACTICALS (60 hours)

l. To study the equipment used in tissue culture: autoclave and laminar air flow chamber.
2. Preparation of Murashige & Skoog's (MS) medium.
3. Demonstration of sterilization and inoculation methods using leaf and nodal explants of tobacco, carrot, *Datura*, *Brassica* etc. (any two).
4. Study of anther, embryo and endosperm culture.
5. Study of micropropagation, somatic embryogenesis & artificial seeds.
6. Isolation of protoplasts.
7. Visit to a plant tissue culture laboratory and submission of field report.

SUGGESTED READINGS:

1. Bhojwani, S.S. (1990). Plant Tissue Culture: Applications and Limitations {Elsevier}
2. Bhojwani, S.S, Bhatnagar, S.P. (2015). The Embryology of Angiosperms, 6th edition. New Delhi, Delhi: Vikas Publication House Pvt. Ltd.
3. Bhojwani, S. S. and Dantu, P. K. (2013). Plant Tissue Culture: An Introductory Text Springer
4. Bhojwani, S. S. and Razdan, M. K. (1996). Plant Tissue Culture: Theory and Practice, Revised Edition, Elsevier
5. Newmann, Karl-Hermann (2020). Plant Cell and Tissue Culture: A Tool in Biotechnology, 2nd Edition Springer

ADDITIONAL RESOURCES:

1. Park, Sunghun (2021). Plant Tissue Culture: Techniques and Experiments, 4th Edition Elsevier
2. Razdan, M. K. (2019). Introduction to Plant Tissue Culture, 3rd Edition CBS / Oxford & IBH
3. Smith, R. H. (2013). Plant Tissue Culture: Techniques and Experiments, 3rd Edition {Elsevier}
4. Stewart, C. Neal (2016). Plant Biotechnology and Genetics, 2nd Edition Wiley-Blackwell
5. Trigiano, R. N. (2011). Plant Tissue Culture, Development, and Biotechnology CRC Press

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DISCIPLINE SPECIFIC ELECTIVE COURSE - 11: Reproductive Ecology

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Reproductive Ecology **BOT-DSE -11**	4	**2**	**0**	**2**	Semester VI	Nil

COURSE LEARNING OBJECTIVES :

1. To acquaint students about the diversity in floral architecture, floral rewards so that they can correlate the concepts with breeding mechanisms.
2. To help them appreciate the adaptive significance of various traits associated with pollination, seed dispersal and seedling recruitment.
3. To sensitize students towards challenges faced by flowering plants on account of climate change and other anthropogenic activities.
4. To build on the concepts of inbreeding and outbreeding depression, seed ecology and resource allocation.

LEARNING OUTCOMES: After completing this course students will:

1. Become familiar with interesting concepts involved in understanding of reproductive ecology such as floral rewards, plant-pollinator interactions and pollinator guilds.
2. Have an understanding of intricacies and complexities involved in the reproductive success.
3. Will have background knowledge and an opportunity to utilize this knowledge to undertake interdisciplinary research.in conservation biology and other allied fields such as plant breeding.

THEORY: 30 Hours

Unit 1: **Introduction to Reproductive Ecology and Floral Biology (6 hours)**

Concept of reproductive ecology: Significance and scope. Floral architecture, floral phenology, sexuality, cryptic sexuality, reproductive allocation, evolution from solitary flowering to inflorescence, floral attractants, and rewards (pollen, nectar, scent, colour).

Unit 2: Pollination Ecology amd **Pollen-Pistil Interactions and Mating Strategies (6 hours)**

Pollination types, adaptations; plant-pollinator interactions (generalized and specialized pollination system, including mutualistic and non-mutualistic interactions), pollinator guilds; pollen banks. Factors affecting pollen-pistil interactions (abiotic, biotic, and anthropogenic); pollen flow. Sexual incompatibility (recognition and rejection reactions); inbreeding and outbreeding depression; resource allocation.

Unit 3: Seed Ecology **(4 hours)**

Seed development (sexual and apomictic), dispersal mechanisms (primary and secondary), dormancy, viability, germination; seedling recruitment; seed banks.

Unit 4 : **Challenges and Contemporary Issues in Reproductive Ecology** **(6 hours)**

Impact of climate change on sexual reproduction**,** global pollinator crisis and pollination failure; habitat fragmentation and altitudinal shifts; impact of invasive species on native plants and pollinators.

PRACTICAL **(60 hours)**

1. To study diversity in floral architecture (type of soil, temperature, humidity etc. to be mentioned).
2. To carry out histochemical tests in pollen (proteins, lipids, starch).
3. To study the structure of nectary of any flower available in the campus (through section, whole mount).
4. To analyse nectar volume and composition (using refractometer/chromatography)
5. To study through temporary preparations - types of stigma (dry and wet) and style (hollow and solid).
6. To study pollen-pistil interaction by demonstrating activity of (**ANY ONE)** esterase, acid phosphatase and peroxidases.

**Project work/Field Trip: Seed dispersal mechanism, Phenological calendar of flower, Estimation of Pollen Production in Anthers (with large number/ small number of pollen grains), or any other topic from the syllabus

SUGGESTED READINGS:

1. Tandon, R., Shivanna, K.R., Koul, M. (Eds) 2020. Reproductive Ecology of Flowering Plants: Patterns and Processes. Springer LINK
2. Shivanna, K.R., Tandon, R. 2014. Reproductive Ecology of Flowering Plants: A Manual. Springer LINK
3. Lovett-Doust, J., Lovett-Doust.L. 1988. Plant Reproductive Ecology: Patterns and Strategies: Oxford University Press, USA.
4. Rustagi, A., Chaudhry, B. (Eds) 2022. Plant Reproductive Ecology-Recent Advances. Intech Open, London, U.K
5. Mangla,Y., Khanduri, P., Gupta, C.K. 2022. Reproductive Biology of Angiosperms: Concepts and Laboratory Methods. Cambridge University Press.

ADDITIONAL READINGS

1. Spencer C.H. Barrett & Christopher G. Eckert (1990) Current issues in plant reproductive ecology. Israel Journal of Botany 39:1-2, 5-12.
2. Nicolson, S.W., Wright, G.A. 2017. Plant–pollinator interactions and threats to pollination: perspectives from the flower to the landscape. Functional ecology 31:22-25
3. Hicks, L. 2020. Flowers colors are changing in response to climate change; Pigment changes can make plants less attractive to pollinators. Science News

DISCIPLINE SPECIFIC ELECTIVE COURSE - 12: Intellectual Property Rights

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Intellectual Property Rights **BOT-DSE -12**	4	**2**	**0**	**2**	Semester VI	Nil

COURSE LEARNING OBJECTIVES

The objective of this course is to impart knowledge of rules, regulations, laws and processes of patents. Besides this students will have adequate knowledge of copyrights, trademarks and shall be thorough with the importance of traditional knowledge and protection of plant varieties.

LEARNING OUTCOMES:

After studying this course the students of Life Sciences will be well-equipped and well informed with the basics of IPR. Especially IPR in India. Students will be informed about the Patents that are integral to research. Students will have working Knowledge of various softwares and will be morally and ethically aware of the rights of the farmers, breeders and researchers.

THEORY : 30 Hours

Unit 1: Introduction to Intellectual Property Rights (IPR) and Geographical Indications and Industrial Designs (8 Hours)

Concept and types; economic importance, IPR in India and world, Genesis and scope, some important examples: IPR and WTO (TRIPS, WIPO), Objectives, Justification, International Position, Multilateral Treaties, National Level, Position of Govt. of India, Objectives, Rights, Assignments, Infringements, Defences of Design Infringement

Unit 2: Patents, Copyrights and Trademarks (9 Hours)

Introduction, Objectives, Rights, Patent Act 1970 and its amendments. Procedure of filing and getting Patents, Patent Infringement. Work protected under copyright law, Rights, Transfer of copyright, Copy right Infringement, Objectives of Trademarks, Types, Rights, Protection of Goodwill, Infringement,

Passing off, Defenses, Domain name

Unit 3: Protection of Traditional Knowledge and Protection of Plant Varieties (7 Hours)
Objectives Concept of Traditional Knowledge, Issues concerning, Bio-Prospecting and Bio-Piracy, Alternative ways, Protectability, Need for a Sui-Generis regime, Traditional Knowledge on the International Arena, at WTO at National level, Traditional Knowledge Digital Library (TKDL).
Objectives of Plant Varieties Protection, Justification, International Position, Plant varieties Protection in India. Rights of Objective, Applications, Concept of Novelty, Concept of inventive step, Microorganisms, Moral Issues related to farmers, breeders and researchers. National Gene Bank, Benefit sharing. Protection of Plant Varieties and Farmer's Rights Act, 2001.

Unit 4: Information Technology, Biotechnology and Intellectual Property Rights (6 Hours)
Computer Softwares and Intellectual Property, Database and Data Protection, Domain Name Protection, Patenting Biological/Biotechnological Inventions

PRACTICALS: 60 Hours

1. Patent search from different website.
2. Trademark search
3. Copyright infringement (Plagiarism check by Urkund and other available software.
4. Geographical Indicators: (Preparation of Inventories)
   Food- Malabar pepper, Basmati rice, Darjeeling Tea, and Requefort cheese.
   Industry- (Mysore agarbatti, Feni Goa, Champagne France).
   Natural Resources- Sandalwood
5. Biopiracy- Neem,Turmeric
6. Industrial designs- Jewelry design, chair design, car design,
7. To prepare IPR e diary.

SUGGESTED READINGS:

1. Misra J.P., 2023. An Introduction to Intellectual Property Rights 3rd Edition (Rep.) Central Law Publication
2. Karki MMS. 2009. Intellectual Property Rights: Basic Concepts. Atlantic Publishers & Distributors (P) Ltd ISBN13: 9788126912629
3. Redd,y S. V. Damodar. 2024. Intellectual Property Rights Law and Practice. Publisher: Asia Law House. ISBN: 9788119107483
4. Miller Arthur R., Davis Michael H. and Neacsu Dana. 2023. Intellectual Property, Patents, Trademarks, and Copyright in a Nutshell (Nutshells) 7th Edition. West Academic Publications. ISBN: 9781685619251
5. Bhandari MK. 2024. Law Relating to Intellectual Property Rights (IPR), Central Law Publication

ADDITIONAL READINGS

6. Mishra, J.P. 2012. An Introduction To Intellectual Property Rights. Central Law Publications. ISBN: 9789381292549, 938129254X
7. Acharya N.K. 2025. Text Book of Intellectual Property Rights. Asia Law House
8. Wadehra BL. 2017. Law Relating To Intellectual Property, Universal Law publishing company
9. Ramakrishna B, Anil Kumar H S. 2017. Fundamentals of Intellectual Property Rights: For Students, Industrialist and Patent Lawyers. Notion Press

Bachelor of Life Science (Program)

SEMESTER VIII

UNIVERSITY OF DELHI

COURSES OFFERED BY DEPARTMENT OF BOTANY FOR SEMESTER-VIII

Under UGCF-2022 based on NEP-2020

(Effective from Academic Year 2022-23)

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Department of Botany

Courses offered in B.Sc. Life Science Semester VIII with Botany as Major Discipline (course contents)

SEMESTER –VIII

(Under UGCF-2022 based on NEP-2020)

DISCIPLINE SPECIFIC CORE COURSE-8: **Plant Stress Biology**

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Integrative Plant Biology **LS-DSC-BOT-8**	4	**2**	**0**	**2**	Semester VII	Nil

COURSE LEARNING OBJECTIVES:

This course would involve study of plants to enhance the understanding of organism/s and/or traits from organismal to molecular levels integrating various core disciplines of plant biology including, but not restricted to, morphology, anatomy, development, taxonomy, inheritance, physiology, biochemistry, molecular and cell biology, genomics, proteomics and bioinformatics studies along with an evolutionary context. Additional areas would include interactions of plants with other organisms in an ecosystem, biotic and abiotic challenges and plant responses, transgenic studies (basic and applied) and an ecological or environmental perspective, wherever applicable.

LEARNING OUTCOMES:

The course would allow students to integrate various sub-disciplines that have been studied over the preceding seven semesters to develop a holistic understanding of plant systems transgressing various subject areas within plant biology. The course would include two main approaches/components:

(i) Integrated case studies on selected plants from algae to angiosperms including all aspects of their growth, development and applications as outlined above.

(ii) Selected trait- or process-based studies of plants to understand the biological, evolutionary and molecular determinants of the traits.

Both these approaches would involve **study of research and review articles** that discuss contemporary questions in plant biology by integrating multiple approaches towards understanding a plant system, **in addition to textbooks**.

The course design would allow students to study important **paradigms in plant sciences**, and train them in **experimental design, data interpretation and adoption of multi-disciplinary approaches to solve scientific questions**. The course would **enable development of critical thinking skills** among students and enhance their **problem-solving abilities**. This is an important component of the course since students in the 8th semester would be involved in B.Sc. Life Science with Botany as Major Discipline at the under-graduate level and would also be eligible to apply for Ph.D. programs in Botany.

THEORY: 30 Hours

Unit 1: Case studies and Trait-based studies on plants from algae to angiosperms (8 hours)

Plant biotic interactions in the Sonoran Desert: current knowledge and future research perspectives Genome-editing: Engineering plants using diverse CRISPR-associated proteins and deregulation of genome-edited crops. The renaissance and enlightenment of *Marchantia* as a model system, *Cuscuta* the Merchant of Proteins, The origin of a land flora. Important components of plant evolution – chloroplast acquisition, multicellularity and land colonization

Unit 2: Photosynthesis (8 Hours)

Lighting the way: Compelling open questions in photosynthesis research. Perspectives on improving photosynthesis to increase crop yield. Air plant genomes shed light on photosynthesis innovation. Alternative electron pathways of photosynthesis power green algal CO_2 capture,

Unit 3: Plant Development and Plant Biotic Interactions (9 Hours)

Molecular mechanisms underlying leaf development, morphological diversification, and beyond, Genetic control of branching patterns in grass inflorescences, Anther development—The long road to making pollen-, Evolution and patterning of the ovule in seed plants. Soil minerals affect taxon-specific bacterial growth. Plant biotic interactions in the Sonoran Desert: current knowledge and future research perspectives.

Unit 4: RNA biology in Plants and Genome-editing (5 Hours)

Beyond transcription: compelling open questions in plant RNA biology. Small RNA-mediated DNA methylation during plant reproduction. Engineering plants using diverse CRISPR-associated proteins and deregulation of genome-edited crops.

PRACTICALS: (60 hours)

1. Observation of phototactic movement in *Chlamydomonas* cells under microscope
2. Observe and compare chloroplast structures in *Chlamydomonas, Spirogyra, Marchantia,* and a land plant.
3. Analyze how selection or mutations affect leaf perimeter, area, lobation (wild vs cultivars of same species) by using ImageJ software.

4. Infer the evolutionary relationships among a group of plants based on trait presence/absence and create a cladogram using any phylogenetic tree making software.
5. Compare net oxygen release in normal vs low-CO_2 environment [one ambient air, one with limited CO_2 (limewater or CO_2 absorbent), measure bubble release (or use digital CO_2 sensor if available)].
6. Studying hormones modulate resource acquisition in root and shoot by application of Auxin and Cytokinin.
7. Demonstrate how plants activate defenses when exposed to pathogens using Leaf disc Assay
8. Observation of change in Morphology, Biomass, Visual Symptoms or Trait effected in same species under different biotic or abiotic stress like: Drought, Pathogen challenge, Pollinator exclusion, Elevated CO_2 (placed under box having baking soda and vinegar which provide CO_2 burst) can be given as project.
9. Using online tool (CRISPRdirect) to set up a Virtual CRISPR Experiment.

SUGGESTED READING

1. Bowman., et al (2022). The renaissance and enlightenment of *Marchantia* as a model system. *The Plant Cell*, 34(10), pp.3512–3542. doi:https://doi.org/10.1093/plcell/koac219.
2. Paterlini, A., & Helariutta, Y. (2020). *Cuscuta* the Merchant of Proteins. Molecular Plant, 13(4), 533-535. https://doi.org/10.1016/j.molp.2020.01.007
3. Romanov, M. S., Bobrov, A. V. C., Iovlev, P. S., Roslov, M. S., Zdravchev, N. S., Sorokin, A. N., ... & Kandidov, M. V. (2024). *American Journal of Botany*, *111*(1), e16264. DOI: 10.1002/ajb2.16264
4. Bowman, J.L. (2022). The origin of a land flora. *Nature Plants*, 8(12), pp.1352–1369. doi:https://doi.org/10.1038/s41477-022-01283-y.
5. Lighting the way: Compelling open questions in photosynthesis research Eckardt et al. *The Plant Cell*, Volume 36, Issue 10, October 2024, Pages 3914–3943, https://doi.org/10.1093/plcell/koae203
6. Perspectives on improving photosynthesis to increase crop yield Croce et al. *The Plant Cell*, Volume 36, Issue 10, October 2024, Pages 3944–3973, https://doi.org/10.1093/plcell/koae132

ADDITIONAL REFERENCES

7. Air plant genomes shed light on photosynthesis innovation Andrew C Willoughby. *The Plant Cell*, Volume 36, Issue 10, October 2024, Pages 3897–3898, https://doi.org/10.1093/plcell/koae213
8. Alternative electron pathways of photosynthesis power green algal CO_2 capture Gilles Peltier et al. *The Plant Cell*, Volume 36, Issue 10, October 2024, Pages 4132–4142, https://doi.org/10.1093/plcell/koae143
9. Beyond transcription: compelling open questions in plant RNA biology Manavella et al. *The Plant Cell*, Volume 35, Issue 6, June 2023, Pages 1626–1653, https://doi.org/10.1093/plcell/koac346
10. Small RNA-mediated DNA methylation during plant reproduction Hiu Tung Chow, Rebecca A Mosher. *The Plant Cell*, Volume 35, Issue 6, June 2023, Pages 1787–1800, https://doi.org/10.1093/plcell/koad010

11. Molecular mechanisms underlying leaf development, morphological diversification, and beyond Nakayama et al. *The Plant Cell*, Volume 34, Issue 7, July 2022, Pages 2534–254. https://doi.org/10.1093/plcell/koac118
12. Genetic control of branching patterns in grass inflorescences Elizabeth A Kellogg. *The Plant Cell*, Volume 34, Issue 7, July 2022, Pages 2518–2533, https://doi.org/10.1093/plcell/koac080
13. Anther development—The long road to making pollen- D Blaine Marchant, Virginia Walbot. *The Plant Cell*, Volume 34, Issue 12, December 2022, Pages 4677–4695, https://doi.org/10.1093/plcell/koac287
14. Evolution and patterning of the ovule in seed plants. Rudall, P. J. *Biological Reviews*, *96*(3), 2021, 943-960. doi: 10.1111/brv.12684
15. Soil minerals affect taxon-specific bacterial growth. Finley, B. K., Mau, R. L., Hayer, M., Stone, B. W., Morrissey, E. M., Koch, B. J., & Hungate, B. A. (2022). *The ISME journal*, *16*(5), 1318-1326.
16. Plant biotic interactions in the Sonoran Desert: current knowledge and future research perspectives. Franklin, K. A., Sommers, P. N., Aslan, C. E., López, B. R., Bronstein, J. L., Bustamante, E., .. & Marazzi, B. *International Journal of Plant Sciences*, Volume *177, Issue* 3, 2016. Pages 217-234, https://www.journals.uchicago.edu/doi/pdf/10.1086/684261
17. Genome-editing: Engineering plants using diverse CRISPR-associated proteins and deregulation of genome-edited crops. Trends in Biotechnology, Volume 42, Issue 5; P560-574 May 2024

Qamar U. Zaman

DISCIPLINE SPECIFIC ELECTIVE COURSE-13: PLANT STRESS BIOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Plant Stress Biology **DSE-13**	4	**2**	**0**	**2**	Semester VII	Nil

COURSE LEARNING OBJECTIVES:

This course explores the physiological, biochemical, and molecular mechanisms by which plants respond to environmental stresses. It covers abiotic and biotic stress factors, their impact on plant growth and development, and adaptive mechanisms to mitigate stress effects. The course also introduces strategies for improving stress tolerance in crops.

LEARNING OUTCOMES:

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

- Identify different types of plant stresses and their effects on plant physiology.
- Understand the molecular and biochemical responses of plants to stress.
- Analyze plant adaptation and tolerance mechanisms under stress conditions.
- Explore strategies to enhance plant resilience against environmental challenges.
- Apply knowledge of plant stress biology in agricultural and environmental contexts.

THEORY: 30 Hours

Unit 1: Introduction to Plant Stress Biology and Various abiotic stresses 10 hours

Types (abiotic and biotic), Perception, Acclimation vs Adaptation, Phenotypic plasticity, **Cross-**talk between abiotic and biotic stress responses.

- Drought stress- Physiological and Biochemical responses, Resistance or Tolerance mechanisms, Role of Aquaporins in drought tolerance.
- Salinity- Osmotic and Cytotoxic effects, Ion homeostasis, Salt-tolerant mechanisms: Developmental and Physiological protective mechanisms – exclusion vs tolerance, Osmoprotectants, Ion transporters, Compatible solutes- glycine betaine, proline
- Temperature - Cold and heat stress (in brief)

Unit 2: Biotic Stress **4 hours**

Stress caused by Pathogens, Herbivores, Parasitic plants and Weeds, Susceptibility and Resistance, PR proteins, Pattern-triggered immunity and Effector triggered immunity. Role of plant-associated microbiomes (endophytes, rhizobacteria) in biotic stress resistance.

Unit 3: Stress Sensing and Signaling Mechanisms and Stress Tolerance **14 hours**

Hormonal regulation (Abscisic acid, Jasmonic acid, Salicylic acid), Reactive Oxygen Species and Nitrous Oxide, Epigenetics, Salt Overly Sensitive pathway, Late embryogenesis abundant proteins (LEA), Calcium signaling, Calcium binding proteins.

Stress Tolerance Mechanisms: Antioxidant enzymes (Superoxide dismutase, Catalase, Peroxidase), Osmolytes, Secondary metabolites (Alkaloids, phenolics and terpenoids), Chaperones (Heat Shock Proteins), Cryoprotectants, Phytoalexins

Unit 4: Crop Improvement Strategies **2 hours**

Traditional plant breeding (Mutation breeding, Protected cultivation) and Biotechnological approaches (brief account of stress tolerant genetically engineered plants).

PRACTICALS: 60 hours

1. To study the effect of salt stress on seed germination (percentage, plant shoot and root length).
2. To study the effect of stress (any one) on chlorophyll content.
3. To determine electrolyte leakage in stressed plants.

4. Estimation of total phenolic content using Folin-Ciocalteu regent.
5. To determine SOD or peroxidase enzyme activity in control and stress plants.

Experiments through demonstration (through photographs)

6. Study of plant adaptations under stress (Stomatal closure, Leaf curling, Root elongation, Stunted plant growth, Wilting) and Effect of ABA.
7. To demonstrate the effect of stress on total protein through 2-D gel electrophoresis profile.
8. Effect of stress on plant membranes.
9. Effect of biotic stress on plants through photographs (necrosis, rotting, nematode attack, apple scab, SAR).

SUGGESTED READINGS:

1. Taiz, L., Zeiger, E., Moller, I. M., Murphy, A. (2018). Plant Physiology and Development, 6th edition. New York, NY: Oxford University Press, Sinauer Associates.
2. Bhatla, S.C., Lal, M.A. (2018). Plant Physiology, Development and Metabolism. Singapore: Springer Nature, Singapore Pvt. Ltd.
3. Giri, B., & Sharma, M. P. (Eds.) (2021). Plant Stress Biology: Strategies and Trends. Springer Nature.
4. Buchanan, B. B., Gruissem, W., & Jones, R. L. (Eds.) (2015). Biochemistry and molecular biology of plants. John wiley & sons.

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

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

DISCIPLINE SPECIFIC ELECTIVE COURSE -14: Immunological Concepts and Applications in Plant Science

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Immunological Concepts and Applications in Plant Science DSE-14	4	**2**	**0**	**2**	Semester VII	Nil

COURSE LEARNING OBJECTIVES:

1. Understanding and Protecting Against Diseases

2. To understand how the immune system defends against viruses, bacteria, and other pathogens

3. To understand how our bodies fight off diseases

4. To Understand how the develop effective treatments and vaccines are developed and vaccines,

5. To learn how to manage conditions like autoimmune disorders.

6. To learn how organ transplantation is done

- **LEARNING OUTCOME:**

By understanding how the immune system works, we can develop public health initiatives and preventative measures to reduce the spread of infectious diseases. Immunology gives the knowledge of effective vaccines and treatments for infectious diseases. The student will understand why the immune system sometimes attacks the body's own tissues, leading to conditions like rheumatoid arthritis, lupus, and type 1 diabetes. Immunotherapy, which harnesses the immune system to fight cancer, is a rapidly growing area of research, and understanding

immunology is crucial for developing and improving these treatments. The student would understand the foundation of vaccine development, allowing scientists to create safe and effective vaccines that protect against a wide range of diseases. The topic give the knowledge about how the immune system interacts with cancer cells is crucial for developing immunotherapies that can target and destroy cancerous tumors. Immunology study helps identify specific targets within the immune system that can be manipulated to treat a variety of diseases. Immunology is essential for determining tissue and organ compatibility during transplantation, helping to prevent the rejection of donated organs by the recipient's immune system. Immunology research plays a vital role in addressing global health challenges, such as fighting pandemics and developing vaccines for diseases that affect populations worldwide.

THEORY: **30 Hours**

Unit 1: Introduction to Immunological Concepts and Plant Immunity: 9 hours

Basic concepts of immunology, Innate and Acquired (Adaptive) immunity, Human Immune system, Concepts of antigen, epitope, hapten, valence, antibodies (immunoglobulins)- structure, types (IgG, IgM, IgA, IgD, and IgE) and functions, antigen-antibody reaction, antisera and vaccines. Immune system in plants, Comparison between the plant and animal immune system. Plant pathogens and pests, Plant-pathogen interactions; Compatible interactions (parasite virulence and host plant susceptibility), Incompatible interactions (parasite avirulence and host plant resistance), non-host and host -resistance, Horizontal and vertical resistance, coevolution of plant defence and pathogen attack mechanisms: the Zigzag Model. Role of Microbiomes in Plant Immunity (beneficial microbes enhancing defense).

Unit 2: Components of Plant Immunity: 10 hours

(i) **Innate Immunity/ Resistance**

Non-specific or Basal Resistance: Passive (Constitutive defenses) including pre-existing mechanical defences (cuticle, waxes, lignified cell wall, bark, trichomes, thorns); pre-existing biochemical defences (alkaloids, phenolic compounds, terpenoids, nutrient deprivation, phytoanticipins); **Active (Inducible Defences):** Pathogen-associated molecular patterns (PAMPs), pattern-recognition receptors (PRRs), PAMP-triggered Immunity (PTI). Popular Models of PTI in plants- Flagellin-induced Resistance,

Pathogen Race-specific resistance: Molecular Models of specific Host-pathogen Recognition, gene-for-gene or receptor-ligand model (Flor's Model), Pathogen effectors, Intracellular nucleotide-binding leucine-

rich repeat receptors (NLRs), Plant Resistance (R) genes, Avirulence (Avr) proteins/ Effectors, Effector-triggered susceptibility (ETS), Effector-triggered immunity (ETI), Hypersensitive response.

(ii) **Acquired Resistance**

Systemic Acquired Resistance (SAR), Induced Systemic Resistance (ISR) Priming of plant immunity for faster future responses.

Unit 3: Signal Transduction Pathways activated during Plant resistance: 5 hours

Phytohormone signaling: salicylic acid, jasmonic acid, ethylene; Calcium signaling: Calmodulin (CaM), Calcineurin B-like proteins (CBLs) in *Arabidopsis;* Mitogen-activated protein kinase (MAPK) Cascades; The Oxidative burst (ROS); Major transcription factor families in plant immunity (WRKY, NAC, MYB, bZIP)

Unit 4: Applications of immunology in Plant Science: 6 hours

Development of disease-resistant crops, engineering enhanced resistance in crops via gene editing (e.g., CRISPR-Cas9), developing novel biopesticides/ biocontrol agents based on induced systemic resistance (ISR), genetic engineering strategies for broad-spectrum resistance by Pseudo-Response Regulator (PRR) and chimeric PRR transgenes. RNAi based antiviral resistance (siRNA).

PRACTICALS: 60 hours

1. To study the structure of antibody (diagrammatic and crystal structure) digitally.
2. Study of diseased plants and identification of its causal pathogen based on visually observed symptoms (Viral, bacterial, Fungal - one disease each)
3. Analysis and interpretation of digitally represented zig-zag model
4. Analysis and Interpretation of Western blots
5. Understanding the concept of immunoprecipitation by performing immunodiffusion.
7. Study and applications of immunological techniques: ELISA, Immunodiffusion, Radioimmunoassay.

SUGGESTED READINGS:

1. Dhia Bouktila and Yosra Habachi (2021) *An Introduction to Plant Immunity*: Bentham Science Publishers, Sharjah, UAE.
2. Iakovidis, M., Chung, E. H., Saile, S. C., Sauberzweig, E., & El Kasmi, F. (2023). *The emerging frontier of plant immunity's core hubs. The FEBS journal, 290(13), 3311–3335. https://doi.org/10.1111/febs.16549*
3. Prescott, L.M., Harley J.P., Klein D. A. (2005). *Microbiology*, 6th edition: McGraw Hill, New Delhi.

ADDITIONAL READING:

Agrios, G.S. (2005) Plant Pathology 5th Edition: Elsewhere Academic Press, Amsterdam.

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

DISCIPLINE SPECIFIC ELECTIVE COURSE -15: Advances in Genetics, Genomics and Plant Breeding

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Advances in Genetics, Genomics and Plant Breeding DSE-15	4	**2**	**0**	**2**	Semester VII	Nil

COURSE LEARNING OBJECTIVES:

To give the knowledge on how to improve crop yields, disease resistance, and nutritional value, ultimately contributing to food security and sustainable agriculture.

To enable more precise and efficient plant breeding, leveraging genomic information to develop superior crop varieties.

LEARNING OUTCOME:

The student will learn the identification and selection of genes associated with desirable traits like higher yield, improved grain quality, and enhanced nutritional content. They will learn to to predict the breeding value of plants, accelerating the selection process and reducing the time required to develop new varieties. They will learn the gene editing techniques like CRISPR/Cas9 enable precise modifications of plant genomes to improve specific traits, further accelerating crop improvement. It alos give insights on the increased Disease Resistance and Stress Tolerance to develop varieties with enhanced immunity to pests and diseases, as well as resilience to environmental stresses like drought, salinity, and high temperatures. By developing crop varieties with higher yields, improved nutritional value, and resistance to pests and diseases, these advances contribute to increased food security and reduced reliance on chemical inputs. Climate-resilient

crops developed through genomic-based breeding can help mitigate the effects of climate change on agriculture, ensuring food production. Genomics has revolutionized plant breeding by shifting from phenotype-based selection to genotype-based selection, enabling more precise and efficient trait selection. Continued advancements in genomics and plant breeding hold immense promise for developing crops with even greater resilience, nutritional value, and yield potential, further contributing to a more sustainable and secure food future. The application of artificial intelligence and machine learning in plant breeding: is also on the horizon, promising further advancements in speed, accuracy, and efficiency.

THEORY: 60 Hours

Unit 1: Chromatin Organization and Fine Structure of Gene and Current Trends in Genomics 04 Hours

Chromatin structure and packaging of DNA: architecture of chromosome in eukaryotes, karyotypes and ideogram. Fine structure of gene. Role of 3D genome architecture (chromosome looping, TADs) in gene regulation. Gene discovery and deciphering gene function for improvement of crops. Applications of genomics in agriculture, health and environment.

Unit 2: Crop Genetics, Molecular Cytogenetics and Applied Genetics 08 Hours

Genome analysis in crops; Utilization of aneuploids in gene localization. Evolutionary significance of chromosomal aberrations in crop improvement, molecular cytogenetical tools for identification and structural analysis of genomes, introgression studies and ploidy detection. Advances in Optical Mapping and Karyotype Evolution. Applications of molecular cytogenetics: Alien gene transfer studies, gene mapping of agronomic traits and crop improvement in wheat, rice, tomato and cotton. Application of transposons in mutagenesis, genome mapping and evolution. Genomic approaches to minor and orphan crops.

Unit 5: Epigenomics and Metagenomics and Genome Editing Techniques 08 Hours

Epigenomics: DNA methylation, histone modifications and chromatin remodelling; Epialleles: inheritance and role in genetic regulation. Basic tools for studying epigenomics: Overview of Bisulfite sequencing and ChIP-Seq. Applications in crop improvement and disease management. Introduction to metagenomics; Environmental metagenomics: role in pollution control and ecosystem management. Plant microbiomes and their roles in stress tolerance and nutrient uptake. Introduction to genome editing, CRISPR-Cas9; applications of genome editing in agriculture and medicine. Ethical concerns: Designer babies, GMOs, and genome editing regulations.

Unit 4: Genetic Systems, Breeding Methods and Molecular Breeding 10 Hours

Gene pools (primary, secondary and tertiary), systems of mating, breeding methods for sexually, asexually/clonally propagated crops; self-incompatibility, male sterility and apomixis. Heterosis: types, genetic and molecular basis; Inbreeding. Molecular DNA markers and mapping populations,

construction of high-density maps, QTL mapping, Association mapping. Integration of genetic maps with physical maps/chromosomes. Gene tagging, Marker Assisted Selection (MAS), Bulk Segregation Analysis (BSA), Genomic selection and Genome Wide Association Studies (GWAS). Breeding for biotic and abiotic stresses, and quality traits. Variety development and release of new varieties, Plant breeders and Farmers' rights.

PRACTICALS: 60 hours

1. Preparation of karyotype and ideogram from mitotic metaphase spread and analysis of degree of asymmetry.
2. Study of molecular cytogenetics: identification of progenitor genomes in allopolyploids crops using GISH (wheat, rice, tomato and cotton).
3. Mapping of ribosomal DNA gene using FISH.
4. Localization of Gene introgression using Fiber-FISH/ND-FISH.
5. Pedigree construction and analysis based on inheritance of monogenic traits in humans.
6. Access a plant-specific genome database (e.g., *Oryza sativa* in Gramene or *Arabidopsis thaliana* in TAIR).
7. Search for transcription factors linked to abiotic stress (e.g., drought, salinity). Note down their family (e.g., MYB, WRKY), function, and expression pattern.
8. Study of DNA methylation in plants using methylation sensitive enzymes.
9. Exploration of Single Nucleotide Polymorphisms (SNPs) in plants and their role in trait variation using Bioinformatics databases and tools.
10. Demonstration of basic method of selfing, emasculation, hybridization and crossing techniques in field/potted plants.
11. Comparison of characteristic features of released and notified varieties, hybrid and parental lines.
12. Comparison of quality parameters in improved varieties of cereals, pulses and oilseeds.
13. Genetics/Genomics/Plant breeding in News/Societal issues: presentation on a news article. Articles should have been published within last 2 years.

SUGGESTED READING:

1. Phundhan Singh (2014). Plant Breeding: Molecular and New Approaches. Kalyani Publishers
2. Phundhan Singh (2015). Essentials of Plant Breeding. Kalyani Publishers
3. B.D. Singh (2022). Plant Breeding: Principles and Methods, 12th Edition. MedTech Science Press.
4. Arthur M. Lesk (2017), Introduction to Genomics, 3rd Edition, OUP Oxford

- Hartl, D.L. Jones, E.W (2009), Genetics: Analysis of Genes and Genomes, 7th Edition, Jones&BarlettPublishers
- Peter S Harper (2010). Practical Genetic Counselling, 7th Edition, CRC Press
- Genetics A Molecular Approach, Russell PJ, Pearson
- Introduction to Genetic Analysis, Griffith AF et al., W H Freeman & Co
- Concepts of Genetics, Klug WS&Cummings MR, Prentice-Hall, Genetics – a conceptual approach, Pierce BA, W H Freeman & Co
- Principles of Genetics, Sunstad DP & Simmons MJ, John Wiley & sons
- Genetics Analysis of Genes & Genomes, Hartl, D.L. Jones, E.W. Jones & Barlett
- Genetic Analysis, Phillip Meneely, Oxford
- The Eukaryotic Chromosome, Bostock CJ & Summer AT, Elsevier
- Structure & Function of Eukaryotic Chromosomes, Hennig W, Springer
- Genes IX, Lewin B, Pearson
- Genome 3, Brown TA, Garland Publishing

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

DISCIPLINE SPECIFIC ELECTIVE COURSE -16: Plant Genomics, Proteomics and Bioinformatics

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Plant Genomics, Proteomics and Bioinformatics DSE-16	4	**2**	**0**	**2**	Semester VII	Nil

LEARNING OBJECTIVES

- To give understanding of the entire genome, including DNA sequences, gene architecture, and functional annotations, providing a holistic view of plant biology It will give the advanced knowledge in areas like crop improvement, disease resistance, and climate change adaptation.
- To provide a comprehensive understanding of plant biology at the molecular level, enabling researchers to identify key genes, proteins, and pathways involved in various plant processes.
- This knowledge can be used to develop more resilient and productive crops through advanced breeding and genetic engineering techniques.

LEARNING OUTCOME:

Genomics helps identify genes related to important traits like yield, disease resistance, and nutritional content, enabling the breeding of superior crop varieties. By understanding how genes respond to environmental stress, genomics can be used to develop plants that are more resilient to drought, heat, and other climate-related challenges. Proteomics focuses on the study of proteins, their structures, and functions, providing insights into cellular processes and protein interactions. Proteomics can identify proteins involved in defense mechanisms against

pathogens, helping to develop new strategies for disease management. Proteomics helps understand how proteins respond to environmental stress, providing valuable information for developing stress-tolerant crops. Bioinformatics provides the computational tools necessary to analyze the vast amount of data generated by genomics and proteomics. Bioinformatics tools are used to build and maintain databases that store and organize plant genomic and proteomic data. Bioinformatics can be used to predict gene function, protein structure, and protein-protein interactions, providing valuable insights into plant biology.

The combination of genomics, proteomics, and bioinformatics provides a powerful approach for understanding plant biology and developing new strategies for crop improvement and adaptation. By integrating data from different omics disciplines, researchers can gain a more comprehensive understanding of plant systems, including gene regulation, protein interactions, and metabolic pathways. The insights gained from genomics, proteomics, and bioinformatics can accelerate the breeding process, leading to faster development of improved crop varietie

THEORY: 30 Hours

Unit 1: Introduction to Genomics and Genome Sequencing
08 Hours

Recap of genomic concepts: genomes, genes, and non-coding regions, prokaryotic and eukaryotic genomes. Basic concepts of structural, functional, and comparative genomics. Introduction to genomics, metagenomics, functional genomics, and system biology. Model organisms in genomics (*A. thaliana*, *E. coli*, *C. elegans*, *S. cerevisiae*). Methods for whole genome sequencing (shotgun & clone by clone), next generation sequencing, Genome sequencing projects (Human genome project, *Arabidopsis* genome project, Rice genome project).

Unit 2: Transcriptomics and Proteomics 12 Hours

Transcriptome sequencing, gene expression studies by EST, microarray and RNA sequencing.

Protein Identification, quantification, characterization, structural and bioinformatics analysis. Conventional proteomics (Native and SDS-PAGE, 2D-PAGE, Western blotting, ELISA), chromatography (Paper, Thin Layer, Size exclusion, Gel filtration, Ion exchange, Affinity); Visual proteomics (X-ray crystallography, NMR); Gel-free, Marker free MS-analysis by nano LC-MS/MS, Data-Dependent Acquisition (DDA), targeted and global proteomics analysis including PTM analysis, localization studies and functional analysis using TargetP, KEGG and GO.

Applications: Basic biological research (protein interaction networks and functional proteomics); disease research and diagnosis (Cancer biomarkers and virus research); drug development; agriculture and food science (crop improvement) and environmental monitoring.

Unit 3: Bioinformatics and Biological databases 04 Hours

Historical background; aims and scope of bioinformatics in Genomics, Transcriptomics, Proteomics, Metabolomics. Introduction to biological databases; study of following databases: NCBI - Resources and tools (BLAST, BankIt, Sequin, Webin), EMBL, DDBJ databases; Nucleic acid databases (GenBank, NDB); Protein databases (PIR, Swiss-Prot, PDB); Metabolic pathway database (KEGG).

Unit 4: Basic concepts of Sequence alignment and Molecular Phylogeny (06 Hours)

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

Molecular Phylogeny, construction of phylogenetic tree, dendrograms, methods of construction of phylogenetic trees- maximum parsimony, maximum likelihood and distance methods.

PRACTICALS: 60 Hours

1. Sequence retrieval (protein and gene) from NCBI (formats- FASTA, GenBank and GenPept formats).
2. Perform pairwise alignment using BLAST.
3. Multiple sequence alignment (MEGA/Clustal omega).
4. Gene annotation using ORF Finder & gene prediction using GENSCAN
5. Locate the genome databases of prokaryotic and eukaryotic organisms (2 each) with completely sequenced genomes and categorize them based on taxonomy and genome size.
6. Protein Structure retrieval from PDB (in PDB format) and visualization by viewing tools (RasMol/Jmol/Mol*/Swiss 3D Viewer/PyMol).
7. To Perform Native and SDS-PAGE for separation of proteins.
8. Demonstration of 2D-PAGE for separation of protein isoforms.
9. Characterization of proteins using Western blotting.
10. Purification of proteins using Gel filtration chromatography.
11. *In-silico* characterization/analysis of proteins using localization, PTMs and functional annotation tools (using TargetP, KEGG and GO).

SUGGESTED READING

- Xiong, J. (2006). Essential Bioinformatics, 1st edition. Cambridge University Press. U.K.
- Pevsner, J. (2009). Bioinformatics and Functional Genomics, 2nd edition, Wiley Blackwell. New Jersey, U.S.

- Mount, D.W. (2004). Bioinformatics: Sequence and Genome analysis 2nd edition, Cold Spring Harbor Laboratory Press, USA.
- Ghosh, Z., Mallick, B. (2008). Bioinformatics – Principles and Applications, 1st edition. Oxford University Press, New Delhi, Delhi.
- Baxevanis, A.D., Ouellette, B.F., John (2005). Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, 3rd edition. Wiley & Sons, Inc. New Jersey, U.S.
- Roy, D. (2009). Bioinformatics, 1st edition. Narosa Publishing House, New Delhi, Delhi.
- Andreas, D., Baxevanis, B.F., Francis, Ouellette. (2004). Bioinformatics: A practical guide to the analysis of genes and proteins, 3rd edition. John Wiley and Sons, New Jersey, U.S.
- Lesk A (2020). Introduction to Bioinformatics, 5th Edition, Oxford University Press. India.
- David mount (2004) Bioinformatics: Sequence and genome analysis, 2nd Edition, Cold Spring Harbor Lab Press.
- Baxevanis A.D., Ouellette, B.F. (2004) Bioinformatics: A practical guide to the analysis of genes and proteins, John Wiley & Sons Inc.
- Dov Stekel (2003) Microarray Bioinformatics, 1st Edition. Cambridge University Press.
- Arthur M. Lesk (2017), Introduction to Genomics, 3rd Edition, Oxford University Press.
- Pennington SR, Dunn MJ (Eds.) (2002). Proteomics: From Protein Sequence to Function, BIOS Scientific Publishers, United Kingdom.
- Daniel C Liebler (2006) Introduction to Proteomics-Tools for New Biology. Humana Press, Totowa, NJ.
- Twyman, R (2014) Principles of Proteomics. Second edition. Garland Science, Taylor and Francis group, UK.
- Comai, L; Katz J and Mallick, P (2017) Proteomics-Methods and Protocols, Springer Protocols, Springer New York.

Bachelor of Applied Life Sciences with Agrochemicals and Pest Management

SEMESTER VII

UNIVERSITY OF DELHI

COURSES OFFERED BY DEPARTMENT OF BOTANY FOR SEMESTER-VII

Under UGCF-2022 based on NEP-2020

(Effective from Academic Year 2022-23

Department of Botany
Courses offered in B.Sc. Applied Life Science with Agrochemicals and Pest Management

SEMESTER –VII

(Under UGCF-2022 based on NEP-2020)

Index

*These courses are already approved.

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 ALS-DSE 7	**4**	**2**	**0**	**2**	**VI Sem**	**Nil**

Course 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.

Theory; 30 Hours

Unit 1 Introduction **08 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. Role of nutrients, vitamins, hormones and supplements in nutrient medium. Composition of MS and White medium.

Unit 2 Techniques of Plant Tissue Culture **08 Hours**

Collection of plant material, sterilization of tissue (maintenance of aseptic conditions by use of autoclave and laminar flow chamber), filter sterilization, inoculation. Protoplast isolation (mechanical and enzymatic), culture, purification (viability test) and fusion (spontaneous, induced), selection of fused protoplasts, applications

Unit 3 Micropropagation **05 Hours**

Selection of plant material and suitable explant, methodology, plant regeneration pathways-somatic embryogenesis, organogenesis, difference between somatic and zygotic embryos.

Unit 4 Tissue culture applications **09 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**

- To study the equipment used in tissue culture: autoclave and laminar air flow chamber.
- Preparation of Murashige & Skoog's (MS) medium.
- Demonstration of sterilization and inoculation methods using leaf

and nodal explants of tobacco, carrot, *Datura*, *Brassica* etc. (any two).
- Study of anther, embryo and endosperm culture.
- Study of micropropagation, somatic embryogenesis & artificial seeds.
- Isolation of protoplasts.
- Visit to a plant tissue culture laboratory and submission of field report.

Suggested Readings:

- Bhojwani, S.S. (1990). Plant Tissue Culture: Applications and Limitations {Elsevier}
- Bhojwani, S.S, Bhatnagar, S.P. (2015). The Embryology of Angiosperms, 6th edition. New Delhi, Delhi: Vikas Publication House Pvt. Ltd.
- Bhojwani, S. S. and Dantu, P. K. (2013). Plant Tissue Culture: An Introductory Text Springer
- Bhojwani, S. S. and Razdan, M. K. (1996). Plant Tissue Culture: Theory and Practice, Revised Edition, Elsevier
- Newmann, Karl-Hermann (2020). Plant Cell and Tissue Culture: A Tool in Biotechnology, 2nd Edition Springer

Additional Resources:

- Park, Sunghun (2021). Plant Tissue Culture: Techniques and Experiments, 4th Edition Elsevier
- Razdan, M. K. (2019). Introduction to Plant Tissue Culture, 3rd Edition CBS / Oxford & IBH
- Smith, R. H. (2013). Plant Tissue Culture: Techniques and Experiments, 3rd Edition
- {Elsevier}
- Stewart, C. Neal (2016). Plant Biotechnology and Genetics, 2nd Edition Wiley-Blackwell
- 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.

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		
Applied Phycology ALS-DSE 5	**4**	**2**	**0**	**2**	**VI Sem**	**Nil**

Course Learning Objective:

To gain knowledge about diversity, life forms, life cycles, morphology and economic importance of algae.

Learning Outcomes:

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

- use of algae for environment, human welfare and industries.
- algal culture techniques and their commercial production

Theory : 30 Hours

Unit 1: Scope of phycology **09 hour**

In emerging research areas, environment and industries. Nutritional value of algae; Common edible algae; Algae as food, feed and fodder with suitable examples. Phycocolloids (Agar-agar, Alginic acid and Carrageenan) and secondary metabolites: Sources and Applications; Pharmaceutical and Nutraceutical uses of algae; Algae in cosmetics; Diatomaceous Earth.

Unit 2: Algae in agriculture and environment **09 hours**

Algae as soil conditioners and biofertilizers; Seaweed liquid extract; Seaweed powder; Algal biorefinery residues. Algae as pollution indicators; wasteland reclamation; Role of algae in wastewater treatment; Ecological importance of Symbiotic associations of algae; Harmful algal blooms; Red tides; Algal toxins.

Unit 3: Algae in biotechnology and research **08 Hours**

Gene sequencing and algal systematics; Algae as a model organism (Chlamydomonas, Chlorella, Acetabularia, Ectocarpus,Porphyra); Bioluminescent forms; Algae in nanotechnology. Biofuels (Bioethanol, Biodiesel, Biohydrogen); Algal Biorefinery.

Unit 4: Algal culture techniques and commercial production **04 Hours** Isolation, purification and sterilisation of algae; Freshwater and marine culture media (BG-11 and Provasoli ES medium); Photobioreactors and large-scale production of microalgae; Seaweed farming.

Practicals **60 hours**

1. Isolation and identification of algal species (any three) in water samples from polluted and non-polluted sources through temporary mounts.
2. Nutritional analysis (protein and carbohydrates) of *Spirulina/ Chlorella/* anyother available edible algae.
3. Study of algal symbiosis (*Azolla* fronds) through sectioning or tease mount.
4. Phycocolloid (Agar-agar/ Alginates/ Carrageenan) extraction (demonstration/ digital resources).
5. Microalgal culture - maintain cultures of species isolated in Experiment 1(any three).
6. Commercial applications of algae through photographs/products (edible, cosmetics, biofuels, pharmaceutical, nutraceutical, phyco-remediation).
7. Study of algae as a model organism (any 2) through digital resources.
8. Project work on any applied aspect of algae/ Visit to any Institute or Industry (Report to be submitted).

Suggested Readings:

1. Bold, H.C. and Wynne, M.J. (1985) Introduction to the Algae: Structure and Reproduction, 2nd edition. Prentice-Hall International INC.
2. Chapman, D.J. and Chapman, V.J. (1980) Seaweeds and their uses. 3rdedn. British Library.
3. Kumar, H.D. (1999) Introductory Phycology, 2nd edition. Affiliated East-West Press, New Delhi.
4. Lee, R.E. (2008) Phycology, 4th edition: Cambridge University Press, Cambridge.
5. Sahoo, D. (2000) Farming the Ocean*:* Seaweed Cultivation and Utilization. Aravali Book International, New Delhi.

Additional Resources:

1. Andersen, R.A. (2005) Algal Culturing Techniques. Elsevier Academic Press.
2. Chapman, D.J. and Chapman, V.J. (1973) The Algae. 2ndedn. Macmillan, London.
3. Fleurence, J. and Levine, I. (2016) Seaweed in Health and Disease Prevention. Academic Press publications.
4. Sahoo, D (2010). Common seaweeds of India. IK International Pvt Ltd.
5. Sahoo, D. and Seckbach, J. (2015) The Algae World. Vol 26 Cellular Origin, Life in Extreme Habitats and Astrobiology. Springer, Dordrecht.
6. Van den Hoek, C. Mann, D.G. and Jahans H.M. (1995) Algae: An Introduction to Phycology. Cambridge University Press.

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

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Industrial and Environmental Microbiology ALS-DSE 6	**4**	**2**	**0**	**2**	**VI Sem**	**Nil**

Course Learning Objectives:

- To introduce students to the concepts, principles, scope and applications of industrial and environmental microbiology.

Learning Outcomes:

Upon successful completion of the course, students will be able to:

- understand how microbiology is applied in manufacturing of industrial products
- know about design of bioreactors
- understand the rationale in medium formulation, design for microbial fermentation, sterilization of medium and air
- comprehend the techniques and the underlying principles in upstream and down-stream processing
- learn the occurrence, abundance and distribution of microorganism in the environment and their role in the environment and also learn different methods for their detection
- understand the basic principles of environment microbiology and application of the same in solving environmental problems - waste water treatment and bioremediation
- comprehend the various methods to determine the quality of water

Theory : 30 Hours

Unit 1: Microbes and quality of environment **04 Hours** Introduction and scope of microbes in industry and environment; Distribution and isolation of microorganisms from soil, air and water.

Unit 2: Bioreactors/Fermenters and fermentation processes **08 Hours** Solid-state and liquid-state (stationary and submerged) fermentations; Batch and continuous Fermentations; Components of a typical bioreactor, Types of bioreactors:

laboratory, pilot scale and production fermenters; Constantly stirred tank fermenter, tower fermenter, fixed bed and fluidized bed bioreactors and air-lift fermenter.

Unit 3: Microbial production of industrial products 10 Hours

Microorganisms generally regarded as safe (GRAS); Downstream processing and uses; Filtration, centrifugation, cell disruption, solvent extraction, precipitation and ultrafiltration, lyophilization; Production of industrially important products: enzyme (amylase); organic acid (citric acid); alcohol (ethanol); antibiotic (penicillin)

Unit 4: Industrial and Environmental Applications 08 Hours

Applications of industrially important enzymes (protease, lipase, and penicillin acylase); Methods of immobilization and its advantages. Water pollution: various sources and control measures; Role of microbes in sewage and domestic wastewater treatment systems. Microorganisms as indicators of water quality: coliforms and faecal coliforms.

Practicals 60 Hours

1. Principles and functioning of instruments: autoclave, laminar air flow, incubators, types of fermenters.
2. Preparation of different culture media (Nutrient medium/ LuriaBertani medium/Potato dextrose medium/Czapek Dox medium).
3. Hydrolysis of casein andstarch by microorganisms.
4. Alcohol production by yeast using sugar/ jaggery.
5. Serial dilution method for isolation of microorganisms from water and soil and study of aero-microflora.
6. To determine the BOD of sewage water.
7. To qualitatively check the enzyme activity (phosphatase/amylase/cellulase) in soil samples.
8. To determine the microbial activity in soil by Triphenyltetrazolium chloride (TTC) assay or by measuring the CO_2 evolution.
9. Determination of coliforms in water samples using eosin methylene blue (EMB) medium.
10. Visit to any educational institute/ industry and a report to be submitted

Suggested Readings:

1. Bertrand, Jean-Claude, Caumette, P., Lebaron, P, Matheron, R., Normand, P., Sime• Ngando, T. (2015). Environmental Microbiology: Fundamentals and Applications. Amesterdam, Netherlands, Springer.
2. Joe, S., Sukesh (2010). Industrial Microbiology. S.Chand& Company Pvt. Ltd. New Delhi, Delhi.

3. Mohapatra.P.K. (2008). Textbook of Environmental Microbiology. I.K. International Publishing House Pvt.Ltd. New Delhi, Delhi.
4. Okafer, Nduka (2007). Modern Industrial Microbiology & Biotechnology. Science Pubishers, Enfield, NH, USA.
5. Pelzar, 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.

Additional Resources:

1. Alef K, and Nannipieri P (1995). Methods in Applied Soil Microbiology and Biochemistry, First Edition Academic Press, USA.
2. Atlas, Bartha. (1997). Microbial Ecology: Fundamentals and Applications. San Fransisco, SF. Pearson.
3. Casida, J.R. (2016). Industrial Microbiology. New Delhi, Delhi, New Age International Publishers.
4. Hurst C.J., Crowford R.L., Garland J.L. and Lipson D.A. (2007). Manual of Environmental Microbiology, American Society of Microbiology, USA.
5. Patel, A.H. (2008). Industrial Microbiology, Bangalore, India: McMillan India Limited.
6. Sharma, P.D.(2005). Environmental Microbiology. Meerut, UP: Alpha Science International, Ltd.
7. Stanbury, P.F., Whitaker, A., Hall, S.J. (2016). Principles of Fermentation Technology. Amesterdam, NDL:Elsevier Publication.
8. Tortora, G.J., Funke, B.R., Case. C.L. (2007). Microbiology (9^{th} edition). San Francisco, SF: Pearson Benjamin Cummings.

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

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		
Natural Resource Management **ALS-DSE 7**	4	2	0	2	**VI Sem**	**Nil**

Course Learning Objectives:

Natural Resources are materials from earth which support life and significantly meet the needs of people. The paper aims to describe the different types of natural resources and their management. Students will study about the importance of each natural resource and how and why they are threatened in current times. They will also be taught about sustainably using our resources

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

- understand the different resources available in nature
- learn the importance of each resource along with the threats to these resources
- gain an in-depth understanding of management of these resources and restoration of natural ecosystems
- study the importance of sustainable practices
- gain an insight into various initiatives taken the world over to save our natural resources.
- understand the concept of clean energy and management of waste

Theory 30 Hours

Unit 1: Natural Resources and Sustainable Utilization **05 Hours**

Definition, fundamental concepts and types, Concept, Goals, Approaches (economic, ecological, socio-cultural)

Unit 2: Land and Water Resources **10 Hours**

Forests (definition, threats, management); Agricultural practices and their impact; Soil degradation (causes, management and remediation/restoration strategies), Freshwater, Marine, Estuarine, Wetlands – Threats and Management

Unit 3: Biological Resources and Energy **05 Hours**

Biodiversity – Levels, Significance, Threats, Management, Clean energy strategies – Solar, Wind, Hydro, Tidal, Geo-thermal, Bio-energy

Unit 4: Climate Change, Contemporary practices and National and International Initiatives **10 Hours**

Impact, adaptation and mitigation (Land, Soil, Water, Biodiversity, Air), EIA, GIS, Energy Audits, Waste Management, Ecosystem Restoration, Carbon footprint, International Solar Alliance; Ramsar Convention; Basel Convention; Carbon Neutral Goals; Net- zero Coalition; Clean Development Mechanism; CAMPA (Compensatory Afforestation Fund Management and Planning Authority); Carbon Credits; REDD+ project, Renewable Energy Certificates

Practicals: **60 Hours**

- Comparison of pH (pH meter) and salinity (Electrical Conductivity) of various soil samples.
- Comparison of field capacity of various soil samples.
- Comparison of pH (pH meter) and TDS (TDS meter) of various water samples.
- Comparison of salinity (titrimetric method) of various water samples.
- Calculation and comparison of BOD and COD of various water samples from given data.
- Comparison of species diversity in various communities by Shannon-Wiener Index.
- Measurement of dominance of woody species by DBH method in the college campus.
- Project (any one of the following):
  a. Rainwater harvesting (site visit)
  b. Ecological restoration (site visit)
  c. Energy audit
  d. Seed germination and seedling growth in garden and contaminated soils
  e. Composting
  f. Any other
- Field visit/s to any degraded ecosystem (landfill, polluted water body, invaded forest) or any ongoing restoration project site.

Suggestive readings:

- Vasudevan, N. (2006). Essentials of Environmental Science. New Delhi, India: Narosa Publishing House.
- Singh, J. S., Singh, S.P. and Gupta, S.R. (2006). Ecology, Environment and Resource
- Conservation. New Delhi, India: Anamaya Publications.
- Rogers, P.P., Jalal, K.F. and Boyd, J.A. (2008). An Introduction to Sustainable Development. New Delhi, India: Prentice Hall of India Private Limited.

- Jordan III, W. R., Gilpin, M. E., Aber, J. D. (1987). Restoration Ecology: a synthetic approach to ecological research. Cambridge, Great Britain: Cambridge University Press.

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

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Intellectual Property Rights ALS-DSE 8	4	**2**	**0**	**2**	**VI Sem**	Nil

Course learning Objectives

The objective of this course is to impart knowledge of rules, regulations, laws and processes of patents. Besides this, students will have adequate knowledge of copyrights, trademarks and shall be thorough with the importance of traditional knowledge and protection of plant varieties.

Learning outcomes:

After studying this course, the students of Life Sciences will be well-equipped and well informed with the basics of IPR. Especially IPR in India. Students will be informed about the Patents that are integral to research. Students will have working Knowledge of various softwares and will be morally and ethically aware of the rights of the farmers, breeders and researchers.

Theory : 30 Hours

Unit 1: Introduction to Intellectual Property Rights (IPR) 03Hours

Concept and types; economic importance, IPR in India and world, Genesis and scope, some important examples: IPR and WTO (TRIPS, WIPO).

Unit 2: Patents, Copyrights and Trademarks 09 Hours

Objectives, Rights, Patent Act 1970 and its amendments. Procedure of filing and getting Patents, Patent Infringement, Introduction, Work protected under copyright law, Rights, Transfer of copyright, Copy right Infringement, Objectives, Types, Rights, Protection of Goodwill, Infringement, Passing off, Defenses, Domain name

Unit 3: Geographical Indications, Traditional Knowledge Protection and Industrial Design

09 Hours

Objectives, Justification, International Position, Multilateral Treaties, National Level, Position of Govt. of India, Objectives Concept of Traditional Knowledge, Issues concerning, Bio-Prospecting and Bio-Piracy, Alternative ways, Protectability, Need for a Sui-Generis regime, Traditional Knowledge on the International Arena, at WTO at National level, Traditional Knowledge Digital Library (TKDL), Objectives, Rights, Assignments, Infringements, Defenses of Design Infringement

Unit 4: Protection of Plant Varieties, IPR and Biotechnology

09 Hours

Plant Varieties Protection- Objectives, Justification, International Position, Plant varieties Protection in India. Rights of Objective, Applications, Concept of Novelty, Concept of inventive step, Microorganisms, Moral Issues related to farmers, breeders and researchers. National Gene Bank, Benefit sharing. Protection of Plant Varieties and Farmer's Rights Act, 2001, Computer Softwares and Intellectual Property, Database and Data Protection, Domain Name Protection, Patenting Biological/Biotechnological Inventions

Practicals: **60 Hours**

1. Patent search from different website.
2. Trademark search
3. Copyright infringement (Plagiarism check by Urkund and other available software.
4. Geographical Indicators: (Preparation of Inventories)

   Food- Malabar pepper, Basmati rice, Darjeeling Tea, and Requefort cheese.

   Industry- (Mysore agarbatti, Feni Goa, Champagne France).

   Natural Resources- Sandalwood
5. Biopiracy- Neem,Turmeric
6. Industrial designs- Jewelry design, chair design, car design,
7. To prepare IPR e diary.

Suggested Readings:

- M.M.S. Karki (2009) Intellectual Property Rights: Basic Concepts. Atlantic Publishers & Distributors (P) Ltd. ISBN13: 9788126912629.
- Rajeev Babel (2023) Intellectual Property Rights in India | Bloomsbury Publications. Publisher Bloomsburry Publication.
- S.V. Damodar Reddy (2024) Intellectual Property Rights -- Law and Practice. Asia Law House. ISBN: 9788119107483.
- JP Misra (2023) An Introduction to Intellectual Property Rights 3rd Edition. Central Law Publication, India

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

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Prerequisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Plant Stress Physiology: Concepts and Strategies **ALS-DSE 9**	**4**	**2**	**0**	**2**	**VI Sem**	**Nil**

Course Learning Objectives:

This course explores the physiological, biochemical, and molecular mechanisms by which plants respond to environmental stresses. It covers abiotic and biotic stress factors, their impact on plant growth and development, and adaptive mechanisms to mitigate stress effects. The course also introduces strategies for improving stress tolerance in crops.

Learning Outcomes:

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

- Identify different types of plant stresses and their effects on plant physiology.
- Understand the molecular and biochemical responses of plants to stress.
- Analyze plant adaptation and tolerance mechanisms under stress conditions.
- Explore strategies to enhance plant resilience against environmental challenges.
- Apply knowledge of plant stress biology in agricultural and environmental contexts.

Theory : 30 Hours

Unit 1: Introduction to Plant Stress Physiology **02 Hours**

Types (abiotic and biotic), Perception, Acclimation vs Adaptation, Phenotypic plasticity.

Unit 2: Abiotic and Biotic Stress **12 Hours**

Drought stress- Physiological and Biochemical responses, Resistance or Tolerance mechanisms
Salinity- Osmotic and Cytotoxic effects, Ion homeostasis, Salt-tolerant mechanisms: Developmental and Physiological protective mechanisms – exclusion vs tolerance, Osmoprotectants, Ion transporters, Compatible solutes- glycine betaine, proline
Temperature - Cold and heat stress (in brief)
Stress caused by Pathogens, Herbivores, Parasitic plants and Weeds, Susceptibility and Resistance, PR proteins, Pattern-triggered immunity and Effector triggered immunity.

Unit 3: Stress Sensing, Signaling and Tolerance Mechanisms 14 Hours

Hormonal regulation (Abscisic acid, Jasmonic acid, Salicylic acid), Reactive Oxygen Species and Nitrous Oxide, Salt Overly Sensitive pathway, Late embryogenesis abundant proteins (LEA), Antioxidant enzymes (Superoxide dismutase, Catalase, Peroxidase), Osmolytes, Secondary metabolites (Alkaloids, phenolics and terpenoids), Chaperones (Heat Shock Proteins), Cryoprotectants, Phytoalexins

Unit 4: Crop Improvement Strategies 0**2 Hours**

Traditional plant breeding (Mutation breeding, Protected cultivation) and Biotechnological approaches (brief account of stress tolerant genetically engineered plants).

Practicals: 60 hours

- To study the effect of salt stress on seed germination (percentage, plant shoot and root length).
- To study the effect of stress (anyone) on chlorophyll content.
- To determine electrolyte leakage in stressed plants.
- To determine SOD or peroxidase enzyme activity in control and stress plants.
- Study of plant adaptations under stress (Stomatal closure, Leaf curling, Root elongation, Stunted plant growth, Wilting) (through photographs).
- To demonstrate the effect of stress on total protein through 2-D gel electrophoresis profile (through photographs).
- Effect of stress on plant membranes (photographs).
- Effect of biotic stress on plants through photographs (necrosis, rotting, nematode attack, apple scab, SAR) (through photographs).

Suggested Readings:

- Taiz, L., Zeiger, E., Moller, I. M., Murphy, A. (2018). Plant Physiology and Development, 6th edition. New York, NY: Oxford University Press, Sinauer Associates.
- Bhatla, S.C., Lal, M.A. (2018). Plant Physiology, Development and Metabolism. Singapore: Springer Nature, Singapore Pvt. Ltd.
- Giri, B., & Sharma, M. P. (Eds.) (2021). Plant Stress Biology: Strategies and Trends. Springer Nature.
- Buchanan, B. B., Gruissem, W., & Jones, R. L. (Eds.) (2015). Biochemistry and molecular biology of plants. John wiley & sons.

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

Bachelor of Applied Life Sciences with Agrochemicals and Pest Management

SEMESTER VIII

UNIVERSITY OF DELHI

COURSES OFFERED BY DEPARTMENT OF BOTANY FOR SEMESTER-VIII

Under UGCF-2022 based on NEP-2020 (Effective from Academic Year 2022-23)

Department of Botany

Courses offered in B.Sc. Applied Life Science with Agrochemicals and Pest Management

SEMESTER –VIII

(Under UGCF-2022 based on NEP-2020)

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*These courses are already approved.

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credit s	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Agriculture Botany and Weed Management ALS-DSC 8	**4**	**2**	**0**	**2**	**Sem VII**	**Nil**

Course Learning Objectives

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

- Explain the role of plants in agricultural systems and the impact of plant characteristics on crop productivity and adaptation.
- Identify major weeds affecting crop production and understand their biological and ecological characteristics.
- Analyze interactions between crops and weeds and their effects on yield and quality.
- Evaluate weed management strategies, both conventional and modern.
- Apply botanical knowledge to solve practical problems in crop and weed management.

Learning Outcomes

Upon successful completion of the course, students will be able to:

- Describe plant structures and functions essential for crop growth and development.
- Explain physiological processes and their relevance to crop productivity.
- Critically assess various weed control methods, including herbicide classification and mode of action.
- Design integrated weed management plans suited to specific cropping systems and ecological conditions.

Theory : 30 Hours

Unit 1 Seed Physiology and Physiology of Growth and Yield 09 hours

Seed dormancy, types, factors causing dormancy, mechanism and methods for breaking seed dormancy, seed viability and seed vigour, Principal of growth analysis, source-sink relationship, factors affecting growth, dry matter partitioning and yield, crop simulations and modeling, use of controlled environment for plant growth and development studies.

Unit 2: Plant Hormone and Reproductive Physiology 10 Hours

Role of hormones in plant growth and development, commercial applications of growth regulators, growth retardant and its usefulness, Photoperiodism, flowering response, photo perception, critical photoperiod, photo-induction, phytochrome and its role in flowering, vernalization, physiology of fruit ripening, and senescence.

Unit 3: Biology of Weeds and Weed Management Practices 04 Hours

Ecology of weeds, competition, reproduction of weeds, Mechanical Practices, Cultural Practices, Biological control.

Unit 4: Weed Control Methods 07 Hours

Herbicide classification, Selectivity of herbicides, absorption and translocation of herbicides, Mode of action of herbicides, Detoxification mechanisms of herbicides. Weed resistance to herbicides, weed control in wheat, rice and vegetable crops. Control of five obnoxious weeds.

Practical : 60 Hours

- To study opening and closing of stomata.
- To determine stomatal index of the given leaf.
- To study the effect of ethylene on shelf life of cut flowers.
- To study the effect of cytokinin on leaf senescence.
- To study effect of heavy metals on growth and development.
- To test the viability of weed seeds.
- To evaluate the allelopathic effects of weeds on germination of crop seeds.
- To evaluate effect of herbicides on seed germination and seedling growth of weeds.

Suggested Readings:

1. Taiz, L. & Zeiger, E. 2006 Plant Physiology (5th edition) Sinauer Associates, Inc. Sunderland,
2. M.A.W.G. Hopkins (2009) Introduction to plant physiology, John Wiley and Sons Inc USA.
3. Mandal, R.C. (2010) Weeds, weedicides and weed control: Principle and Practice Agro Botanical Publishers, Delhi
4. Das TK (2011) Weed Science: Basics and Applications JPublisher ai Brothers
5. F. M. Ashton and T. J. Monaco (2002) *Weed Science: Principles and Practices*. John Wiley and Sons. Inc.
6. V. S. Rao (2002) *Principles of Weed Science.* Oxford and IBH Publishers, New Delhi

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

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Biofertilizers ALS-DSE 10	4	2		2	7Th Sem	**Nil**

Course 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.

Theory : 30 Hours

Unit 1: Introduction **08 hours**

Introduction to microbial inoculants or biofertilizers, macro and micro nutrition of plants, chemical fertilizers versus biofertilizers; Role of seaweed liquid fertilizers, 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 and Role of Cyanobacteria 09 hours

Study of important microbial inoculants: *Rhizobium*, *Azospirillum*, *Azotobacter*, Actinorhizae; Characteristics, isolation, identification, and crop response, Role of Cyanobacteria (blue-green algae) in rice cultivation; *Azolla* and *Anabaena azollae* association, nitrogen fixation, and factors affecting growth.

Unit 3: Mycorrhizal association 08 hours

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 4: Organic farming 05 hours

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

Practical: (60 Hours)

1. Study of *Rhizobium* from root nodules of leguminous plants by Gram staining method.
2. Observation of arbuscular mycorrhizal fungi from plant roots.
3. Isolation of arbuscular mycorrhizal spores from rhizosphere soil.
4. Isolation of *Anabaena* from *Azolla* leaf.
5. Study of Earthworm, *Azolla*, AMF: Arbuscules-vesicles through specimen / digital resources.
6. Study of Biocontrol methods and their application -Pheromone trap, *Trichoderma*, *Pseudomonas*, Neem etc. through digital resources.
7. Rapid test for pH, $NO3^{-}$, $SO4^{2-}$, Cl^{-} and organic matter of different composts.
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 ofat least 6 Hours and a dissertation submission).

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.

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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 and Management **ALS-DSE 11**	**4**	**2**	**0**	**2**	**Sem VII**	**Nil**

Course 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

Theory : 30 Hours

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 and their treatment **10 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, Treatment of toxic compounds: Role of immobilized cells/enzymes, microbial remediation, Biopesticides, bioreactors, bioleaching, biomining, biosensors, biotechniques for air pollution abatement and odour control. Bioindicators and Bioprospecting

Unit 4: Legislations and Policies for Environmental Protection **08 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, 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 microbes suspended 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.

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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 ALS-DSE 12	4	2	0	2	**Sem VII**	**Nil**

Course 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.

Theory : 30 Hours

Unit 1: Introduction to Plant Diseases and Diagnosis **10 Hours**

Definition; History of Plant Pathology, Concept and basic components of disease; Causes and classification of diseases; Disease cycle; Significance of plant diseases, 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 2: 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 3: 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 4: 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 gormenis tritici* 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.

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 **ALS-DSE 13**	**4**	**2**	**0**	**2**	**Sem VII**	**None**

Course Learning Objectives

The Learning Objectives of this course are as follows:

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

Learning outcomes

The Learning Outcomes of this course are as follows:

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

Theory : 30 Hours

Unit 1: Introduction to Protected Agriculture **02 hours**

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

Unit 2: Plant Growth Requirements and Media formulations **05 hours**

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

Unit 3: Hydroponic growing systems and associated pest & diseases 12 hours

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 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 4: Organic farming and its management, Marketing & Policies 11 hours

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

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

Practical: 60 hours

- Study of various instruments used in hydroponics.
- Preparation of growth media for hydroponics.
- Estimation of NPK, DO, TDS, pH of growing media.
- Demonstration of different irrigation techniques in hydroponics.
- Demonstration of construction of a sustainable hydroponic unit.
- Perform rapid tests for estimation of NPK in different soil samples (samples from at least three different sites).
- Bulk density and porosity of soilless media e.g. coco-peat, perlite, vermiculite,expanded clay, rockwool (any two media).
- Demonstration of growing a leafy vegetable/fruity vegetable/ medicinal herb/aromatic plant in Hydroponics solution.
- Study of traditional organic inputs and formulation of biofertilizer.
- Preparation of biopesticides, plant health promoters like *Panchgavya, Beejamrut*
- etc.
- Field visit to organic farm/hydroponic farm and submission of visit report.

Essential/recommended reading:

- 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 Publishing House, 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 Food Production Systems. Springer, Cham.

Suggestive readings:

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

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CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credit s	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Intelligent Plant Systems **ALS-DSC-14**	**4**	**2**	**0**	**2**	**VII Sem**	**Nil**

Course Learning Objectives

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

Learning outcomes

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

Theory : 30 Hours

Unit 1: Introduction **03 hours**

An Introduction to Plant Structure (Morphological and Anatomical details).

Unit 2: Plants Intelligence and Sensory Biology **06 hours**

Brief History and Introduction to Plant Intelligence and Memory, Cell to cell communication, Self-recognition, Recognition of Neighbors and Relatives.

Unit 3: Learning in Plants **08 hours**

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

Unit 4: Intelligent Behavior 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.

Practicals: **60 hours**

1. Study the structure of plant cell using temporary mount.
2. Study of the cell as an osmotic system (Plasmolysis and De-plasmolysis).
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) Specialized 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.

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