Draft Model Curriculum for 3yr./4yr. Degree Course with Apprenticeship Embedded Degree program

B.Sc. in Botany with Double Major in Tissue Culture & Vertical Gardening

Higher Education Department

Government of Odisha

Under National Education Policy 2020

Semester	Course (paper)	Course Name	Credit
Semester I	MJ -1.1	Microbiology and Phycology	4
	MJ -1.2	Analytical techniques in plant sciences	4
	MJ -1.3	Cell biology	4
	MJ- 1.4	Mycology & Phytopathology	4
	MJ -2.1	Vertical garden: structure, management and landscaping	4
	AEC (Ability Enhancement Courses)	English: Business Communication	4
	VAC (Value Added Course)	Environmental Studies & Disaster Management	3
		TOTAL	**27**
Semester II	MJ 1.5	Archegoniatae	4
	MJ 1.6	Anatomy of Angiosperms and economic botany	4
	MJ 1.7	Genetics	4
	MJ- 1.8	Basic molecular biology	4
	MJ 2.2	Macro-propagation of plants	4
	AEC (Ability Enhancement Courses)	English: Word and Presentation skill	4
	VAC (Value Added Course)	Good Citizenship / **or any other discipline**	3
		TOTAL	**27**
Semester III	MJ 1.9	Plant ecology and phytogeography	4
	MJ 1.10	Plant systematics	4
	MJ 1.11	Reproductive biology of angiosperms	4
	MJ- 1.12	Basic plant physiology	4
	MJ 2.3	Micropropagation for horticultural crops	4
	MJ -2.4	Hardening and nutrition management of micro-propagated plants	4
	MDC (Multidisciplinary Course)	Botany/ **or any other discipline**	3
	SEC (Skill Enhancement Course)	Botany **or/ any other discipline**	3
		TOTAL	**30**
Semester IV	MJ -1.13	Basic plant biotechnology	4
	MJ- 1.14	Basic plant metabolites	4
	MJ- 1.15	Natural resource management	4
	MJ -2.5	Commercial floriculture through vertical gardening, hydroponic and aeroponic	4
	MJ -2.6	Irrigation, fertigation and disease control	4
	MDC (Multidisciplinary Course)	**Botany/or any other discipline**	3
	SEC (Skill Enhancement Course)	**Botany/or any other discipline**	3
		TOTAL	**26**
Semester V	**Internship/Apprenticeship/Industry Training**		**20**
Semester VI	**Internship/Apprenticeship/Industry Training**		**20**
TOTAL			**150**

**** The 4yr. program of AEDP shall be as per 3 yr./4yr. UG Degree Program under NEP-2020***

Programme Objectives:

- To prepare the students for a career in Applied Botany
- To prepare the students for Higher Education and Research in Applied Botany
- To develop a conceptual understanding on vertical gardening and its application.
- To enable the student to acquire basic skills necessary to understand the subject and to master the skills to handle equipment's utilized to learn the subject.
- To promote wider reading on the subject and allied inter disciplinary subject.

Programme Outcome:

- To prepare the students for a career in Botany related Skill Based work Force.
- To prepare the students for Higher Education, Research and Technological interventions in Applied Botany.
- To develop a conceptual understanding of the subject and to develop an inquisitiveness in the subject with practical training for company ready manpower.
- To enable the student to acquire basic skills necessary to understand the subject and to master the skills, to handle equipment's utilized to learn the subject and motivate for startup and agriculture and horticulture related company products.
- To generally promote wider reading on the subject and allied inter-disciplinary subjects for entrepreneurship and product development/technology.

Semester-I

Major-I **Credit-04**

1.1. Microbiology and Phycology

Course Objectives:

- To introduce the diverse group of microorganisms and their habitat relationship.
- To learn the discovery, nature and multiplication of virus particles.
- To know the characteristics, growth and physiology of bacteria and their role in agriculture, health and industry.
- To learn the general characteristics and ecological distribution of bacteria, algae and cyanobacteria and their immense importance to the mankind.
- To have knowledge about the habitats, distribution and diversity of algae in the soil, freshwater and marine environments.

Course Outcomes

- The students learn about the diverse nature of microbes and their interaction with other organisms.
- The students certainly get the opportunities to learn the basics of the nature and impact of viruses.
- The students shall be able to understand the potential of various microbes and the approaches to use them for human welfare.
- The students would be able to identify the important microbes including bacteria, cyanobacteria, and algae available in local environments and understand their beneficial roles.
- The students shall learn about the immense potential the algal resources and understand the methods of cultivation and use of algae.

Unit-I:

Learning Outcome: The learners are able to identify diverse group of microorganisms, general features of viruses and their economic importance**.**

- The microbial world, microbial nutrition, growth and metabolism.
- Viruses**:** Discovery, nature, physicochemical and biological characteristics; classification (Baltimore), general structure with special reference to viroids and prions; replication (a general account), DNA virus (T-phage), lytic and lysogenic cycle; RNA virus (TMV). Economic importance of viruses. Vaccine production, role in research, medicine and diagnostics. Viral plant diseases- symptoms, effect and control

Unit–II:

Learning Outcome: The students understand the growth, physiology and economic importance of bacteria and cyanobacteria.

- Bacteria**: -** Discovery, general characteristics, types- archaebacteria, eubacteria,mycoplasma and spheroplasts, Cell structure, inclusions, nutrition, reproduction-vegetative, asexual and recombination (conjugation, transformation and transduction). Economic importance of bacteria with reference to their role in agriculture, medicine and industry.
- Cyanobacteria**:-** Ecology, occurrence, cell structure, heterocyst, reproduction, economic importance; role in biotechnology. Morphology and life-cycle of *Nostoc*. General characteristics of prochlorophyceae, Evolutionary significance of Prochloron.

Unit–III:

Learning Outcome: The students able to grasp the general characteristics, ecological distribution and economic importance of algae.

- **Algae: -** General characteristics; Ecology and distribution; range of thallus organization; Cell structure and components; cell wall, pigments, reserve food (of only groups represented in the syllabus), flagella; methods of reproduction. Classification; criteria, system of Fritsch, and evolutionary classification of Lee (only up to groups); Role of algae in the environment, agriculture, biotechnology and industry.
- **Chlorophyta: -** General characteristics, occurrence, range of thallus organization, cell structure and reproduction. Morphology and life cycles of *Chlamydomonas*, *Volvox*, *Oedogonium* and *Coleochaete*.

Unit-IV:

Learning Outcome: The students will able to understand the general characteristics, ecological distribution and economic importance of algae and cyanobacteria.

- **Charophyta:-** General characteristics; occurrence, morphology, cell structure and life-cycle of *Chara*; evolutionary significance.
- **Xanthophyta:-** General characteristics; Occurrence, morphology and life- cycle of *Vaucheria*.
- **Phaeophyta:-**Characteristics, occurrence, cell structure and reproduction. Morphology and life-cycles of *Ectocarpus* and *Fucus*.
- **Rhodophyta:-**General characteristics, occurrence, cell structure and reproduction. Morphology and life-cycle of *Polysiphonia*.

Practical:

1. Electron micrographs/Models of viruses –T-Phage and TMV, Line drawings/ Photographs of Lytic and Lysogenic Cycle.
2. Types of Bacteria to be observed from temporary/permanent slides/photographs.
3. Examination of bacteria from bacterial culture by Gram's staining method.
4. Electron micrographs of bacteria, binary fission, endospore, conjugation, root Nodule (live materials and photographs).
5. Bacterial growth measurement by turbidometry
6. Hemocytometry
7. Colony counting using colony counter
8. Phycology: - Study of vegetative and reproductive structures of *Nostoc*, *Chlamydomonas* (electronmicrographs), Volvox, *Oedogonium, Coleochaete, Chara, Vaucheria, Ectocarpus, Fucus* and *Polysiphonia, Procholoron*, Diatoms through, temporary preparations and permanent slides

Textbooks:

- ✓ *Singh, V., Pandey, P.C., and Jain, D.K. (2017). Microbiology and Phycology,Rastogi Publication, Meerut.*
- ✓ *Pandey BP (2022). Botany for B.Sc. Students (Archigoniates & Plant Architecture), S. Chand publication, New Delhi*
- ✓ *Dubey RC & Maheshwari DK (2021) A text book of Microbiology, S. Chand publication, New Delhi*
- ✓ *Pandey BP (2023). Botany for B.Sc. Students Semester I, NEP 2020; S. Chand publication, New Delhi*

Reference Books:

- ✓ *Lee, R.E. (2008). Phycology, Cambridge University Press, Cambridge. 4th edition.*
- ✓ *Prescott, L.M., Harley J.P., Klein D. A. (2010). Microbiology, McGraw-Hill, India. 8th edition.*
- ✓ *Kumar, H.D. (1999). Introductory Phycology. Affiliated East-West Press, Delhi.*
- ✓ *Campbell, N.A., Reece J.B., Urry L.A., Cain M.L., Wasserman S.A. Minorsky P.V., Jackson R.B. (2008). Biology, Pearson Benjamin Cummings, USA. 8th edition.*
- ✓ *Pelczar, M.J., Chan, E.C.S., Krieg, N.R. (2011) Microbiology, 8th edition, Tata McGraw-Hill Co, New Delhi.*
- ✓ *Willey, Sherwood and Christopher. Laboratory exercises in Microbiology. McGraw- Hill, India. 9th edition.*
- ✓ *Vasistha B.R. (2017) Botany for Degree student, Algae, S. Chand Publication, New Delhi.*
- ✓ *Mishra B. K. (2018) Microbiology and Phycology, Kalyani Publishers, New Delhi.*

Major I **Credit-04**

1.2 Analytical Techniques in Plant Sciences

Course Objective

- To learn the principles and operations of microscopes of various complexity and their application in biological studies.
- To learn the techniques of centrifugation for separation of biological samples.
- To learn the methods of radioisotopes measurement in and their importance in study of biological materials and processes.
- To understand and the principles and applications of spectrophotometry and to understand the basic structural design of a standard instrument.
- To learn about various chromatographic techniques in separation of plant extracts.
- To acquaint the students with the advanced methods for characterization of biomolecules

Course Outcomes:

- Proper understanding of the microscopy and knowledge to analyze plant samples using electron microscopy and flow Cytometer.
- Separation of biomolecules and cell organelle and appropriate application of the knowledge of centrifugation for the same.
- Basic knowledge on the use of radioisotopes for analysis of biological samples.
- Extraction and qualitative and quantitative analysis of extracts as well as the assay mixtures using spectrophotometer.
- Skilful application of chromatographic techniques for separation of amino acids, pigments and biomolecules.
- Proper method for characterizing protein and nucleic acids and skill on handling electrophoresis equipment for preparation of gels.

Unit-I:

Learning Outcomes: Students will able to acquires knowledge about principles of microscopy and their types.

Imaging and related techniques: Principles of microscopy; Light microscopy; Fluorescence microscopy; Flow cytometry (FACS); Transmission and Scanning electron microscopy – sample preparation for electron microscopy, cryofixation, negative staining, shadow casting, freeze fracture, freeze etching.

Unit-II:

Learning Outcomes: Students will learn about the principles of centrifugation in biomolecule separation and importance of radiography in biological research

Cell fractionation: Centrifugation: Differential and density gradient centrifugation, Sucrose density gradient, $CsCl_2$ gradient, analytical centrifugation, ultracentrifugation. Radioisotopes: Use in biological research, auto-radiography, pulse chase experiment.

Unit-III:

Learning Outcomes: Students will learn about the components and working principle of different types of Spectrophotometer

Spectroscopy: Principles, Components and working mechanism of UV-Visible and Infra-Red spectroscopy, Fluorescence spectroscopy, Chlorophyll *a* fluorescence, Flame photometer, Bomb Calorimeter and Atomic Absorption Spectrophotometer.

Unit-IV:

Learning Outcomes: Students will learn about the separation methods for biomolecules using chromatography and electrophoresis instruments.

- **Chromatography:** Principle of chromatography, paper chromatography, column chromatography, TLC, HPLC, Ion-exchange chromatography, Molecular sieve chromatography, Affinity chromatography.
- **Characterization of proteins and nucleic acids:** Electrophoresis: AGE, PAGE, SDS-PAGE. Mass spectrometry; X-ray diffraction, X-ray crystallography.

Practicals:

1. Study of different microscopic techniques observation through simple and compound microscope
2. Study of PCR using demonstration.
3. To separate pigments by paper chromatography.
4. To separate phytochemicals by thin layer chromatography.
5. Qualitative analysis of total Carbohydrates, Proteins & Lipids.
6. Demonstration of SEM/ Electrophoresis/ Chromatography.
7. Measuring OD using spectroscopy.
8. Beer Lombard's law and its validation

Textbooks:

- ✓ *Patil, C. S. (2017). Advanced Analytical Techniques, ABE Books, New Delhi.*
- ✓ *Pandey BP (2023). Botany for B.Sc. Students Semester I, NEP 2020; S. Chand publication, New Delhi*

Reference Books:

- ✓ *Aneja, K. R. (2014). Laboratory manual of microbiology and biotechnology, Medtech, New Delhi*
- ✓ *Ausubel, F., Brent, R., Kingston, R. E., Moore, D.D., Seidman, J.G., Smith, J.A., Struhl, K. (1995). Short Protocols in Molecular Biology. John Wiley & Sons. 3rd edition.*
- ✓ *Plummer, D.T. (1996). An Introduction to Practical Biochemistry. Tata McGraw-Hill Publishing Co. Ltd. New Delhi. 3rd edition.*
- ✓ *Ruzin, S.E. (1999). Plant Micro technique and Microscopy, Oxford University Press, New York. U.S.A. Pandey, B.P. (2023). Botany for B.Sc. Students Semester I: NEP 2020, S. Chand Publishing.*

Major I **Credit -04**

1.3 Cell Biology

Course Objectives:

- To understand the basic components of prokaryotic and eukaryotic cells and the role of various macromolecules in the cells.
- Understand how the formation of cytoskeleton
- To have an understanding on nucleic acids as the genetic material;
- To learn the basic mechanism of replication of nucleic acids
- Understand how cells undergo mitosis & meiosis

Course Outcomes

- Students will understand the structures and purposes of basic components of prokaryotic and eukaryotic cells, especially macromolecules, membranes, and organelles.
- Students will understand the components of cell wall & cytoskeleton
- Students will understand how these cellular components are used to generate and utilize energy in cells.
- Students will apply their knowledge of cell biology to selected examples of changes or losses in cell function. These can include responses to environmental or physiological changes.
- Students will understand the cellular components underlying mitotic and meiotic cell division.

Unit-I:

Learning Outcomes: Students will understand the orgin, growth and basic components of cell, cell wall & cytoskeleton.

- The Cell: Cell as a unit of structure and function; Characteristics of prokaryotic and eukaryotic cells; Origin of eukaryotic cell (Endosymbiotic theory). Unique features of plant cells
- Plasmodesmata: Structure, role in movement of molecules & macromolecules, comparison with gap junctions.
- Plant Cell wall: Chemistry, structure and function.
- Cytoskeleton: The concept, structure and roles of microtubules, microfilaments and intermediary filament.

Unit–II:

Learning Outcomes: Students will recognize composition of Plasma Membrane and origin, structure, function of cell organelles

- Plasma Membrane: Overview of membrane structure and function; fluid mosaic model; Chemical composition of membranes; Membrane transport – Passive, active and facilitated transport, endocytosis and exocytosis.
- Cell organelles: Endoplasmic Reticulum, Golgi apparatus, Lysosomes & plant Vacuole.

Unit-III:

Learning Outcomes: Students will realize the importance of photosynthesis and cellular respiration

- Cell organelles: Chloroplast, Mitochondria and Peroxisomes: Structural organization & Function.
- Biogenesis & semiautonomous nature of mitochondria and chloroplast.
- Nucleus: Structure-nuclear envelope, nuclear pore complex, nuclear lamina & Function

Unit-IV:

Learning Outcomes: Students will understand the cellular units (DNA& RNA) underlying mitotic and meiotic cell division

- Nucleolus: Structure and function of nucleolus, Chromatin organization, its packaging role of nuclear matrix in chromosome organization and function, matrix binding proteins.
- Nucleic acids: Structure of nitrogenous bases; Structure and function of nucleotides; Types of nucleic acids; Structure of A, B, Z types of DNA; Types of RNA
- Cell division: Eukaryotic cell cycle, different stages of mitosis and meiosis. Cell cycle, Regulation of cell cycle.

Practical:

1. Study of plant cell structure with the help of epidermal peel mount of Onion/Rhoeo
2. Demonstration of the phenomenon of protoplasmic streaming in Hydrilla leaf.
3. Counting the cells per unit volume with the help of hemocytometer. (Yeast/pollen grains).
4. Study the phenomenon of plasmolysis and deplasmolysis.
5. Study of different stages of mitosis and meiosis using acetocarmine and acetoorcine method from Onion root tip and bud respectively.
6. To find out the mitotic index

Textbooks:

- ✓ *Rastogi, V. B. (2016). Introductory Cytology, Kedar Nath & Ram Nath, Meerut*
- ✓ *Verma PS & Agarwal VK (2022) Cell Biology (Cytology, Biomoleculus and Molecular Biology) S Chand Publication ,New Delhi.*
- ✓ *Gupta, P. K. (2017). Biomolecules and Cell Biology, Rastogi Publication, Meerut.*
- ✓ *Kumar S. (2023). Cell biology, Pragati prakashan, Meerut*

Reference Books:

- ✓ *Sahoo, K. (2017) Biomolecules and Cell Biology, Kalyani Publishers, New Delhi.*
- ✓ *Tymoczko, J.L., Berg, J.M. and Stryer, L. (2012) Biochemistry: A short course, 2nd ed., W.H. Freeman*
- ✓ *Nelson, D.L. and Cox, M.M. (2008) Lehninger Principles of Biochemistry, 5th Edition, W.H. Freeman and Company.*
- ✓ *Cooper, G.M. and Hausman, R.E. 2009 The Cell: A Molecular Approach. 5th edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.*
- ✓ *Kumar HD , Molecular Biology 2ed Vikas Publication*
- ✓ *Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. 2009 The World* of the Cell. 7th edition. Pearson Benjamin Cummings Publishing, San Francisco

Major I **Credit-04**

1.4 Mycology and Phytopathology

Course Objectives

- To learn classification and diversity of fungi and their nutritional requirements.
- To learn the life cycle and ecology of some important genera of fungi and their pathogenicity.
- To understand the beneficial fungal interactions.
- To learn about edible fungi and their role in human nutrition.
- To learn the beneficial application of fungi in agriculture and medicine.
- To know the phyto-pathological processes and the method of their prevention and control.

Course Outcomes

- Have an idea on the vast fungal diversity in nature and method of their identification and culture.
- Know the life cycle of commonly occurring fungal genera and the disease caused by them.
- Have knowledge on the types of fungal associations and their importance.
- Have knowledge and skill on the application of fungi and fungal biomolecules in human welfare.
- Have skill to understand the host - parasite relationship and its role in establishment of viral, fungal and bacterial diseases in plants.
- Understand the causes and conditions for commonly occurring plant diseases and the methods of their control.

Unit-I:

Learning Outcomes: To introduce the students with the classification and diversity of fungi and their nutritional requirements**.**

- Introduction to true fungi: Definition, General characteristics; Affinities with plants and animals; Thallus organization; Cell wall composition; Nutrition; Classification; spore of fungi
- Zygomycota: General characteristics; Ecology; Thallus organization; Life cycle with reference to *Rhizopus*.
- Ascomycota: General characteristics (asexual and sexual fruiting bodies); Ecology; Life cycle, Heterokaryosis and parasexuality; life cycle and classification with reference to *Saccharomyces, Aspergillus*, *Penicillium,* and *Neurospora.*
- Basidiomycota: General characteristics; Ecology and Classification; Life cycle of *Puccinia* and *Agaricus*.

Unit-II:

Learning Outcomes: To introduce the students with the general characteristics, classification of allied fungi and the beneficial symbiotic asociations.

- **Allied Fungi:** General characteristics; Status of Slime molds, Classification;Occurrence; Types of plasmodia; Types of fruiting bodies.
- **Oomycota:** General characteristic; Ecology; Life cycle and classification with reference to *Phytophthora,* and *Albugo.*
- **Symbiotic associations**: Lichen – Occurrence; General characteristics; Growth forms and range of thallus organization; Nature of associations of algal and fungal partners; Reproduction. Economic importance of Lichens, Mycorrhiza-Ectomycorrhiza, Endomycorrhiza and their significance.

Unit-III:

Learning Outcomes: To introduce the students with the role of fungi in food industries, agriculture and medicine.

Applied Mycology: Role of fungi in biotechnology & research, Mushroom cultivation, Application of fungi in food industry (Flavor & texture, Fermentation, Baking,Organic acids, Enzymes, Mycoproteins); Secondary metabolites (Pharmaceutical preparations); Agriculture (Biofertilizers); Mycotoxins; Biological control (Mycofungicides, Mycoherbicides, Mycoinsecticides, Myconematicides); Medical mycology.

Unit-IV:

Learning Outcomes: To introduce the students with the phytopathological processes and method for prevention and control of plant diseases.

- **Phytopathology:** Terms and concepts; General symptoms; Geographical distribution of diseases; etiology; symptomology; Host- Pathogen relationships; disease cycle and environmental relation; prevention and control of plant diseases, and role of quarantine. **Bacterial diseases** – Citrus canker and angular leaf spot disease of Cotton. Viral diseases – Tobacco Mosaic, Vein Clearing. Fungal diseases – Early blight of potato, Loose and covered smut.

Practical:

1. Introduction to the world of fungi (Unicellular, coenocytic/ septate mycelium, ascocarps & basidiocarps).
2. *Rhizopus*: study of asexual stage from temporary mounts and sexual structures through permanent slides.
3. *Aspergillus, Penicillium and Saccharomyces*: study of asexual stage from temporary mounts. Study of Sexual stage from permanent slides/photographs.
4. *Puccnia* : Study of different stages from temporary mounts and permanent slides.
5. *Agaricus*: Specimens of button stage and full-grown mushroom; sectioning of gills of Agaricus, and fairy rings are to be shown.
6. *Albugo*: Study of symptoms of plants infected with *Albugo*; asexual phase study through section/ temporary mounts and sexual structures through permanent slides.
7. Phytopathology: Herbarium specimens of bacterial diseases; Citrus Canker; Viral diseases: Mosaic disease of ladies' finger, papaya, cucurbits, moong, black gram, Fungal diseases: Blast of rice, Tikka disease of ground nut, powdery mildew of locally available plants and White rust of crucifers.

Text Books:

- ✓ *Mishra, B. K. (2017), Mycology and Phytopathology, Kalynai Publishers, New Delhi.*
- ✓ *Pandey BP (2022).Plant Pathology, S. Chand publication, New Delhi*

Reference Books:

- ✓ *Sharma, P. D. (2017). Mycology and Phytopathology Rastogi Publication, Meerut.*
- ✓ *Agrios, G.N. (1997) Plant Pathology, 4th edition, Academic Press, U.K.*
- ✓ *Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996). Introductory Mycology, John Wiley &Sons (Asia) Singapore. 4th edition.*
- ✓ *Webster, J. and Weber, R. (2007). Introduction to Fungi, Cambridge University Press, Cambridge. 3rd edition.*
- ✓ *Sethi, I.K. and Walia, S.K. (2011). Text book of Fungi and Their Allies, Macmillan Publishers India Ltd.*

- ✓ *Mehrotra, R. S. (2011). Plant Pathology. Tata Mc Graw-Hill Publishing Company Limited, New Delhi*
- ✓ *Vashishta B.R, Sinha A.K & Kumar. A Botany For Degree Students : FUNGI (S chand Publica) New Delhi*
- ✓ *Dubey RC & Maheshwari DK (2021) A text book of Microbiology, S. Chand publication, New Delhi*

Major-II **Credit 04**

2.1 Vertical Gardening Structure, Management and Landscaping

Course Objectives:

- To train students on the structural design for establishing a vertical garden.
- To build up exposure on interiors and exterior vertical gardens.
- To understand the technologies, and have knowledge to establish vertical gardens for obtaining esthetic valences, benefit for environment and human health.
- To have knowledge on constructing and maintaining the vertical gardens.
- To have and understanding on modern concepts for landscape development for vertical gardens.

Course Outcomes:

On completion of the course the students will have

- A basic understanding on the concept, scope and applications of vertical gardens in the urban environment.
- The knowledge on the structural and space requirement for establishing a vertical garden.
- The skill to make benefit cost analysis for establishment and management of a vertical garden.
- The ability to establish a vertical garden to combat climate change related crop production.

Unit I

Origins and rise of vertical gardening through history, Green walls / Living walls; Living wall system structure for pre-vegetated panels, Material used in making panel; plastic, expanded polystyrene, synthetic fabric for supporting plants species; Modular green wall-components, structure and construction;

Vertical Garden Modules -detachable cups/pots, Green wall cup type/ Biowall cups. Vegetated mat wall: Building and installation of modular Green walls: Structures and components for green wall system.

Unit II

Light- General considerations; design for interior and exterior structures for proper lighting. Sun exposure and the surrounding context. Design as per growth habit of plant. Green facades, free standing systems for lighting- fences or columns, modular panels, geotextiles; Supporting structures,

Watering: selection for Succulent and hardy plants, Design for water circulation, and reuse. Cleaning and de-clogging system. Microclimate establishment.

Unit III

Vertical landscaping: concept and importance of landscaping, basic landscape designs; background, contrast, balance and rhythm. Landscaping for plant varieties, growth habits, light requirement. Light exposure and surrounding context.

Landscaping for ornamental, horticultural, foliage and green walls. Versatile applications of vertical gardening for both indoor and outdoor spaces

Unit IV

Management of vertical gardens-structural specifications, space, water, and nutrient management; benefit-cost analysis. Balance-sheet for a vertical garden; maintenance cost, environmental benefit, carbon footprint, temperature management.

Practical Syllabus:

1. The practical steps to design, install, and maintain vertical garden structures.

2. Identification and description of annuals, biennials, trees, shrubs, climbers, indoor plants, cacti and succulents, herbaceous perennials, grasses and bulbous ornamentals.

3. Study and identification of various Horticultural Tools, Planting tools and implements for vertical gardening Practices of various propagation techniques viz. cuttings,

budding, grafting, layering, etc.

4. GI net, iron frame, and PVC pipe structure system for garden and wall.

5. The betel nut wood structure system

6. Visit to commercial nursery units for vertical gardening and hydroponic systems

Textbooks

- ✓ *Arora, J.S. 2006. Introductory Ornamental Horticulture. Kalyani Publishers, Ludhiana*
- ✓ *Bose, Chowdhury and Sharma. 1991.Tropical Garden Plants in colour. Horticulture and allied publishers, 3D Madhab Chatterjee street Kolkata.*
- ✓ *Bose, T.K. Mukherjee, D. 2004. Gardening in India. Oxford & IBH Publishers.*
- ✓ *Chadha, K.L. and Chaudhary, B. 1986. Ornamental Horticulture in India. Publication and Information division. ICAR, New Delhi.*
- ✓ *Chowdhury Bimal Das and Balai Lal Jana.2014.Flowering Garden trees. Pointer publishers, Jaipur. India.*
- ✓ *Peter. K.V. 2009.Ornamental plants. New India publishing agency, Pitampura, New Delhi.*
- ✓ *Randhawa, G.S. Amitabha Mukhopadhyay, 2004. Floriculture in India. Allied Publishers Pvt. Ltd., New Delhi.*
- ✓ *Tiwari A.K. and R. Kumar. 2012. Fundamentals of ornamental horticulture and landscape gardening. New India*

Reference books

- ✓ *Jack Bake, 'Vertical Gardening' Kindle Edition*
- ✓ *The Green Wall (Learning more about vertical Gardening) by DUEEP Jyot Singh, JD_Biz Publishing*
- ✓ *DIY Vertical Gardens by Keri Algar*
- ✓ *Joy of Gardening (How to create and grew Herbs, Vegetables and Fruits in a container and Vertical Garden) by James and Janeen Brown*
- ✓ *Vertical Gardening: A Step-by-Step Guide to Container Gardening with Original Ideas for Your Green Project by Haines, Devon*
- ✓ *The Vertical Garden: From Nature to the City by Patrick Blanc and W.W. Norton, 2008*

AEC Paper I

English: Business Communication

Credits: 4

S. No	Modules	Outcomes
1.	**English Language and Communication: Introduction**	• Communication, its Importance and Factors • Types of Communication • Verbal and Non-verbal Communication • Styles of Communication
2	**English Language and Communication: Listening and Speaking**	• Types of Listening • Speaking to communicate effectively • Style of speaking in Various Situations • English Pronunciation
3	**English Language and Communication: Reading and Writing**	• Reading methods and techniques. • Reading texts to Understand meaning • Writing Process • Writing short and Long texts
4	**English Language and Communication: Grammar and Vocabulary**	• Grammar • Sentence structure • Functions of Language

Reference Book: A Course book for ENGLISH COMMUNICATION (Publisher: Orient BlackSwan)

VAC Paper I

Environmental Studies & Disaster Management

(Credit-3)

Unit 1: Multidisciplinary nature of environmental studies (8 Period)

Definition, scope and importance

Need for public awareness

Environmental Pollution

Definition

• Cause, effects and control measures of:-

a) Air pollution

b) Water pollution

c) Soil pollution

d) Marine pollution

e) Noise pollution

f) Radiation pollution

Unit 2: Natural Resources: (8 Period)

Renewable and non-renewable resources:

Natural resources and associated problems.

a) Forest resources: Use and over-exploitation, deforestation, case studies. Timber extraction, mining, dams and their effects on forest and tribal people.

b) Water resources: Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems.

c) Mineral resources: Use and exploitation, environmental effects of extracting and using mineral resources, case studies.

d) Food resources: World food problems, changes caused by agriculture and overgrazing, effects of modern agriculture, fertilizer-pesticide problems, waterlogging, salinity, case studies.

e) Energy resources: Growing energy needs, renewable and non-renewable energy sources, use of alternate energy sources. Case studies.

Biodiversity:- Introduction-Definition; Biogeographically classification of India

India as a mega diversity nation. Hot sports of biodiversity, Threats to biodiversity. Endangered and endemic species of India. Conservation of biodiversity. In Situ and Ex-so conservation of biodiversity

Unit-3: Disaster Management (8 Period)

1. Disaster Management: Types of disasters (natural and Man-made) and their causes and effect)

2. Vulnerability Assessment and Risk analysis: Vulnerability to various disasters (Flood, Cyclone, Earthquake, Heat waves, Desertification and Lighting)

3. Institutional Framework: Institutional arrangements for disaster management (National Disaster Management Authority (NDMA), State Disaster Management Authority (SDMA), Disaster Management Act, 2005, District Disaster Management Authority (DDMA), National Disaster Response Force(NDRF) and Odisha Disaster Rapid Action Force(ODRAF)

4. Preparedness measures: Disaster Management cycle, Early Warning System, Pre Disaster and Post-Disaster Preparedness, strengthening of SDMA and DDMA, Community Preparedness for flood cyclone, heat waves, fire safety, lightening and snake biting. Stake holders participation, Corporate Social Responsibility (CSR)

5. Survival Skills: Survival skills adopted during and after disaster (Flood, Fire, Earthquake, Cyclone and Lightening), Disaster Management Act-2005, Compensation and Insurance

Unit 4: Social Issues and the Environment (6 Period)

A. a) Environmental Ethics: Issues and possible solutions.

b) Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Case studies

c) Environment Protection Act

d) Air (Preservation Control of Pollution) Act

e) Water (Preservation Control of Pollution) Act

f) Wildlife Protection Act

g) Forest Conservation Act

h) Solid waste management Cause, effect and Control Measure of Urban and Industrial waste (Role of each individual in conservation of Natural resources and prevention of pollution)

B. Human Population and the Environment

Population Ecology: Individuals, species, population, community

Human population growth, population control method

Urbanisation and its effect on society

Unit 5: Field work (15 Periods of 30 hrs)

- Visit to an area to document environmental assets: river/forest/flora/fauna, etc.
- Visit to a local polluted site- Urban/Rural/Industrial/Agricultural
- Study of common plants, insects, birds and basic principles of identification.
- Study of simple ecosystems-pond, river, Delhi Ridge , etc.

Semester II

Major I **Credit -04**

1.5 Archegoniate

Course Objectives

- To know the principles, hypotheses and process of adaptation of plants to land habitat.
- To learn about the origin classification, and characteristics of bryophytes through some representative genera.
- To learn about the origin and distribution of vascular plants and stages of evolution of conducting tissues.
- To study the morphology, and characteristics of pteridophytes through some representative genera.
- To learn the characteristics, classification and importance of the gymnosperms.
- To have a general knowledge on the fossils and fossilization processes.

Course Outcomes:

- Able to understand the mechanism of the evolution of the higher plants and their adaptation to land habit.
- Knowledge on the diversity of archegoniates and their and their pattern of habitat specific distribution.
- Knowledge on the characteristics of bryophytes and skill to differentiate the genera on the basis of their morphology and anatomy.
- Ability to identify the members of pteridophytes and knowledge on their characteristic features.
- Understand the unique features and distribution of gymnosperms.
- Capacity to analyze various types of fossils on the basis of their characters.

Unit-I:

Leaning Outcomes: The students will gain knowledge on the basic characteristics of Archegoniates.

- Introduction: Unifying features of archegoniates; Transition to land habit; Alternation of generations. General characteristics; Origin of land plants and Adaptations to land habit;
- Bryophytes: Origin and Classification; Range of thallus organization. Classification (up to family). Structure, Reproduction and evolutionary trends in *Riccia*, *Marchantia*, *Anthoceros* and *Funaria* (developmental stages not included).
  Ecological and economic importance of bryophytes.

Unit-II:

Leaning Outcomes: The learners shall acquire an understanding on the origin, evolution and structural uniqueness of pteridophytes.

Pteridophytes: General characteristics, classification. Classification (up to family), morphology, anatomy and reproduction of *Psilotum*, *Selaginella*, *Equisetum, Pteris* and *Marsilea*. Apogamy, and apospory, heterospory and seed habit, telome theory, stellar evolution and economic importance.

Unit-III:

Leaning Outcomes: The learners shall have the skill to identify and evaluate the importance of gymnosperms in a habitat

Gymnosperms: General characteristics, classification (up to family), morphology, anatomy and reproduction of *Cycas*, *Pinus, Ginkgo* and *Gnetum*. (Developmental details not to be included). Ecological and economic importance.

Unit-IV:

Leaning Outcomes: The student will have knowledge to identify and analyze a fossil specimen.

Palaeobotany: Geological time scale, fossils and fossilization process. Morphology, anatomy and affinities of *Rhynia, Calamites, Lepidodendron, Lyginopteris, Cycadeoidea and Williamsonnia*.

Practical:

1. Morphology, anatomy and reproductive structures of *Riccia, Marchantia, Anthoceros, Funaria.*
2. *Psilotum*- Study of specimen, transverse section of synangium (permanent slide).
3. *Selaginella*- Morphology, whole mount of leaf with ligule, transverse section of stem, whole mount of strobilus, whole mount of microsporophyll and megasporophyll (temporary slides), longitudinal section of strobilus (permanent slide).
4. *Equisetum*- Morphology, transverse section of internode, longitudinal section of strobilus, transverse section of strobilus, whole mount of sporangiophore, whole mount of spores (wet and dry) (temporary slide), transverse section of rhizome (permanent slide).
5. Study of temporary preparations and permanent slides of *Marsilea*.
6. *Pteris*- Morphology, transverse section of rachis, vertical section of sporophyll, whole mount of sporangium, whole mount of spores (temporary slides), transverse section of rhizome, whole mount of prothallus with sex organs and young sporophyte (permanent slide).
7. *Cycas*- Morphology (coralloid roots, bulbil, leaf), whole mount of microsporophyll and megaspore, T.S root, leaflet, rachis
8. *Pinus*- Morphology (long and dwarf shoots, whole mount of dwarf shoot, male and female cones), T.S. Needle, stem, L.S. male cone, whole mount of microsporophyll, whole mount of Microspores (temporary slides), L.S. of female cone.
9. *Gnetum*- Morphology (stem, male & female cones), transverse section of stem, vertical section of ovule (permanent slide).
10. Study of some fossil slides / photographs as per theory.

Textbooks:

- ✓ *Vasistha, B. R. (2017) Botany for Degree student, Bryophyta, S. Chand Publication, New Delhi.*
- ✓ *Singh, V., Pandey, P.C. and Jain, D.K. (2017). Archegoniate, Rastogi Publication, Meerut.*
- ✓ *Pandey B.P (2020) Botany For Degree Students NEP S Chand Publication New Delhi.*

Reference Books:

- ✓ *Acharya, B. S. (2017), Archegoniate, Kalyani Publishers, New Delhi.*
- ✓ *Vashistha, P.C., Sinha, A.K., Kumar, A. (2010). Pteridophyta. S. Chand. New Delhi, India.*
- ✓ *Bhatnagar, S.P. & Moitra, A. (1996). Gymnosperms. New Age International (P) Ltd Publishers, New Delhi, India.*
- ✓ *Raven, P.H., Johnson, G.B., Losos, J.B., Singer, S.R. (2005). Biology. Tata McGraw Hill, Delhi.*
- ✓ *Rashid. A. An Introduction To Archegoniate Plants (Vikas Publication) New Delhi.*

Major -I **Credit- 04**

1.6 Anatomy of Angiosperms & Economic Botany

Course Objectives

- To explain the tissues and tissue systems in plants.
- To explain the organization of shoot and root apices.
- To educate the students on the activity of meristems for primary and secondary growth of plants
- To explain about various types of woods in plants and their developmental pattern.
- To give a comprehensive idea about economic botany and its importance in human welfare.
- To provide knowledge on general account, cultivation, propagation and uses of common crops.

Course Outcomes:

- The ability to examine the internal anatomy of plant systems and organs.
- Develop a critical understanding of the evolution of the concept of organization of shoot and root apex.
- Evaluate the adaptive and protective morphological systems of plants.
- Be able to know the origin and evolution of crops and the importance of wild relatives in crop improvement.
- Develop a basic knowledge on germplasm and the basics for their conservation.
- Have an understanding of plants as a source of food, beverages, spices, and materials and its application in human welfare.

Unit-I:

Learning Outcomes: Students will learn about the plant tissues and their anatomical structures. They will also learn about adaptive modifications in plants to adjust at different environments**.**

- Introduction and scope of Plant Anatomy: Applications in systematics, forensics and pharmacognosy.
- Tissues: Classification of tissues; Simple and complex tissues (no phylogeny); cyto-differentiation of tracheary elements and sieve elements; Pits and plasmodesmata; Cell wall ingrowths and transfer cells, adcrustation and incrustation, Ergastic substances.
- Adaptive and Protective Systems: Epidermal tissue system, cuticle, epicuticular waxes, trichomes (uni-and multicellular, glandular and non-glandular: two examples of each), stomata (classification); Anatomical adaptations of xerophytes and hydrophytes.

Unit-II:

Learning Outcomes: Students will learn about the leaf anatomical components. They will also learn about the organization of root and shoot system in plant.

- **Leaf:** Anatomy of dicot and monocot leaf, Kranz anatomy.
- **Stem:** Organization of shoot apex (Apical cell theory, Histogen theory, Tunica Corpustheory, continuing meristematic residue, cyto-histological zonation); Types of vascular bundles; Anatomy of dicot and monocot stem. Vascular Cambium: Structure, function and seasonal activity of cambium; secondary growth in stem(normal and anomalous). Root Stem transition.
- **Root:** Organization of root apex (Apical cell theory, Histogen theory, Korper-Kappe theory); Quiescent centre; Root cap; Anatomy of dicot and monocot root; Endodermis, exodermis and origin of lateral root. Secondary growth in roots

Unit-III:

Learning Outcomes: Students will learn about the plant domestication and cultivation of important crop pla**nts.**

- **Origin of Cultivated Plants**: Concept of Centers of Origin, their importance with reference to Vavilov's work. Examples of major plant introductions; Crop domestication and loss of genetic diversity; evolution of new crops/varieties, importance of germplasm diversity.
- **Cereals:** Cultivation and brief account of Wheat, Rice and millets.
- **Legumes:** General account, importance to man and ecosystem.
- **Sugars & Starches**: Morphology, cultivation and processing of sugarcane, products and by-products of sugarcane industry. Potato – morphology, cultivation, propagation & uses.

Unit –IV:

Learning Outcomes: Students will learn about the important timber, spice, oils and fats and drug yielding plants.

- **Timber plants**: General account with special reference to teak and pine. Fibers: Classification based on the origin of fibres, Cotton and Jute (morphology, extraction and uses).
- **Spices:** Listing of important spices, their family and part used, economic importance with special reference to fennel, saffron, clove and black pepper Beverages: Tea, Coffee (morphology, processing & uses).
- **Oils & Fats**: General description, classification, extraction, their uses and health implications groundnut, coconut, linseed and *Brassica* (Botanical name, family & uses)
- **Drug-yielding plants**: Therapeutic and habit-forming drugs with special reference toCinchona, Digitalis, Papaver and Cannabis

Practical:

1. Epidermal system: cell types, stomata types; trichomes: non-glandular and glandular.
2. Root: monocot, dicot, secondary growth.
3. Stem: monocot, dicot - primary and secondary growth (normal and anomalous); periderm; lenticels.
4. Leaf: isobilateral, dorsiventral, C4 leaves (Kranz anatomy).
5. Ecological anatomy.
6. Cereals: Rice (habit sketch, study of paddy and grain, starch grains).
7. Legumes: Soya bean/moong bean/black gram, Groundnut, (habit, fruit, seed structure, micro-chemical tests).
8. Spice and Beverages: clove, black pepper, Tea (plant specimen, tea leaves), Coffee (plant specimen, beans).
9. Fiber-yielding plants: Cotton (specimen, whole mount of seed to show lint and fuzz; whole mount of fiber and test for cellulose), Jute (specimen, transverse section of stem, test for lignin on transverse section of stem and fiber).

Textbooks:

- ✓ *Singh, V., Pandey, P.C. and Jain, D.K. (2017). Anatomy of Angiosperms, Rastogi Publication, Meerut.*
- ✓ *Pandey, B. P. (2017) Plant Anatomy, S. Chand Publication, New Delhi.*
- ✓ *Pandey, B. P. (2017) Economic Botany , S. Chand Publication, New Delhi.*

Reference Books:

- ✓ *Eames, A.J. and Mc Daniels, L.H., (1953). An introduction to plant anatomy, Tata Mc Grow Hills, New Delhi*
- ✓ *Esau, K. (1977). Anatomy of Seed Plants. John Wiley & Sons, Inc., Delhi.*
- ✓ *Tayal, M. S. (2012) Plant Anatomy Rajpal and Sons, New Delhi*
- ✓ *Mishra, B. K. (2017). Anatomy of Angiosperms, Kalyani Publishers, New Delhi.*
- ✓ *Pandey, B. P. (2017) Plant Anatomy, S. Chand Publication, New Delhi.*
- ✓ *Kochhar, S.L. (2012). Economic Botany in Tropics, MacMillan & Co. New Delhi, India.*
- ✓ *Samba Murty, A.V.S.S. and Subrahmanyam, N.S. (2011). Text Book of Modern Economic Botany, CBS Publishers and Distributors, New Delhi.*
- ✓ *Hill, Albert F. Economic Botany, Tata Mc Grow Hill Publishing Company, Ltd. New Delhi.*
- ✓ *Wickens, G.E. (2001). Economic Botany: Principles & Practices. Kluwer Academic Publishers, The Netherlands.*
- ✓ *Singh, V., Pandey, P.C. and Jain, D.K. (2017). Economic Botany, Rastogi Publication, Meerut.*
- ✓ *Baruah, B. (2017). Economic Botany, Kalyani Publishers, New Delhi.*

Major I **Credit 04**

1.7 Genetics

Course Objective

- To know general organization, possible function, and frequency of genes and non-gene DNA sequences in a typical eukaryotic genome.
- Practical methodology for applying Mendelian laws (heavily reliant on problem solving).
- Extensions of Mendelian genetics, including different forms of allelic relationships.
- To know different types of mutations, affect genes and the corresponding mRNAs and proteins.
- Inheritance of linked genes, including recombination mapping, and the physical basis of these rules (chromosomal behaviour during meiosis)

Course Outcomes:

- Learn the basic principles of inheritance at the molecular, cellular and organismal levels.
- Understand the mechanism of inheritance and its relationship with the expression of morphological traits.
- Understand the relationships between molecule/cell level phenomena ("modern" genetics) and organism-level patterns of heredity ("classical" genetics)
- Know about the variations by polyploidy, chromosomal aberration and gene mutations.
- Test and deepen their mastery of genetics by applying this knowledge in a variety of problem-solving situations

Unit-I:

Learning Outcomes: To acquire the basic principles of inheritance at the molecular, cellular and organismal levels

- Mendelian genetics and its extension Mendelism: History; Principles of inheritance; Chromosome theory of inheritance; Autosomes and sex chromosomes; Incomplete dominance and codominance; Multiple alleles, Lethal alleles, Interaction of genes, Pleiotropy, Recessive and Dominant traits, Polygenic inheritance.
- Extrachromosomal Inheritance: Chloroplast mutation: Variegation in Four o'clock plant; Mitochondrial mutations in yeast; cytoplasmic male sterility; Maternal effects- shell coiling in snail; Infective heredity- Kappa particles in Paramecium.

Unit-II:

Learning Outcomes: Relationships between modern genetics and classical genetics

Linkage, crossing over and chromosome mapping: Linkage and crossing over- Cytological basis of crossing over; Recombination frequency, two factor and three factor crosses; Interference and coincidence; Numerical based on gene mapping; Sex Linkage.

Unit-III:

Learning Outcomes: To develop mutants using different mutagens

- Variation in chromosome number and structure: Deletion, Duplication, Inversion, Translocation, Position effect, Euploidy and Aneuploidy
- Gene mutations: Types of mutations; Molecular basis of Mutations; Mutagens - physical and chemical (Base analogs, deaminating, alkylating and intercalating agents); Detection of mutations: CIB method. Role of Transposons in mutation. DNA repair mechanisms.

Unit-IV:

Learning Outcomes: Applying this knowledge in a variety of problem-solving situations of genetics

- The structure of gene: Classical vs. molecular concepts of gene; Cis-Transcomplementation test for functional allelism; Structure of Phage T4, rII Locus.
- Population and Evolutionary Genetics: Gene pool, Allele frequencies, Genotype frequencies, Hardy-Weinberg Law, role of natural selection, mutation, genetic drift.Genetic variation and Speciation

Practical:

1. Analysis of allelic and genotypic frequencies.
2. Mendel's laws through seed ratios. Laboratory exercises in probability and chi-square analysis.
3. Chromosome mapping using test cross data.
4. Pedigree analysis for dominant and recessive autosomal and sex-linked traits.
5. Incomplete dominance and gene interaction through seed ratios (9:7, 9:6:1, 13:3, 15:1, 12:3:1, 9:3:4).
6. Blood Typing: ABO groups & Rh factor.
7. Chromosome anomaly: Translocation Ring, Laggards and Inversion Bridge, break etc. (through photographs).

Text Books:

- ✓ *Singh B. D. (2017). Fundamental of Genetics, Kalyani Publishers, New Delhi.*
- ✓ *Gupta P. K. (2017). Genetics, Rastogi Publication, Meerut.*
- ✓ *Verma P. S (2022) Genetics Revised Ed. Schand Publication. New Delhi*

Reference Books:

- ✓ *Gardner, E.J., Simmons, M.J., Snustad, D.P. (1991). Principles of Genetics, John Wiley & Sons, India. 8th edition.*
- ✓ *Sinnot, E.W., Dunn, L.C. and Dobzhansky, T. (1985) Principles of Genetics, Tata Mc Grow Hill, New Delhi*
- ✓ *Klug, W.S., Cummings, M.R., Spencer, C.A. (2012). Concepts of Genetics. Benjamin Cummings, U.S.A. 10th edition.*
- ✓ *Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., Doebley, J. (2010). Introduction to Genetic Analysis. W.H. Freeman and Co., U.S.A. 10th edition.*
- ✓ *Strickberger, M.W. Genetics, Pearson Publishers, 3rd Edition*
- ✓ *Rastogi V. B. (2017). Genetics, Kedar Nath & Ram Nath, Meerut*

Major I **Credit 04**

1.8 Basic Molecular Biology

Course Objectives

- To understand the Historical perspective of DNA and DNA as the carrier of genetic information.
- To learn the Organization and structure of DNA and RNA in pro-and eukaryotes.
- To understand the structure and function organellar and nuclear genomes.
- To understand the General principles of replication and the relationship with genetic code.
- To study about Processing and modification of RNA in prokaryotes and eukaryotes for translation.

Course Outcomes:

On completion of the course the students shall

- Be able to describe Organization and structure and replication of DNA and RNA.
- Have theoretical and practical knowledge the prokaryotic and eukaryotic nucleic acids.
- Have a clear understanding on the structure and function of organellar genome.
- Understand the processes of bidirectional, semi-conservative and semi discontinuous mode of replication and the importance of the genetic code.
- Have ability to understand the mechanism of translation in prokaryotes and eukaryotes.

Unit- I:

Learning Outcomes: Students will gain knowledge about historical perspective and experimental proof of nucleic acids as genetic material.

Nucleic acids: Carriers of genetic information: Historical perspective; DNA as the carrier of genetic information (Griffith's, Hershey & Chase, Avery, McLeod; McCarty), Types of genetic material, denaturation and renaturation, cot curves. Organization of DNA and structure of RNA- Prokaryotes, Viruses, Eukaryotes, Fraenkel-Conrat's experiment. Organelle DNA - mitochondria and chloroplast DNA. The Nucleosome – Chromatin structure - Euchromatin, Heterochromatin- Constitutive and Facultative heterochromatin.

Unit-II:

Learning Outcomes: This is to gain knowledge about general principles and mechanism of replication of DNA and RNA processing

The replication of DNA: Chemistry of DNA synthesis (Kornberg's discovery); General principles– bidirectional, semi-conservative and semi-discontinuous replication, RNA priming; Various models of DNA replication, including rolling circle, θ (theta) mode of replication, replication of linear ds-DNA, replication of the 5′ end of linear chromosome; Enzymes involved in DNA replication. Central dogma and genetic code: Key experiments establishing-The Central Dogma (Adaptor hypothesis and discovery of mRNA template), Genetic code (deciphering & salient features).

Unit-III:

Learning Outcomes: This is to learn the Mechanism of Transcription and transcriptional regulation in Prokaryotes and Eukaryotes

- Mechanism of Transcription: Transcription in prokaryotes and eukaryotes;
- Regulation of transcription in prokaryotes and eukaryotes: Principles of transcriptional
- Regulation; Prokaryotes: Operon concept- Regulation of lactose metabolism and tryptophan synthesis in E. coli. Eukaryotes: transcription factors, heat shock proteins, steroids and peptide hormones; Gene silencing
- Processing and modification of RNA: Split genes-concept of introns and exons, removal of

introns, spliceosome machinery, splicing pathways, group I & group II intron splicing, alternative splicing eukaryotic mRNA processing (5′ cap, 3′ polyA tail); Ribozymes, exon shuffling; RNA editing and mRNA transport.

Unit-IV:

Learning Outcomes: Students will gain knowledge on Mechanism of Translation and Translation regulation in Prokaryotes and Eukaryotes**.**

Translation (Prokaryotes and eukaryotes): Ribosome structure and assembly; Charging of tRNA, aminoacyl tRNA synthetases; Various steps in protein synthesis, proteins involved in initiation, elongation and termination of polypeptides; Fidelity of translation; Inhibitors of protein synthesis; post-translational modifications of proteins.

Practical:

1. Preparation of LB medium and raising E. coli.
2. Isolation of genomic DNA from suitable plant material.
3. RNA estimation by orcinol method.
4. DNA estimation by diphenylamine reagent/UV Spectrophotometry.
5. Photographs establishing nucleic acid as genetic material (Messelson and Stahl's, Avery et al, Griffith's, Hershey & Chase's and Fraenkel & Conrat's experiments)
6. Study of Barr body from buccal smear preparation.

Textbooks:

- ✓ *Gupta P. K. (2017). Molecular Biology, Rastogi Publication, Meerut.*
- ✓ *Verma P. S & Agarwal V. K (2022) Molecular Biology Revised Ed. S. chand Publication. New Delhi*

Reference Books:

- ✓ *Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M., Losick, R. (2007).*
- ✓ *Molecular Biology of the Gene, Pearson Benjamin Cummings, CSHL Press, New York, U.S.A. 6th edition.*
- ✓ *Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics. John Wiley and Sons Inc., U.S.A. 5th edition.*
- ✓ *Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. Benjamin. Cummings. U.S.A. 9th edition.*
- ✓ *Sheeler, P. and Bianchi, D.E. (2009) Molecular Biology of the Cell, Willey Publisher, New Delhi*
- ✓ *Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., Doebley, J. (2010). Introduction to Genetic Analysis. W.H. Freeman and Co., U.S.A. 10th edition.*
- ✓ *Alberts, B. et al. 2014. Molecular Biology of the cell Garland Science. 6 th Edition*
- ✓ *Power, C. B. (2017) Cell Biology, Himalaya Publishing House, New Delhi*
- ✓ *Sahu, A.C. (2017). Essentials of Molecular Biology, Kalynai Publishers, New Delhi.*
- ✓ *Kumar H. D Molecular Biology 2nd Ed.Vikas Publication New Delhi.*

Major II **Credit 04**

2.2 Macro-propagation of plants

Course Objectives:

- To provide basic knowledge on the concepts of micropropagation.
- To explain various processes of micropropagation of horticulture and garden plants.
- To train students on the layering techniques for various plant types.
- To understand the benefits of micropropagation of economically valuable plants.

Course Outcomes:

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

- Explain various methods plant propagation and their utilization.
- Understand advantages and disadvantages of vegetative, asexual and sexual plant propagation methods.
- Assess the benefits of asexual propagation of certain economically valuable plants.
- Demonstrate skills related to vegetative plant propagation techniques.
- Apply a specific macro-propagation technique for a given plant species.

Unit I

Basic concepts of macro-propagation: Definition, need and potentialities of macro-propagation; asexual and sexual methods of propagation - advantages and disadvantages. Propagation facilities: Mist chamber, humidifiers, greenhouses, glasshouses, cold frames, hot beds, poly-houses, phytotrons nursery - tools and implements. Identification and propagation by division and separation: Bulbs, pseudobulbs, corms, tubers and rhizomes; runners, stolon, suckers and offsets.

Unit II

Apomixis: Definition, facultative and obligate; types – recurrent, non-recurrent, adventitious and vegetative; advantages and disadvantages. Polyembryony: Definition, classification, horticultural significance; chimera and bud sport. Propagation of foliage and flowering plants using apomictic embryos.

Layering: Definition, principle and factors influencing layering. Plant propagation by layering: Ground layering – tip layering, simple layering, trench layering, mound (stool) layering and compound (serpentine layering). Air layering technique – application in woody trees.

Unit III

Cuttings: Definition, different methods of cuttings; root and leaf cuttings.

Stem cuttings: Definition of stem tip and section cuttings; plant propagation by herbaceous, soft -wood, semi hard wood, hard wood and coniferous stem cuttings. Physiological and bio chemical basis of rooting; factors influencing rooting of cuttings; Use of plant growth regulators in rooting of cuttings.

Unit IV

Grafting: Definition, principle, types, graft incompatibility, collection of scion wood stick, scion-stock relationship, and their influences, bud wood certification; micrografting. Propagation by veneer, whip, cleft, side and bark grafting techniques. Budding: Definition; techniques of 'T', inverted 'T', patch and chip budding.

Practical Syllabus

1. Preparation of nursery beds – flat, raised and sunken beds.

2. Propagation through apomictic process

3. Propagation by separation and division technique.

4. Propagation by cuttings.

5. Propagation by layering.

6. Propagation by grafting.

7. Propagation by budding

Textbooks

- ✓ *Ramawat K G & Goyal S Comprehensive Biotechonology 4th ed S chand Publication New Delhi.*
- ✓ *Chawla, H. S. (2010). Introduction to Plant Biotechnology. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.*
- ✓ *Singh, B. D. (2018). Plant Biotechnology Kalyani Publishers, New Delhi.*

Reference Books

- ✓ *Bhojwani, S.S. and Razdan, M.K., (1996). Plant Tissue Culture: Theory and Practice. Elsevier Science Amsterdam. The Netherlands.*
- ✓ *Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington.*
- ✓ *Stewart, C.N. Jr. (2008). Plant Biotechnology & Genetics: Principles, Techniques and Applications. John Wiley & Sons Inc. U.S.A.*
- ✓ *Gupta, P. K. (2017). Plant Biotechnology, Rastogi Publication, Meerut.*
- ✓ *Dubey, R. C. (2017). Advanced Biotechnology, S, Chand Publication, New Delhi*

AEC Paper II

English: Word and Presentation skill

Credits: 4

S. No	Modules	Outcomes

1.	**Basic Communication**	● Explain: ○ Structures in present and present continuous tense ○ Structures in past & past continuous tense ○ Structure in present perfect & present perfect continuous tense ○ Structures in future tense ○ Modals: helping verbs ○ Prepositions ○ Idioms ● Practice speech on a given topic. ● Practice Extempore speech
2	**Communication**	● Describe communication. ● Describe the Process of communication. ● Discuss the Importance of communication ● Explain various Types of communication. ● Demonstrate Useful Phrases for Everyday Use ● Explain the technique of Asking Questions
3	**Hotel English**	● Describe the Essential qualities of a good speaker. ● Discuss Speech improvement- pronunciation. ● Explain the importance of Stress in speech. ● Describe Intonation and modulation. ● Describe Common phonetics- difficulties

VAC Paper I

Good Citizenship

Credits:3

Objectives/Learning Goals of the Course

- Development of good human being and a responsible citizen
- Developing a sense of right and wrong leading to ethically correct behavior.
- Inculcating a positive attitude and a healthy work culture.

Learning Objectives:

- Understanding Basic Values of Indian Constitution.
- Understand how to be a patriot.
- Develop professionalism and understand the ethics relating to various professions.

1. **Indian Constitution (1 Credit= 15 hours)**

   Salient Values of Preamble: Sovereign, Socialist, Secular, Democratic, Republic, Justice, Liberty, Equality and Fraternity

2. **Patriotism (1 Credit= 15 hours)**

   Patriotic Value and ingredients of nation building, Concept of Good Citizenship, Emotional connection with the country, Duties of citizens and Qualities of good citizens

3. **Work Ethics (1 Credit= 15 hours)**

   Punctuality, Cleanliness, Law abidingness, Rational Thinking and Scientific Temper

Semester -III

Major I **Credit 04**

1.9 Plant Ecology & Phytogeography

Course objectives

- To learn the interaction of biotic components with non-living components of an ecosystem.
- To introduce to various natural ecosystems and how the interaction among different biotic and abiotic factors influencing the stability and diversity of an ecosystem.
- To study the physical, biological and chemical characteristics of factors influencing population.
- To know the experimental approach to determine the physical, chemical and organic matters of soil.
- To introduce the students to the characteristics and dynamism of population ecology.

Course Outcomes:

- Have ability to understand the ecological functioning of ecosystems and would certainly help students to maintain the local ecosystems.
- Have information on species' geographical range and how the size and life history influenced by the various components of ecosystems.
- An understanding of the factors that influence patterns of abundance and distribution in populations.
- Have knowledge on the process of soil formation and approaches to study the nature of soils.
- Have skill to evaluate the dynamics of change of population characteristics.

Unit-I:

Learning Outcomes: The students learn the concept of ecology and inter-relationships between the living world and its environment.

- Introduction and Concept of ecology, Autoecology, Synecology, System ecology: Levels of organization. Inter-relationships between the living world and the environment, the components of environment, concept of hydrosphere and lithosphere and dynamism, homeostasis.
- Light, temperature, wind and fire.Variations; adaptations of plants to their variation.

Unit-II:

Learning Outcomes: The students get idea on the formation, composition and profile of soil and state of water in environment.

Soil: Formation; Composition; Physical; Chemical and Biological components; Soil profile; Role of climate in soil development.

Water: Importance: States of water in the environment; Atmospheric moisture; Precipitation types (rain, fog, snow, hail, dew); Hydrological Cycle

Unit-III:

Learning Outcomes: The students grasp about the dynamics of population ecology and plant communities.

- Biotic interactions and Population ecology: Characteristics and Dynamics.
- Plant communities: Concept of ecological amplitude; Habitat and niche; Characters: analytical

and synthetic; Ecotone and edge effect; Dynamics: succession – processes, types; climax concepts.

Unit-IV:

Learning Outcome: The students know about the ecosystem process and phytogeography of India.

- Ecosystems: Structure; Processes; Trophic organization; Food chains and Foodwebs; Ecological pyramids.
- Functional aspects of ecosystem: Principles and models of energy flow; Production and productivity; Ecological efficiencies; Biogeochemical cycles; Cycling of Carbon, Nitrogen and Phosphorus.
- Phytogeography: Principles; Continental drift; Theory of tolerance; Endemism; Phytogeographical division of India; Vegetation of Odisha.

Practical:

1. Determination of pH of various soil and water samples (pH meter, universal indicator/Lovibond comparator and pH paper)
2. Analysis for carbonates, chlorides, nitrates, sulphates, organic matter and base deficiency from two soil samples by rapid field tests.
3. Determination of dissolved oxygen of water samples from polluted and unpolluted sources.
4. Study of morphological adaptations of hydrophytes, xerophytes, halophiles (two each).
5. Determination of minimal quadrat size for the study of herbaceous vegetation in the college campus, by species area curve method (species to be listed).
6. Quantitative analysis of herbaceous vegetation for frequency, density and abundance in the college campus.
7. Field visit to familiarize students with ecology of different sites.

Textbooks:

- ✓ *Sharma, P.D. (2017). Fundamentals of Ecology. Rastogi Publications, Meerut, India.*
- ✓ *Shukla R.S. and Chandel P.S. (2016). A Text Book of Plant Ecology. S Chand Publication, New Delhi.*

Reference Books:

- ✓ *Odum, E.P. (2005). Fundamentals of ecology. Cengage Learning India Pvt. Ltd., New Delhi. 5thedition.*
- ✓ *Singh, J.S., Singh, S.P., Gupta, S. (2006). Ecology Environment and Resource Conservation. Anamaya Publications, New Delhi, India.*
- ✓ *Wilkinson, D.M. (2007). Fundamental Processes in Ecology: An Earth Systems Approach. Oxford University Press. U.S.A.*
- ✓ *Kormondy, E.J. (1996). Concepts of ecology. PHI Learning Pvt. Ltd., Delhi, India. 4th edition.*
- ✓ *Santra, S. C. (2015) Environmental Science. New Central Book Agency (P) Ltd. Kolkata.*
- ✓ *Das M. C. and Das S. P. (2009). Fundamental of Ecology. Tata MGrow Hill, New Delhi.*
- ✓ *Shukla R.S. and Chandel P.S. (2016). A Text Book of Plant Ecology. S Chand Publication, New Delhi.*
- ✓ *Kumar H D by Modern Concept of Ecology Revised Ed. Vikas Publication.*

Major I **Credit-04**

1.10 Plant Systematics

Course Objectives

- A comprehensive presentation of the rules, regulations and codes of governing principles of the International Code of Nomenclature of Algae, Fungi and Plants (ICN)
- To provide knowledge on basic concepts of plant nomenclature and the tools used for naming the taxa.
- To impart knowledge on the traditional and advanced systems of classification of lower and higher plants.
- To acquaint the students with the modern approaches for developing systematic relationships in the plant kingdom.
- To enlighten the students about the phylogeny and the methods for building phylogeny among taxa of various angiosperms.
- To educate the students on the specific taxonomic characteristics of some angiosperm families and the method to make morphological studies of plant materials.

Course Outcomes:

- Knowledge on various levels of taxonomic hierarchy and the relationships among various hierarchical levels with respect to their similarities and variations of characters.
- The skill to use various taxonomic literature, Flora and herbaria, keys of both physical and digital types for plant identification and floristic studies.
- Critical thinking on the ancient, traditional and modern classification systems and evaluation of their applicability in taxonomic placement of taxa.
- Knowledge on the evolution of the concepts in classifying plants and weighing the potential of various tools.
- Ability to build the phylogeny among various taxa of different levels of hierarchy and identifying the apomorphy and plesiomorphy.
- Critical observations of the morphology of plant materials for taxonomic description and identification to the family, genus and species level.

Unit I:

Learning Outcome: The students shall gain knowledge on the importance of specimens, herbaria and flora for study of plant taxonomy**.**

Plant identification, Classification, Nomenclature; Biosystematics. Identification: Field inventory; Functions of Herbarium; Important herbaria and botanical gardens of the worldand India; Virtual herbarium; E-flora; Documentation: Flora, Monographs, Journals; Keys: Single access and Multi-access

Unit-II:

Learning Outcome: The learners shall have basic understanding on the application of rules of ICN for plant identification and nomenclature.

- Taxonomic hierarchy: Concept of taxa (family, genus, species); Categories and taxonomic hierarchy; Species concept (taxonomic, biological, evolutionary).
- Botanical nomenclature: Principles and rules (ICN); Ranks and names; Typification, author citation, valid publication, rejection of names, principle of priority and its limitations; Names of hybrids.

Unit-III:

Learning Outcome: The students shall be able to classify a plant as per the correct taxonomic hierarchy.

- Systematics- an interdisciplinary science: Evidence from palynology, cytology, phytochemistry

and molecular data.

- Systems of classification: Major contributions of Theophrastus, Bauhin, Tournefort, Linnaeus, Adanson, de Candolle, Bessey, Hutchinson, Takhtajan and Cronquist; Classification systems of Bentham and Hooker (up to series) and Hutchinson (up to series); Brief reference of Angiosperm Phylogeny Group (APG III) classification.

Unit-IV:

Learning Outcome: The student shall have the skill to apply modern taxonomic tools in plant taxonomy.

- Phylogeny of Angiosperms: Terms and concepts (primitive and advanced, homology and analogy, parallelism and convergence, monophyly, Paraphyly, polyphyly and clades). Origin& evolution of angiosperms; co- evolution of angiosperms and animals; methods of illustrating evolutionary relationship (phylogenetic tree, cladogram).
- Families of Angiosperms: Descriptive studies of *Magnoliaceae, Rosaceae, Rubiacae, Poaceae, Orchidaceae, Musaceae, Acanthaceae, Apocynaceae, Asclepiadaceae, Lamiaceae.*

Practical:

1. Study of vegetative and floral characters of available materials of the families included in theory syllabus (Description, V.S. flower, section of ovary, floral diagram/s, floral formula/e and systematic position according to Bentham & Hooker's system of classification).
2. Field visit, plant collection and herbarium preparation and submission. Mounting of properly dried and pressed specimen of at least fifteen wild plants with herbarium label (to be submitted in the record book)

Textbooks:

- ✓ *harma O. P. (2009) Plant Taxonomy, Tata Mc Grow Hill, New Delhi*
- ✓ *Sharma A. K, Sharma R, Taxonomy of Angiosperms and Utilisation of plants, Pragati Prakasan, Meerut*

Reference Books:

- ✓ *Singh, G. (2012). Plant Systematics: Theory and Practice. Oxford & IBH Pvt. Ltd., New Delhi.3rdedition.*
- ✓ *Jeffrey, C. (1982). An Introduction to Plant Taxonomy. Cambridge University Press, Cambridge.*
- ✓ *Judd, W.S., Campbell, C.S., Kellogg, E.A., Stevens, P.F. (2002). Plant Systematics-A Phylogenetic Approach. Sinauer Associates Inc., U.S.A. 2nd edition.*
- ✓ *Saxena, H. O. and Brahman, M. The Flora of Orissa, CSIR Publication.*
- ✓ *Bose T. K. (2009). Trees of the World, Regional Plant Resource Centre, Bhubaneswar, Odisha, India*
- ✓ *Radford, A.E. (1986). Fundamentals of Plant Systematics. Harper and Row, New York.*
- ✓ *Hanes, H. H. (2009). Botany of Bihar and Orissa,*
- ✓ *Mohanty, C. R. (2017). Textbook of Plant Systematics, Kalynai Publisher, New Delhi.*
- ✓ *Subrahmainayam, M. S. (2011) Modern Plant Taxonomy, Vikash Publishing House, New Delhi*

Major I **Credit 04**

1.11 Reproductive Biology of Angiosperms

Course Objectives

- To give a comprehensive idea about economic botany and its importance in human welfare.
- To know the origin, introduction, domestication and evolution of new crops / varieties of crop plants.
- To create awareness about importance of germplasm diversity.
- To provide knowledge on general account, cultivation, propagation and uses of common crops and processing of the materials.
- To know the extraction and uses of different oils as well as essential oils.

Course Outcomes:

- Have an understanding on the fundamental concepts of Economic Botany.
- Develop a basic knowledge on the evolution of crops/varieties.
- be aware about the importance of germplasm diversity and learn the methods for their conservation.
- Increase appreciation of diversity of plants and plant products used in everyday life of human and the methods for their enhanced production.
- Have an understanding of plants as a source of food, beverages, spices, and materials.

Unit-I:

Learning Outcome: Learn about structure and function of anther and pollen as well as their abnormalities

- Introduction: History and scope.
- Anther: Anther wall: Structure and functions, micro-sporogenesis, callose deposition and its significance.
- Pollen biology: Micro-gametogenesis; Pollen wall structure, MGU (male germ unit) structure, NPC system; Palynology and scope (a brief account); Pollen wall proteins; Pollen viability, storage and germination; Abnormal features: Pseudomonads,polyads, massulae, pollinia.

Unit-II:

Learning Outcome: Learn about the structure and function of ovule and embryo sac.

Ovule: Structure; Types; Special structures–endothelium, obturator, aril, caruncle and hypostase; Female gametophyte– mega-sporogenesis and mega-gametogenesis; Types and ultrastructure of different mature embryo sacs (Details of *Polygonum* type), Developmental pattern of mono-, bi- and tetrasporic embryo sacs.

Unit-III:

Learning Outcome: Develop knowledge about process of pollination, fertilization and self-incompatibility.

- **Pollination and fertilization**: Pollination types and significance; adaptations;structure of stigma and style; path of pollen tube in pistil; double fertilization.
- **Self-incompatibility**: Basic concepts; Methods to overcome self- incompatibility: mixed pollination, bud pollination, stub pollination; Intraovarian and *in vitro* pollination; Modification of stigma surface.

Unit-IV:

Learning Outcome: Students will be aware of the details of endosperm, embryo, seed, polyembryony and apomixes**.**

- **Endosperm:** development, structure and functions
- **Embryo:** Types of embryogeny; General pattern of development of dicot and monocot embryo; Suspensor: structure and functions; Embryo- endosperm relationship; Nutrition of embryo; Embryo development in *Paeonia*.
- **Seed:** Structure, importance and dispersal mechanisms
  Polyembryony and apomixes: Introduction; Classification; Causes and applications

Practical:

1. Anther: Wall and its ontogeny; Tapetum (amoeboid and glandular); MMC, spore tetrads, uninucleate, bicelled and dehisced anther stages through slides/micrographs, male germ unit (MGU) through photographs and schematic representation.
2. Pollen grains: Fresh and acetolyzed showing ornamentation and aperture, psuedomonads, polyads, pollinia (slides/photographs, fresh material), ultrastructure of pollen wall (micrograph); Pollen viability: Tetrazolium test, Germination: Calculation of percentage germination in different media using hanging drop method.
3. Ovule: Types-anatropous, orthotropous, amphitropous/ campylotropous, circinotropous, unitegmic, bitegmic; Tenuinucellate and crassinucellate; Special structures: Endothelium, obturator, hypostase, caruncle and aril (permanent slides/specimens/photographs). Female gametophyte through permanent slides/ photographs: Types, ultrastructure of mature egg apparatus.
4. Embryogenesis: Study of development of dicot embryo through permanent slides/photographs; dissection of developing seeds for embryos at various developmental stages; Study of suspensor through electron micrographs.
5. Tracing the path of pollen tube.
6. Study of haustorial endosperm

Textbooks:

- ✓ *Singh, V., Pandey, P.C, and Jain, D.K. (2017). Reproductive Biology of Angiosperms, Rastogi Publications, Meerut*
- ✓ *Bhojwani SS /S P Bhatnagar and Dantu PK (2015) - The Embryology of Angiosperms 6th ed Vikas Publication*.

Reference Books:

- ✓ Maheswari, P. (2009). Embryology of Angiosperms.
- ✓ *Shivanna, K.R. (2003). Pollen Biology and Biotechnology. Oxford and IBH Publishing Co. Pvt. Ltd. Delhi.*
- ✓ *Raghavan, V. (2000). Developmental Biology of Flowering plants, Springer, Netherlands.*
- ✓ *Johri, B.M. l (1984). Embryology of Angiosperms, Springer-Verlag, Netherlands.*
- ✓ *Mishra, B. K. (2017). Reproductive Biology of Angiosperms, Kalyani Publishers, New Delhi.*
- ✓ *Pandey, B. P., (2017). Taxonomy of Angiosperm. S. Chand Publication New Delhi*

Major I **Credit 04**

1.12 Basic Plant Physiology

Course Objectives

- About the mechanism and physiological activities in plants.
- On nutrient uptake and translocation to different plant parts.
- On the nature and physiological roles of various plant hormones on plant growth and development.
- On the physiological requirements for plant morphogenesis and flowering
- On the role of light responsive pigments in plant morphogenesis.

Course Outcomes

- The governing principles behind various physiological processes in plants.
- About various uptake and transport mechanisms (water and solutes) in plants and the factors governing these processes.
- The role of various plant hormones, signaling compounds, and stress responses.
- The skills to manipulate the plant hormones in plants for desired morphological and physiological responses.
- The climatic and physiological requirements for molecular signaling of plants for growth, differentiation, maturity.

Unit -I:

Learning Outcome: The learners shall have the knowledge on importance of water for basic physiological processes of plants.

- Structure and properties of water; pH and buffers; cellular buffering systems; Cell water Potential and its components, plasmolysis and imbibition, soil water potential.
- Water absorption by roots, aquaporins, pathway of water movement,symplast, apoplast, trans-membrane pathways.
- Ascent of sap–cohesion-tension theory. root pressure; water movement to leaves.
- Transpiration: Processes; mechanism of stomatal movement; factors affecting transpiration; guttation.
- Translocation in the phloem: experimental evidence in support of phloem as the site of sugar translocation. pressure–flow model; phloem loading and unloading; source–sink relationship.

Unit-II:

Learning Outcome: The students shall know about the nutrient uptakes and hormonal regulation of plant growth and metabolism**.**

- Mineral nutrition: essential and beneficial elements, macro and micronutrients, mineral deficiency symptoms, chelating agents.
- Nutrient Uptake: Transport of ions across cell membrane, passive absorption, electrochemical gradient, facilitated diffusion, active absorption, role of ATP, carrier systems, proton ATPase pump and ion flux, uniport, co-transport,Symport and antiport.
- Plant growth regulators: Auxin: Biosynthesis, transport, distribution and function
- Gibberellins: Biosynthesis, transport, distribution and function
- Cytokinin: Biosynthesis, transport, distribution and function
- Abscisic acid: Biosynthesis, transport, distribution and function
- Ethylene: Biosynthesis, transport, distribution and function

Unit-III:

Learning Outcome: The students shall know about photosynthesis and storage of metabolites by plants.

- Photosynthesis: general concept; photosynthetic apparatus; photosynthetic pigments and photosystems; Red drop and Emerson's enhancement effect.
- Primary photochemical reactions: photon, exciton and electron transfer.
- Non-cyclic electron flow: role of tyrosine and phaeophytin, quinine cycle, oxygen evolving complex and water splitting. Cyclic electron flow: process and function; role of ferredoxin-quinone reductase
- C3, C4 and CAM pathways of carbon fixation.
- Photorespiration
- Synthesis and Catabolism of Sucrose and Starch.

Unit-IV:

Learning Outcome: The learners shall have the skill to understand the photomorphogenesis.

- Physiology of flowering: Photoperiodism, flowering stimulus, floral meristems, external and internal factors of flower evocation; florigen concept; ABC model of floral organ identity; chemical signals for floral evocation.
- Seed dormancy: causes, effects, breaking of seed dormancy.
- Senescence: Types and causes, biochemical basis
- Phytochrome: Discovery, chemical nature, role of phytochrome in photo- morphogenesis, low energy responses (LER) and high irradiance responses (HIR), mode of action.

Practical:

1. Determination of osmotic potential of plant cell sap by plasmolytic method.
2. Determination of water potential of given tissue (potato tuber) by weight method.
3. Study of the effect of wind velocity and light on the rate of transpiration in excised twig/leaf.
4. Calculation of stomatal index and stomatal frequency from the two surfaces of leaves of a mesophyte and xerophyte.
5. To calculate the area of an open stoma and percentage of leaf area open through stomata in a mesophyte and xerophyte (both surfaces).
6. To study the phenomenon of seed germination (effect of light).
7. To study the induction of amylase activity in germinating barley grains
8. To demonstrate suction due to transpiration.
9. Measurement of relation between transpiration and transpiring surface
10. Measurement of cuticular resistance to transpiration.
11. Measurement of primary photochemical reactions by fluorescence.
12. Jain V K Fundamental of Plant physiology,20th ed. S chand publication ,New Delhi

Text Books:

- ✓ *Pandey and Sinha (2011). Plant Physiology, Vikash Publishing House, New Delhi*

Reference Books:

- ✓ *Sinha, R. K. (2015). Modern Plant Physiology, Narosa Publishing House, New Delhi.*
- ✓ *Hopkins, W.G. and Huner, A. (2008). Introduction to Plant Physiology. John Wiley and Sons. U.S.A. 4th edition.*
- ✓ *Taiz, L., Zeiger, E., MØller, I.M. and Murphy, A (2015). Plant Physiology and Development. Sinauer Associates Inc. USA. 6th edition.*

- ✓ *Bajracharya D. (1999). Experiments in Plant Physiology-A Laboratory Manual. Narosa Publishing House, New Delhi.*
- ✓ *Salisbury, F. B. and Ross, C. W. Plant Physiology Wadsworth Publishing Company, California*
- ✓ *Sahoo, A. C. (2018). Outlines of Plant Physiology Kalyani Publishers, New Delhi.*
- ✓ *Srivastava, N. K. (2017). Plant Physiology, Rastogi Publications, Meerut.*

Major II **Credit - 04**

2.3 Micropropagation for horticultural crops

Course Objectives:

- To have a basic idea on principles and methods of Plant Tissue culture and in vitro tissue differentiation.
- To have theoretical and practical knowledge on direct and indirect regeneration of plants for vertical gardens.
- To study on genetic fidelity and true to type plant regeneration for quality plant production.
- To train the students on commercial plant regeneration for vertical gardens.

Course Outcomes:

On completion of the course the students will have the ability to

- Understand the methods of micropropagation and its advantages.
- Describe the true to type plant regeneration of desired variety
- Have skill to prepare explant, establishment of aseptic culture and mass production of planting materials.
- Establish micropropagation for self-employment.

Unit I

Laboratory design and equipment's for micropropagation; Composition of media; Nutrient and hormone requirements; sterilization of the seeds, explants and calli; Organogenesis (Callus mediated and direct adventitious); Shoot multiplication, rooting,

Unit II

Tissue culture mediated plant regeneration protocols of Orchids, Rose, ferns, Chrysanthemum, Gladioli, gerbera; Micropropagation of foliage plants- Philodendron, Aglaonema, Dieffenbachia.

Unit III

Micropropagation of banana, strawberries, grapevines, and dwarf papaya-Media preparation, explant collection, hormone composition, Organogenesis; Shoot multiplication, rooting,

Unit IV

Somatic Embryogenesis-scope, methods and limitations; somatic embryo, synthetic seeds-media, production, storage; Protoplast isolation, purification and storage; media for protoplast culture and fusion; suspension culture. Hybrid protoplast analysis, isolation and callus generation. Chemical and physical mutation. *Agrobacterium*-mediated gene transfer for improvement.

Practical:

1. Tissue Culture: laboratory setup (drawing component wise)

2. Demonstration and operation of instruments for Plant tissue culture (Autoclave, Laminar air flow cabinet, and Hot air oven, pH meter, Micro-balance,

3. Preparation of tissue culture (MS) medium / stock solutions.

4. Demonstration of surface sterilization techniques.

5. Collection of explants of banana, rose, orchid,

6. Surface sterilization of different explants.

7. Culture of Demonstration of aseptic inoculation of nodal, shoot apical meristem or floral or pod explants of banana, rose and orchid, plant species.

8. Synthetic seed formation and germination.

9. Gel electrophoresis and visualization (demonstration/photography)

10. Microscopic observations, data recording for callusing, regeneration, rooting and photograph

Textbooks:

- ✓ *Chawla, H. S. (2010). Introduction to Plant Biotechnology. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.*
- ✓ *Ramawat, K. G. & Goyal, S. Comprehensive Biotechonology 4th ed Schand Publication New Delhi.*

Reference Books:

- ✓ *Bhojwani, S.S. and Razdan, M.K., (1996). Plant Tissue Culture: Theory and Practice. Elsevier Science Amsterdam. The Netherlands.*
- ✓ *Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington.*
- ✓ *Stewart, C.N. Jr. (2008). Plant Biotechnology & Genetics: Principles, Techniques and Applications. John Wiley & Sons Inc. U.S.A.*
- ✓ *Singh, B. D. (2018). Plant Biotechnology Kalyani Publishers, New Delhi.*
- ✓ *Gupta, P. K. (2017). Plant Biotechnology, Rastogi Publication, Meerut.*
- ✓ *Dubey, R. C. (2017). Advanced Biotechnology, S, Chand Publication, New Delhi*

Major II **Credit - 04**

2.4 Hardening and nutrition management of micro-propagated plants

Course Objectives:

- To have a basic idea on principles and methods of hardening and acclimatization.
- To study green house and net house organization of commercial tissue culture.
- To have theoretical and practical knowledge on standardization of hardening environment.
- To study on net pot for long term transport of tissue culture plants and genetic fidelity and true to type plant regeneration.
- To study the acclimatization of plants in green house.

Course Outcomes:

On completion of the course the students shall be able to

- Have knowledge the about methods of hardening of micro-propagated plants.
- Describe the true to type plant regeneration of desire variety.
- Have skill to handle the in vitro grown plants produced in aseptic culture
- Prepare the required conditions for proper hardening of plantlets
- Gain knowledge on methods for measuring biochemical, and physiological changes of plants during hardening.

Unit I

Washing of media, methods of washing of plantlets. Artificial media used for net pot, liquid media in green house transfer, Control of humidity, temperature and light conditions; Plant performance analysis.

Unit II

Primary hardening medias-composition, nutrient management, sterilization, maintenance. Secondary hardening media-types, preparation, nutrient balance, microbial load management. Light regime during hardening; light source, intensity and duration; acclimatization, green house, net house.

Unit III

Liquid fertilizer use, types of liquid fertilizer during hardening; fertilizer dose commitment. Growth management and control; Liquid fertilizer application, Foliar spray, media fertigation, media nutrition management.

Unit IV

Irrigation during hardening-frequency, and duration; moisture management; moisture management of plantlets and hardening chamber; fungal and bacterial load management; antifungal and antibacterial agents; anti-transpirants during hardening. Metabolic and Stomatal Regulators; Film-Forming Compounds; stress hardening, Liquid fertilizer use, mirco-irrigation application

Practical:

1.Demonstration of hardening chamber.

2.Demonstration of techniques of hardening

3.Hardening experiments for rose plantlets

4. Hardening experiments for banana plantlets

5. Hardening experiments for orchid plantlets

6. Experiment with Application of anti-transpirants.

7. Hardening in different media

8. Demonstration of micro-irrigation, foliar stray, micronutrient management

9. Demonstration of net shed house, secondary hardening in net pot and poly bags.

Textbooks:

- ✓ *Bhojwani S.S., Razdan M. K (2005) Plant tissue culture: Theory and practice, Studies in plant science 5,North Holland, Elsevier, New Delhi*
- ✓ *Adrian, J and Assoumani M (1983) Gums and hydrocolloids in nutrition. In: M. Rechcigl (Ed), hand book of nutritional supplements, Vol. II. Agricultural use. CRS Press, Boca Raton, FL.*
- ✓ *Kyte et al. (2013). Plants From Test Tubes: An Introduction to Micropropogation. fourth Edition, Timber Press, London.*
- ✓ *Paiva R.& Reis M V. Micropropagated Plants Production and Establishment. International Society for Horticulture Science, Leuven, Belgium.*
- ✓ *Chawla, H. S. (2010). Introduction to Plant Biotechnology. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.*
- ✓ *Ramawat K G & Goyal S Comprehensive Biotechonology 4thed Schand Publication New Delhi*.

Reference Books:

- ✓ *Aiken M.M and Yeoman M.M (1986) A rapid screening technique for the selection of high yielding capsaicin cell line of Capsicum frutescensMill. In: P. Morris et al (Eds.) Secondary Metabolism in Plant Cell Cultures. Cambridge University Press, London*
- ✓ *Anderson S.B, Christiansen I and Faresveit B (1990) Carrot (Daucus carota L.): In vitro production of haploids and field trials. In: Y.P.S. Bajaj (Ed.) Biotechnology in Agriculture and Forestry, Vol. 12. Haploids in crop improvement I. Springer, Berlin.Cervelli R and Senaratna T (1995) Economic aspects of Somatic embryogenesis. In: J. Aitken-Christie et al. (Eds.) Automation and environment control in plant tissue culture. Kluwer,Dordrest*
- ✓ *Smith R.H (2000) Plant Tissue Culture: techniques and Experiments, Second edition, Academic Press, USA*

Semester IV

Major-I **Credit- 04**

1.13 Basic Plant Biotechnology

Course Objectives:

- To have a basic idea on principles and methods of Plant Tissue culture and in vitro tissue differentiation.
- To study about Somatic embryogenesis; Embryo culture and embryo rescue
- To have theoretical and practical knowledge on Protoplast isolation, fusion, culture and Selection of hybrid cells for regeneration of hybrid plants.
- To study about Recombinant DNA technology and its application.
- To study various techniques of gene transfer and its application in plant improvement.

Course Outcomes

- Have knowledge the about methods of Plant Tissue culture and its application.
- Be able to describe the Somatic embryogenesis; Embryo culture and embryo rescue
- Have skill to isolate plant Protoplast and differentiate the normal and hybrid protoplasts
- Have knowledge the Gene Construct; construction of genomic and cDNA libraries, screening DNA libraries
- Gain knowledge on methods for developing transgenic plants and application of transgenics for human welfare.

Unit -I:

Learning Outcome: Understanding of the various process of tissue culture mediated plant regeneration protocols.

Plant Tissue Culture: Historical perspective; Aseptic tissue culture techniques; Composition of media; Nutrient and hormone requirements (role of vitamins and hormones). Totipotency; Micropropagation (using nodal explant); Organogenesis (Callus mediated and direct adventitious); Somatic Embryogenesis; Protoplast isolation, culture and fusion, plant acclimatization

Unit-II:

Learning Outcome: Gain knowledge about the fundamental aspects of recombinant DNA technology.

Recombinant DNA technology-I: Restriction Endonucleases (History, Types I-IV, biological role and application); Restriction Mapping (Linear and Circular); Cloning Vectors: Prokaryotic (pUC 18 and pUC19, pBR322, Ti plasmid, BAC); Lambda phage, M13 phagemid, Cosmid, Shuttle vector; Eukaryotic Vectors (YAC and briefly PAC, MAC, HAC). Gene Cloning (Recombinant DNA, Bacterial transformation and selection of Recombinant clones, PCR mediated gene cloning).

Unit-III:

Learning Outcome: Gain knowledge about the recombinant DNA technology, gene transfer technology and production of transgenic plants**.**

Recombinant DNA technology-II: Gene Construct; construction of genomic and cDNA libraries, screening DNA libraries to obtain gene of interest by genetic selection; complementation, colony hybridization; Probes-oligonucleotide, heterologous, Methods of gene transfer- *Agrobacterium*-mediated, Direct gene transfer by Polyethylene Glycol (PEG) Electroporation, Microinjection, Microprojectile bombardment; Selection of transgenics– selectable marker and reporter genes (Kanamycin, Luciferase, GUS, GFP).

Unit-IV:

Learning Outcome: Have knowledge on chloroplast transformation and biosafety concerns of GM crops.

Chloroplast Engineering: Chloroplast genome, chloroplast transformation: rationale, methods used for generation of transplastomic plants, vectors for chloroplast transformation, transplastomics without antibiotic resistant gene, applications of chloroplast transformation. Biosafety concerns of genetically modified (GM) crops.

Practical:

1. Tissue Culture: laboratory setup (drawing component wise)
2. Demonstration of instruments for Plant tissue culture like Autoclave, Laminar air flow cabinet, and Hot air oven.
3. Demonstration of sterilization techniques for glassware
4. Preparation of tissue culture (MS) medium.
5. Demonstration of surface sterilization techniques.
6. Demonstration of aseptic inoculation of nodal or leaf explants of any available plant species.
7. Isolation of plasmid DNA.
8. Gel electrophoresis and visualization (demonstration/photography)

Textbooks:

- ✓ *Chawla, H. S. (2010). Introduction to Plant Biotechnology. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.*
- ✓ *Ramawat K G & Goyal S Comprehensive Biotechonology 4th ed Schand Publication New Delhi*.

Reference Books:

- ✓ *Bhojwani, S.S. and Razdan, M.K., (1996). Plant Tissue Culture: Theory and Practice. Elsevier Science Amsterdam. The Netherlands.*
- ✓ *Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington.*
- ✓ *Stewart, C.N. Jr. (2008). Plant Biotechnology & Genetics: Principles, Techniques and Applications. John Wiley & Sons Inc. U.S.A.*
- ✓ *Singh, B. D. (2018). Plant Biotechnology Kalynai Publishers, New Delhi.*
- ✓ *Gupta, P. K. (2017). Plant Biotechnology, Rastogi Publication, Meerut.*
- ✓ *Dubey, R. C. (2017). Advanced Biotechnology, S, Chand Publication, New Delhi*

Major-I **Credit- 04**

1.14 Basic Plant Metabolites

Course Objectives:

- To learn the anabolic and catabolic cellular processes and their regulations.
- To understand the mechanism of signal transduction in plants and the major signalling pathways.
- To learn the photochemical and biochemical mechanisms for photosynthetic carbon fixation.
- To learn the mechanism of carbon oxidation and ATP synthesis.
- To understand the pathways of synthesis and oxidation and of lipids and fatty acids.
- To understand the role of enzymes and enzyme action.

Course Outcomes:

- The students shall be able to explain the importance of biochemical pathways and regulatory pathways.
- The students can explain the role of enzymes in metabolic activities.
- The students shall have ability to differentiate various carbon metabolic pathways.
- The students shall have proper level of knowledge on carbon oxidation and energysynthesis.
- The students can explain the processes of lipid metabolism and its importance in thegerminatin g seeds.
- The students shall be able to understand and explain the amino acid metabolic pathways.

Unit–I:

Learning Outcomes: Students will learn about the cellular metabolism and understand metabolic pathways and regulation of glycolysis, TCA cycle, ATP synthesis

- Concept of metabolism: Introduction, anabolic and catabolic pathways
- Glycolysis and its regulation, Fate of pyruvate, oxidative pentose phosphate pathway, oxidative decarboxylation of pyruvate; regulation of PDH, NADH shuttle.
- TCA cycle, amphibolic role, anaplerotic reactions, regulation of the TCA cycle,
- Mechanism of ATP synthesis, substrate level phosphorylation, chemiosmotic mechanism (oxidative and photophosphorylation), ATP synthase enzyme
- Boyers conformational model, Racker's experiment, Jaggendorf's experiment
- Role of uncouplers in ATP synthesis and their application.

Unit-II:

Learning Outcomes: Students will learn about fatty acid synthesis, breakdown and their regulation in plants**.**

- Fatty acid biosynthesis: Synthesis, and breakdown of triglycerides and their importance.
- Fatty acid Breakdown: β-oxidation, α oxidation, glyoxylate cycle
- Regulation of fatty acid metabolism. Gluconeogenesis and its role in mobilization of lipids during seed germination

Unit-III:

Learning Outcomes: The learner will understand the aminoacid biosynthesis, degradation along with their regulation in plants.

- Amino acid biosynthesis and degradation in plants and its importance (proteasomal pathway) Synthesis of amino acid of alpha-ketoglutarate family, 3-phosphoglycerate precursor family, oxalo-acetate and pyruvate family, PEP erythrose-4-phosphate precursor family, Ribose-5-phosphate precursor family.
- Feedback control of amino acid biosynthesis: sequential, concerted and cumulative feedback control

Unit- IV:

Learning Outcomes: Students will learn about the enzymes and their classification, kinetics, inhibition and regulation.

- Enzymes: General properties, nomenclature and classification,
- Energetics of enzyme reactions, free energy change, forward and reverse reactions.
- Michaelis-Menten kinetics of enzyme reactions and its significance, Reciprocal plot, Brigg's-Halden modification, determination of V_{max} and K_m
- Enzyme inhibition: competitive, non-competitive inhibition, determination of K_i,
- Role of regulatory enzymes: allosteric, covalent modulation

Practical:

1. Detection of organic acids: citric, tartaric, oxalic and malic from laboratory samples.
2. Detection and quantification of protein from plant samples samples following Bradford method using spectrophotometer/colorimeter.
3. Detection/Estimation of the nature of carbohydrate – glucose, fructose, sucrose and starch from laboratory samples.
4. Detection of Ca, Mg, Fe, S from plant ash sample
5. Estimation of amino-nitrogen by formol titration method (glycine)
6. Estimation of titratable acidity from lemon.

Textbooks:

- ✓ *Gupta, S, K. (2017). Plant Metabolism, Rastogi Publication, Meerut.*
- ✓ *Pandey B P (2019) Botany For Degree Student S Chand Publication. New Delhi*

Reference Books:

- ✓ *Taiz, L., Zeiger, E., MØller, I.M. and Murphy, A (2015). Plant Physiology and Development.Sin auer Associates Inc. UA. 6th edition.*
- ✓ *Heldt, Hans-Walter. Plant Bio-Chemistry (3rd ed.), 2005. Elsevier Academic Press.*

Major-I **Credit- 04**

1.15 Natural Resource Management

Course Objectives:

- To introduce the types of natural resources and the concept of sustainable development.
- To understand the status of biological diversity and their management.
- To know the contemporary tools such as EIA and GIS for assessment and conservation of natural resources.
- To know about the non-conventional energy resources and their application.
- To learn the concept of resource accounting for better natural resource management

Course Outcomes:

- Be able to understand importance of each component of natural resources and try to use the available resources judiciously.
- Know about different biological conventions and treaties emphasizing the conservation of biological diversities.
- Clearly understand the importance of sustainable use of natural resources and procedures for their assessment.
- Have skill to use renewable energy sources for the betterment of the human civilization and actively participate in popularization of the methods of energy and resource conservation.
- Know the national and international efforts for management and accounting of natural resources.

Unit-I:

Learning Outcome: The learners shall gain knowledge about the importance of natural resources.

- **Natural resources:** Definition and types.
- **Sustainable utilization**: Concept, approaches (economic, ecological and socio-cultural).
- **Land:** Utilization (agricultural, horticultural, silvicultural); Soil degradation andmanagement.
- **Water:** Fresh water (rivers, lakes, groundwater, water harvesting technology, rainwater storage and utilization.

Unit-II:

Learning Outcome: The students shall be able to know the processes for maintaining sustainability.

- Biological Resources: Biodiversity-definition and types; Significance; Threats; Management strategies; Bioprospecting; IPR; CBD; National Biodiversity Action Plan).
- Forests: Definition, Cover and its significance (with special reference to India); Major and minor forest products; Depletion; Management.

Unit-III:

Learning Outcome: The students shall have skills to use modern tools for effective resource assessment and utilization.

- Energy: Renewable and non-renewable sources of energy-solar, wind, tidal, geothermal and bioenergy resources.
- Contemporary practices in resource management: EIA, GIS, Participatory ResourceAppraisal, Ecological Footprint with emphasis on carbon footprint

Unit-IV:

Learning Outcome: The learners shall gain accounting skills for management and conservation of natural resources.

Resource Accounting; Waste management. National and international efforts in resourcemanagement and conservation

Practical

1. Estimation of solid waste generated by a domestic system (biodegradable and non-biodegradable) and its impact on land degradation.
2. Collections of data on forest cover of specific area.
3. Measurement of dominance of woody species by DBH (diameter at breast height) method.
4. Calculation and analysis of ecological footprint.
5. Ecological modeling.
6. Estimation of soil moisture content and soil texture.
7. Estimation of soil porosity
8. Estimation of soil water-holding capacity.
9. Estimation of soil organic matter and soil carbon

Textbooks:

- ✓ *Pandey, B. W. 2005. Natural Resource Management. Mittal Publication, New Delhi*
- ✓ *Singh J S & Singh S P (2017) Ecology, Environmental science, Conservation. (Revised Ed) S Chand Publication New Delhi*

Reference Books:

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

Major II **Credit 04**

2.5 Commercial floriculture through vertical gardening, hydroponic and aeroponic

Course Objectives:

- To make aware the students on the importance of commercial floriculture
- To train on the production techniques in floriculture.
- To Explain the breeding techniques of some flowering plants.
- To provide training on post-harvest operations in floriculture.
- To provide hands-on experience on various hydroponics and aeroponics.

Course Outcomes:

After completing the course, the learners will be able to:

- Understand basics of hydroponics and aeroponics.
- Develop basic facilities for commercial soilless floriculture at pilot scale and/or commercial scale.
- Devise and implement a strategy for marketing of the product.
- Establish themselves as entrepreneurs (Hydroponic cultivator).

Unit l

Floriculture - Importance, area and production in India. Importance, morphology and taxonomy, verities, climate and soil, seeds and sowing, manuring, irrigation, intercultural operations, diseases and their control, harvesting and yield of: (a) Rose, (b) Fern, (c) Orchids, (d) Crossandra (e) Dahlia (f) aroids (g) Philodendron

Unit II

Morphology and taxonomy, verities, climate and soil, seeds and sowing, manuring, irrigation, intercultural operations, diseases control, harvesting and yield of: (a) gladiolus (b) gerbera (c) carnation, (d)marigold, (e) anthurium.

Postharvest handling of cut and loose flowers-marigold, orchids, tuberose, rose, gerbera, carnation. Post-harvest handling of foliage-Philodendron, ferns, *Cycas*, palms, broad leaves, grasses and fillers.

Unit III

Growing of flowering plants under protected environments- glass house, plastic house, net house, infrastructure for epiphytic culture-construction, cost, operation and maintenance.

Unit IV

Hydroponic techniques; Circulating methods - Nutrient Film Technique (NFT), Deep Flow Technique (DFT), Dutch bucket; Non circulating methods - Root dipping, Floating, Capillary action; substrate, media, plantation, irrigation, fertigation and care; disease control. Factors affecting hydroponics

Aeroponics techniques; root mist and fog feed methods; Aeroponic units (including greenhouse facilities); Growth media; Nutrients dynamics (NPK, DO, TDS, pH); growth conditions-quality, light intensity, photoperiod and temperature; irrigation, fertigation and care; disease control. Factors affecting aeroponics.

Practical

1. Identification of commercially important floricultural crops.

2. Propagation technique in Hibiscus/Rose/Chrysanthemum/tuberose.

3. Propagation technique in Gladiolus/ carnation Petunia

4. Training and pruning of rose/Jasminum.

5. Use of chemicals and other compounds for prolonging the vase life of cut flowers.

6. Flower arrangement practices, Preparation of bouquets, garland.

7.Study of techniques used in hydroponics (Circulating methods such as Nutrient Film

8. Technique (NFT), Deep Flow Technique (DFT),

9. Dutch bucket; Non circulating methods such as Root dipping, Floating,

Capillary action; Aeroponics such as root mist and fog feed techniques).

10. Study of various instruments used in hydroponics (Pressure gauge, Filters, PVC

Tanks, Venturi/Reciprocating Pump/Mixing tank, EC meter, pH meter, TDS meter,

water pump, net cups, air pump, thermometer, lux meter, drip irrigation system.

11. Construction of sustainable hydroponic and aeroponic units (including greenhouse facilities)

12. Preparation of growth media for Hydroponics.

13. Estimation of NPK, DO, TDS, pH of growth media.

14. Study of suitable conditions for Hydroponics-quality, light intensity, photoperiod andtemperature.

15. Growing a leafy vegetable/fruity vegetable/medicinal herb /aromatic plant in

Hydroponics /Aeroponic solution

16.Study of safety measures, certification standards and government policies. 01 Week

17. Visit to Hydroponic/Aquaculture/Aeroponic farm/Institute.

Textbooks

- ✓ *Meier Schwarz. (1995). Soilless Culture Management. Advanced Series in Agricultural Sciences, vol 24. Springer, Berlin.*
- ✓ *Hasan, M.; Sabir, N.; Singh, A.K.; Singh, M.C.; Patel, N.; Khanna, M.; Rai, T.; and Pragnya, P. (2018). Hydroponics Technology for Horticultural Crops, Tech. Bull. TBICN 188/2018.Publ. by I.A.R.I., New Delhi.*
- ✓ *Misra, R.L., Misra S. (2017). Soilless Crop production. Daya Publishing House, Astral*

Reference Books

- ✓ *Goddek, S., Joyce, A., Kotzen, B., Burnell, G.M. (2019). Aquaponics Food Production Systems. Springer Cham.*
- ✓ *Meier Schwarz. (1995). Soilless Culture Management. Advanced Series in Agricultural Sciences, vol 24. Springer, Berlin.*

Major II **Credit 04**

2.6 Irrigation, fertigation and disease control

Course objectives:

- To develop students with proficiency in plant protection
- To employ students and implement their acquired knowledge in basic and applied aspects of plant protection.
- To enhance students' ability of in-depth thinking, development of scientific attitude,
- To manage the problems of disease in gardening and generating solutions

Course Outcome:

- Acquire a critical knowledge of care of plants of vertical garden.
- Identify and explain methods for proper irrigation and fertigation in an ornamental garden.
- Acquire skills on identification of diseases of various ornamental plants.
- Take proper care of the plants.

Unit l

Importance, design values, propagation, planting of flowering annuals, biennials andperennials: location of plants as per water and light requirement and availability; plant types for vertical garden: (a) Climbers (b) Creepers (c) Palms (d) Ferns (e) Grasses (f) Cacti, (g) Succulents.

Unit II

Automated, remotely controllable irrigation systems, frequency or duration of irrigation. Irrigation monitoring-volume, pressure, frequency. Types of irrigation: spray, drip, root zone, foliage irrigation. Green wall irrigation systems. Recycled irrigation.

Plant nutrition: fertilizer injection, media fertigation, nutrient addition to loose media, mat media and structural media, Weightless media, High Nutrient holding system for fast growing plants. Use of Cocopeat, Perlite, Sphagnum moss, vermiculite, vermicompost, shredded bark and leaf molds for slow nutrition.

Unit III

Comprehensive definition, causes of pest outbreak, losses caused by insect pests, Categories of pests: Major pests, minor pests, Monophagous pests, Polyphagous pest, Pathogenic Pests,

Regular Pests, and Sporadic Pests with examples. Concept of vectors with examples. Symptoms: Major types of plant disease symptoms caused by fungi, bacteria and viruses.

Unit IV

Root rot (*Pythium*, *Phytophthora*), Powdery Mildew (*Podosphaera pannosa*), Downy Mildew (Peronospora sparsa); Bacterial and fungal leafspot, pest and vector borne diseases-spider mites and mealy bugs, nematodes. Viral mosaic.

Disease prevention, management and control, pesticides-equipment, handling, application and precautions. Cultural practices for disease management

Practical Syllabus

l. Identification and description of various plants grown in ornamental gardens.

2. Tools, implements and containers used in ornamental gardening.

3. Demonstration and use of irrigation equipment

4. Demonstration of types and styles of irrigation using photos or videos.

5. Planting, designing and establishment of plant as per their light and water requirement.

6. Demonstration and use of fertilizers for vertical garden

7. Study of various instruments for fertigation

8. Experiments for standardization of fertigation of media

Textbooks

- ✓ *Atwal, A. S. 1986: Agricultural Pests of India and South-East Asia. Kalyani Publishers,Ludhiana*
- ✓ *Dasgupta, M K 1988: Principles of Plant Pathology. Allied Publishers Pvt. Ltd., Calcutta*
- ✓ *Mandahar, C L, 1987: Introduction of Plant Virus. Chandan Co. (Pvt.) Ltd., New Delhi*
- ✓ *Basu, A N and Giri, B K 1993:The Essentials of Viruses, Vectors and Plant Diseases.Wiley Eastern Ltd., New Delhi*
- ✓ *Agarios,GN 1988:Plant Pathology Academic Press Inc, New York*
- ✓ *Prasad. T.V. Hand book of Entomology. New Vishal Publications, New Delhi Minor*

Reference Books

- ✓ *Matthews,G.A. 1979, Pesticide Application Method. Longman, London.*
- ✓ *Bindra ,O.S and Singh,H. 1977.Pesticide Application Equipment Oxford and IBH Publishing Co.;New Delhi*
- ✓ *Chatterjee,P.B. 1997. Plant Protection Techniques. Bharati Bhawan(Publishers and Distrbutors), Patna.Brent,K.J and Atkin,R.K.(Eds),1987. Rational Pesticide Use. Cambridge University Press, Cambridge*