OFFICE OF THE REGISTRAR :: DIBRUGARH UNIVERSITY :: DIBRUGARH

Ref. No. DU/DR-A/137th AC/L.Sc./Syllabus(Botany)/FYIPGP 9th & 10th Sem./2026/877 Date: 25.08.2026

NOTIFICATION

As recommended by the meeting of the ***Board of Studies (BoS) in Life Sciences*** and 161st Meeting of the Post Graduate Board, D.U. held on 23.06.2026, the Academic Council, Dibrugarh University in its 137th meeting held on 29.06.2026 ***vide Resolution No. 14*** has approved the syllabus of 9th and 10th semesters of FYIPGP Life Sciences (Botany) with effect from 2026-2027 academic session.

The syllabus is attached herewith.

Issued with due approval.

25/8/26

Deputy Registrar (Academic) i/c
Dibrugarh University

Copy forwarded for kind information and necessary action to:

1. The Hon'ble Vice-Chancellor, Dibrugarh University.
2. The Deans, Dibrugarh University.
3. The Registrar, Dibrugarh University.
4. The Controller of Examinations, Dibrugarh University.
5. The Inspector of Colleges, Dibrugarh University.
6. The Head, Department of Life Sciences, Dibrugarh University.
7. The Heads / Chairpersons of the Teaching Departments / Centre of Studies, Dibrugarh University.
8. The Joint / Deputy Controller of Examinations – 'C' / 'A' & 'B', Dibrugarh University.
9. The Senior Programmer, Dibrugarh University with a request to upload the Notification along with attached syllabi on the DU website.
10. File.

25/8/26

Deputy Registrar (Academic) i/c
Dibrugarh University

Syllabus of FYIPGP in Life Sciences (Botany)

(Up to 10th semester)

Department of Life Sciences

Approved in the BOS held on 16th June, 2026

DIBRUGARH UNIVERSITY

Dibrugarh, Assam

786004

Vision of the Department:

Investigate and analyze biological diversity for designing solutions to mitigate public health issues and climate change through sustainable management of bioresources.

Mission of the Department:

The Department is committed to develop competent human resources in the field of life sciences to address issues associated with sustainable development goals, health and welfare of the society.

Thrust Areas of Research

Inventorization, Bioprospecting and Database Development of Endemic Flora & Fauna of Northeast India

Values of the Department

1. Excellence in Education: Commitment to provide high-quality education in life sciences.
2. Research Integrity: Upholding the highest standards of honesty and ethical practices in
3. research.
4. Innovation: Encouraging creativity and innovation in both teaching and research.
5. Collaboration: Fostering collaborative efforts within the department and with external
6. partners.
7. Diversity and Inclusion: Embracing diversity and striving for an inclusive environment for all students and staff.

Programs offered:

1) M.Sc. in Life Sciences (Botany)
2) M. Sc. in Life Sciences (Zoology)
3) FYIPGP in Life Sciences (Botany)
4) FYIPGP in Life Sciences (Zoology)
5) Ph.D. in Life Sciences

Programme Educational Objectives (PEOs)

1) Formulate strategies to achieve sustainable development in harnessing biological resources.
2) Evaluate environmental problems and design innovative solutions.
3) Demonstrate an attitude to employ multidisciplinary approaches for problem solving.

Programme Outcomes (POs)

1) Develop ideas to assess and inventorize existing biological resources of this region
2) Formulate innovative strategies for conservation of biogenetic resources for human welfare

3) To explore and validate ethnobiological knowledge of Northeast India

4) To provide solutions for existing societal problems using biological knowledge

5) Develop research skills to solve complex biological issues and achieving SDGs

6) Execute good communication skills for disseminating knowledge of biological sciences

7) To promote the attitude to work as a team appreciating ethical values

Programme Specific Outcomes (PSOs)

1) Evaluate the diversity and evolution of organisms

2) Analyze the fundamentals of life sustaining processes

3) Design strategies for issues concerning public health and human welfare

4) Critically analyze the environmental issues and develop strategies to address them

5) Formulate measures to mitigate climate change effects

COURSE STRUCTURE
FYIPGP LIFE SCIENCES (BOTANY)

Year	Sem.	Corse code	Title of the course	Credit
I	I	Core-I	Algae, Fungi, and Archegoniates	4
		Minor-I	Algae, Fungi, and Archegoniates	4
		GEC-I	Natural Resource Management	3
		AEC-I	Modern Indian Language	4
		SEC-I	Seritechnique	3
		VAC-I	Understanding India	2
		Total credit		**20**
	II	Core-II	Angiosperm systematics	4
		Minor-II	Angiosperm Systematics	4
		GEC-II	Biodiversity and human welfare	3
		AEC-II	English Language and Communication Skills	4
		SEC-II	Vermicomposting/Introduction to Artificial Intelligence in Biological Sciences	3
		VAC-II	Yoga	2
		VAC-Compulsory Add-on Course	Environmental Studies	4
		Total credit		**20**
CERTIFICATE				
II	III	Core-III	Cell biology	4
		Core-IV	Biochemistry & Molecular biology	4
		Minor-III	Biotechnology, tissue culture, and animal cell culture	4
		GEC-III	Ethnobiology	3
		SEC-III	Multi-Disciplinary Course: Basic Analytical Tools and Techniques in Science	3
		VAC-III	Digital and Technological Solutions / Digital Fluency	2
			Total credit	**20**
		Core-V	Genetics	4
	IV	C ore-VI	Microbiology & immunology	4
		Core-VII	Bioinformatics and biostatistics	4
		Core-VIII	Evolutionary biology	4
		Minor-IV	Biodiversity and Conservation Biology	4
		Total credit		**20**
		UG Diploma		

III	V	Core-IX	Plant Anatomy	4
		Core-X	Plant ecology and phytogeography	4
		Core-XI	Embryology of angiosperms	4
		Minor-V	Anatomy and embryology of angiosperms	4
		INT./CE	(Internship+Comm. Engagement) /Comm. Engagement/Internship	4
		Total credit		**20**
	VI	Core-XII	Plant physiology	4
		Core-XIII	Utilization of Plant resources	4
		Core-XIV	Plant breeding & crop improvement	4
		Core-XV	Plant pathology	4
		Minor-VI	Plant physiology	4
			Total credit	**20**
			UG DEGREE	
IV	**VII**	Core -XVI	Environmental Biology	4
		Core -XVII	Advanced molecular biology	4
		Core -XVIII	Advanced cell biology	4
		Research Methodology	Research Methodology and Research Ethics	4
		Minor -VII	Advanced analytical techniques	4
			Total	**20**
	VIII	Core -XIX	Intermediary metabolism	4
		Core-XX	Advanced genetics	4
		Minor -VIII	Bioethics & IPR	4
		Dissertation **Or** DSE-I & DSE-II	Dissertation Or Climate change & biological adaptations & Computational biology	8 4+4
			Total	**20**
V	IX	DSC-I	Plant Stress Biology	4
		DSC-II	Plant Biotechnology	4
		DSC-III	Plant Immunity	4
		DSE -III	DSE-III-A/B/C/D	4
		Project/ field-based learning	Field study	4
		Total		**20**
	X	DSC-IV	Advanced Anatomy & Embryology	4
		DSC-V	Plant Omics	4
		DSE-IV	DSE-IV-A/B/C/D	4
		Dissertation Or DSE-V & DSE-VI	Dissertation Or DSE-V & DSE-VI from online platform	8 Or 4+ 4
			Total	20
		M.Sc. in Life Sciences (Botany)		

COURSE DETAILS

SEMESTER-I

Title of the Course	**:**	**Algae, Fungi, and Archegoniate**
Nature of course	**:**	**CORE**
Code	**:**	**CORE-I**
Total Credits	**:**	**04**
Distribution of Marks	**:**	**40+60=100**
Total classes	**:**	**60**

Course outcomes:

1) describe different groups of the plant kingdom
2) organize the organisms into different categories based on morphological Characteristics
3) analyze the interrelationship among different species and genera within each group of plants

Learning Outcomes:

1) understand the various groups in the Kingdom
2) compare various organisms based on morphology
3) classify different groups of plants

Mapping of CO with Bloom's taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual						
Conceptual		CO1		CO2,CO3		
Procedural						
Metacognitive						

Mapping of Course outcomes to Programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	AVERAGE
CO1	3	2	2	2	2	2	2	2.1
CO2	3	2	2	2	2	2	2	2.1
CO3	3	2	3	1	1	2	2	2.0
AVERAGE	3	2	2.3	1.7	1.7	2	2	

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

Modes of internal assessment:

1. One internal examination (theory)
2. One internal examination (Lab)
3. Viva-voce
4. Group discussion
5. Home assignments

Attainment strategies of Cos:

1. Continuous evaluation through in and end semester theory and practical examinations
2. Field collection and identification of specimens
3. Submission of collected specimens
4. Practical record book

Course content:

Unit I: Algae: **9 classes**

General characteristics; Ecology and distribution; Range of thallus organization and reproduction; Reserved food; Pigments; Classification of algae; Morphology and life-cycles, Economic importance of algae

Unit II: Fungi: **9 classes**

Introduction- General characteristics, ecology, and significance, range of thallus organization, cell wall composition, nutrition, reproduction, and classification; True Fungi- General characteristics, ecology, and significance, life cycle

Symbiotic Associations-Lichens: General account, reproduction, and significance; Mycorrhiza: ectomycorrhiza and endomycorrhiza and their significance

Unit III: **Bryophytes**: **9 classes**

General characteristics, adaptations to land habit, Classification, Range of thallus organization. Classification (up to family), morphology, anatomy and reproduction, Ecology, and economic importance of bryophytes

Unit IV: Pteridophytes: **9 classes**

General characteristics, Early land plants, Classification (up to family), morphology, anatomy and reproduction, Heterospory and seed habit, stellar evolution. ecological and economic importance of Pteridophytes. Life history of *Lycopodium, Selaginella & Isoetes,* Ferns

Unit V: Gymnosperms: **9 classes**

General characteristics, Classification (up to family), morphology, anatomy and Reproduction, Ecological and economic importance; distribution of Gymnosperms in NE India; *Ginkgo, Pinus; Taxus, Gnetum*

Lab activities

1. Specimen study of blue-green algae/cyanobacteria (*Anabaena, Nostoc, Gloeotrichia*)
2. Specimen study of Algae (*Volvox, Ulothrix, Ectocarpus, Polysiphonia*)
3. Study of fungi: colony, view of the hyphae under microscope, *Mucor, Rhizopus, Aspergillus, Penicillium, Agaricus*)
4. Specimen study of Bryophytes (*Riccia, Marchantia, Anthoceros, Polytrichum, Funaria*)
5. . Specimen study of Pteridophytes (*Lycopodium, Selaginella, Marsilea, Isoetes, Equisitum)*
6. Specimen study of Gymnosperms (*Cycas, Pinus, Thuja, Gnetum*)

Textbooks

1. Campbell, N.A. and Reece, J. B. (2008) Biology 8th edition, Pearson Benjamin Cummings, San Francisco.

2. Raven, P.H et al (2006) Biology 7th edition Tata McGraw-Hill Publications, New Delhi

3. Griffiths, A.J.F et al (2008) Introduction to Genetic Analysis, 9th edition, W.H. Freeman & Co. NY

Suggested Readings

1. Tortora, G.J., Funke, B.R., Case, C.L. (2010). Microbiology: An Introduction, Pearson Benjamin Cummings, U.S.A. 10th edition.

2. Kumar, H.D. (1999). Introductory Phycology. Affiliated East-West. Press Pvt. Ltd. Delhi. 12. 2nd edition.

3. Vashishta, P.C., Sinha, A.K., Kumar, A., (2010). Pteridophyta, S. Chand. Delhi, India. Bhatnagar, S.P. and Moitra, A. (1996). Gymnosperms. New Age International (P) Ltd Publishers, New Delhi, India.

4. Parihar, N.S. (1991). An introduction to Embryophyta. Vol. I. Bryophyta. Central Book Depot, Allahabad.

SEMESTER-I

Title of the Course	**:**	**Algae, Fungi, and Archegoniates**
Nature of Course	**:**	**MINOR**
Code	**:**	**MINOR-I**
Total Credits	**:**	**04**
Distribution of Marks	**:**	**40+60=100**
Total classes	**:**	**60**

Course outcomes:

1) describe different groups of the plant kingdom

2) organize the organisms into different categories based on morphological Characteristics

3) to analyze the interrelationship among different species and genera within each group of plants

Learning Outcomes:

1) understand the various groups in the Kingdom

2) compare various organisms based on morphology

3) classify different groups of plants

Mapping of CO with Bloom's taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual						
Conceptual		CO1		CO2,CO3		
Procedural						
Metacognitive						

Mapping of Course outcomes to Programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	AVERAGE
CO1	3	2	2	2	2	2	2	2.1
CO2	3	2	2	2	2	2	2	2..1
CO3	3	2	3	1	1	2	2	2.0
AVERAGE	3	2	2.3	1.7	1.7	2	2	

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

Modes of internal assessment:

1. One internal examination (theory)
2. One internal examination (Lab)
3. Viva-voce
4. Group discussion
5. Home assignments

Attainment strategies of Cos:

1. Continuous evaluation through in and end semester theory and practical examinations
2. Field collection and identification of specimens
3. Submission of collected specimens
4. Practical record book
5. Seminar/group discussion

Course content:

Unit I: Algae: **9 classes**

General characteristics; Ecology and distribution; Range of thallus organization and reproduction; Reserved food; Pigments; Classification of algae; Morphology and life-cycles, Economic importance of algae

Unit II: Fungi: **9 classes**

Introduction- General characteristics, ecology, and significance, range of thallus organization, cell wall composition, nutrition, reproduction, and classification; True Fungi- General characteristics, ecology, and significance, life cycle

Symbiotic Associations-Lichens: General account, reproduction, and significance; Mycorrhiza: ectomycorrhiza and endomycorrhiza and their significance

Unit III: **Bryophytes**: **9 classes**

General characteristics, adaptations to land habit, Classification, Range of thallus organization. Classification (up to family), morphology, anatomy and reproduction, Ecology, and economic importance of bryophytes

Unit IV: Pteridophytes: **9 classes**

General characteristics, Early land plants, Classification (up to family), morphology, anatomy and reproduction, Heterospory and seed habit, stellar evolution. ecological and economic

importance of Pteridophytes. Life history of *Lycopodium, Selaginella & Isoetes,* Ferns

Unit V: Gymnosperms: **9 classes**

General characteristics, Classification (up to family), morphology, anatomy and Reproduction, Ecological and economic importance; distribution of Gymnosperms in NE India; *Ginkgo, Pinus; Taxus, Gnetum*

Lab activities

1. Specimen study of blue-green algae/cyanobacteria (*Anabaena, Nostoc, Gloeotrichia*)
2. Specimen study of Algae (*Volvox, Ulothrix, Ectocarpus, Polysiphonia*)
3. Study of fungi: colony, view of the hyphae under microscope, *Mucor, Rhizopus, Aspergillus,Penicillium, Agaricus*)
4. Specimen study of Bryophytes (*Riccia, Marchantia, Anthoceros, Polytrichum, Funaria*)
5. . Specimen study of Pteridophytes (*Lycopodium, Selaginella, Marsilea, Isoetes, Equisitum)*
6. Specimen study of Gymnosperms (*Cycas, Pinus, Thuja, Gnetum*)

Textbooks

1. Campbell, N.A. and Reece, J. B. (2008) Biology 8th edition, Pearson Benjamin Cummings, San Francisco.
2. Raven, P.H et al (2006) Biology 7th edition Tata McGraw-Hill Publications, New Delhi
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Suggested Readings

1. Tortora, G.J., Funke, B.R., Case, C.L. (2010). Microbiology: An Introduction, Pearson Benjamin Cummings, U.S.A. 10th edition.
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4. Parihar, N.S. (1991). An introduction to Embryophyta. Vol. I. Bryophyta. Central Book Depot, Allahabad.

SEMESTER-I

Title of the Course	**:**	**Natural Resource Management**
Nature of course	**:**	**GEC**
Code	**:**	**GEC-I**
Total Credits	**:**	**03**
Distribution of Marks	**:**	**40+60=100**
Total classes	**:**	**45**

Course outcomes:

1. Distinguish between renewable and non-renewable resources
2. Analyse threats to natural and biological resources of NE India
3. Examine management strategies for sustainable utilization of resources

Learning outcomes

1. Differentiate natural and biological resources of NE India
2. Identify the threats and issues related to the natural resources
3. Execute conservation and management strategies for natural resources

Mapping of CO with Bloom's taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual						
Conceptual				CO1, CO2, CO3		
Procedural						
Metacognitive						

Mapping of Course outcomes to Programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	AVERAGE
CO1	3	2	2	2	2	2	2	2.1
CO2	3	2	2	2	2	2	2	2.1
CO3	3	2	3	1	1	2	2	2.0
AVERAGE	3	2	2.3	1.7	1.7	2	2	

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

Modes of internal assessment:

1. One internal examination (theory)
2. One internal examination (Lab)
3. Viva-voce
4. Group discussion
5. Home assignments

Attainment strategies of Cos:

1. Continuous evaluation through in and end semester theory and practical examinations
2. Field demonstration of natural resources
3. Demonstration of modern tools like GIS
4. Participation in seminar/conference
5. Practical record book

Course content

UNIT-I: Natural resources: 07 classes

Definition and types. Natural resources of NE India. Renewable and non-renewable sources of energy.

UNIT-II: Sustainable utilization of land and water resources: **15 classes**

Soil degradation and management; water resources (Freshwater, marine, estuarine) wetlands; Threats and management strategies and their management.

UNIT-III: Biodiversity: **08 classes**

Definition, types, significance, threats, management strategies, CBD, Bioprospecting

UNIT IV: **15 classes**

Contemporary practices in resource management: EIA, GIS, Participatory Resource Appraisal, Ecological Footprint with emphasis on carbon footprint, Resource Accounting; Waste management. National and international efforts in resource management and conservation.

SUGGESTED READINGS:

1. Vasudevan, N. (2006). Essentials of Environmental Science. Narosa Publishing House, New Delhi.
2. Singh, J. S., Singh, S.P. and Gupta, S. (2006). Ecology, Environment and Resource Conservation. Anamaya Publications, New Delhi.

SEMESTER I

Title of the Course : SERITECHNIQUE
Code :SEC I
Nature of the Course : SEC
Total Credits : 03
Distribution of Marks : 60+40=100 Total classes: 45

Course outcomes

1. Discuss the concept of sericulture.
2. Explain the rearing technique and associated tools.
3. Examine the diseases and learn the control measures.

Learning outcomes:

After the completion of this course, the learner will be able to:
CO1: Comprehend the aspects of Seri-technology
CO2: Analyze and develop the skill to rear silkworms for entrepreneurship and explore the challenges in entrepreneurship development.

Mapping of CO with Bloom's taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual						
Conceptual				CO1, CO2, CO3		
Procedural						
Metacognitive						

Mapping of Course outcomes to Programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	AVERAGE
CO1	3	2	2	2	2	2	2	2.1
CO2	3	2	2	2	2	2	2	2.1
CO3	3	2	3	1	1	2	2	2.0
AVERAGE	3	2	2.3	1.7	1.7	2	2	

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

Modes of internal assessment:

1. One internal examination (theory)
2. One internal examination (Lab)
3. Viva-voce
4. Group discussion
5. Home assignments

Attainment strategies of Cos:

1. Continuous evaluation through in and end semester theory and practical examinations

2. Field collection and identification of local flora
3. Submission of collected specimens in the form of herbaria/bottle specimen
4. Practical record book/field book
5. Seminar/group discussion

Unit 1: Sericulture:

Introduction: history and present status; Silk route. Sericulture industry in different states, employment, potential in mulberry and non-Mulberry sericulture. Entrepreneurship in sericulture:Identification of wild and domesticated silkworms

Unit 2: Rearing of silkworms:

Mulberry silkworm rearing -Rearing house and rearing appliances, Early age and Lateage rearing. Types of mountages Spinning, harvesting and storage of cocoons. Non mulberry silkworm rearing: Host plants of nonmulberry silkworm, maintenance of host plants of *Antheraea assamensis*, rearing technology of A*ntheraea* spp and *Samia cynthiaricini*

Unit 3: Pests and diseases:

Pests of silkworm: Uzi fly, *Apanteles*, dermestid beetles and vertebrates. Pathogenesis of silkworm diseases: Protozoan, viral, fungal and bacterial. Symptoms, Control and prevention of pests and diseases.

Unit 4: (12 lectures)

i) Sex separation in larva, pupa and adult of silkworm

ii) Identification of different diseased silkworms based on external symptoms (Grasserie,Flacherie, Muscardine and Pebrine) and Identification of permanent slide of gut bacteria of silkworm, spores of Pebrine, spores of Muscardine

iii) Rearing of eri silk worm on artificial diet

Unit 5: (12 lectures)

i) Identification and study of Sericulture products

ii)Extraction of protein from silk gland

iii) Extraction of DNA from silk moth legs and purity test

iv) Project

SUGGESTED READINGS

- Handbook of Practical Sericulture: S.R. Ullal and M.N. Narasimhanna CSB, Bangalore
- Silkworm Rearing and Disease of Silkworm, 1956, Ptd. By Director of Ptg., Stn. & Pub. Govt. Press,Bangalore
- Appropriate Sericultural Techniques; Ed. M. S. Jolly, Director, CSR &TI,Mysore
- Handbook of Silkworm Rearing: Agriculture and Technical Manual1, Fuzi Pub. Co. Ltd., Tokyo, Japan1972.

- Manual of Silkworm Egg Production; M. N. Narasimhanna, CSB, Bangalore1988.
- Silkworm Rearing; Wupang—Chun and Chen Da-Chung, Pub. By FAO, Rome1988.
- A Guide for Bivoltine Sericulture; K. Sengupta, Director, CSR & TI

SEMESTER-II

Title of the Course : Angiosperm Systematics
Nature of Course : CORE
Code : CORE-II
Total Credits : 04
Distribution of Marks: 40+60=100
Total classes 60

Course outcomes

1. identify the diversity of angiosperms, including major families, genera, and species.
2. develop proficiency in using taxonomic keys, morphological features, and molecular data to classify and identify angiosperms.
3. ability to interpret phylogenetic trees and understand their implications for classification and evolution
4. evaluation of phylogenetic analyses, and taxonomic controversies within angiosperm

Learning Outcomes:

1. identify angiosperm taxa at the family, genus, and species levels using morphological, anatomical, and molecular characters
2. classify the local angiosperm flora based on their morphological, anatomical, and molecular characters
3. analysis of the evolutionary relationships among angiosperms and major clades of angiosperms
4. examine the phylogenetic analyses, and taxonomic controversies within angiosperm

Mapping of CO with Bloom's taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual						
Conceptual		CO1				
Procedural			CO3	CO4		CO2
Metacognitive						

Mapping of Course outcomes to Programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	AVERAGE
CO1	3	2	2	2	2	2	2	2.1
CO2	3	2	2	2	2	2	2	2.1
CO3	3	2	3	1	1	2	2	2.0
CO4	3	2	3	2	2	2	2	2.3
AVERAGE	3	2	2.5	1.7	1.7	2	2	

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

Modes of internal assessment:

1. One internal examination (theory)
2. One internal examination (Lab)
3. Viva-voce
4. Group discussion
5. Home assignments

Attainment strategies of Cos:

1. Continuous evaluation through in and end semester theory and practical examinations
2. Field collection and identification of local flora
3. Submission of collected specimens in the form of herbaria/bottle specimen
4. Practical record book/field book
5. Seminar/group discussion

Course content:

Unit 1: Significance of Plant Systematics **9 classes**

Introduction to systematics; Plant identification, Classification, Nomenclature. Evidences from

palynology, cytology, phytochemistry and molecular data. Field inventory; Functions of Herbarium; Important herbaria and botanical gardens of the world and India; Virtual herbarium; E-flora; Documentation: Flora, Monographs, Journals; Keys:Single access and Multi-access.

Unit 2: Taxonomic hierarchy **5 classes**

Concept of taxa (family, genus, species); Categories and taxonomic hierarchy; Species concept

(taxonomic, biological, evolutionary).

Unit 3: Botanical nomenclature **06 classes**

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 4: Systems of classification **10 classes**

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

Unit 5: Biometrics, numerical taxonomy and cladistics **7 classes**

Characters; Variations; OTUs, character weighting and coding; Cluster analysis; Phenograms, cladograms (definitions and differences).

Unit 6: Phylogeny of Angiosperms **8 classes**

Terms and concepts (primitive and advanced, homology and analogy, parallelism and convergence, monophyly, Paraphyly, polyphyly and clades). Origin and evolution of angiosperms; Co-evolution of angiosperms and animals; Methods of illustrating evolutionary relationship (phylogenetic tree, cladogram).

Lab activities

1. Study of vegetative and floral characters of the following families
    a. Magnoliaceae
    b. Brassicaceae
    c. Malvaceae
    d. Lamiaceae
    e. Solanaceae
    f. Asteraceae
    g. Poaceae
2. Mounting of a properly dried and pressed specimen of any wild plant with herbarium label (to be submitted in the record book).

Suggested Readings

1. Singh, (2012). Plant Systematics: Theory and Practice Oxford & IBH Pvt. Ltd., New Delhi. 3rdedition.

2. Jeffrey, C. (1982). An Introduction to Plant Taxonomy. Cambridge University Press, Cambridge.

3. 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.

4. Maheshwari, J.K. (1963). Flora of Delhi. CSIR, New Delhi.

5. Radford, A.E. (1986). Fundamentals of Plant Systematics. Harper and Row, New York

SEMESTER-II

Title of the Course : Angiosperm Systematics
Nature of Course : MINOR
Course Code : MINOR-II
Total Credits : 04
Distribution of Marks : 40+60=100
Total classes 60

Course outcomes

1. identify the diversity of angiosperms, including major families, genera, and species.
2. develop proficiency in using taxonomic keys, morphological features, and molecular data to classify and identify angiosperms.
3. ability to interpret phylogenetic trees and understand their implications for classification and evolution
4. evaluation of phylogenetic analyses, and taxonomic controversies within angiosperm

Learning Outcomes:

1. identify angiosperm taxa at the family, genus, and species levels using morphological, anatomical, and molecular characters
2. classify the local angiosperm flora based on their morphological, anatomical, and molecular characters
3. analysis of the evolutionary relationships among angiosperms and major clades of angiosperms
4. examine the phylogenetic analyses and taxonomic controversies within angiosperm

Mapping of CO with Bloom's taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual						
Conceptual		CO1				
Procedural			CO3	CO4		CO2
Metacognitive						

Mapping of Course outcomes to Programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	AVERAGE
CO1	3	2	2	2	2	2	2	2.1
CO2	3	2	2	2	2	2	2	2.1
CO3	3	2	3	1	1	2	2	2.0
CO4	3	2	3	2	2	2	2	2.3
AVERAGE	3	2	2.5	1.7	1.7	2	2	

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

Modes of internal assessment:

1. One internal examination (theory)
2. One internal examination (Lab)
3. Viva-voce
4. Group discussion
5. Home assignments

Attainment strategies of Cos:

1. Continuous evaluation through in and end semester theory and practical examinations
2. Field collection and identification of local flora
3. Submission of collected specimens in the form of herbaria/bottle specimen
4. Practical record book/field book
5. Seminar/group discussion

Course content:

Unit 1: Significance of Plant Systematics 9 classes

Introduction to systematics; Plant identification, Classification, Nomenclature. Evidences from

palynology, cytology, phytochemistry and molecular data. Field inventory; Functions of Herbarium; Important herbaria and botanical gardens of the world and India; Virtual herbarium; E-flora; Documentation: Flora, Monographs, Journals; Keys:Single access and Multi-access.

Unit 2: Taxonomic hierarchy 5 classes

Concept of taxa (family, genus, species); Categories and taxonomic hierarchy; Species concept

(taxonomic, biological, evolutionary).

Unit 3: Botanical nomenclature 06 classes

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 4: Systems of classification 10 classes

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

Unit 5: Biometrics, numerical taxonomy and cladistics 7 classes

Characters; Variations; OTUs, character weighting and coding; Cluster analysis; Phenograms, cladograms (definitions and differences).

Unit 6: Phylogeny of Angiosperms **8 classes**

Terms and concepts (primitive and advanced, homology and analogy, parallelism and convergence, monophyly, Paraphyly, polyphyly and clades). Origin and evolution of angiosperms; Co-evolution of angiosperms and animals; Methods of illustrating evolutionary relationship (phylogenetic tree, cladogram).

Lab activities

6. Study of vegetative and floral characters of the following families
    h. Magnoliaceae
    i. Brassicaceae
    j. Malvaceae
    k. Lamiaceae
    l. Solanaceae
    m. Asteraceae
    n. Poaceae
7. Mounting of a properly dried and pressed specimen of any wild plant with herbarium label (to be submitted in the record book).

Suggested Readings

1. Singh, (2012). Plant Systematics: Theory and Practice Oxford & IBH Pvt. Ltd., New Delhi. 3rdedition.

2. Jeffrey, C. (1982). An Introduction to Plant Taxonomy. Cambridge University Press, Cambridge.

3. 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.

4. Maheshwari, J.K. (1963). Flora of Delhi. CSIR, New Delhi.

5. Radford, A.E. (1986). Fundamentals of Plant Systematics. Harper and Row, New York

SEMESTER-II

Title of the Course	**:**	**Biodiversity and Human Welfare**
Nature of Course	**:**	**GEC**
Code	**:**	**GEC-II**
Total Credits	**:**	**03**
Distribution of Marks	**:**	**60+40=100**
Total classes	**:**	**45**

Course outcome

1. Differentiate the level of biological diversity
2. Examine the cause of the loss of biodiversity
3. Analyse the biodiversity conservation strategies
4. Evaluate the role of organisms in human welfare

Learning outcomes

1. Distinguish the biodiversity levels
2. Analyse threats to biodiversity
3. Understand the conservation strategies for biodiversity
4. Examine the role of plants, animals and microbes in human welfare

Mapping of CO with Bloom's taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual						
Conceptual		CO1				
Procedural			CO3	CO4		CO2
Metacognitive						

Mapping of Course outcomes to Programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	AVERAGE
CO1	3	2	2	2	2	2	2	2.1
CO2	3	2	2	2	2	2	2	2.1
CO3	3	2	3	1	1	2	2	2.0
CO4	3	3	2	2	2	1	1	2.0
AVERAGE	3.0	2.2	2.2	1.7	1.7	1.7	1.7	

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

Modes of internal assessment:

1. One internal examination (theory)
2. Viva-voce

3. Group discussion
4. Home assignments

Attainment strategies of Cos:

1. Continuous evaluation through in and end-semester theory and practical examinations
2. Field demonstration of local flora and fauna
3. Demonstration of biodiversity conservation models
4. Participation in seminar/conference

Course content

UNIT-I: 09 classes

Biodiversity and its scope- Genetic diversity, Species diversity, Plant and animal diversity at the ecosystem level. Values and uses of Biodiversity: Ethical and aesthetic values, Precautionary principle,

UNIT-II: 12 classes

Loss of Biodiversity: Loss of genetic diversity, Loss of species diversity, Loss of ecosystem diversity, Management of Biodiversity: Organizations associated with biodiversity management-Methodology for execution-IUCN, UNEP, UNESCO, WWF, NBPGR; Biodiversity legislation and conservations, Biodiversity information management and communication.

UNIT-III: 12 classes

Conservation of Biodiversity: Conservation of genetic diversity, species diversity and ecosystem diversity, *In situ* and *ex situ* conservation, Social approaches to conservation, Biodiversity awareness programs, Sustainable development.

UNIT-IV: 12 classes

Role of plants and animals in relation to Human Welfare; Importance of forestry and wildlife; their utilization and commercial aspects; Ornamental plants animals (fishes) and of NE India. Uses of microorganisms in human welfare (food, agriculture, medicine)

SUGGESTED READINGS:

1. Krishnamurthy, K.V. (2004). An Advanced Text Book of Biodiversity - Principles and Practices. Oxford and IBH Publications Co. Pvt. Ltd. New Delhi.

SEMESTER II

Title of the Course	**:**	**Vermicomposting**
Nature of the Course	**:**	**SEC**
Code	**:**	**SEC II**
Total Credits	**:**	**03**
Distribution of Marks	**:**	**60+40=100**
Total classes	**:**	**45**

Course outcomes:

1) describe the biology of some important species of earth worms used in vermiculture
2) demonstrate skills on production of vermicompost.
3) analyze benefits and problems with vermiculture and vermicompost

Leaning Outcome:

1) identify the earthworm species used in vermiculture
2) understand the benefit of vermiculture
3) display the skill of vermicompost production
4) interpret the problems associated with the vermicomposting technique

Mapping of CO with Bloom's taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual						
Conceptual		CO1				
Procedural			CO2	CO3		
Metacognitive						

Mapping of Course outcomes to Programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	AVERAGE
CO1	3	2	2	2	2	1	1	1.8
CO2	3	2	2	2	2	2	2	2.1
CO3	3	2	2	1	1	2	2	1.8
AVERAGE	3	2	2.0	1.7	1.7	1.7	1.7	

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

Modes of internal assessment:

1. One internal examination
2. Viva-voce
3. Group discussion
4. Home assignments

Attainment strategies of Cos:

1. Continuous evaluation through in and end semester theory and practical examinations
2. Hands-on training on preparation of vermicompost
3. Demonstration of large-scale production of vermicompost
4. Field collection of locally available earthworms for vermicomposting
5. Seminar/group discussion

Unit -1: Introduction to vermiculture (Lecture 7)

Vermiculture - definition, meaning, history, economic importance, value in the maintenance of soil structure, role as four r's of recycling (reduce, reuse, recycle and restore), Role in biotransformation of the residues generated by human activity and production of organic fertilizers, Useful species of earthworms, local and exotic species of earthworms

Unit -2: Biology of certain important earthworms native to NE India (Lecture 8)

Taxonomy and reproduction of Lumbricidae. Vital cycle: alimentation, fecundity, annual reproducer potential; limit factors (gases, diet, humidity, temperature, PH, light, and climatic factors).

Unit-3: Process of Vermicomposting (Lecture 8)

Small scale earthworm farming for home gardens - earthworm compost for home gardens
Conventional commercial composting - earthworm composting larger scale (pit, brick and, heap systems)
Earthworm farming, extraction (harvest), vermicomposting harvest and processing. Vermiwash collection, composition and use.
Enemies of earthworms, sickness and worm's enemies; frequent problems – prevention and fixation.

Unit-4: Applications of vermiculture (Lecture 7)

Benefits of vermicompost, Use of vermicompost in agriculture, Basic characteristics of earthworm suitable for vermicomposting, Problems in vermicomposting, vermicomposting of dairy waste.

Hands-on activities

1. Key to identify different types of earthworms.
2. Study of Life stages & development of earthworms.
3. Study of Vermiculture, Vermiwash& Vermicompost equipments, devices.
4. Preparation vermibeds, maintenance of vermicompost & climatic conditions.
5. Study of verms diseases & enemies
6. Field trip- collection of native earthworms & their identification

Suggested Readings:

Bhatt J.V. & S.R. Khambata (1959) “Role of Earthworms in Agriculture” Indian Council

of Agricultural Research, New Delhi

Edwards, C.A. and J.R. Lofty (1977) "Biology of Earthworms" Chapman and Hall Ltd., London.

Lee, K.E. (1985) "Earthworms: Their ecology and Relationship with Soils and Land Use" Academic Press, Sydney.

Wallwork, J.A. (1983) "Earthworm Biology" Edward Arnold (Publishers) Ltd. London.

Kevin, A and K.E.Lee (1989) "Earthworm for Gardeners and Fisherman" (CSIRO, Australia, Division of Soils).

Dash, M.C., B.K.Senapati, P.C. Mishra (1980) " Verms and Vermicomposting" Proceedings of the National Seminar on Organic Waste Utilization and Vermicomposting Dec. 5-8, 1984, (Part B), School of Life Sciences, Sambalpur University, Jyoti Vihar, Orissa.

Kumar, A. (2005) Verms and Vermitechnology, APH Publishing.

Lekshmy, M. S., Santhi R. (2012) Vermitechnology, Sara Publications, New Delhi, India

Chauhan, A. (2012) Vermitechnology, Vermiculture, Vermicompost and Earthworms: Vermiculture, Vermicomposting, Vermitechnology and Mirobes,Lambert Academic Publishing, Germany

Semester-II

Title of the Course	**:**	**INTRODUCTION TO ARTIFICIAL INTELLIGENCE (AI) IN BIOLOGICAL SCIENCES**
Course Code	**:**	**SEC_II**
Nature of the Course	**:**	**SEC**
Total Credits	**:**	**3**
Distribution of Marks	**:**	**60+40=100**

COURSE OUTCOMES:

CO1: Comprehend the concept of AI

CO2: Explore the concept of data in terms of biological sciences and will understand how biological data are generated

CO3: Learn how AI is applied in the field of biological sciences

CO4: Explain the ethical consideration of using AI in biological sciences

Mapping of CO with Bloom's taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create

Factual						
Conceptual		CO1				
Procedural		CO4	CO2 CO3			
Metacognitive						

Mapping of Course outcomes to Programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	AVERAGE
CO1	2	2	2	2	2	1	1	1.7
CO2	2	2	2	2	2	2	2	2.0
CO3	2	2	2	1	1	2	2	1.7
CO4	2	1	1	1	1	1	1	1.1
AVERAGE	2.0	1.7	1.7	1.5	1.5	1.5	1.5	

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

UNITS	CONTENTS	L	T	P	Total Hours
1 **(Marks)** **10TH**	**Overview of Artificial Intelligence in Biological Sciences:** Introduction to Artificial Intelligence (AI). Understanding the basics of machine learning and deep learning in the context of biological data analysis.	04	01	00	05
2 **(Marks)** **10TH + 2 PR**	**Biological Data and Data Collection Techniques:** Introduction to biological data: types, sources, and characteristics, Methods for collecting and preprocessing biological data. Ethical considerations in data collection and handling . **Practical/Case studies on above topics**	04	01	02	05
3 **(Marks)** **10TH + 2 PR**	**Overview of AI applications in Pharmaceutical sciences, Biotechnology, and Life sciences:** Case studies highlighting the use of AI in drug discovery, areas of Life Sciences, biotechnology. Challenges and opportunities in integrating AI into biological research workflows. **Practical/case studies on above topics**	04	01	02	05
4 **(Marks)** **10TH + 3 PR**	**Role of AI in biological data analysis:** Predictive modeling, biomarker discovery, and personalized treatment, Application of AI in precision medicine: patient stratification, disease diagnosis, and treatment optimization, AI-driven approaches in environmental biotechnology: biodiversity conservation, pollution monitoring and ecological modeling. **Practical/case studies on above topics**	10	01	03	15

5 **(Marks)** **10TH + 3 PR**	**Ethical Considerations in AI-driven Biology Research:** Understanding bias and fairness issues in biological data and AI algorithms. Addressing privacy concerns associated with the use of biomedical data in AI-driven studies, Promoting transparency, accountability, and responsible conduct in AI-based biological research. Ethical guidelines **Practical/case studies on above topics**	10	01	03	15
	Total (in Hrs)	**32**	**05**	**10**	**45**

Where, ***L: Lectures*** ***T: Tutorials*** ***P: Practicals***

MODES OF IN-SEMESTER ASSESSMENT: **(40 Marks)**

- One Internal (TH) Examination - **10 Marks**
- One Internal (PR) Examination - **10 Marks**
- Others - **20 Marks**
  - Quiz
  - Seminar presentation
  - Assignment

SUGGESTED READINGS/REFERENCES:

1. "Hands-On Artificial Intelligence for Beginners: An introduction to AI concepts, algorithms, and their implementation" By Patrick D. Smith, David Dindi. 2018. Packt.
2. Artificial Intelligence by Meenu Kumar. ISBN-10 - 8119416910; ISBN- 13 : 978-8119416912. 2018.2023. Orange House Pvt Ltd
3. An Introduction to Artificial Intelligence and Machine Learning – I : By Day-To-Day Examples by by Manikandan Paneerselvam. **ISBN-13 :** 979-8890267610
4. Artificial Intelligence : New Horizon in health Sciences, AI and Health Sciences: By Dr. Sivanesan and Dr. Juhi Agarwal. ISBN-13 : 978-9358471212 and ISBN-10:9358471212, 2024. Adhyyan Books
5. Artificial Intelligence and Molecular Biology by Lawrence E. Hunter. ISBN: 9780262581158 . 1993. AAAI Press
6. Fundamentals of Artificial Intelligence by KR Choudhury. ISBN 978-81-322-3970-3 ; ISBN 978-81-322-3972-7 (e Book). 2020, Springer.

SEMESTER-III

Title of the Course : Cell Biology
Nature of Course : CORE
Code : CORE-III
Total Credits : 04
Distribution of Marks : 40+60=100
Total classes : 60

Course Outcomes:

1) differentiate the structure and functions of cellular components
2) evaluate the cell division mechanism and cell cycle.
3) analyze cell signalling mechanism.

Learning Outcomes:

1) understand the cell structure and functions of cell organelles.
2) analyze cell division and cell cycle mechanisms.
3) interpret the cell signalling mechanisms.

Mapping of CO with Bloom Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual						
Conceptual				CO1, CO3	CO2	
Procedural						
Metacognitive						

Mapping of Course outcomes to Programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	AVERAGE
CO1	3	2	2	2	2	2	2	2.1
CO2	3	2	2	2	3	2	2	2.3
CO3	3	2	3	3	3	2	2	2.5
AVERAGE	3.0	2.0	2.3	2.3	2.7	2.0	2.0	

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

Modes of internal assessment

1. One internal examination (theory)
2. One internal examination (Lab)
3. Viva-voce
4. Group discussion
5. Home assignments

Attainment strategies of Cos:

1. Continuous evaluation through in and end semester theory and practical examinations
2. Laboratory practices on cells, cellular organelles and cellular processes
3. Practical record book/field book
4. Seminar/group discussion

Course contents

Unit-I: Overview of cell: Prokaryotic and Eukaryotic cells **10 classes**

Plasma Membrane and Cytoskeleton: Various models of plasma membrane structure, Transport across membranes: Active and Passive transport, Cell junctions: Tight junctions, Desmosomes, Gap junctions, Structure and Functions: Microtubules, Microfilaments and Intermediate filaments

Unit-II: Endomembrane System: Structure and Functions: **08 classes**

Endoplasmic Reticulum, Golgi Apparatus, Lysosomes

Unit-III: Mitochondria and Peroxisomes: **09 classes**

Mitochondria: Structure, Semi-autonomous nature, Endosymbiotic hypothesis Mitochondrial Respiratory Chain, Chemi-osmotic hypothesis, Peroxisomes

Unit-IV: Nucleus: **09 classes**

Structure of Nucleus: Nuclear envelope, Nuclear pore complex, Nucleolus Chromatin: Euchromatin and Hetrochromatin and packaging (nucleosome).

Unit-V: **Cell Division and Cell Signalling** **09 classes**

Mitosis, Meiosis, Cell cycle and its regulation, GPCR and Role of second messenger (cAMP).

Lab activities

1. Study of plant cell structure with the help of epidermal peel mount of Onion/Crinum/Rheo.
2. Demonstration of the phenomenon of protoplasmic streaming in *Hydrilla /Vallisnaria*
3. Measurement of cell size by micrometric method.
4. Cell counting using haemocytometer. (Yeast/pollen grains).
5. Study of cell and its organelles with the help of electron micrographs (Demonstration).
6. Cytochemical staining of: DNA- Feulgen and cell wall in the epidermal peel of onion using Periodic Schiff's (PAS) staining technique.
7. Study the phenomenon of plasmolysis and deplasmolysis.
8. Study different stages of mitosis and meiosis.
9. Preparation of permanent slide to demonstrate: Mucopolysaccharides by PAS reaction
10. Visualization of Proteins by Mercurobromophenol blue/FastGreen
11. Preparation of permanent slide to show the presence of Barr body in human female blood cells/cheek cells.

Textbooks

1. Karp G., Cell and Molecular Biology: Concepts and Experiments, 7th Edition (John Wiley & Sons, Inc., 2013).
2. Scott, M. P. et al, Molecular Cell Biology, 6th Edition (W. H. Freeman, 2007).
3. Alberts, B. et al., Molecular Biology of the Cell, 5th Edition (Garland Publishing, 2008).

4. Becker, W. M. et al., The World of Cell, 8th Edition (Benjamin Cummings, 2011).

Suggested Readings

1. Molecular and Cell Biology (Schaum's Outlines series special Indian edition) by W. D.Stansfield, J. S.C. Colome, R. J. Cano and R. N. Sharan (2010), McGraw Hill Education.
2. Cooper, G. M. and Hausman, R. E., The Cell: A Molecular Approach, 5th Edition (ASM Press and Sinauer Associates, Inc., 2009).

SEMESTER-III

Title of the Course	**:**	**Biochemistry and Molecular biology**
Code	**:**	**CORE-IV**
Nature of course	**:**	**CORE**
Total Credits	**:**	**04**
Distribution of Marks	**:**	**40+60=100**
Total classes	**:**	**60**

Course outcomes:

1) differentiate the biomolecules of living organisms, their interactions for perpetuation of life
2) analyze structure-function relationships of nucleic acids and protein
3) distinguish between replication, transcription and translation in prokaryotes and eukaryotes
4) interpret the gene expression mechanisms

Learner Outcome:

1) identify the various biomolecules and understand their function
2) differentiate the cellular processes such as replication, transcription and translation
3) understand gene expression mechanism

Mapping of CO with Bloom's taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual						
Conceptual			CO4	CO1, CO2, CO3		
Procedural						
Metacognitive						

Mapping of Course outcomes to Programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	AVERAGE
CO1	3	2	2	2	2	2	2	2.1
CO2	3	2	2	2	2	2	2	2.1
CO3	3	2	3	1	1	2	2	2.0
CO4	3	3	2	2	2	1	1	2.0
AVERAGE	3.0	2.2	2.2	1.7	1.7	1.7	1.7	

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

Modes of internal assessment

1. One internal examination (theory)

2. One internal examination (Lab)
3. Viva-voce
4. Group discussion
5. Home assignments

Attainment strategies of Cos:

1. Continuous evaluation through in and end-semester theory and practical examinations
2. Laboratory practices on biochemical and molecular biology processes
3. Practical record book/field book
4. Seminar/group discussion

Course content

Unit I **7 classes**

Introduction to Biochemistry, scopes; chemical basis of life, functional groups; water as solvent, ionization of water, weak acids; pH, buffer solution; types of chemical bonds in biological systems and types of biomolecules (Macro and small molecules) and functions. Laws of thermodynamics, concept of free energy, energy coupling reactions, ATP as energy currency molecule, redox reactions and concept of electron transport chain in mitochondria.

Unit-II **8 classes**

Proteins: Classification and functions of proteins. Amino acids, properties, and functions. Peptide bonds and peptide groups; structural organization of protein- primary, secondary, tertiary, and quaternary. Ramachandran Plot. The structural and functional relationship of protein- Ribonuclease-A, myoglobin, hemoglobin; protein denaturation and renaturation. Catabolic route and reactions of amino acids (Transamination, oxidative deamination and decaroxylation, urea cycle). Structure and classification of enzyme. Introduction to mechanism of enzyme action, and enzyme inhibition.

Unit-III **8 classes**

Carbohydrates: Overview on the sources, and biological functions; Classification (monosaccharide, disaccharide, and polysaccharide). Classes and structure of mono and disaccharides; glycosidic bond: Stereoisomerism, mutarotation, anomer, epimer etc.; glycoproteins and glycolipids. Catabolic pathways of carbohydrates (Glycolysis, Krebs cycle, Pentose phosphate pathway, gluconeogenesis, glycogen metabolism).

Unit-IV **7 classes**

Lipids: Structure, classification, and biological functions of lipids; storage and membrane lipids, lipoprotein. Fatty acids: classification; saturated, unsaturated, polyunsaturated; essential and non-essential fatty acids. Concept of beta-oxidation.

Unit-V Molecular biology **15 classes**

Nucleic acids: Types and functions of DNA, RNA; constituent monomers (nucleotides and nucleoside), DNA as genetic material, Structure of DNA and tRNA. DNA replication: Chemistry of replication, DNA polymerases, synthesis of leading and lagging strands

Prokaryotic transcription: RNA polymerase, promoters, sigma factors, initiation, elongation, and termination (Rho-dependent and independent), Eukaryotic transcription: types of eukaryotic RNA polymerases. Overview on the regulation of gene expression in prokaryotes; Transcriptional regulation in bacteria.

Lab activities

1. Preparation of different biochemical solutions, dilutions, preparation of buffer solutions, etc.
2. Identification of unknown carbohydrates (starch, sucrose, glucose, galactose, and fructose)
3. Quantitative estimation of ascorbic acid
4. Quantitative estimation of glucose
5. Quantitative estimation of protein
6. Quantitative estimation of free phosphate
7. Separation of amino acids by TLC and determination of Rf value.
8. Bead and stick model of nucleic acid
9. Study of chromatin organization
10. DNA isolation and agarose gel electrophoresis

SUGGESTED READINGS:

1. Karp, G. (2010). *Cell and Molecular Biology: Concepts and Experiments*. VI Edition. John Wiley and Sons.Inc.
2. De Robertis, E.D.P. and De Robertis, E.M.F. (2006). *Cell and Molecular Biology*. VIII Edition. Lippincott Williams and Wilkins,Philadelphia.
3. Cooper, G.M. and Hausman, R.E. (2009). *The Cell: A Molecular Approach*. V Edition. ASM Press and Sunderland, Washington, D.C.; Sinauer Associates,MA.
4. Bruce Albert, Bray Dennis, Levis Julian, Raff Martin, Roberts Keith and Watson James (2008). *Molecular Biology of the Cell*, V Edition, Garland publishing Inc., New York and London.
5. Karp, G. (2010). *Cell and Molecular Biology: Concepts and Experiments*. VI Edition. John Wiley and Sons.Inc.
6. De Robertis, E.D.P. and De Robertis, E.M.F. (2006). *Cell and Molecular Biology*. VIII Edition. Lippincott Williams and Wilkins,Philadelphia.
7. Cooper, G.M. and Hausman, R.E. (2009). *The Cell: A Molecular Approach*. V Edition. ASM Press and Sunderland, Washington, D.C.; Sinauer Associates,MA.
8. Bruce Albert, Bray Dennis, Levis Julian, Raff Martin, Roberts Keith and Watson James (2008). *Molecular Biology of the Cell*, V Edition, Garland publishing Inc., New York and London

SEMESTER III

Title of the Course : Biotechnology, tissue culture, and animal cell culture
Nature of Course : MINOR
Code : MINOR-III
Total Credits 04
Distribution of Marks: 40+60=100
Total classes : 60

Course outcomes:

1) To interpret the principle, practices and application of biotechnology.
2) To examine the process of genetic engineering.
3) To demonstrate plant tissue culture and animal cell culture.

Learning Outcomes:

1) To apply the concept of biotechnology
2) To discuss the tools and techniques involves in genetic engineering.
3) To understand the process of plant tissue culture and animal cell culture.

Mapping of CO with Bloom's taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual						
Conceptual						
Procedural			CO1, CO3	CO2		
Metacognitive						

Mapping of Course outcomes to Programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	AVERAGE
CO1	3	2	2	2	2	2	2	2.1
CO2	3	2	2	2	2	2	2	2.1
CO3	3	2	3	3	3	2	2	2.6
AVERAGE	3.0	2.0	2.3	2.3	2.3	2.0	2.0	

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

Modes of internal assessment

1. One internal examination (theory)
2. One internal examination (Lab)
3. Viva-voce
4. Group discussion

5. Home assignments

Attainment strategies of Cos:

1. Continuous evaluation through in and end semester theory and practical examinations
2. Laboratory practices on biotechnology, cell and tissue culture
3. Practical record book/field book
4. Seminar/group discussion

Course content

Section-A

Unit 1: Recombinant DNA technology (Lecture: 5)

Introduction to biotechnology; Restriction Endonucleases (History, Types I-IV, biological role and application); Cloning Vectors; types

Unit-2: Gene Cloning (Lecture: 8)

Recombinant DNA technology, Bacterial Transformation and selection of recombinant clones, PCR mediated gene cloning, DNA libraries, cDNA libraries, colony hybridization; Somatic cell nuclear transfer.

Unit-3: Applications of Biotechnology (Lecture: 12)

Pest resistant (Bt-cotton); herbicide resistant plants (RoundUp Ready soybean); Transgenic crops with improved quality traits (Flavr Savr tomato, Golden rice); Improved horticultural varieties (Moondust carnations); Role of transgenics in bioremediation (Superbug); edible vaccines; Industrial enzymes (Aspergillase, Protease, Lipase); Gentically Engineered Products–Human Growth Hormone; Humulin; Biosafety concerns.

Unit-4: Animal cell culture (Lecture: 8)

Historical perspective; Composition of media; Nutrient and hormone requirements, maintenance of aseptic condition, types of cell lines, Application of cell culture, MTT assay

Unit-5: Plant Tissue Culture (Lecture: 12)

Historical perspective; Composition of media; Nutrient and hormone requirements (role of vitamins and hormones); Totipotency; Organogenesis; Embryogenesis (somatic and zygotic); Protoplast isolation, culture and fusion; Tissue culture applications (micropropagation, androgenesis, Cryopreservation; Germplasm Conservation).

Section-B

Lab activities

1. Preparation of MS medium and callus.
2. Demonstration of in vitro sterilization and inoculation methods using leaf and nodal explants of tobacco, Datura, Brassica etc.
3. Study of anther, embryo and endosperm culture, micropropagation, somatic embryogenesis & artificial seeds through photographs.
4. Construction of restriction map of circular and linear DNA from the data provided
5. Study of methods of gene transfer through photographs: Agrobacterium-mediated, direct gene transfer by electroporation, microinjection, microprojectile bombardment.
6. Study of steps of genetic engineering for production of Bt cotton, Golden rice, Flavr Savr tomato through photographs.
7. Isolation of plasmid DNA.
8. Restriction digestion and gel electrophoresis of plasmid DNA.
9. Demonstration of animal cell culture technique through photographs/animation

Suggested Readings

1. Bhojwani, S.S. and Razdan, M.K., (1996). Plant Tissue Culture: Theory and Practice. Elsevier Science Amsterdam. The Netherlands.

2. Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington.

3. Bhojwani, S.S. and Bhatnagar, S.P. (2011). The Embryology of Angiosperms. Vikas Publication House Pvt. Ltd., New Delhi. 5th edition.

4. Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics. John Wiley and Sons, U.K. 5th edition.

5. Stewart, C.N. Jr. (2008). Plant Biotechnology & Genetics: Principles, Techniques and Applications. John Wiley & Sons Inc. U.S.A

SEMESTER III

Title of the Course	**:**	**Ethnobiology**
Code	**:**	**GEC-III**
Nature of the Course	**:**	**GEC-III**
Total Credits	**:**	**03**
Distribution of Marks	**:**	**60+40=100**
Total classes	**:**	**45**

Course outcome:

1) Discuss the indigenous practices of ethnic groups of Northeast India
2) Use of traditional knowledge system of the region for sustainable development
3) Compare medicinal and agronomic values of biological resources of the region
4) Protection of traditional knowledge through IPR

Learning outcome:

1) Understand the traditional practices of ethnic communities of the region
2) Implementation of IKS for sustainable development goals
3) Apply the indigenous knowledge in daily life
4) Analyze the IPR for protection of traditional knowledge

Mapping of CO with Bloom's taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual						
Conceptual		CO1			CO4	
Procedural			CO2	CO3		
Metacognitive						

Mapping of Course outcomes to Programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	AVERAGE
CO1	2	2	3	3	2	2	2	2.3
CO2	2	2	3	3	2	2	2	2.3
CO3	2	2	3	3	2	2	2	2.3
CO4	2	2	3	3	2	1	1	2.0
AVERAGE	2.0	2.0	3.0	3.0	2.0	1.8	1.8	

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

Modes of internal assessment

1. One internal examination (theory)
2. Viva-voce
3. Group discussion
4. Home assignments

Attainment strategies of Cos:

1. Continuous evaluation through in and end semester theory and practical examinations

2. Demonstration of traditional practices of ethnic communities (medicine, food, beverages)
3. Demonstration of traditional methods of conservation of food and beverages
4. Participation in seminar/conference

Course content

Unit 1: Ethnobiology (Lectures 15)

Concept, history and theory; hypotheses, evolution and scope; Indigenous knowledge and traditional practices, ethnobiology of northeast India. Major ethnic groups in North East India; their social institutions, livelihood, cultural and religious practices, other belief systems, sacred groove. Methods of biological resource conservation & ecorestoration. Scope for development of plant resources.

Unit 2:Traditional Knowledge (Lectures 10)

Traditional knowledge system of different indigenous communities of North Eastern India. Application and practices of traditional knowledge system in agriculture, healthcare, livelihood and alternative food & fodder. Sustainable utilization of biological resources and biodiversity conservation. Current status of Ethnobiology, biodiversity and traditional knowledge.

Unit 3: Ethnobiology and Its Relevance in Contemporary Research (Lectures 8)

Ethnobiology & drug discovery; Ayurvedic drug preparation and drug adulteration. Chemical composition of few medicinal and aromatic plants, extraction, and uses pertaining to typical Indian formulation of drugs. Ethnopharmacological validation of traditional medicine; approaches to drug discovery from ethnobotanical leads.

Unit 4: Traditional Agronomic Practices: (Lectures 5)

Shifting cultivation, weeds and their management, beekeeping, Aquaculture

Unit 5 : Protection of Traditional Knowledge (Lectures 7)

Ethnobiology & IPR; biopiracy, National Biodiversity protection initiatives; Convention on Biological Diversity, Nagoya protocol.

Suggested Readings

1) S.K. Jain, Manual of Ethnobotany, Scientific Publishers, Jodhpur, 1995.
2) S.K. Jain (ed.) Glimpses of Indian. Ethnobotny, Oxford and I B H, New Delhi – 1981

3) Lone et al, Palaeoethnobotany
4) S.K. Jain (ed.) 1989. Methods and approaches in ethnobotany. Society of ethnobotanists, _Lucknow, India.
5) S.K. Jain, 1990. Contributions of Indian ethnobotny.Scientific publishers, Jodhpur.
6) Colton C.M. 1997. Ethnobotany – Principles and applications. John Wiley and sons – _Chichester
7) Rama Ro, N and A.N. Henry (1996). The Ethnobotany of Eastern Ghats in Andhra Pradesh, India.Botanical Survey of India. Howrah._8) Rajiv K. Sinha – Ethnobotany The Renaissance of Traditional Herbal Medicine – INA –SHREE Publishers, Jaipur-1996_9) Faulks, P.J. 1958.An introduction to Ethnobotany, Moredale pub. Ltd

SEMESTER III

Title of the Course : Analytical Tools and Techniques in Science (Multi disc.)
Code : SEC-III
Nature of the Course : SEC
Total Credits : 03
Distribution of Marks : 60+40=100
Total classes: 45

Course Outcomes:

1) analyze different separation techniques
2) compare various microscopic techniques
3) examine the structure of DNA and its amplification
4) contrast among blotting techniques
5) investigate biological and chemical samples through the application of different tools and techniques

Learning Outcome:

1) demonstrate various separation techniques
2) operate different microscopes
3) describe DNA structure and amplification
4) distinguish between blotting techniques
5) evaluate biological and chemical samples with the use of various tools and techniques

Mapping of CO with Bloom's taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual						
Conceptual						
Procedural				CO1, CO2, CO3, CO4		CO5
Metacognitive						

Mapping of Course outcomes to Programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	AVERAGE
CO1	2	2	2	3	2	2	2	2.1
CO2	2	2	2	2	2	2	2	2.0
CO3	2	2	3	2	2	2	2	2.0
CO4	2	2	2	2	2	1	1	1.7
CO5	2	2	2	2	2	1	1	1.7
AVERAGE	2.0	2.0	2.2	2.2	2.0	1.6	1.6	

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

Modes of internal assessment:

1. One internal examination (theory)
2. One internal examination (lab)
3. Viva-voce
4. Group discussion
5. Home assignments

Attainment strategies of Cos:

1. Continuous evaluation through in and end semester theory and practical examinations
2. Demonstration of the major equipment used in analytic techniques
3. Practical record book
4. Hands-on activities in operating instruments

Unit 1: Chromatographic methods:

Adsorption and partition principle. Thin layer chromatography (TLC), Paper (radial, ascending, descending), and column chromatography. Fundamentals of spectroscopic techniques: (a) UV-vis spectroscopy: Overview of spectroscopy techniques, Basic principles of electromagnetic radiation, Interaction of light with matter, Components of a UV-Vis spectrophotometer, Sample handling techniques, Beer-Lambert Law and its application in UV-Vis spectroscopy, Factors affecting absorbance spectra (solvent, pH, temperature, etc.), Applications of UV-Vis Spectroscopy in qualitative and quantitative analysis, in kinetic studies (monitoring reaction rates). (b) IR Spectroscopy: Introduction to IR Spectroscopy, Components of an IR spectrometer, Sample handling techniques, Vibrational modes of molecules, Theory behind IR spectra interpretation.

Unit 2: Microscopy:

Concept of Resolution and Magnification, Optical Microscopy- Bright Field Microscopy, Dark Field Microscopy, Phase Contrast Microscopy, Fluorescence Microscopy and Electron Microscopy. Centrifugation technique- Principle of centrifugation, Differential and Density gradient centrifugation (Rate Zonal Centrifugation, Isopycnic Centrifugation). Concept of DNA structure, PCR-based DNA amplification: PCR chemicals and principle of PCR. Electrophoretic separation of biomolecules- principle; Blotting techniques—Southern, Northern, and Western.

Unit 3: Lab. activities

1. Separation of biological/chemical samples using Paper Chromatography and TLC
2. Spectrophotometric estimation of biological/chemical samples
3. Structural elucidation of unknown compounds using IR spectroscopy
4. Handling of Microscope and visualization of different samples
5. Separation of samples using centrifuge
6. Amplification of DNA using PCR
7. Agarose gel electrophoresis of PCR amplified DNA

Suggested readings:

1. Biophysical chemistry: principles and techniques. Upadhyaya, Upadhyaya & Nath, Himalaya publishing house, ISBN-978-93-5142-227-3

SEMESTER-IV

Title of the Course : Genetics
Code : CORE-V
Nature of Course : Core
Total Credits : 04
Distribution of Marks : 60+40=100
Total classes; 60

COs:

1) Interpret the basic patterns of inheritance
2) Evaluate genetic disorders and mutations

Learning Outcome:

1) Understand the concept of inheritance
2) Analyze mutations and genetic disorders

Mapping of CO with Bloom's taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual						
Conceptual				CO1		
Procedural					CO2	
Metacognitive						

Mapping of Course outcomes to Programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	AVERAGE
CO1	2	2	2	3	2	2	2	2.1
CO2	2	2	2	2	2	2	2	2.0
AVERAGE	2.0	2.0	2.0	2.5	2.0	2.0	2.0	

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

MODES OF IN-SEMESTER ASSESSMENT:

1. One Theory exam
2. One Practical exam
3. Group Discussion/Seminar/Viva/Assignments

Attainment strategies of COs:

1. Continuous evaluation through in and end semester theory examination
2. In and end semester practical examination
3. Submission of practical file
4. Viva-voce examination

Unit-I: Mendelian genetics and its extension **15 classes**

Mendelism: History; Principles of inheritance; Chromosome theory of inheritance; autosomesand sex chromosomes; Probability and pedigree analysis; Incomplete dominance and codominance; Multiple alleles, Lethal alleles, Epistasis, Pleiotropy, Recessive and Dominant traits; Polygenic inheritance.

Unit-II: Extrachromosomal Inheritance **9 classes**

Chloroplast mutation: Variegation in Four o'clock plant; Mitochondrial mutations in yeast; Maternal effects-shell coiling in snail; Infective heredity- Kappa particles in *Paramecium*.

Unit-III: Linkage, crossing over, and chromosome mapping **9 classes**

Linkage and crossing over-Cytological basis of crossing over; Genetic mapping, Sex linked, Sex influenced, Sex limited inheritances, quantitative traits/loci.

Unit IV: Chromosomal & gene mutation **12 classes**

Chromosomal mutation: Deletion, Duplication, Inversion, Translocation, Position effect, Euploidy and Aneuploidy. Gene mutations: Types of gene mutations; Molecular basis of Mutations; Mutagens – physical and chemical (Base analogs, deaminating, alkylating and intercalating agents); Detection of mutations: ClB method; Transposons

Unit V: Lab activities **15 classes**

1. Mitosis & Meiosis through temporary squash preparation
2. Mendel's laws through seed ratios. Laboratory exercises in probability and chi-square.
3. Chromosome mapping using point test cross data.
4. Pedigree analysis for dominant and recessive autosomal and sex-linked traits.
5. Study of aneuploidy: Down's, Klinefelter's, and Turner's syndromes.
6. Study of Mendel's laws and gene interactions. Verify result using chi-square test.
7. Study of Human Karotypes by pictorial demonstration.
8. Chromosome mapping using point test cross data.
9. Preparation of polytene chromosome from *Chironomous/Drosophilla* larvae

Suggested readings

1. Genetics: Analysis & Principles Author: Robert J. Brooker Publisher: McGraw-Hill Science Engineering; 4 edition (21 January 2011)

2. Concepts of Genetics Authors: William S. Klug, Michael R. Cummings, Charlotte A. Spencer, Michael A. Palladino, Darrell KilliannPublisher: Benjamin-Cummings Pub Co; Student edition (19 November 2014)

3. Introduction to Genetic Analysis (Introduction to Genetic Analysis (Griffiths)) Hardcover – Import, 16 Feb 2007 Authors: Anthony J. F. Griffiths, Susan R. Wessler , Richard C. Lewontin, Sean B. CarrollPublisher: WH Freeman; 11th ed. 2016 edition (12 January 2015)

SEMESTER-IV

Title of the Course : Microbiology & Immunology
Code : CORE-VI
Nature of Course : Core
Total Credits : 04
Distribution of Marks : 60+40=100
Total classes 60

COs:

1) Classify microorganisms based on different parameters
2) Demonstrate different processes involved in microbiology
3) Differentiate between microbial groups
4) Apply microbes for human welfare
5) Evaluate different antibiotics, immunological processes and vaccines

Learning Outcome:

1) Distinguish microbes based on different parameters
2) Understand different microbial processes for application in human welfare
3) Describe immunological concepts
4) Understand antibiotic classes and vaccines

Mapping of CO with Bloom's taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual						
Conceptual		CO1				
Procedural			CO2, CO4	CO3	CO5	
Metacognitive						

Mapping of Course outcomes to Programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	AVERAGE
CO1	2	2	2	3	2	2	2	2.1
CO2	2	2	2	2	2	2	2	2.0
CO3	2	2	3	2	2	2	2	2.0
CO4	2	2	2	2	2	1	1	1.7
CO5	2	2	2	2	2	1	1	1.7
AVERAGE	2.0	2.0	2.2	2.2	2.0	1.6	1.6	

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

Modes of in-semester assessment:

1. One Theory exam
2. One Practical exam
3. Group Discussion/Seminar/Viva/Assignments

Attainment strategies of COs:

1. Continuous evaluation through in and end semester theory examination
2. Submission of assignment on relevant topic
3. Submission of practical record book
4. Viva-voce examination

Unit I: Brief history and development of microbiology: **10 classes**

Introduction to study of Microbiology, conflict over spontaneous generation, role of microorganisms in disease, scope of microbiology, development of Koch's postulate.

Classification of microorganisms; morphological, biochemical and molecular characteristics; nutritional types in microorganisms; Culture media, microbial growth curve, uncultured microbes.

Unit II: Prokaryotic cell structure and viruses: **15 classes**

Bacterial cell wall, cytoplasmic structure and inclusions bodies, sporulation and spore, diversity in bacterial structure; actinomycetes, rickettsias, mycoplasma; archaea. Basic structures, classification, double-stranded and single-stranded DNA and RNA viruses, replication strategies of DNA and RNA viruses; viroids and prions; bacteriphages with suitable examples.

Unit-III: Application of microbes: **10 classes**

Role of microbes in bio-geo-chemical cycling, biological nitrogen fixation; industrial application of microbes: alcohol, organic acids, vaccine, antibiotics; microbial biofilm; wastewater treatment; biofertilizer and biopesticides; Microbial diseases and their control: Host-pathogen relationship, mechanisms of virulence, quorum sensing, pathogenesis in plants and animals

Unit-IV: Immunology **10 classes**

Immunity and types (innate immunity and adaptive immunity); Natural immunity and artificial immunity; Active and passive immunity; discrimination between self and non-self,; Immune responses; Antibody-mediated immune response (AMIS) and Cell-mediated immune response (CMIS); Cells of the immune system; lymphoid organs; Antigens – basic concepts, Immunoglobulins.

Unit V: Lab Course: **15 classes**

1. Bacterial growth on solid and broth media, pure culture technique, slant preparation
2. Bacterial colony morphology and diversity
3. Gram staining of bacteria
4. Biochemical characterization of bacteria
5. Demonstration of lymphoid organs (by video)
6. Histological study of spleen, thymus and lymph nodes through slides/ photographs
7. Model and/or Chart preparation/submission

Suggested Readings

1. Willey, J., Sherwood, L. and WoolvertonC., Microbiology, 10th edition (McGraw-Hill Science, 2017).
2. Pelczar, M.J., Chan, E.C.S. and Kreig, N.R., Microbiology, Publisher McGraw Hill Education (India) Private Limited, ISBN-10 0074623206, 5th Edition, 2001.
3. Tortora, G.J., Fernke, B.R. and Case, C.L., Microbiology – An Introduction, 9th Edition,
4. Basic Immunology: Functions and Disorders of the Immune System, Abul K. Abbas, Andrew H. Lichtman, Shiv Pillai (Elseviers Saunders 4 th Edition).
5. Kuby Immunology, Thomas J. Kindt, Barbara A. Osborne, Richard A . Goldsby (W.H. Freeman Publishers, Sixth Edition).
6. M. T. Madigan, J. M. Martinko, K. S. Bender, D. H. Buckley, D. A. Stahl, T. Brock, Brock Biology of Microorganisms, 14th Edition , Pearson Hall International, 2017.
7. Molecular and Cell Biology (Schaum's Outlines series special Indian edition) by W. D. Stansfield, J. S.C. Colome, R. J. Cano and R. N. Sharan (2010), McGraw Hill Education
8. Delves, P., Martin, S., Burton, D., Roitt, I. Roitt's Essential Immunology (WileyBlackwell, 11th Edition).

SEMESTER-IV

Title of the Course : Bioinformatics and biostatistics
Code : CORE-VII
Total Credits : 04
Distribution of Marks : 60+40=100

COs:

1. Understanding the basic concepts of bioinformatics and biostatistics
2. Use of biological databases for data retrieval
3. Analysis of biological data for solving biological problems
4. Evaluation of the significance of biological experiments

Learning Outcome:

1. Describe the various biological databases
2. Summarize the data retrieve from biological databases
3. Compare and contrast the biological data for better interpretation
4. Application of statistical tools for testing the significance of tests

Mapping of CO with Bloom's taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual						
Conceptual		CO1				
Procedural			CO2	CO3	CO4	

Metacognitive						

Mapping of Course outcomes to Programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	AVERAGE
CO1	2	2	2	2	2	2	2	2.0
CO2	2	2	2	2	2	2	2	2.0
CO3	2	2	2	2	2	2	2	2.0
CO4	2	2	2	2	2	2	2	2.0
AVERAGE	2.0	2.0	2.0	2.0	2.0	2.0	2.0	

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

Modes of in-semester assessment:

1. One Theory exam
2. One Practical exam
3. Group Discussion/Seminar/Viva/Assignments

Attainment strategies of COs:

1. Continuous evaluation through in and end semester theory examination
2. Submission of assignment on relevant topic
3. Submission of practical record book
4. Viva-voce examination

Unit I: Introduction to Bioinformatics **10 lectures**

Introduction, Biological Databases, Classification of Biological Databases, Biological Database Retrieval System. National Centre for Biotechnology Information (NCBI), Protein Database, Gene Expression Database, EMBL Nucleotide Sequence Database (EMBL-Bank). DNA Data Bank of Japan (DDBJ), Data Submission at DDBJ, Protein Information Resource (PIR), Swiss-Prot.

Unit-II: Sequence Alignments & Molecular Phylogeny **15 lectures**

Sequence analysis tools. BLAST, Concept of Alignment, Multiple Sequence Alignment (MSA), MSA by CLUSTALW, Scoring Matrices, Percent Accepted Mutation (PAM), Blocks of Amino AcidSubstitution Matrix (BLOSUM). Methods of Phylogeny, Software for Phylogenetic Analyses, Consistency of Molecular Phylogenetic Prediction.

Unit-III: Biostatistics (Descriptive) **10 lectures**

Sampling: Sample size and sampling types. Frequency Distributions and Measures of central tendency: mean, mode, median. Measures of dispersion: range, variance, standard deviation, coefficient of variation, measures of skewness and kurtosis.

Unit-IV: Biostatistics (Inferential) **10 lectures**

Basic concept of Probability, Bayesian Rules, Random variable, Distributions of random variables, Binomial, Poisson. Correlation and regression. Test of Significance: Hypothesis testing; null and alternative hypotheses; Type I and Type II errors; level of significance and p-value. Parametric tests: Student's t-test, Z-test, Analysis of Variance (One-

way ANOVA and Two-way ANOVA), and multiple comparison procedures (Post-hoc tests/Critical Difference analysis). Non-parametric tests: Chi-square test and Mann–Whitney U test.

Unit V: Lab Course **15 lectures**

1. Nucleic acid and protein databases.
2. Sequence retrieval from databases.
3. Sequence alignment.
4. Sequence homology and Gene annotation.
5. Construction of phylogenetic tree.
6. Statistical Measures: mean, mode, median, variance, standard deviation
7. Tests of significance

Suggested Readings

1. Abraham Silberschatz, Henry F. Korth, S. Sudarshan, "Database System Concepts", McGraw-Hill, 6th Edition, 2011.
2. Date C.J, "An Introduction to Database", Addison-Wesley Pub Co, 7th Edition, 2001
3. Elmashri& Navathe, "Fundamentals of Database System", Addison-Wesley Publishing, 3rd Edition, 2000
4. Jhonson RA et al. (2015) Miller &Freund's probability and statistics for engineers.
5. Ross S (2018) Introduction to probability and statistics for engineers and scientists.
6. Fundamentals of Biostatistics by Bernard Rosner Publisher: Cengage Learning; 7 edition

SEMESTER-IV

Title of the Course : Evolutionary Biology
Code : CORE-VIII
Nature of coure : CORE
Total Credits : 04
Distribution of Marks: 60+40=100
Total classes : 60

COs:

1. Describe the concept and theories of Evolution
2. Analyze the evolutionary evidences and theories of origin of life
3. Evaluate population genetics and evolution of man

Learning Outcomes:

1. Understand the theory of origin of life on Earth
2. Discuss the theories on the basis of evidences
3. Analyze population genetics

Mapping of CO with Bloom's taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual						
Conceptual		CO1		CO2, CO3		
Procedural						
Metacognitive						

Mapping of Course outcomes to Programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	AVERAGE
CO1	3	2	2	2	2	2	2	2.14
CO2	3	2	2	2	2	2	2	2.14
CO3	3	2	3	1	1	2	2	2.0
AVERAGE	3	2	2.3	1.7	1.7	2	2	

3 for highest correlation,2 for moderate correlation, and1 for lowest correlation

Modes of in-semester assessment:

1. One Theory exam
2. One Practical exam
3. Group Discussion/Seminar/Viva/Assignments

Attainment strategies of COs:

1. Continuous evaluation through in and end semester theory examination
2. Submission of assignment on relevant topic
3. Submission of practical record book
4. Viva-voce examination

15 lectures

Unit 1: Life's Beginnings: Chemogeny, RNA world, Fe-S complex theory of the origin of metabolism, Biogeny, Origin of photosynthesis, Evolution of eukaryotes. Historical review of evolutionary concept: Lamarckism, Darwinism, Neo- Darwinism, Germplasm theory, Synthetic theory and its significance. Causes of variation at individual level-recombination, mutation, hybridization and lateral gene transfer; factors affecting variation at individual level.

10 lectures

Unit 2: Evidences of Evolution: Fossil record : types of fossils, transitional forms, geological time scale, evolution of horse, neutral theory of molecular evolution, example of globin gene family. Role of neutral mutation in evolution or adaptation and adaptability.

10 lectures

Unit 3: Population genetics in evolution: Application of Hardy-Weinberg Law in population genetics, gene

pool and genetic equilibrium; Evolutionary forces upsetting H-W equilibrium; Concept of natural selection-types of selection, role of natural selection on population genotypes. Genetic Drift: mechanism, founder's effect, bottleneck phenomenon, Role of Migration and Mutation in changing allele frequencies in evolution.

10 lectures

Unit 4: Product of evolution: Micro evolutionary changes (inter-population variations, clines, races, Species concept, Isolating mechanisms, modes of speciation—allopatric, sympatric, Adaptive radiation / macroevolution (exemplified by Galapagos finches. Mass extinctions (causes and effects), example of K-T extinction. Evolution of Man.

Unit 5: Lab Course **15 lectures**

1. Study of fossils from models/ pictures
2. Study of homology and analogy from suitable specimens
3. Study and verification of Hardy-Weinberg Law by chi square analysis
4. Demonstration of role of natural selection and genetic drift in changing allele frequencies
5. Graphical representation and interpretation of data of height/ weight of a sample of 100 humans in relation to their age and sex.

Suggested Readings

1. Concept of Species. Slobodehikoff
2. Introduction to Evolution .Harper and Row. New York.
Roberts, A. (2018) Evolution: the human story, Dorling, Kindersley Ltd.
Hall, B.K. and Hallgrimson, B. (2013). Evolution. V Edition, Jones and Barlett Publishers.
Barton N.H., Briggs D.E.G., Eisen J.A., Goldstein D.B. and Patel N.H., (2007) 1st Ed. Evolution, Cold Spring Harbor Laboratory Press.

SEMESTER-IV

Title of the Course : Biodiversity and Conservation Biology
Code : Minor IV
Nature of Course : Minor
Total Credits : 04
Distribution of Marks: 60+40=100
Total classes: 60

COs:

1. Describe the concept of biodiversity, its conservation and legislation
2. Analyze the monitoring strategies and threats to biodiversity
3. Evaluate biodiversity of a region for formulation of conservation strategies

Learning Outcomes:

1. Understand the concept of biodiversity and biodiversity indices
2. Discuss the threats to biodiversity and possible conservation methods
3. Describe environmental legislation
4. Monitor biodiversity and take steps for conservation

Mapping of CO with Bloom's taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual						
Conceptual		CO1				
Procedural				CO2	CO3	
Metacognitive						

Mapping of Course outcomes to Programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	AVERAGE
CO1	3	2	2	2	2	2	2	2.14
CO2	3	2	2	2	2	2	2	2.14
CO3	3	2	3	1	1	2	2	2.0
AVERAGE	3	2	2.3	1.7	1.7	2	2	

3 for highest correlation,2 for moderate correlation, and1 for lowest correlation

Modes of in-semester assessment:

1. One Theory exam
2. One Practical exam
3. Group Discussion/Seminar/Viva/Assignments

Attainment strategy of COs:

1. Continuous evaluation through in and end semester theory examination
2. Submission of assignment on relevant topic
3. Submission of practical record book
4. Viva-voce examination

Unit 1: Biodiversity **15 lectures**

Biodiversity concept, Definition and type of biodiversity: species, genetic and molecular diversity. Biodiversity hotspots in India.Biogeographical realms of the world, geographic origins and distribution of species. Reduction in biological diversity, present scenario.

Unit 2: Monitoring and documentation of biodiversity **10 lectures**

Measuring biodiversity, biodiversity indices- Shannon-Wiener, Margaleff and Simpson). Biodiversity Utility.

Unit 3: Conservation **10 lectures**

Conservation of biodiversity in protected habitats, seed banks, gene banks, germ plasma repositories, conventions of biological diversity.

Unit 4:Habitat restoration and Environmental legislation **10 lectures**

Habitat restoration strategies. Protective legislation for specific animals, protective legislation for wildlife.

Unit 5: Lab activities **15 lectures**

1. To determine the frequency, density and abundance of the primary producers of a grassland community by quadrate method.
2. To determine the abundance and density of soil fauna.
3. To study aquatic ecosystem.
4. Field survey

SEMESTER-V

Title of the Course : Plant Anatomy
Code : CORE-IX
Nature of course : CORE
Total Credits : 04
Distribution of Marks: 40+60
Total classes: 60

Course outcome

1. Describe the anatomical features of plants
2. Illustrate the different developmental stages of plants
3. Examine and analyze the primary and secondary anatomy of plants

Learning outcome

1. Recognize the anatomical characteristics of plants
2. Describe the developmental stages in plants
3. Illustrate the primary and secondary anatomy of plants

Mapping of CO with Bloom's taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual						
Conceptual			CO1			
Procedural				CO2	CO3	
Metacognitive						

Mapping of Course outcomes to Programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	AVERAGE
CO1	3	2	2	2	2	2	2	2,4
CO2	3	2	2	2	2	2	2	2.4
CO3	3	2	3	1	1	2	2	2.0
AVERAGE	3	2	2.3	1.7	1.7	2	2	

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

Modes of internal assessment

1. One internal examination (theory)
2. One internal examination (Lab)
3. Viva-voce
4. Group discussion
5. Home assignments

Attainment strategies of Cos:

1. Continuous evaluation through in and end-semester theory and practical examinations
2. Laboratory practices
3. Practical record book/field book
4. Seminar/group discussion

Course content:

Unit I: Plant Cells, Tissues, and Tissue Systems **12 classes**

Introduction, objectives, and scope of Plant Anatomy; General structure of plant cells - structure of plant cell wall. Tissue and tissue systems - Definitions, structure, and functions of Meristematic tissues and permanent tissues (Simple and Complex). A brief account of plant secretary tissues/cells. Concept of tissue systems - Ground tissues, Dermal tissues and Vascular tissues.

Unit-II: Classification of meristems: **12 classes**

Based on location (apical, intercalary and lateral), Origin (promeristem, primary and secondary meristem)

and function (protoderm, procambium and ground meristem).

Apical meristems: Generalised structure of Root & shoot apex, theories on organization of Root & Shoot Apical Meristem (SAM) - Apical cell theory, Tunica-Corpus theory and Histogen theory, Quiescent centre theory and Korper – Kappe theory.

Unit III: Primary anatomy of Angiosperms **08 classes**

Primary anatomy of root & stem: Dicot, monocot; Nodal anatomy. Anatomy of leaf: Dicot, Monocot; Types of trichomes and stomata.

Unit IV: Secondary anatomy of Angiosperms **13 classes**

Secondary Growth: Normal Secondary growth in stem and root. Anomalous secondary growth in dicot & monocot stem. Applications of anatomy in Plant systematics, forensics and Pharmacognosy.

Lab activities

1. Study of meristems through permanent slides and photographs.
2. Tissues (parenchyma, collenchyma and sclerenchyma); Macerated xylary elements, Phloem (Permanent slides, photographs)
3. Study of dicot and monocot stem anatomy; permanent slide preparation
4. Study of dicot and monocot root anatomy; permanent slide preparation
5. Study of Dicot and Monocot leaf anatomy

Suggested readings

Mauseth, J.D. (1988). Plant Anatomy. The Benjamin/Cummings Publisher, USA.
Bhojwani, S.S. & Bhatnagar, S.P. (2011). Embryology of Angiosperms. Vikas Publication House Pvt. Ltd. New Delhi. 5th edition.

SEMESTER-V

Title of the Course	**:**	**Embryology of Angiosperms**
Code	**:**	**CORE-X**
Nature of course	**:**	**Core**
Total Credits	**:**	**04**
Distribution of Marks:		**40+60**
Total classes:		**60**

Course outcome

1. Describe the embryological features of plants
2. Illustrate the different embryological developmental stages of plants
3. Examine and analyze the reproductive processes in plants

Learning outcome

1. Recognize the anatomical characteristics of plants
2. Describe the developmental stages in plants
3. Illustrate the embryological developmental processes in plants

Mapping of CO with Bloom's taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual						
Conceptual			CO1			
Procedural				CO2	CO3	
Metacognitive						

Mapping of Course outcomes to Programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	AVERAGE
CO1	3	2	2	2	2	2	2	2,4
CO2	3	2	2	2	2	2	2	2.4
CO3	3	2	3	1	1	2	2	2.0
AVERAGE	3	2	2.3	1.7	1.7	2	2	

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

Modes of internal assessment

1. One internal examination (theory)
2. One internal examination (Lab)
3. Viva-voce
4. Group discussion
5. Home assignments

Attainment strategies of Cos:

1. Continuous evaluation through in and end-semester theory and practical examinations
2. Laboratory practices
3. Practical record book/field book
4. Seminar/group discussion

Course content

Unit I: Microsporogenesis in Angiosperms **12 classes**

Microsporangium: Development and structure of mature anther; Microsporogenesis - Microspore mother cells, microspore tetrads and their types; Pollinia. Formation of vegetative and generative cells, structure of male gametophyte, Pollen embryosac (Nemec phenomenon)

Unit II: Megasporogenesis in Angiosperms **12 classes**

Megasporangium: Structure of typical Angiosperm ovule, Types of ovules, development of ovule, Megasporogenesis: Megaspore mother cell, megaspores

Megagametogenesis: Embryosac- monosporic, bisporic and tetrasporic, Structure of mature embryosac.

Unit III: Pollination and post pollination events **12 classes**

Pollination and fertilization: Structural and functional aspects of pollen, stigma and style. Post pollination

events; Current aspects of fertilization; Significance of double fertilization

Endosperm – Types and its biological importance. Free nuclear (Cocos nucifera), cellular (Cucumis), helobial types. Ruminate endosperm

Unit IV: Embryogenesis and seed & fruit development 9 classes

Development of monocot and dicot embryo, Structure Dicot and Monocot embryo, development and types of fruits

Apomixis and polyembryony: Definition, types and practical applications

Lab activities:

1. Types of ovules: anatropous, orthotropous, circinotropous, amphitropous/ campylotropous.
2. Female gametophyte: *Polygonum* (monosporic) type of Embryo sac Development (Permanent slides/photographs).
3. Ultrastructure of mature egg apparatus cells through electron micrographs.
4. Pollination types and seed dispersal mechanisms (including appendages, aril, caruncle) (Photographs and specimens).
5. Study of different types of placentation

Suggested readings

Mauseth, J.D. (1988). Plant Anatomy. The Benjamin/Cummings Publisher, USA.
Bhojwani, S.S. & Bhatnagar, S.P. (2011). Embryology of Angiosperms. Vikas Publication House Pvt. Ltd. New Delhi. 5th edition.

SEMESTER-V

Title of the Course : Plant Ecology and Phytogeography
Code : CORE-XI
Nature of course ; Core
Total Credits : 04
Distribution of Marks : 40+60
Total classes: 60

Course outcomes:

1. Understanding Plant Ecological Principles
2. Interpret of Plant Adaptations
3. Examine Ecosystem Dynamics
4. Explain Phytogeographical Concepts

Learning outcomes:

1. Describe the plant ecological concepts
2. Discuss plant adaptations concerning the environment
3. Interpret the dynamics of ecosystems
4. Explain the concept of vegetation in different geographical regions

Mapping of CO with Bloom's taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual						
Conceptual		CO1				
Procedural		CO4	CO2	CO3		
Metacognitive						

Mapping of Course outcomes to Programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	AVERAGE
CO1	2	3	2	3	2	2	2	2.3
CO2	2	3	2	3	3	2	2	2.8
CO3	3	3	2	2	3	2	2	2.8
CO4	2	3	2	2	2	2	2	2.3
AVERAGE	2.2	3.0	2.0	2.5	2.5	2.0	2.0	

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

Modes of internal assessment

1. One internal examination (theory)
2. One internal examination (Lab)
3. Viva-voce
4. Group discussion
5. Home assignments

Attainment strategies of Cos:

1. Continuous evaluation through in and end-semester theory and practical examinations
2. Laboratory practices
3. Practical record book/field book
4. Seminar/group discussion

Course content

Unit I: Introduction to Ecology and Environmental Factors 12 classes

Basic concepts; Levels of organization. Inter-relationships between the living world and the environment, the components and dynamism, homeostasis.

Soil: Importance; Origin; 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; Water in soil; Water table.

Light, temperature, wind and fire : Variations; adaptations of plants to their variation.

Unit II: Biotic Interactions 08 classes

Trophic organization, basic source of energy, autotrophy, heterotrophy; symbiosis, commensalism,

parasitism; food chains and webs; ecological pyramids; biomass, standing crop.

Unit III: Population Ecology **10 classes**

Characteristics and Dynamics. Ecological Speciation

Concept of ecological amplitude; Habitat and niche; Characters: analytical and synthetic; Ecotone and edge effect; Dynamics: succession – processes, types; climax concepts.

Unit IV: Ecosystems **7 classes**

Structure; Processes; Trophic organization; Food chains and Food webs; Ecological pyramids. Principles and models of energy flow; Production and productivity; Ecological efficiencies; Biogeochemical cycles; Cycling of Carbon, Nitrogen, and Phosphorus**.**

Unit V: Phytogeography **8 classes**

Principles; Continental drift; Theory of tolerance; Endemism; Brief description of major terrestrial biomes (one each from tropical, temperate & tundra); Phytogeographical division of India; Local Vegetation.

Lab activities

1. Study of instruments used to measure microclimatic variables: Soil thermometer, maximum and minimum thermometer, anemometer, psychrometer/hygrometer, rain gauge and lux meter.
2. Analysis for carbonates, chlorides, nitrates, sulphates, and, organic matter from soil samples
3. Determination of dissolved oxygen of water samples from polluted and unpolluted sources.
4. Study of morphological adaptations of hydrophytes and xerophytes (two each).
5. Determination of minimal quadrat size for the study of herbaceous vegetation in the university campus
6. Quantitative analysis of herbaceous vegetation for density and abundance in the college campus.
7. Field visit to familiarise students with ecology of different sites.

Suggested Readings

1. Odum, E.P. (2005). Fundamentals of ecology. Cengage Learning India Pvt. Ltd., New Delhi. 5th edition.
2. Singh, J.S., Singh, S.P., Gupta, S. (2006). Ecology Environment and Resource Conservation. Anamaya Publications, New Delhi, India.
3. Sharma, P.D. (2010). Ecology and Environment. Rastogi Publications, Meerut, India. 8th edition.
4. Wilkinson, D.M. (2007). Fundamental Processes in Ecology: An Earth Systems Approach. Oxford University Press. U.S.A.
4.Kormondy, E.J. (1996). Concepts of ecology. PHI Learning Pvt. Ltd., Delhi, India. 4th edition.

SEMESTER-V

Title of the Course : Anatomy and Embryology of Angiosperms
Code : Minor-V
Nature of course : Minor
Total Credits : 04
Distribution of Marks: 40+60
Total classes: 60

Course outcome

1. Describe the anatomical features of plants
2. Illustrate the different developmental stages of plants
3. Examine and analyze the reproductive processes in plants

Learning outcome

1. Recognize the anatomical characteristics of plants

2. Describe the developmental stages in plants
3. Illustrate the developmental processes in plants

Mapping of CO with Bloom's taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual						
Conceptual			CO1			
Procedural				CO2	CO3	
Metacognitive						

Mapping of Course outcomes to Programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	AVERAGE
CO1	3	2	2	2	2	2	2	2,4
CO2	3	2	2	2	2	2	2	2.4
CO3	3	2	3	1	1	2	2	2.0
AVERAGE	3	2	2.3	1.7	1.7	2	2	

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

Modes of internal assessment

1. One internal examination (theory)
2. One internal examination (Lab)
3. Viva-voce
4. Group discussion
5. Home assignments

Attainment strategies of Cos:

1. Continuous evaluation through in and end-semester theory and practical examinations
2. Laboratory practices
3. Practical record book/field book
4. Seminar/group discussion

Course content:

Unit I: Plant Cells, Tissues, and Tissue Systems **09 classes**

Introduction, objectives, and scope of Plant Anatomy; General structure of plant cells - structure of plant cell wall. Tissue and tissue systems - Definitions, structure, and functions of Meristematic tissues and permanent tissues (Simple and Complex). A brief account of plant secretary tissues/cells. Concept of tissue systems - Ground tissues, Dermal tissues and Vascular tissues.

Unit-II: Classification of meristems: **09 classes**

Based on location (apical, intercalary and lateral), Origin (promeristem, primary and secondary meristem)

and function (protoderm, procambium and ground meristem).

Apical meristems: Generalised structure of Root & shoot apex, theories on organization of Root & Shoot Apical Meristem (SAM) - Apical cell theory, Tunica-Corpus theory and Histogen theory, Quiescent centre theory and Korper – Kappe theory.

Unit III: Primary and Secondary anatomy of Angiosperms 09 classes

Primary anatomy of root & stem: Dicot, monocot; Nodal anatomy. Anatomy of leaf: Dicot, Monocot; Types of trichomes and stomata.

Secondary Growth: Normal Secondary growth in stem and root. Anomalous secondary growth in dicot & monocot stem. Applications of anatomy in Plant systematics, forensics and Pharmacognosy.

Unit IV: Sporogenesis in Angiosperms 09 classes

Microsporangium: Development and structure of mature anther; Microsporogenesis - Microspore mother cells, microspore tetrads and their types; Pollinia. Formation of vegetative and generative cells, structure of male gametophyte, Pollen embryosac (Nemec phenomenon)

Megasporangium: Structure of typical Angiosperm ovule, Types of ovules, development of ovule, Megasporogenesis: Megaspore mother cell, megaspores

Megagametogenesis: Embryosac- monosporic, bisporic and tetrasporic, Structure of mature embryosac.

Unit V: Pollination and embryogenesis 09classes

Pollination and fertilization: Structural and functional aspects of pollen, stigma and style. Post pollination events; Current aspects of fertilization; Significance of double fertilization

Endosperm – Types and its biological importance. Free nuclear (Cocos nucifera), cellular (Cucumis), helobial types. Ruminate endosperm

Development of monocot and dicot embryo, Structure Dicot and Monocot seed

Apomixis and polyembryony: Definition, types and practical applications

Lab. Activities

1. Study of meristems through permanent slides and photographs.
2. Tissues (parenchyma, collenchyma and sclerenchyma); Macerated xylary elements, Phloem (Permanent slides, photographs)
3. Study of dicot and monocot stem anatomy; permanent slide preparation
4. Study of dicot and monocot root anatomy; permanent slide preparation
5. Study of Dicot and Monocot leaf anatomy
6. Types of ovules: anatropous, orthotropous, circinotropous, amphitropous/ campylotropous.
7. Female gametophyte: *Polygonum* (monosporic) type of Embryo sac Development (Permanent slides/photographs).
8. Ultrastructure of mature egg apparatus cells through electron micrographs.
9. Pollination types and seed dispersal mechanisms (including appendages, aril, caruncle) (Photographs and specimens).
10. Study of different types of placentation

Text book

Mauseth, J.D. (1988). Plant Anatomy. The Benjamin/Cummings Publisher, USA.

Bhojwani, S.S. & Bhatnagar, S.P. (2011). Embryology of Angiosperms. Vikas Publication House Pvt.

Semester-V

Title of the course: Internship/Community Engagement

Course code: Int./Comm.

Total credit: 4

Duration: 120 hours

Course Structrure

Internship + Community Engagement :(2+2) =4 Credit

Or

Internship/Community Engagement :4 Credit

Note:

Internship + Community Engagement or **Internship/Community Engagement** should be carried out during semester break or convenient period of total **120 hours**.

SEMESTER-VI

Title of the Course : Plant Physiology
Code : CORE-XII
Nature of course : Core
Total Credits : 04
Distribution of Marks : 40+60
Total classes: 60

Course outcome

CO 1: Ability to identify different physiological processes in plant.

CO 2: Ability to discuss absorption, transpiration, photosynthesis, growth in plants.

CO3: Examine the metabolic process in plants

Learning outcomes:

1. Demonstrate physiological processes in plants
2. Explain the absorption, transpiration, photosynthesis, growth in plants
3. Evaluate the metabolic activities of plants

Mapping of CO with Bloom's taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual						
Conceptual			CO1			
Procedural				CO2		
Metacognitive						

Mapping of Course outcomes to Programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	AVERAGE
CO1	3	3	2	3	3	2	2	2.6
CO2	3	3	2	3	3	2	2	2.6
CO3	3	3	3	3	3	2	2	2.7
AVERAGE	3.0	3.0	2.3	3.0	3.0	2.0	2.0	

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

Modes of internal assessment

1. One internal examination (theory)
2. One internal examination (Lab)
3. Viva-voce
4. Group discussion
5. Home assignments

Attainment strategies of Cos:

1. Continuous evaluation through in and end-semester theory and practical examinations
2. Laboratory practices
3. Practical record book/field book
4. Seminar/group discussion

Unit I: Plant-water relations **10 classes**

Water Potential and its components, water absorption by roots, aquaporins, the pathways of water movement, symplast, apoplast, transmembrane pathways, root pressure, guttation. Ascent of sap–cohesion-tension theory. Transpiration and factors affecting transpiration, antitranspirants, and mechanism of stomatal movement.

Unit II: Mineral nutrition & Translocation in the phloem **10 classes**

Soil as a nutrient reservoir; Essential and beneficial elements, criteria for essentiality; macro and micronutrients, mineral deficiency symptoms, absorption and transport of ions across cell membrane, role of ATP, carrier systems, proton ATPase pump and ion flux, uniport

Experimental evidence in support of phloem as the site of sugar translocation. Pressure–Flow Model; Phloem loading and unloading; Source–sink relationship.

Unit-III: Photosynthesis & Respiration **16 classes**

Oxygenic and anoxygenic photosynthesis, Photophosphorylation, Thylakoid membrane in photophosphorylation, C3 cycle, C4 cycle and CAM pathways, photorespiration.

Aerobic and anaerobic respiration, glycolysis and Kreb's cycle, mitochondrial electron transport chain

Unit IV: Plant growth regulators & Physiology of flowering **9 classes**

Discovery, chemical nature (basic structure), bioassay and physiological roles of Auxin, Gibberellins, Cytokinin, Abscisic acid, Ethylene, Brassinosteroids and Jasmonic acid.

Photoperiodism, flowering stimulus, florigen concept, vernalization, seed dormancy.

Lab activities

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. Calculation of stomatal index and stomatal frequency from the two surfaces of leaves of a mesophyte and xerophyte.
4. To study the phenomenon of seed germination (effect of light).
5. Determination of rate of transpiration
6. Determination of effect of light and CO_2 on photosynthesis

Textbooks

1. Taiz, L. and Zeiger, E., Plant Physiology, 5th edition (Sinauer Associates, USA, 2012).

2. URL: http://www.sinauer.com/media/wysiwyg/tocs/PlantPhysiology5.pdf

Suggested Readings

1. Lambers, H. and Chapin, F. S., Plant Physiological Ecology (Springer, 2000).

2. Mukherji, S. and Ghosh, A.K., Plant Physiology, 1st edition (New Central Book Agency Private Ltd. Kolkata, 2009).

3. http://www.annualreviews.org/journal/arplant

4. Hormones: http://nptel.ac.in/courses/102103012/27

SEMESTER-VI

Title of the Course : Utilization of plant Resources
Code : CORE-XIII
Nature of course ; Core
Total Credits : 04
Distribution of Marks: 40+60
Total classes 60

Course outcomes:

1. Identify and classify economically important plant species based on their taxonomic characteristics.
2. Describe the diversity of plant species used by humans across different geographical regions.
3. Discuss agricultural and horticultural techniques used to cultivate economically important plants.
4. Evaluate sustainable practices for the production and management of economically significant crops

Learning outcomes:

1. Identify and classify economically important plant species based on their botanical characteristic
2. Describe the traditional, medicinal, industrial, and commercial uses of plants
3. Explain the anatomical and physiological features of plants that are relevant to their economic uses
4. Understand agricultural and horticultural techniques used in the cultivation and management of economically significant plants

Mapping of CO with Bloom's taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual						
Conceptual		CO1				
Procedural			CO2	CO3	CO4	
Metacognitive						

Mapping of Course outcomes to Programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	AVERAGE
CO1	3	2	2	3	3	2	2	2.4

CO2	3	2	2	3	3	2	2	2.4
CO3	3	2	3	3	3	2	2	2.6
CO4	2	2	3	3	3	2	2	2.4
AVERAGE	2.7	2.0	2.5	3.0	3.0	2.0	2.0	

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

Modes of internal assessment:

1. One internal examination (theory)
2. One internal examination (Lab)
3. Viva-voce
4. Group discussion
5. Home assignments

Attainment strategies of Cos:

1. Continuous evaluation through in and end-semester theory and practical examinations
2. Field collection and identification of specimens
3. Submission of collected specimens
4. Practical record book

Course content

Unit I: Origin of Cultivated Plants 10 classes

Concept of Centres 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.

Unit II: Cereals, Legumes &Sources of sugars and starches 12 classes

Wheat and Rice (origin, morphology, processing & uses); Brief account of millets.

Origin, morphology and uses of Chick pea, Pigeon pea and fodder legumes. Importance to man and ecosystem.

Morphology and processing of sugarcane, products and by-products of sugarcane industry. Potato – morphology, propagation & uses.

Unit III: Spices, Beverages & Sources of oils and fats 12 classes

Listing of important spices, their family and part used. Economic importance with special reference to fennel, saffron, clove and black pepper

Tea, Coffee (morphology, processing & uses)

General description, classification, extraction, their uses and health implications groundnut, coconut, linseed, soybean, mustard and coconut (Botanical name, family & uses). Essential Oils: General account, extraction methods, comparison with fatty oils & their uses.

Unit IV: Natural Rubber & Drug-yielding plants,Timber & Fibers 11 classes

Para-rubber: tapping, processing and uses.
Therapeutic and habit-forming drugs with special reference to Cinchona, Digitalis, Papaver and Cannabis; Tobacco (Morphology, processing, uses and health hazards).

General account with special reference to teak and pine.
Classification based on the origin of fibers; Cotton, Coir and Jute (morphology, extraction and uses).

Lab activities

1. Cereals: Wheat (habit sketch, L. S/T.S. grain, starch grains, micro-chemical tests) Rice (habit sketch, study of paddy and grain, starch grains, micro-chemical tests).
2. Legumes: Soybean, Groundnut, (habit, fruit, seed structure, micro-chemical tests).
3. Sources of sugars and starches: Sugarcane (habit sketch; cane juice- micro-chemical tests), Potato(habit sketch, tuber morphology, T.S. tuber to show localization of starch grains, w.m. starch grains, micro-chemical tests).
4. Rubber: specimen, photograph/model of tapping, samples of rubber products.
5. Woods: *Tectona, Pinus*: Specimen, Section of young stem.
6. 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).
7. Submission of specimens

Textbooks

1. Economic Botany- A comprehensive study by S L Kochhar, Fifth Edition(2016), Cambridge University Press, UK

2. A Text Book of Economic Botany by V Verma, (2009)Anne Books Pvt Ltd, New Delhi 3. Economic Botany: Principles and Practices by G.E. Wickens (2012) Kluwer Academic Publishers, New York

SEMESTER-VI

Title of the Course : Plant Breeding & Crop Improvement
Code : CORE-XIV
Nature of course : Core
Total Credits : 04
Distribution of Marks: 40+60
Total classes: 60

Course outcomes:

1. Describe the methods used in plant breeding to improve crops

2. Demonstrate proficiency in classical and modern plant breeding techniques
3. Understand selection criteria and methods for breeding new varieties
4. Conduct laboratory work related to plant breeding

Learning outcomes:

1. Explain the fundamental principles of plant breeding and crop improvement
2. Discuss the advantages and limitations of different breeding approaches
3. Understand selection criteria and methods for breeding new varieties

Mapping of CO with Bloom's taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual						
Conceptual		CO1				
Procedural		CO3	CO2		CO4	
Metacognitive						

Mapping of Course outcomes to Programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	AVERAGE
CO1	3	3	2	3	3	2	2	2.4
CO2	3	3	3	3	3	2	2	2.6
CO3	3	2	3	2	2	2	2	2.3
CO4	3	3	3	3	3	2	2	2.7
AVERAGE	3.0	2.7	2.7	2.7	2.7	2.0	2.0	

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

Modes of internal assessment:

1. One internal examination (theory)
2. One internal examination (Lab)
3. Viva-voce
4. Group discussion
5. Home assignments

Attainment strategies of Cos:

1. Continuous evaluation through in and end-semester theory and practical examinations
2. Field collection and identification of specimens
3. Submission of collected specimens
4. Practical record book

Unit 1: Plant Breeding **10 classes**

Introduction and objectives. Breeding systems: modes of reproduction in crop plants. Important

achievements and undesirable consequences of plant breeding.

Unit 2: Methods of Crop Improvement **18 classes** Introduction: Centres of origin and domestication of crop plants, plant genetic resources; Acclimatization; Selection methods: For self-pollinated, cross-pollinated and vegetatively propagated plants; Hybridization: For self, cross and vegetatively propagated plants: Procedure, advantages and limitations.

Unit 3: Inbreeding depression and heterosis **08 classes**

History, genetic basis of inbreeding depression and heterosis; Applications.

Unit 5: Crop improvement and breeding **09 classes**

Role of mutations; Polyploidy; Distant hybridization and role of biotechnology in crop improvement.

Lab activities

1. Reproductive biology of self- and cross-pollinating plants
2. Vegetative reproduction – Cutting, Budding, , grafting and layering
3. Hybridization: Emasculation, bagging, pollination and production of hybrids
4. Pollen fertility – Tetrazolium test

Suggested readings

1. Singh, B.D. (2005). Plant Breeding: Principles and Methods. Kalyani Publishers. 7th edition.
2. Chaudhari, H.K. (1984). Elementary Principles of Plant Breeding. Oxford – IBH. 2ndedition.

SEMESTER-VI

Title of the Course : Plant pathology & crop protection
Code : CORE-XV
Nature of course : core
Total Credits : 04
Distribution of Marks: 40+60
Total classes: 60

Course outcomes:

1. Identify and describe major groups of plant pathogens
2. Understand the biology, life cycles, and modes of action of various plant pathogens
3. Learn integrated disease management strategies, including cultural, biological, chemical, and genetic approaches
4. Analyze disease cycles and the influence of environmental conditions on disease development.

Learning outcomes:

1. Classify major groups of plant pathogens
2. Describe the biology and life cycle of plant pathogens
3. Explain the plant disease management strategies
4. Evaluate disease cycles and development patterns

Mapping of CO with Bloom's taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual						
Conceptual		CO1				
Procedural			CO2	CO3	CO4	
Metacognitive						

Mapping of Course outcomes to Programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	AVERAGE
CO1	3	2	2	3	3	2	2	2.4
CO2	3	2	2	3	3	2	2	2.4
CO3	3	2	3	3	3	2	2	2.6
CO4	2	2	3	3	3	2	2	2.4
AVERAGE	2.7	2.0	2.5	3.0	3.0	2.0	2.0	

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

Modes of internal assessment:

1. One internal examination (theory)
2. One internal examination (Lab)
3. Viva-voce
4. Group discussion
5. Home assignments

Attainment strategies of Cos:

1. Continuous evaluation through in and end-semester theory and practical examinations
2. Field collection and identification of specimens
3. Submission of collected specimens
4. Practical record book

Total lectures-60

Unit-I. 10 lectures

Phytopathology:Terms and concepts; General symptoms; Geographical distribution of diseases; Etiology; Symptomology; Host-Pathogen relationships; Disease cycle and environmental relation.

Unit II. 12 lectures

Prevention and control of plant diseases, and role of quarantine. Bacterial diseases – Citrus

canker and angular leaf spot of cotton. Viral diseases – Tobacco Mosaic viruses, Bhendi yellow vein mosaic virus. Fungal diseases – Early blight of potato, Black stem rust of wheat, White rust of crucifers. Diseases caused by phytoplasma-Little leaf of Brinjal

Unit III. **12 lectures**

Cultural methods of plant protection – Tillage, crop rotation, trap crops, fertilizer applications, land fallowing, timely sowing, and proper soil selection. Mechanical methods – Field sanitation, Hand picking, Destruction of infected plants/plant parts, Destruction of egg masses, light traps, use of sticky bands, bagging for the pests, and Pheromone traps. Physical methods – Heat and soil solarisation

Unit IV. **11 lectures**

Chemical methods of plant protection –Definition, uses and examples of Bactericides, Fungicides, Insecticides, Nematicides, Acaricides , Molluscicides and Rodenticides

Biological methods – Definition, Important biocontrol agents. a) Fungi : (Trichoderma, Metarhizium, Verticillium) b) Bacteria : Pseudomonas, Bacillus c) Insect : Crysopyrilla / Trichogramma d) Virus 4c: Legal methods – Plant quarantine in India. 4d: Crop resistance – Uses of resistant varieties and their examples

Lab activities

1. Study of common plant diseases:

   Fungal diseases – Early blight of potato, Black stem rust of wheat, White rust of crucifers, and other locally available diseases

   Bacterial diseases – Citrus canker and angular leaf spot of cotton and other locally available diseases

   Viral disease- tobacco mosaic virus, Bhendi yellow vein mosaic virus

2. Isolation of plant pathogen and establishment of Koch's postulates.
3. Study of plant origin and chemical pesticides.
4. Preparation and submission of plant disease albums.

Suggested readings

1. Singh, B.D. (2005). Plant Breeding: Principles and Methods. Kalyani Publishers. 7th edition.
2. Chaudhari, H.K. (1984). Elementary Principles of Plant Breeding. Oxford – IBH. 2ndedition.

3. Acquaah, G. (2007). Principles of Plant Genetics & Breeding. Blackwell Publishing
4. Sethi, I.K. and Walia, S.K. (2011). Textbook of Fungi and Their Allies, Macmillan Publishers India Ltd.
5. Sharma, P.D. (2011). Plant Pathology, Rastogi Publication, Meerut, India.

SEMESTER-VI

Title of the Course : Plant Physiology
Code : Minor-VI
Nature of course : Minor
Total Credits : 04
Distribution of Marks : 40+60
Total classes: 60

Course outcome

CO 1: Ability to identify different physiological processes in plant.

CO 2: Ability to discuss absorption, transpiration, photosynthesis, growth

in plants.

CO3: Examine the metabolic process in plants

Learning outcomes:

1. Demonstrate physiological processes in plants
2. Explain the absorption, transpiration, photosynthesis, growth in plants
3. Evaluate the metabolic activities of plants

Mapping of CO with Bloom's taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual						
Conceptual			CO1			
Procedural				CO2		
Metacognitive						

Mapping of Course outcomes to Programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	AVERAGE
CO1	3	3	2	3	3	2	2	2.6
CO2	3	3	2	3	3	2	2	2.6
CO3	3	3	3	3	3	2	2	2.7
AVERAGE	3.0	3.0	2.3	3.0	3.0	2.0	2.0	

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

Modes of internal assessment

1. One internal examination (theory)
2. One internal examination (Lab)
3. Viva-voce
4. Group discussion
5. Home assignments

Attainment strategies of Cos:

1. Continuous evaluation through in and end-semester theory and practical examinations
2. Laboratory practices
3. Practical record book/field book
4. Seminar/group discussion

Unit I: Plant-water relations **09 classes**

Water Potential and its components, water absorption by roots, aquaporins, the pathways of water movement, symplast, apoplast, transmembrane pathways, root pressure, guttation. Ascent of sap–cohesion-tension theory. Transpiration and factors affecting transpiration, antitranspirants, and mechanism of stomatal movement.

Unit II: Nutrient Uptake & Mineral nutrition **08 classes**

Soil as a nutrient reservoir; Essential and beneficial elements, criteria for essentiality; macro and micronutrients, mineral deficiency symptoms, absorption and transport of ions across cell membrane, role of ATP, carrier systems, proton ATPase pump and ion flux, uniport

Unit III: Translocation in the phloem **07 classes**

Experimental evidence in support of phloem as the site of sugar translocation. Pressure–Flow Model; Phloem loading and unloading; Source–sink relationship.

Unit-IV: Photosynthesis & Respiration **12 classes**

Oxygenic and anoxygenic photosynthesis, Photophosphorylation, Thylakoid membrane in photophosphorylation, C3 cycle, C4 cycle and CAM pathways, photorespiration.
Aerobic and anaerobic respiration, glycolysis and Kreb's cycle, mitochondrial electron transport chain

Unit V: Plant growth regulators & Physiology of flowering **09 classes**

Discovery, chemical nature (basic structure), bioassay and physiological roles of Auxin, Gibberellins, Cytokinin, Abscisic acid, Ethylene, Brassinosteroids and Jasmonic acid. Photoperiodism, flowering stimulus, florigen concept, vernalization, seed dormancy.

Lab activities

Plant physiology

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. Calculation of stomatal index and stomatal frequency from the two surfaces of leaves of a mesophyte and xerophyte.
4. To study the phenomenon of seed germination (effect of light).
5. Determination of rate of transpiration
6. Determination of effect of light and CO_2 on photosynthesis

Suggested readings

1. Taiz, L. and Zeiger, E., Plant Physiology, 5th edition (Sinauer Associates, USA, 2012).

2. URL: http://www.sinauer.com/media/wysiwyg/tocs/PlantPhysiology5.pdf

Suggested Readings

1. Lambers, H. and Chapin, F. S., Plant Physiological Ecology (Springer, 2000).

2. Mukherji, S. and Ghosh, A.K., Plant Physiology, 1st edition (New Central Book Agency Private Ltd. Kolkata, 2009).

3. http://www.annualreviews.org/journal/arplant

4. Hormones: http://nptel.ac.in/courses/102103012/27

SEMESTER-VII

Title of the Course	**:**	**Environmental Biology**
Code	**:**	**Core-XVI**
Nature of course	**: Core**	
Total Credits	**:**	**04**
Distribution of Marks	**:**	**40+60**
Total classes	**:**	**60**

COs:

1. Analyze ecological concepts and population dynamics
2. Evaluate environmental issues
3. Evaluate legislative measures and strategies for achieving SDGs.

Learning Outcomes:

1. Apply concepts of ecology to understand issues
2. Analyze problems and legislative measures
3. Apply strategies for SDG

Mapping of CO withBloom Taxonomy

Knowlege Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual						

Conceptual				CO1	CO2,CO3	
Procedural						
Metacognitive						

Mapping of Course outcomes to Programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	AVERAGE
CO1	3	2	2	2	2	2	2	2.14
CO2	3	2	2	2	2	2	2	2.14
CO3	3	2	3	1	1	2	2	2.0
AVERAGE	3	2	2.3	1.7	1.7	2	2	

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

Modes of internal assessment

1. One internal examination (theory)
2. One internal examination (Lab)
3. Viva-voce
4. Group discussion
5. Home assignments

Attainment strategies of Cos:

1. Continuous evaluation through in and end-semester theory and practical examinations
2. Laboratory practices
3. Practical record book/field book
4. Seminar/group discussion

Unit 1: Scope of ecology; concepts of ecological factors; Ecosystem dynamics and management: structure and function, energy flow concept, the productivity concept and methods of measurement of productivity; diversity, stability and complexity of ecosystem; nutrient cycling with special reference to carbon, nitrogen & phosphorus cycles

11 lectures

Unit 2: Population dynamics: population attributes, biotic potential and environmental resistance, population growth forms, age structure, survivorship curves, population fluctuations, interactions and regulation of population; concept of ecological niche, fundamental and realized niche; niche width and overlap; concept of meta population, demes and dispersal.

8 lectures

Unit 3: Environmental degradation and management: Global environmental issues (deforestation, greenhouse effect, depletion of ozone layer); Concept of EIA; Use of GPS, GIS and remote sensing in environmental management.

9 lectures

Unit 4: Sustainable Development Goals: India's National Action Plan on Climate Change; concept of ecotoxicology; International agreements and programmes: Earth Summit, UNFCCC, Montreal and Kyoto protocols.

8 lectures

Unit 5: Environment legislation in India: Wildlife Protection Act, 1972; Water (Prevention and Control of Pollution) Act, 1974; Forest (Conservation) Act 1980; Air (Prevention & Control of Pollution) Act, 1981; Environment Protection Act, 1986; Biological Diversity Act, 2002; Scheduled Tribes and other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006

Lab activities

1. To record the atmospheric temperature, relative humidity (RH), light intensity.
2. To study the physical and chemical characteristics of soil (C, N, content, base deficiency and pH of soil by rapid soil test method.
3. To determine the minimum size and number of the quadrat necessary for sampling the flora and fauna by "species - area – curve" method.
4. To determine the frequency, density and abundance of the primary producers of a grassland community by quadrat method.
5. To determine the abundance and density of soil fauna.
6. To determine the standing crop biomass of a grassland ecosystem by harvest method.
7. Basic exercise to Calculate and Assess carbon footprint/ Solid waste generation/ water consumption for a specific duration at individual/ family/ University/ locality level.
8. Estimation of TS, TSS and TDS of water samples.
9. Estimation of Turbidity, acididy, alkalinity of water samples

Suggested readings:

1. Concepts of Ecology-by E.J. Karmondy
2. Ecology -by C. Krebs
3. Ecology Work Book - by R. Misra.
4. Environmental Chemistry-by A.K.Dey
5. Fundamentas of Ecology - by E.P. Odum.
6. General Animal Ecology by Ananthakrishnan, T.K.and T.R.Viswanathan (1978).
7. Climate and Plant Distribution – Woodword
8. Soil Conservation in India – Gupta & Whytri
9. Tropical Ecosystems: Ecology & Management – Shing & Singh
10. Field Biology and Ecology- Benthon & Weaver
11. Environmental Pollution – S.M. Shafi.
12. Remote Sensing – Sahu & Solanki
13. Handbook of Agricullture – ICAR
14. Modern Concept of Ecology-by H.D. Kumar
15. Plant Ecology and Soil sciences-by Sukla and Sandal
16. Population Ecology-by M. Begon & M. Mortimer.
17. Practical methods in Plant Ecology and Environmetal Sciences- by R.K. Trivedy.

SEMESTER-VII

Title of the Course	**:**	**Advanced Molecular Biology**
Code	**:**	**Core-XVII**
Nature of course	**:**	**Core**
Total Credits	**:**	**04**
Distribution of Marks	**:**	**40+60**
Total classes	**:**	**60**

COs:

1. Analyze the organization of genome in prokaryotes and eukaryotes
2. Evaluate molecular processes
3. Evaluate the expression of genes is regulated, the role of DNA repair and recombination

Learning Outcomes:

1. Discuss the structural and functional organization of genomes, mechanisms of DNA replication, transcription, translation, and gene regulation in both prokaryotic and eukaryotic systems.
2. Analyze the molecular mechanisms of DNA repair, recombination, and post-transcriptional/post-translational modifications, along with their significance in genome stability and cellular function.
3. Describe key molecular biology techniques such as DNA/RNA isolation, PCR, electrophoresis, cloning, and gene expression analysis, and apply them in research and biotechnological applications.

Mapping of CO withBloom Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual						
Conceptual				CO1	CO2,CO3	
Procedural						
Metacognitive						

Mapping of Course outcomes to Programme outcomes

CO/PO	PO 1	PO 2	PO 3	PO4	PO5	PO6	PO7	AVERAGE
CO1	3	2	2	2	2	2	2	2.14
CO2	3	2	2	2	2	2	2	2.14
CO3	3	2	3	1	1	2	2	2.0
AVERAGE	3	2	2.3	1.7	1.7	2	2	

3 for highest correlation, 2 for moderate correlation, and1 for lowest correlation

Modes of internal assessment

Modes of internal assessment

1. One internal examination (theory)
2. One internal examination (Lab)
3. Viva-voce
4. Group discussion

5. Home assignments

Attainment strategies of Cos:

1. Continuous evaluation through in and end-semester theory and practical examinations
2. Laboratory practices
3. Practical record book/field book
4. Seminar/group discussion

Unit 1: Genome organization and replication (9 lectures)

Genome organisation in prokaryotes and eukaryotes, nucleosome, histone proteins. Genome complexity: C-value paradox, Structural and regulatory genes; Enzymology of DNA replication, fidelity in replication, replication of single stranded circular DNA end replication problem, DNA synthesis by reverse transcriptase.

Unit 2: Transcription and regulation of gene expression (11 lectures)

DNA-dependent synthesis of RNA, Regulatory elements, promoter, operators; Transcription and regulation of *lac, trp,* and *ara* operons. Eukaryotic promoters and enhancers, Transcription factors, Activators and repressors.

RNA processing and splicing, Transcriptional and post-transcriptional gene silencing, ribozyme, RNA editing. Genetic imprinting, Regulatory RNAs: Ribo-switches, RNA interference, miRNA, siRNA

Unit 3: Protein synthesis and degradation (9 lectures)

Genetic code and its features, the translation machinery, the structure and functions of tRNA and ribosomes. Mechanism of protein biosynthesis and its regulation, fidelity and proofreading in protein synthesis, direction of chain growth. Co- and Post-translational modifications, co-translational transport and degradation of proteins. Protein purification, sequencing.

Unit 4: DNA Repair and Recombination (9 lectures)

Alteration in DNA molecule, repair of incorrect bases, DNA repair enzymes, repair of thymine dimers, recombination repair, SOS repair.

Recombination: homologous and non- homologous recombination, site specific recombination, Holliday structure.

Unit 5: Basic methodologies of DNA and gene manipulation (7 lectures)

Cutting, separating and visualising DNA, blotting techniques, Southern blotting, foot printing, RFLP, DNA sequencing, polymerase chain reaction.

(15 lectures)

Unit 6: Lab Course

1. Estimation of RNA in biological samples by orcinol method
2. Estimation of DNA in biological samples by diphenylamine method
3. Isolation of DNA from biological samples.
4. To perform Agarose gel electrophoresis for the detection of DNA
5. Calculate molecular mass of unknown DNA and protein fragments from gel pictures
6. Restriction digestion analysis of DNA using agarose gel electrophoresis

Suggested Readings

- Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009). *The World of the Cell.* VII Edition. Pearson Benjamin Cummings Publishing, San Francisco.
- Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts,Peter Walter: *Molecular Biology of the Cell*, IV Edition.
- Cooper G.M. and Robert E. Hausman R.E. *The Cell:A Molecular Approach***,** V Edition, ASM Press and Sinauer Associates.
- De Robertis, E.D.P. and De Robertis, E.M.F. (2006). *Cell and Molecular Biology*. VIII Edition. Lippincott Williams and Wilkins, Philadelphia.
- Karp, G. (2010) *Cell and Molecular Biology: Concepts and Experiments*. VI Edition. John Wiley and Sons.Inc.
- Lewin B. (2008). *Gene XI*, Jones and Bartlett

McLennanA., BatesA., Turner,P. and White M. (2015).*Molecular Biology* IV Edition. GS, Taylor and Francis Group, New York and London.

SEMESTER-VII

Title of the Course	**:**	**Advanced Cell Biology**
Code	**:**	**Core-XVIII**
Nature of course	**:**	**Core**
Total Credits	**:**	**04**
Distribution of Marks	**:**	**40+60**
Total classes	**:**	**60**

COs:

1. Examine the internal structure and working of various cellular organelles.
2. Evaluate the concept of cell communication and cell signaling.
3. Explain Classical genetics and Population Genetics.

LearningOutcomes:

- Discuss the working of cell organelles
- Analyze the functioning cell communication and cell signaling
- Describe the concept of classical genetics and population genetics.

Mapping of CO with BloomTaxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual						
Conceptual				CO1	CO2,CO3	
Procedural						
Metacognitive						

MappingofCourseoutcomestoProgrammeoutcomes

CO/PO	PO 1	PO 2	PO 3	PO4	PO5	PO6	PO7	AVERAGE
CO1	3	2	2	2	2	2	2	2.14

CO2	3	2	2	2	2	2	2	2.14
CO3	3	2	3	1	1	2	2	2.0
AVERAGE	3	2	2.3	1.7	1.7	2	2	

3 for highest correlation,2 for moderate correlation, and1 for lowest correlation

Modes of internal assessment

1. One internal examination (theory)
2. One internal examination (Lab)
3. Viva-voce
4. Group discussion
6. Home assignments

Attainment stategies of Cos:

1. Continuous evaluation through in and end-semester theory and practical examinations
2. Laboratory practices
3. Practical record book/field book
4. Seminar/group discussion

Course content

Unit 1: Membrane structure and function 10 Lectures

Membrane structure and function: Molecular organisation of the plasma membrane; Membrane lipids & Membrane fluidity, Membrane transport: diffusion, facilitated diffusion, active transport; Carriers & Channel Proteins: ATP-driven pumps, Aquaporins, Ion channels; electrical properties of the plasma membrane

Unit 2: Cytoskeletons 6 Lectures

Elements of the cytoskeleton, dynamics of microfilaments; Role of actin & microtubule cytoskeleton in cell shape, intracellular motility, motor proteins, mitosis & locomotion; Functions of intermediate filaments.

Unit 3: Cell communication and Integration of cellular macromolecules 10 Lectures

General principles of cell communication, cell adhesion and the role of different adhesion molecules, gap junctions, extracellular matrix, integrins, neurotransmission and its regulation. Regulation of hematopoiesis

Protein sorting and transport to the endoplasmic reticulum, Golgi body and lysosomes; protein glycosylation within the Golgi body and protein secretion.

Unit 4: Cell cycle, and cell signaling : 10 Lectures

Cell cycle: Phases of the cell cycle, checkpoints and regulators of cell cycle progression in eukaryotes, Cell death (Programmed apoptosis and necroptosis), mechanisms of cell cycle regulation.

Cell signaling: Principles of cellular signaling mechanism: Types of signals. Cell surface Receptors (Ion channel, G-proteins and enzyme-linked), GTPase cycle and its regulation, signal transduction pathways (GPCR, Cytokine, Integrin): second messengers, signaling pathways and regulation; Calcium and NO in signal transduction.

Unit 5: Introduction to Cancer Biology **09 Lectures**

Genetic rearrangement in progenitor cells, oncogenes, tumor suppressor genes, cancer and the cell cycle, Oncogenesis; initiation, promotion, progression, cell behavior in oncogenesis, virus-induced cancer, carcinogens, metastasis, interaction of cancer cell with normal cells, apoptosis, therapeutic intervention of uncontrolled cell growth.

Unit 6: Lab Course **15 lectures**

1. Localization of neutral mucopolysaccharides in cell by periodic acid Schiff reaction.
2. Localization of general lipid by Sudan Black B method.
3. Study of cancer cells through permanent slides.
4. Localization of metachromatic substances in cells by Toluidine blue/Congo red technique.
5. Microtubules in vesicle transport in fish chromatophore.
6. Assignment on cell communication and signaling.

SUGGESTED READINGS

- **Molecular Biology of the Cell** – Alberts B., Johnson A., Lewis J., Raff M., Roberts K., and Walter P. (Garland Science, 6th Edition, 2014)
- • **Cell Biology** – Pollard T.D., Earnshaw W.C., Lippincott-Schwartz J., and Johnson G.T. (Elsevier, 3rd Edition, 2016)
- • **The Cell: A Molecular Approach** – Cooper G.M. and Hausman R.E. (Sinauer Associates, 7th Edition, 2018)
- • **Lodish Molecular Cell Biology** – Lodish H., Berk A., Kaiser C.A., Krieger M., Bretscher A., Ploegh H., Amon A., and Martin K.C. (W.H. Freeman, 9th Edition, 2021)
- • **Karp's Cell Biology** – Iwasa J., Marshall W., and Karp G. (Wiley, 9th Edition, 2023)
- • **Principles of Genetics** – Snustad D.P. and Simmons M.J. (Wiley, 7th Edition, 2015)
- • **Genetics: Analysis and Principles** – Brooker R.J. (McGraw Hill, 7th Edition, 2023)
- • **Concepts of Genetics** – Klug W.S., Cummings M.R., Spencer C.A., and Palladino M.A. (Pearson, 12th Edition, 2018)
- • **Principles of Population Genetics** – Hartl D.L. and Clark A.G. (Sinauer

Associates, 4th Edition, 2007)

- **Population Genetics** – Hamilton M.B. (Wiley-Blackwell, 1st Edition, 2009)

SEMESTER VII

Title of the Course : Research Methodology and Research Ethics
Course Code : RM
Nature of the Course : Compulsory
Total Credits 04
Distribution of Marks : 40 + 60 = 100
Total classes 60

COs:

1. Apply research concepts for survey and data collection

2. Evaluate collected data through statistical tools

3. Discuss ethics of research and publication

Learning Outcomes:

1) Discuss research concepts for data collection
2) Analyze data through statistical tools
3) Understand research ethics and publication guidelines

Mapping of CO with Bloom's taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual						
Conceptual		CO3	CO1		CO2	
Procedural						
Metacognitive						

Mapping of Course outcomes to Programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	AVERAGE
CO1	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	3
CO3	3	3	3	3	3	3	3	3
AVERAGE	3	3	3	3	3	3	3	

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

MODES OF IN-SEMESTER ASSESSMENT:

- One Theory exam
- Group Discussion/Seminar/Viva/Assignments

Attainment strategy:

- Continuous evaluation through in and end semester theory examination

Unit 1: Fundamentals of Research Methodology: Introduction to Research in Life

Sciences, Types of Research: Basic, Applied, and Translational, Formulating Research Questions and Hypotheses, Literature Review and Meta-Analysis

Unit 2: Experimental Design, Data Collection and Analysis: Principles of Experimental Design, Sampling Techniques and Sample Size Determination, Data Collection Methods: Surveys, Observations, and Experiments, Use of Statistical Tools and Software. Data Analysis and Interpretation

Unit 3: Research Ethics: Ethical Principles in Life Sciences Research, Responsible Conduct of Research (RCR), Avoiding Plagiarism and Misconduct, Guidelines for Animal and Human Research.

Unit 4: Publication Ethics and Communication: Writing Research Papers and Reports, Peer Review Process and Responding to Reviewers. Open Access Publishing and Predatory Journals. Presenting Research: Posters, Oral Presentations, and Conferences

Suggested Readings:

- CSIR Guidelines for Ethics in Research and in Governance - CSIR (2019)
- Ethics in Science Education, Research and Governance- Kambadur Muralidhar, Amit Ghosh, Ashok Kumar Singhvi - INSA (2019)
- Research Design: Qualitative, Quantitative, and Mixed Methods Approaches by John W Creswell and J. David Creswell
- Research Methodology: A Step-by-Step Guide for Beginners by Ranjit Kumar
- Research Methology : methods and techniques by CR Kothari & Gaurav Garg
- Introducing Research Methodology: A Beginner′s Guide to Doing a Research Project by Uwe Flick

SEMESTER-VII

Title of the Course	**:**	**Advanced Analytical Techniques**
Code	**:**	**Minor-VII**
Nature of course	**:**	**Minor**
Total Credits	**:**	**04**
Distribution of Marks	**:**	**40+60**
Total classes	**:**	**60**

COs:

1. Analyze and compare different nucleic acid extraction and sequencing techniques
2. Investigate biological samples through the application of different bioimaging and biophysical tools and techniques

3. Examine genomic DNA and products of ts amplification

Learning Outcomes:

1. Demonstrate various analytical techniques used in biological sciences
2. Evaluate biological samples with the use of various analytical tools and techniques
3. Describe DNA structure and amplification

Mapping of CO with Bloom Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual						
Conceptual				CO1	CO2	
Procedural					CO3	
Metacognitive						

Mapping of Course outcomes to Programme outcomes

CO/PO	PO 1	PO 2	PO 3	PO4	PO5	PO6	PO7	AVERAGE
CO1	3	2	2	2	2	2	2	2.14
CO2	3	2	2	2	2	2	2	2.14
CO3	3	2	3	1	1	2	2	2.0
AVERAGE	3	2	2.3	1.7	1.7	2	2	

3for highest correlation,2 for moderate correlation, and1 for lowest correlation

Modes of internal assessment

1. One internal examination (theory)
2. One internal examination (Lab)
3. Viva-voce
4. Group discussion
5. Home assignments

Attainment strategies of Cos:

1. Continuous evaluation through in and end-semester theory and practical examinations
2. Laboratory practices
3. Practical record book/field book
4. Seminar/group discussion

Course content

Unit-I : 11 classes

Nucleic acid extraction and visualization, Agarose Gel Electrophoresis. Polymerase Chain Reaction (PCR)- principle and types, Plasmid isolation and purification

Unit II: **12 classes**

Bioimaging techniques- electron microscopy principle, uses and sample preparation, fluorescent microscopy principle and uses, Flow cytometry – principle and application, Fluorescence in-situ hybridization, Genomic in-situ hybridization and Fluorescence-Activated Cell Sorting (FACS)

Unit III: **13 classes**

Biophysical Methods: High Performance Liquid Chromatography (HPLC), Fourier Transform Infrared Spectroscopy (FTIR), Nuclear Magnetic Resonance Spectroscopy (NMR), X-ray diffraction (XRD), Gas chromatography (GC), Mass Spectroscopy (MS)

Unit IV: **09 classes**

DNA sequencing techniques- Pyrosequencing, Nextgen sequencing, Genome editing – CRISPR

Lab activities

1. Nucleic acid extraction from biological samples
2. Visualization of DNA by Agarose gel electrophoresis
3. Nucleic acid amplification by PCR
4. Demonstration of HPLC, FTIR, NMR, XRD, etc.

Suggested Readings:

1. Principles of Biochemistry and Molecular Biology by K. Wilson and J. Walker, Cambridge University Press.

2. Principles of Instrumental analysis by D. A. Skoog and J. J. Leary, Saunders College Publishing, Philadelphia.

3. Textbook of Structural biology by Anders Lilgas, Lars Lilgas, JuiPiskur et al, World Scientific Publisher

SEMESTER-VIII

Title of the Course : Intermediary Metabolism
Code : Core-XIX
Nature of course : Core
Total Credits : 04
Distribution of Marks: 40+60
Total classes : 60

COs:

1. Analyze the concept of bioenergetics and energy metabolism.
2. Evaluate the role of co-ordinated regulation of metabolism.
3. Explain the importance of metabolic pathways and regulation in the biological

system.

Learning Outcomes:

- Discuss the mechanisms involved in energy metabolism
- Analyze lipid, nitrogen and nucleotide metabolism
- Describe the integration and regulatory strategies of metabolic pathways in the biological system.

Mapping of CO with Bloom Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual						
Conceptual				CO1	CO2,CO3	
Procedural						
Metacognitive						

Mapping of Course outcomes to Programme outcomes

CO/PO	PO 1	PO 2	PO 3	PO4	PO5	PO6	PO7	AVERAGE
CO1	3	2	2	2	2	2	2	2.14
CO2	3	2	2	2	2	2	2	2.14
CO3	3	2	3	1	1	2	2	2.0
AVERAGE	3	2	2.3	1.7	1.7	2	2	

3 for highest correlation,2 for moderate correlation, and1 for lowest correlation

Modes of internal assessment

1. One internal examination (theory)
2. One internal examination (Lab)
3. Viva-voce
4. Group discussion
5. Home assignments

Attainment strategies of Cos:

1. Continuous evaluation through in and end-semester theory and practical examinations
2. Laboratory practices
3. Practical record book/field book
4. Seminar/group discussion

Course content

Unit 1: Bioenergetics and energy metabolism: 11 lectures

Concept of energy transduction process, Biological oxidation-reduction reactions, reduction potential and free energy, Structure of ATP and its phosphoryl transfer potential, Electron transport chain, ATP Synthesis and Chemiosmosis; Phosphorylation: substrate level and oxidative phosphorylation and its regulation. Photophosphorylation and carbon fixation reactions in chloroplast; C3, C4 and C2 plants, photorespiration.

Unit 2: Lipid metabolism: 10 lectures

Overview of fatty acid transport, β-oxidation in mitochondria and peroxisomes, and its energetics,

oxidation of saturated, and unsaturated fatty acids (odd and even number carbon atoms), Omega oxidation. Biosynthesis of fatty acid (Palmitate), chain elongation and desaturation, biosynthesis of eicosanoids, ketone bodies, and cholesterol, and their physiological significance.

12 lectures

Unit 3: Amino acids and nucleotide metabolism: Overview of nitrogen fixation in biological system, biosynthesis of amino acids (phenylalanine, arginine, histidine, tryptophan), Cofactors of amino acid metabolism. Metabolism of purine and pyrimidine(de novo and salvage pathway), regulation of nucleotide biosynthesis, and degradation of nucleotides, inborn errors of metabolism.

12 lectures

Unit 4: Integration and regulatory strategies of metabolic pathways: Citric acid cycle as metabolic hub; amphibolic and anaplerotic reactions. Co-ordinated regulation- glycolysis and gluconeogenesis, glycogen synthesis and breakdown; Co-ordinated regulation of fatty acid oxidation and biosynthesis; hormonal regulation of fatty acid and carbohydrate metabolism, allosteric and covalent modifications. Interlinking between carbohydrate, lipid and protein metabolism.

Unit 5: Lab Course: **15 lectures**

1. Fractionation of tissue by differential centrifugation.
2. Estimation of protein, carbohydrate, free phosphate in biological samples.
3. Estimation of ascorbic acid (Colourimetric).
4. Estimation of cholesterol.
5. Estimation of urea in biological samples.
6. Separation of protein and determination of molecular mass by SDS-PAGE.

Suggested Readings:

- Principles of Biochemistry (2013) 6th ed., Nelson, D.L. and Cox, M.M., W.H. Freeman and Company (New York), ISBN:13:978-1-4641-0962-1 / ISBN:10:1-4641-0962-1.
- Principles of Biochemistry (2013) 4th ed., Voet, Donald,Voet, Judith &Pratt, charlotte. Wiley & Sons, Inc. (New Jersey), ISBN:978-1-11809244-6.
- Textbook of Biochemistry with Clinical Correlations (2011) 7th ed., Devlin, T.M., John Wiley & Sons, Inc. (New Jersey), ISBN:978-0-470-28173-4.

Berg, J.M., Tymoczko, J.L. and Stryer L., (2012) W.H. Biochemistry (7th ed.), Freeman and Company (New York), ISBN:10: 1-4292-2936-5, ISBN:13:978-1-4292-2936-4

SEMESTER-VIII

Title of the Course : Advanced Genetics & Plant breeding
Nature of course : CORE
Code : XX
Total Credits : 04
Distribution of Marks: 40+60=100
Total classes : 60

Course outcomes

CO1: Evaluate classical and molecular genetic mechanisms, including Mendelian deviations, extranuclear inheritance, molecular mutational pathways, mutagens, and cellular DNA repair systems.

CO2 : Apply principles of population and evolutionary genetics to calculate allele and genotype frequencies using the Hardy–Weinberg equilibrium, while evaluating the evolutionary impacts of selection, drift, and gene flow.

CO3: Assess human genetic principles and biomedical applications, analyzing genetic disorders, karyotypes, genetic counseling, and the frameworks of eugenics, euphenics, euthenics, and pharmacogenomics.

CO4: Utilize advanced experimental designs and mixed statistical models—such as Best Linear Unbiased Prediction (BLUP)—to characterize plant genetic resources, evaluate diversity, and conserve germplasm.

Mapping of CO with Bloom Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual						
Conceptual				CO1	CO1	CO4
Procedural			CO2	CO3		
Metacognitive						

Mapping of Course outcomes to Programme outcomes

CO/PO	PO 1	PO 2	PO 3	PO4	PO5	PO6	PO7	AVERAGE
CO1	2	2	2	2	2	2	2	2
CO2	2	2	2	2	2	2	2	2
CO3	2	2	2	2	2	2	2	2
CO4	2	2	2	2	2	2	2	2
AVERAGE	2	2	2	2	2	2	2	

3 for highest correlation,2 for moderate correlation, and1 for lowest correlation

Modes of internal assessment

1. One internal examination (theory)
2. One internal examination (Lab)
3. Viva-voce
4. Group discussion
5. Home assignments

Attainment strategies of Cos:

1. **Continuous evaluation through in and end-semester theory and practical examinations**
2. Laboratory practices
3. Practical record book/field book
4. Seminar/group discussion

Unit-I: Deviations of Mendelism **08 classes**

Deviations of Mendelism, Sex Determination, Sex related characters, Extranuclear inheritance, Significance of Crossing over. Mutation at molecular level, Spontaneous and induced mutation, Mutagens & their action, DNA damage & repair.

Unit-II: Population Genetics, Human Genetics, and Genomics **15 classes**

Concept of population genetics and the Hardy-Weinberg law. Human genetics: genetic disorders and syndromes; euthenics, eugenics, and euphenics. Genetic counselling. Basic idea on the human genome project (HGP), genomic library, and gene targeting. Evolutionary genetics: Genetic drift, gene flow, and natural selection.

Unit-III: Plant breeding **07 Classes**

Introduction to plant breeding: genetic resources, genetic variation, types and conservation

Experimental designs in plant breeding: BLUP, mixed design models

Unit- IV : Genetic tools in plant breeding **15 classes**

Genetic tools in plant breeding; QTL mapping, MAS; types and applications. Genomic breeding, Genome-Wide Association Studies (GWAS) and genomic prediction, pharmacogenomics. Metagenomics, gene editing, CRISPR-Cas9, application of gene editing in agriculture and medicine

Lab activities: **15 classes**

- . Calculation of allelic and genotypic frequencies based on Hardy-Weinberg equilibrium using population datasets.
- Karyotype analysis: Identification of normal human chromosomes and common numerical/structural aberrations from prepared photographs.
- Studies on physical and chemical mutagens
- Photographs/animation of CRISPR-Cas9
- Study on QTL mapping

SEMESTER VIII

Title of the Course : Bioethics, and IPR

Code : MINOR-VIII
Nature of course : Minor
Total Credits 04
Distribution of Marks : 40+60
Total classes 60

Course outcomes

1. Analyze biosafety and ethical perspectives in research.
2. Evaluate various types of IPRs.
3. Discuss the various agreement and treaties.
4. Apply the knowledge to apply for a patent.

Learning Outcomes:

1. Describe the concept of biosafety and bioethics.
2. Analyze the IPR types.
3. Understand the agreement and treaties.
4. Discuss the patent filling process.

Mapping of CO with Bloom Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual						
Conceptual		CO3	CO4	CO1	CO2	
Procedural						
Metacognitive						

Mapping of Course outcomes to Programme outcomes

CO/PO	PO 1	PO 2	PO 3	PO4	PO5	PO6	PO7	AVERAGE
CO1	2	2	2	2	2	2	2	2
CO2	2	2	2	2	2	2	2	2
CO3	2	2	2	2	2	2	2	2
CO4	2	2	2	2	2	2	2	2
AVERAGE	2	2	2	2	2	2	2	

3 for highest correlation,2 for moderate correlation, and1 for lowest correlation

Modes of internal assessment

6. One internal examination (theory)
7. One internal examination (Lab)
8. Viva-voce
9. Group discussion
10. Home assignments

Attainment strategies of Cos:

5. Continuous evaluation through in and end-semester theory and practical examinations
6. Laboratory practices
7. Practical record book/field book
8. Seminar/group discussion

Course content

UNIT I:

Concepts in Bioethics: Historical perspective of Bioethics, Conflicting issue: GMO, GMP, Cloning, environmental hazards. Biosafety in Laboratories. Principles and guidelines for research in human and animals: Nuremberg code, ICMR guidelines for research using animal 1980 and amendments . Cruelty to Animal Act 1960

UNIT 2: 15 lectures

Concept of Intellectual Property Rights (IPR) and its significance. Types of IPR- Patents, Patent Cooperation Treaty, copyright, trademarks, industrial design, trade secrets and geographical indication.

UNIT 3: 12 lectures

Agreement and treaties: GATT & TRIPs Agreement, Madrid Agreement, Hague Agreement, WIPO Treaties. Indian Patent Act 1970 and recent amendments. Patent filing and granting procedure.

UNIT4: 10 lectures

Biopiracy and bioprospecting: Concept of biopiracy, Nagaya Protocol, Biodiversity Act 2002

Indigenous Knowledge System, concept of bioprospecting. Scope of bioprospecting with examples.

UNIT 5: 8 lectures

Proxy filing for a patent application; survey of indigenous knowledge with respect to NE India and report submission.

Suggested Readings:

- M K Sateesh . Bioethics and Biosafety. Kindle Edition
- Shomini Parashar, Deepa Goel IPR, Biosafety and Bioethics Pearson India 2013
- Private Power, Public Law: The Globalization of Intellectual Property Rights By Susan K. Sell Cambridge University Press, 2000
- Essentials of Intellectual Property: Law, Economics, and Strategy By Alexander I. Poltorak; Paul J. Lerner Wiley, 2011 (2nd edition)

Diane O. Fleming, Debra L. Hunt Biological Safety: Principles and Practices, 4th Edition. ASM 2006

Suggested Readings:

- M K Sateesh .Bioethics and Biosafety. Kindle Edition
- Shomini Parashar, Deepa Goel IPR, Biosafety and Bioethics Pearson India 2013
- Private Power, Public Law: The Globalization of Intellectual Property Rights By Susan K. Sell Cambridge University Press, 2000
- Essentials of Intellectual Property: Law, Economics, and Strategy By Alexander I. Poltorak; Paul J. Lerner Wiley, 2011 (2nd edition)

Diane O. Fleming, Debra L. Hunt Biological Safety: Principles and Practices, 4th Edition.

ASM 2006

SEMESTER VIII

Title of the Course	**:**	**Dissertation**
Course Code	**:**	**Dissertation**
Nature of the Course	**:**	
Total Credits	**:**	**08**

Course Structure

Dessertation

SEMESTER-VIII

Title of the Course : Climate change & biological adaptations
Code : DSE-I
Nature of course : DSE Total Credits
: 04
Distribution of Marks : 40+60 Total
classes 60

Course outcomes:

1) Analyze Climate change and biological responses to it.
2) Evaluate biodiversity and impact of human interference
3) Evaluate conservation strategies, GIS and remote sensing tools

Learning Outcomes:

1) Discuss biological changes in response to climate change
2) Apply the GIS and remote sensing tools for evaluation of biodiversity
3) Analyze conservation measures

Mapping of CO with Bloom Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual						
Conceptual				CO1	CO2,CO3	
Procedural						
Metacognitive						

Mapping of Course outcomes to Programme outcomes

CO/PO	PO 1	PO 2	PO 3	PO4	PO5	PO6	PO7	AVERAGE
CO1	3	2	2	2	2	2	2	2.14
CO2	3	2	2	2	2	2	2	2.14
CO3	3	2	3	1	1	2	2	2.0
AVERAGE	3	2	2.3	1.7	1.7	2	2	

3 for highest correlation,2 for moderate correlation, and1 for lowest correlation

Modes of internal assessment

11. One internal examination (theory)
12. One internal examination (Lab)
13. Viva-voce
14. Group discussion
15. Home assignments

Attainment strategies of Cos:

9. Continuous evaluation through in and end-semester theory and practical examinations

10. Laboratory practices
11. Practical record book/field book
12. Seminar/group discussion

Course content:

Unit-I: Fundamentals of Climate Change 11 classes

Introduction to climate systems and climate change, Greenhouse gases and Global warming, Climate change indicators and feedback loops, Historical climate patterns and predictions

Unit-II: Biological Responses to Climate Change 11 classes

Physiological adaptations in plants and animals, Behavioral changes in species, Evolutionary adaptations and natural selection, Phenological shifts (e.g., migration, flowering times)

Unit-III: Ecosystem level impacts 11 classes

Changes in biodiversity and species distribution, Ecosystem resilience and vulnerability, Impact on aquatic and terrestrial ecosystems, Role of keystone species

Unit-IV: Human Influence and Conservation, GIS & remote sensing 12 classes

Anthropogenic drivers of climate change, Conservation strategies for threatened species, Restoration ecology and habitat management, Policy and international agreements (e.g., Paris Agreement)

Introduction to Remote Sensing and GIS techniques: Satellites, Sensors, Platforms and Resolutions, Infrared and Microwave Remote Sensing: Principles and Applications, Interpreting Optical Remote Sensing Images, Projection of climate change scenarios and Tools for mapping and monitoring

GIS applications based on model outputs and GIS databases, Remote sensing technologies to monitor climate change processes (vegetation biomass, monitoring flooding, soil moisture and depth, surface micro topography etc.)

Lab activities

1. Effect of temperature in plant growth and germination
2. Effect of pH on aquatic ecosystem (plankton diversity and DO)
3. Study of butterfly diversity in different habitats
4. Study of the process of remote sensing & GIS (demonstration)
5. Study of plant adaptations in xeric and aquatic environment
6. Study of ant behavior in different temperature gradients
7. Study of life cycle of any insect under different temperature conditions

Suggested Reading:

1. "Climate Change Biology" by Lee Hannah
2. "The Sixth Extinction: An Unnatural History" by Elizabeth Kolbert

3. Research papers on climate change and adaptation from journals like Nature and Science.

SEMESTER VIII

Title of the Course : Computational Biology

Code : DSE-II
Nature of course: DSE
Total Credits : 04
Distribution of Marks: 40+60 Total
classes 60

1) Analyze biological databases and interpret data.
2) Evaluate protein structure and conformations
3) Analyze ligand properties
3) Evaluate protein ligand interactions Learning

Outcomes:

1) Apply the concepts of computational biology to interpret data
2) Analyze protein structure, predict structure and conformational changes
3) Describe pharmacokinetic properties of ligands
4) Analyze protein ligand interactions through docking and simulation

Mapping of CO with Bloom Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual						
Conceptual						
Procedural				CO1, CO3	CO2,CO4	
Metacognitive						

Mapping of Course outcomes to Programme outcomes

CO/PO	PO 1	PO 2	PO 3	PO4	PO5	PO6	PO7	AVERAGE
CO1	3	2	2	2	2	2	2	2.14
CO2	3	2	2	2	2	2	2	2.14
CO3	3	2	3	2	2	2	2	2.0
CO4	3	2	3	2	2	2	2	2.28
AVERAGE	3	2	2.5	2	2	2	2	

3for highest correlation,2 for moderate correlation, and1 for lowest correlation

Modes of internal assessment

1. One internal examination (theory)
2. One internal examination (Lab)
3. Viva-voce
4. Group discussion
5. Home assignments

Attainment strategies of Cos:

1. Continuous evaluation through in and end-semester theory and practical examinations

2. Laboratory practices
3. Practical record book/field book
4. Seminar/group discussion

Course content

UNIT-I:

Scope of Computational Biology and Bioinformatics. Major biological databases and information retrieval. Conversion of file types. BLAST analysis and Primer designing.

Computational Phylogenetic analysis.

UNIT-II:

Protein structure, protein folding and Ramachandran plot analysis. Protein structure prediction tools, homology modeling and structure validation. Molecule visualization tools.

UNIT-III:

Computer Aided Drug Designing- Pharmacokinetics and Pharmacodynamics, ADMET properties, Lipinski rule of 5, Molecular Docking analysis and QSAR.

Concept of Molecular dynamics simulation – protein preparation, ligand preparation, forcefields, energy minimization. Steps of MD simulation. RMSD, RMSF.

Unit-IV: Sequencing technologies: sanger VS NGS, genome assembly basics, gene finding, biological networks, KEGG pathways, STRING database

Lab activities

1. Retrieval of sequences of nucleotides and amino acids, structure of proteins from databases
2. BLAST analysis
3. Phylogenetic tree construction
4. Primer designing
5. Protein structure prediction and validation
6. ADMET screening and Lipinski analysis
7. Active site detection
8. Protein ligand docking analysis
9. Gene regulatory network analysis
10. Gene finding

Suggested Reading:

- Bioinformatics: Principles and Applications by Z. Ghosh and B. Mallick, Oxford University Press.
- Bioinformatics: Sequence and Genome Analysis by D.W. Mount, Cold Spring Harbor Laboratory
- Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins by A.D. Baxevanis and B.F.F. Ouellette, Wiley-interscience.
- Understanding Bioinformatics by Marketa Zvelebil and Jeremy Baum, Garland Science.

Semester-IX

Title of the Course :Plant Stress Biology
Nature of course :Discipline Specific Core
Code:DSC-I
Total Credits :04
Distribution of Marks:40+60=100
Total classes :60

Course Outcomes (COs)

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

- CO-1 (Understand): Differentiate between abiotic and biotic plant stresses, and explain the fundamental concepts of acclimation, adaptation, and susceptibility.
- CO-2 (Analyze): Evaluate the morphological, physiological, and biochemical responses of plants to drought, salinity, and temperature extremes, including the protective roles of osmolytes, antioxidants, and aquaporins.
- CO-3 (Explain): Explain the mechanisms of biotic stress resistance, distinguishing between pattern-triggered immunity (PTI) and effector-triggered immunity (ETI), and assess the protective role of the plant microbiome.
- CO-4 (Synthesize): Diagram and critically analyze complex stress-sensing and signaling pathways, including calcium signaling, the Salt Overly Sensitive (SOS) pathway, and hormonal cross-talk (ABA, JA, SA).
- CO-5 (Apply & Execute): Experimentally measure, quantify, and analyze plant stress indicators in a laboratory setting using physiological, biochemical, and molecular techniques (e.g., electrolyte leakage, antioxidant assays, spectrophotometry).

Mapping of CO with Bloom Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual						
Conceptual	CO1			CO2		
Procedural		CO3				
Metacognitive					CO5	CO4

Mapping of Course outcomes to Programme outcomes

CO/PO	PO 1	PO 2	PO 3	PO4	PO5	PO6	PO7	AVERAGE
CO1	3	2	2	2	2	2	2	2.14
CO2	3	2	2	2	2	2	2	2.14
CO3	3	2	3	2	2	2	2	2.0
CO4	3	2	3	2	2	2	2	2.28
CO5	3	2	3	2	2	2	2	2.28
AVERAGE	3	2	2.5	2	2	2	2	

3for highest correlation,2 for moderate correlation, and 1 for the lowest correlation

Modes of internal assessment

1. One internal examination (theory)
2. One internal examination (Lab)
3. Viva-voce
4. Group discussion
5. Home assignments

Attainment strategies of Cos:

1. Continuous evaluation through in and end-semester theory and practical examinations
2. Laboratory practices
3. Practical record book/field book
4. Seminar/group discussion

Unit 1: Introduction to Plant Stress Biology

Introduction to plant stress, Types (abiotic and biotic), Acclimation, Adaptation

Unit 2: Abiotic stress (Drought, Salt, and Temperature)

Physiological and Biochemical responses to drought and salinity stress, Resistance or Tolerance mechanisms of drought & salinity stress (Antioxidant enzymes, Osmolytes, Secondary metabolites, Heat Shock Proteins, Cryoprotectants, Phytoalexins) Role of Aquaporins in drought tolerance

Temperature - Cold and heat stress: Morphological, Physiological, and Biochemical responses

Unit 3: Biotic Stress

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

Unit 4: Stress Sensing & Signaling,

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

Lab activities:

1. To study the effect of salt stress on seed germination (percentage, plant shoot and root length)
2. To study the effect of stress (any one) on chlorophyll content
3. To determine electrolyte leakage in stressed plants
4. Estimation of total phenolic content
5. To determine SOD or peroxidase enzyme activity in control and stress plants

Experiments through demonstration (through photographs)

6. Study of plant adaptations under stress (Stomatal closure, Leaf curling, Root elongation, Stunted plant growth, Wilting) and Effect of ABA.

7. To demonstrate the effect of stress on total protein through 2-D gel electrophoresis profile. 8. Effect of stress on plant membranes.

9. Effect of biotic stress on plants through photographs (necrosis, rotting, nematode attack, apple scab, SAR).

Suggested Readings

1. Taiz, L., Zeiger, E., Moller, I. M., Murphy, A. (2018). Plant Physiology and Development, 6th edition. New York, NY: Oxford University Press, Sinauer Associates.

2. Bhatla, S.C., Lal, M.A. (2018). Plant Physiology, Development and Metabolism. Singapore: Springer Nature, Singapore Pvt. Ltd.

3. Giri, B., & Sharma, M. P. (Eds.) (2021). Plant Stress Biology: Strategies and Trends. Springer Nature.

4. Buchanan, B. B., Gruissem, W., & Jones, R. L. (Eds.) (2015). Biochemistry and molecular biology of plants. John wiley & sons.

Semester-IX

Title of the Course :Plant Biotechnology
Nature of course :Discipline Specific Core
Code :DSC-II
Total Credits :04
Distribution of Marks:40+60=100
Total classes :60

Course Outcomes (COs)

- CO-1: Describe the core principles, historical milestones, and scope of plant biotechnology, alongside foundational molecular tools like restriction enzymes, probes, and cloning libraries.
- CO-2: Compare different plant tissue culture regeneration pathways (organogenesis, somatic embryogenesis, protoplast fusion), and analyze the precise nutritional and physiological factors that govern cellular totipotency.
- CO-3: Critique the mechanisms of direct and indirect gene transfer methodologies, explicitly evaluating the efficiency of *Agrobacterium*-mediated transformation versus physical delivery techniques like particle bombardment.
- CO-4: Synthesize case studies of prominent genetically modified crops (e.g., Bt Cotton, Golden Rice), formulate a balanced assessment of molecular farming, and debate the ethical and environmental implications of transgenics.
- CO-5: Demonstrate hands-on proficiency in preparing Murashige and Skoog (MS) media, maintaining aseptic conditions, executing explant sterilization, raising cell suspension cultures, and synthesizing synthetic seeds.

Mapping of CO with Bloom Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual						
Conceptual	CO1			CO2		
Procedural		CO3				
Metacognitive					CO5	CO4

Mapping of Course outcomes to Programme outcomes

CO/PO	PO 1	PO 2	PO 3	PO4	PO5	PO6	PO7	AVERAGE
CO1	3	2	2	2	2	2	2	2.14
CO2	3	2	2	2	2	2	2	2.14
CO3	3	2	3	2	2	2	2	2.0
CO4	3	2	3	2	2	2	2	2.28
CO5	3	2	3	2	2	2	2	2.28
AVERAGE	3	2	2.5	2	2	2	2	

Modes of internal assessment

1. One internal examination (theory)
2. One internal examination (Lab)
3. Viva-voce
4. Group discussion
5. Home assignments

Attainment strategies of Cos:

1. Continuous evaluation through in and end-semester theory and practical examinations
2. Laboratory practices
3. Practical record book/field book
4. Seminar/group discussion

Unit I: Introduction to Plant Biotechnology

Plant Biotechnology: Introduction, History, Model plants, Scope and Applications

Restriction enzymes, molecular probes, genomic and cDNA libraries

Unit II: Plant Cell, Tissue, and Organ Culture

History, concept of totipotency, nutritional requirements of culture, media preparation, aseptic condition, applications, and limitations

Regeneration Protocols: Single Cell Culture, Organogenesis and Somatic Embryogenesis, Factors and Significance

Protoplast Culture and Fusion: Protoplast isolation and culture, Protoplast fusion, methods and factors, Applications

Unit III: Techniques for plant transformation

Indirect gene transfer methods (*Agrobacterium-mediated* transfer)

Direct Gene transfer methods (electroporation, particle bombardment, microinjection, PEG, silicon carbide)

Unit-IV: Transgenic plants and their application

Transgenic plants, some genetically modified plants (Flavr Savr tomato, Bt brinjal, Bt corn, Bt cotton, Golden rice, virus resistant plants, pest resistant plants), and molecular farming, applications, and limitations (ethical and environmental issues) of transgenic plants

Lab activities

1. Medium preparation of Murashige and Skoog
2. Surface sterilization and inoculation of nodal explants on MS medium
3. To raise suspension culture by using friable calli
4. Synthetic seed preparation

5. Study of some established transgenic plants

Suggested readings

1. Bhojwani SS & Dantu PK (2013) Plant Tissue Culture: An Introductory Text, Springer.
2. Park S (2021) Plant Tissue Culture: Techniques and Experiments, Fourth Edition, Academic Press, Elsevier.
3. Razdan MK (2003). Introduction to Plant Tissue Culture, Science Publishers, USA
4. Slater A, Scott NW and Fowler MR (2008) Plant biotechnology: the genetic manipulation of plants, second edition, Oxford University Press.
5. Sahni S, Prasad BD and Kumar P (2017) Plant Biotechnology: Transgenics, Stress

Semester-IX

Title of the Course	**:Plant Immunity**
Nature of course	**:Discipline Specific Core**
Code	**:DSC-III**
Total Credits	**:04**
Distribution of Marks	**:40+60=100**
Total classes	**:60**

Course outcomes

- CO-1 (Understand): Differentiate between compatible and incompatible plant-pathogen interactions, host/non-host resistance, and vertical/horizontal resistance mechanisms, while evaluating the role of beneficial microbiomes.
- CO-2 (Analyze): Categorize structural and biochemical defenses into constitutive (passive) and inducible (active) systems, and explain the molecular mechanisms driving PAMP-triggered immunity (PTI).
- CO-3 (Compare): Critique the distinct anatomical origins, chemical signals, and temporal dynamics of Systemic Acquired Resistance (SAR) versus Induced Systemic Resistance (ISR) and defense priming.
- CO-4 (Synthesize): Model and map molecular signal transduction cascades activated during defense, including phytohormonal cross-talk (SA/JA/Ethylene), calcium signaling (CaM/CBLs), MAPK cascades, and the oxidative burst (ROS).
- CO-5 (Apply): Propose bio-engineering and translational strategies (such as CRISPR-Cas9, RNAi-mediated silencing, and chimeric PRRs) to build durable, broad-spectrum disease resistance in commercial crops.
- CO-6 (Execute): Perform macro and microscopic diagnostic assays to identify plant diseases, characterize structural barriers, and quantitatively measure antioxidant activities and defensive secondary metabolites.

Mapping of CO with Bloom Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create

Factual						
Conceptual	CO1			CO2		
Procedural		CO3				
Metacognitive					CO5	CO4

Mapping of Course outcomes to Programme outcomes

CO/PO	PO 1	PO 2	PO 3	PO4	PO5	PO6	PO7	AVERAGE
CO1	3	2	2	2	2	2	2	2.14
CO2	3	2	2	2	2	2	2	2.14
CO3	3	2	3	2	2	2	2	2.0
CO4	3	2	3	2	2	2	2	2.28
CO5	3	2	3	2	2	2	2	2.28
CO6	3	2	3	2	2	2	2	2.28
AVERAGE	3	2	2.5	2	2	2	2	

Modes of internal assessment

1. One internal examination (theory)
2. One internal examination (Lab)
3. Viva-voce
4. Group discussion
5. Home assignments

Attainment strategies of Cos:

5. Continuous evaluation through in and end-semester theory and practical examinations
6. Laboratory practices
7. Practical record book/field book
8. Seminar/group discussion

Unit I-Plant Immunity

Immune system in plants, Plant-pathogen interactions; Compatible interactions (parasite virulence and host plant susceptibility), Incompatible interactions (parasite avirulence and host plant resistance), non-host and host -resistance, Horizontal and vertical resistance, Role of Microbiomes in Plant Immunity (beneficial microbes enhancing defense)

Unit II: Components of Plant Immunity:

Innate Immunity/ Resistance: Non-specific or Basal Resistance: Passive (Constitutive defenses) including pre-existing mechanical defences (cuticle, waxes, lignified cell wall, bark, trichomes, thorns); pre-existing biochemical defences (alkaloids, phenolic compounds, terpenoids, nutrient deprivation, phytoanticipins)

Active (Inducible Defences): Pathogen-associated molecular patterns (PAMPs), pattern-recognition receptors (PRRs), PAMP-triggered Immunity (PTI).

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

Unit III: Major Signal Transduction Pathways Activated During Plant Resistance:

Phytohormone signaling: salicylic acid, jasmonic acid, ethylene

Calcium signaling: Calmodulin (CaM), Calcineurin B-like proteins (CBLs) in Arabidopsis Mitogen-activated protein kinase (MAPK) Cascades; The Oxidative burst (ROS)

Unit IV: Applications of immunology in Plant Science

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

Lab activities:

1. Visual identification of bacterial, fungal, and viral diseases of plants
2. Determination of antioxidant activities of plant extracts
3. Study of CRISPR-Cas9 (Process and photograph)
4. Study of physical meanse for plant defence (e.g. cuticle, waxes, lignified cell wall, bark etc)
5. Estimation of plant secondary metabolites

Suggested Readings:

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

SEMESTER IX

Title of the Course	**: Fundamentals of Angiosperm Systematics and Diversity**
Course Code	**: DSE-III-A**
Nature of the Course	**: Discipline Specific Elective**
Total Credits	**: 04**
Distribution of Marks	**: 40+60=100**
Total classes	**: 60**

COs:

CO1: Apply the rules of the International Code of Nomenclature (ICN) to properly name, type, and publish plant species.

CO2: Critically analyze and compare traditional classification systems with the modern Angiosperm Phylogeny Group (APG-IV) framework.

CO3: Assess the phytogeography of India, identifying major botanical provinces and the conservation status of regional flora.

CO4: Independently identify, describe, and classify angiosperm specimens using dichotomous keys and classical literature.

Learning Outcomes:

1. Comprehend and apply the rules of botanical nomenclature for naming and typing plants.
2. Compare historical classification systems with the modern APG-IV framework to understand angiosperm evolution.
3. Identify regional flora and evaluate their phytogeographical and conservation significance.

Mapping of CO with Bloom's taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual						
Conceptual				CO2	CO3	
Procedural			CO1, CO4			
Metacognitive						

Mapping of Course outcomes to Programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	AVERAGE
CO1	3	2	1	1	3	2	2	**2.0**
CO2	3	2	1	1	2	2	2	**1.9**
CO3	3	2	2	3	2	2	2	**2.3**
CO4	3	3	1	2	2	2	2	**2.1**
AVERAGE	**3.0**	**2.3**	**1.3**	**1.8**	**2.3**	**2.0**	**2.0**	**2.1**

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

MODES OF IN-SEMESTER ASSESSMENT:

- One Theory exam
- One Practical exam
- Group Discussion/Seminar/Viva/Assignments

Attainment strategy:

- Continuous evaluation through in and end semester theory examination
- In and end semester practical examination based on identification of supplied specimens.
- Submission of practical file with record of studied specimens
- Submission of collected specimens
- Viva-voce examination

Unit 1: Principles of Taxonomy and Nomenclature: **12 classes**

Aims and Principles of Systematics; Alpha, Beta, Gamma and Omega Taxonomy; Historical background of plant classifications. Basic Principles and Major Rules of Botanical Nomenclature (Author's citation, Principles of Priority, Effective and Valid Publication, Typification). Methods of naming; International Code of Nomenclature for Algae, Fungi and Plants (ICN), taxonomic hierarchy. Introduction to Draft Biocode, Phylocode, e-Floras, and digital databases. Taxonomic literatures: Classical literatures, general index, monographs and revisions, floras and manuals.

Unit 2: Systems of Classification and Plant Evolution: 12 classes

Types of Plant classifications: Artificial, Natural, Phenetic, and Phylogenetic; Critical account of the systems of Bentham & Hooker, and Takhtajan (1987, 1997). History, principles, and brief account of Angiosperm phylogeny group (APG) systems, specifically APG-IV (2016). Theories on the Origin of Angiosperms, evidences, migration of plants and barriers. Centre of Origin, Primitive and advanced angiosperms, and evolutionary trends.

Unit 3: Phytogeography and Regional Diversity: 12 classes

Concept of Phytogeography, Static and Dynamic Phytogeography, Phytochoria, and botanical provinces of India. Vicariance, Endemism, and Hotspots. History, Organisation, Activities, and Publications of the Botanical Survey of India (BSI). Plant Diversity of India and Flora of North East India. Endemic, Exotic, and RET (Rare, Endangered, Threatened) Plants with specific reference to North East India.

Unit 4: Herbarium Techniques and Taxonomic Resources: 09 classes

Herbarium techniques: methods of collection, identification, preparation of herbarium specimens, documentation, Arrangement of Herbarium, and Virtual herbaria. Role and importance of major Herbaria and Botanic Gardens of the world and India.

Unit 5: Classical Systematics Practical 15 classes

- Work out, drawing, description, and identification of plant specimens from selected families (Magnoliaceae, Orchidaceae, Cyperaceae, Poaceae, Zingiberaceae, Fabaceae, Brassicaceae, Lamiaceae, Asteraceae as per APG-IV).
- Comparative description of 5-6 angiosperms and their identification using keys.
- Preparation of taxonomic keys (dichotomous) at family, generic, and species levels based on locally available plants.
- Field trips within and around the University Campus for the compilation of field notes, preparation of herbarium sheets, and familiarization with local flora.

SEMESTER IX

Title of the Course : Cytogenetics and Crop Improvement-I (Advances in Genetics & Cytogenetics)
Course Code : DSE-III-B
Nature of the Course : Discipline Specific Elective
Total Credits : 04
Distribution of Marks : 40+60=100
Total classes : 60

Course outcomes

CO1: Evaluate chromosome organization, specialized chromosomal structures, and the cytogenetic mechanisms governing cell division and inheritance.

CO2: : Apply principles of polygenic inheritance, multiple allelism, linkage, and crossing over to perform genetic mapping and calculate interference/coincidence.

CO3: Distinguish between nuclear, extra-nuclear, maternal, and environmentally influenced patterns of inheritance and sex determination.

CO4: Differentiate between various DNA-based marker technologies (RFLP, RAPD, AFLP, SSR, SNP) and select appropriate tools for crop improvement and genetic analysis.

CO5: Explain the mechanisms of genome organization, gene architecture, DNA replication, transcription, and telomere maintenance in prokaryotes and eukaryotes.

CO6: Demonstrate proficiency in basic rDNA applications, cytological tissue preparation, staining protocols, and microscopic analysis of mitosis and meiosis.

Mapping of CO with Bloom's taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual						
Conceptual				CO3, CO4	CO1	
Procedural			CO2			
Metacognitive		CO5, CO6				

Mapping of Course outcomes to Programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	AVERAGE
CO1	3	2	1	1	3	2	2	**2.0**
CO2	3	2	1	1	2	2	2	**1.9**
CO3	3	2	2	3	2	2	2	**2.3**
CO4	3	3	1	2	2	2	2	**2.1**

CO5	3	3	3	2	2	2	2	
CO6	3	2	3	2	2	2	2	
AVERAGE	**3.0**	**2.8**	**1.8**	**1.8**	**2.5**	**2.0**	**2.0**	**2.1**

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

MODES OF IN-SEMESTER ASSESSMENT:

- One Theory exam
- One Practical exam
- Group Discussion/Seminar/Viva/Assignments

Attainment strategy:

- Continuous evaluation through in and end semester theory examination
- In and end semester practical examination based on identification of supplied specimens.
- Submission of practical file with record of studied specimens
- Submission of collected specimens
- Viva-voce examination

Unit1: 8 classes

Cell theory and exceptions, Gross structure and chemistry of eukayotic and prokaryotic chromosomes, specialized chromosomes and their cytogenetic significances, mitotic apparatus. Synaptenemal complex, chromosome theory of inheritance, concept of karyotype and idiogram.

Unit2: 9 classes

Polygenic inheritance: Previous knowledge of mendelism and modifications, transgressive variation, Multiple alleles: alleles,multiple alleles and isoalleles, sexual incompatibility in plants, blood group alleles in man, multiple alleles and complex loci. Linkage, recombination and gene mapping: Morgan's works on , Drosophila, Coupling and repulsion hypothesis, cytological evidence of crossing over, gene mapping, interference and coincidence.

Unit3: 9 classes

Genetical control of sex: Chromosomal basis of sex determination ,balanced theory of sex determination, environmental and hormonal control of sex, concept of sex linked, sex limited and sex influenced characters, Extra nuclear transmission of traits; maternal effect and maternal inheritance, Killer trait in paramecium ,Co2sensitivity in Drosophila ,plastid inheritance, concept of sex linked, sex limited and sex influenced characters,Unit 4: Molecular markers: Basic concepts of molecular genetic markers: viz. microsatellite, RFLP,RAPD,AFLP,ISSR, SNP

Unit 4: 9 classes

DNA: Structure and function; DNA as the genetic material ;repetitive and unique sequence) Organization of genome (Satellite DNA; repititiveDNA,palindromicsequence);finestructureofgene;Organizationof genes (continuous gene, split or interrupted gene; overlapping gene, pseudogene).Replication of DNA: enzymes involved : replication of linear DNA (leading and lagging strand replication), circular DNA, and mitochondrial

DNA; telomere replication (end replication problem, telomerase); Transcription process and factors, Reverse transcriptase and its significance.

Unit 5: **9 classes**

Recombinant DNA technology: Various steps in rDNA technology and application in the field of medicine, environment and agriculture, role played by microorganisms in recombinant DNA technology

Lab activities

1. Preparation of fixatives and stains used in cytological works ,killing and fixing of tissue and organs and their preservative, use of pretreatment for chromosome spreading.
2. Study of mitosis by squash techniques using suitable stains like acetocarmine, aceto-orcein, haematoxyline, fuelgen techniques etc. in plant materials (squash from root tips or shoot tips of common economic and crop plants).
3. Study of meiosis by smearing techniques using suitable stains. in plant materials (smear from PMC' sof common economic and crop plants).
4. ----------

SEMESTER IX

Title of the Course : General Microbiology
Course Code : DSE-III-C
Nature of the Course : Discipline Specific Elective
Total Credits : 04
Distribution of Marks : 40+60=100
Total classes : 60

Course outcomes

- CO1: Explain the fundamental criteria of microbial classification and apply molecular taxonomy tools such as ribotyping.
- CO2: Discuss bacterial ultrastructure, cell-wall synthesis, and growth kinetics while evaluating physical, chemical, and antibiotic-mediated microbial control.
- CO3: Analyze structural properties, replication strategies, and pathogenicity of sub-viral agents, viruses, and oncogenic variants.
- CO4: Interpret complex biochemical pathways, regulatory mechanisms (Pasteur effect), and cellular bioenergetics of microbial respiration and photosynthesis.
- CO5: Demonstrate hands-on laboratory proficiency in microbial cultivation, isolation, staining, biochemical identification, and antimicrobial resistance testing.

Mapping of CO with Bloom's taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual						

Conceptual		CO1, CO2				
Procedural				CO3		
Metacognitive					CO4	CO5

Mapping of Course outcomes to Programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	AVERAGE
CO1	3	2	1	1	3	2	2	**2.0**
CO2	3	2	1	1	2	2	2	**1.9**
CO3	3	2	2	3	2	2	2	**2.3**
CO4	3	3	1	2	2	2	2	**2.1**
CO5	3	3	1	2	2	2	2	2.1

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

MODES OF IN-SEMESTER ASSESSMENT:

- One Theory exam
- One Practical exam
- Group Discussion/Seminar/Viva/Assignments

Attainment strategy:

- Continuous evaluation through in and end semester theory examination
- In and end semester practical examination based on identification of supplied specimens.
- Submission of practical file with record of studied specimens
- Submission of collected specimens
- Viva-voce examination

Unit 1: **12 classes**

Classification of Microorganisms; New approaches to bacterial taxonomy; Basis of microbial classification; Bergey's manuals; Advantages and limitations of DNA and RNA systematic, ribotyping.

Unit 2: **12 classes**

Bacteria: Bacterial cell wall structure; synthesis of cell wall components, Nutrition; Kinetics of bacterial growth; pure culture and cultural characteristics

Control of Microorganisms: Physical, chemical, and biological, Antibiotics and their modes of action

Virus: Process of infection; Function of DNA and RNA in viruses; Replication of viruses (replication of different types of nucleic acids in viruses). Viroids, prions, Interferons. Viruses and cancer

Unit 3: **12 classes**

Microbial metabolism: Biochemistry of fermentation (Alcohol and lactic acid fermentation), pathways and energetics of carbohydrate breakdown (EMP-pathway, HMP shunt, Entner-Douderff (E-D) pathway, Phosphoketolase Pathway, kreb cycle); Pasteur effect; proteolytic degradation to amino acids; deamination; Transamination; decarboxylation; microbial electron transport system; Mechanism of phosphorylations.

Unit 4: **09 classes**

Bacterial photosynthesis: photosynthetic bacteria (oxygenic and anoxygenic); photosynthesis (oxygenic and anoxygenic) in bacteria (pigments; light reactions; photophosphorylations); CO2 - fixation.

Lab activities **15 classes**

1. Gram Stain, capsule stain
2. Isolation and morphological characterization of microorganisms from soil, air, and water
3. Study of bacterial growth
4. Biochemical characterization of bacteria
5. Identification of appropriate antibiotic against bacteria
6. Study of antimicrobial resistance

Suggested readings

1. Microbiology by N.J. Pelczar, Jr. E.C.S.Chan and N.R. Krieg; Mac Graw Hill Book Company.
2. General Microbiology by R.Y.Stanier, M. Doudoroff and E.A. Adelberg; Mac Millan India.
3. Microbiology by L.M.Prescott,J.P.Harley and D.A.Klein . McGrawHill.
4. Text Book of Microbiology by R. Ananthanarayan and C.K. Joyaram Panikar . Orient Longman,Madras.
5. General Microbiology byC.B. Power and H.E. Daginawala ;Himalaya Publishing House,India.
6. A text book of Microbiology by R.C. Dubey and D.K. Maheswari., S.Chand& Co. Ltd.
7. Microbiology: An Introduction – G.J.Tortora, B.R. Funke and C.L.Case. Pearson Education
8. Microbiology by P.D.Sharma .RastogiPublications.
9. Bergey'smannual of Systematic Bacteriology, 2ndEdition.
10. Bergey'smannual of Determinitive Bacteriology, 9thEdition.
11. Molecular Virology by G.A.Knight . MC Graw Hill BookCompany.
12. General Virology by S. Luria and J.Darnoll.
13. Genes XI by B. Lewin , Oxford University Press ,India.
14. Petroleum Microbiology by R.M. Atlas , Mac Millan PublishingCompany.
15. Prescot and Dunn's Industrial Microbiology by G. Reed ; AVI, PublishingCompany.
16. Annual Review ofMicrobiology.
17. Annual Review ofBiochemistry.
18. Agricultural Microbiology by G. Rangaswami and D.J.Bagyaraj; PrenticeHall.

SEMESTER IX

Title of the Course : PLANT ECOLOGY-I
Course Code : DSE-III-D
Nature of the Course : Discipline Specific Elective
Total Credits : 04
Distribution of Marks : 40+60=100
Total classes : 60

Course outcomes

- CO1: Explain fundamental concepts of autecology, population characteristics, population dynamics, and the mechanisms of ecotype differentiation.
- CO2: Evaluate community structural properties (analytic/synthetic characters), plant successional theories, and global phytogeographical distribution models alongside endemism hypotheses.
- CO3: Analyze the soil-plant relationship, including soil horizons, physicochemical dynamics, the rhizosphere effect, and the distribution of major soil types in India and Assam.
- CO4: Compare the structural, functional, and physicochemical characteristics of aquatic habitats with major terrestrial global biomes.
- CO5: Appraise ecological plant adaptations induced by diverse environmental stress factors and apply quantitative field ecology methods to assess community properties

Mapping of CO with Bloom's taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual	CO1, CO4					
Conceptual		CO1, CO2				
Procedural				CO3		
Metacognitive					CO5	

Mapping of Course outcomes to Programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	AVERAGE
CO1	3	2	1	1	3	2	2	**2.0**
CO2	3	2	1	1	2	2	2	**1.9**
CO3	3	2	2	3	2	2	2	**2.3**
CO4	3	3	1	2	2	2	2	**2.1**
CO5	3	3	1	2	2	2	2	2.1

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

MODES OF IN-SEMESTER ASSESSMENT:

- One Theory exam
- One Practical exam
- Group Discussion/Seminar/Viva/Assignments

Attainment strategy:

- Continuous evaluation through in and end semester theory examination
- In and end semester practical examination based on identification of supplied specimens.
- Submission of practical file with record of studied specimens

- Submission of collected specimens
- Viva-voce examination

Unit1: **05 classes**

Definition; Autecology and population dynamics: ecological clock, population characteristics and dynamics, gene ecology: ecotypes- delimitation and significance of ecotypes, ecospecies and cenospecies.

Unit2: **10 classes**

Synecology: origin, development and structure of vegetation, methods and purpose of vegetation study; plant community- characteristics of plant community, classification, analytic and synthetic characters, concept of ecotone, flagship and keystone species; plant succession: definition, theories of plant succession, the climax concept. Phytogeography: principles of phytogeography, static phytogeography and dynamic phytogeography – basis of dynamic phytogeograghy; endemism: concept, age and area hypothesis, endemic flora of the world.

Unit3: **08 classes**

Soil and plant relationship: soil formation, soil horizons, physico – chemical properties of soil, soil nutrients and plants; the rhizosphere concept, rhizosphere population, role of soil microorganisms in functioning and restoration of ecosystem, major soil types of India with special reference to the soil of Assam.

Unit 4: **12 classes**

Aquatic ecology: fresh water environment, structure, function and physico-chemical nature of major fresh water bodies; terrestrial ecology: terrestrial environment and its physico – chemical nature in comparison to fresh water habitats; major biomes of the world, with special reference to tropical rain forest, tropical deciduous forest, coniferous forest, tropical savanna and grassland, temperate grassland and desert biome.

Unit 5: **10 classes**

Plant adaptation: ecological significance of plant adaptation, adaptation induced by soil, water, light, and biotic factors; plant and plant communities as indicators of cropland, mineral resources, and pollution.

Unit 6: Lab course: **15 classes**

1. To study the floristic composition of different stands with respect to biotic disturbances as grazed, protected and extensively disturbed areas.
2. To determine the minimum size and number of quadrat necessary for sampling herbaceous vegetation.
3. To study the percentage frequency of species in different stands and comparison with Raunkiaer's Frequency Classes thereof.
4. To study the vegetation of a grassland community by 'Physiognomic method' – the biological spectrum method.
5. To study the Importance Value Index (IVI) of species in different stands.
6. To study the Leaf Area Index (LAI) of different species in a community.
7. To study the Stomatal Index (SI) of some species growing in various habitats.
8. To determine the Association Index (AI) of species in different habitats.
9. To determine the Similarity Index (SI) and Dissimilarity Index (DI) of species in

different habitats.

10. To study the primary productivity of a fresh water ecosystem by light and dark bottle method.
11. To study the texture, colour, humus and organic matter content in different soil samples.
12. To determine the moisture content, bulk density, porosity, and water holding capacity of different soil samples.
13. Estimation of total nitrogen content in different soil samples.
14. Estimation of nitrogen content in plants.
15. Estimation of phosphorous content in various soil samples.

Semester-X

Title of the Course :Advanced Plant Anatomy & Embryology
Nature of course :Discipline Specific Core
Code :DSC-IV
Total Credits :04
Distribution of Marks :40+60=100
Total classes :60

Course outcomes

- CO1: Explain the structural organization, regulatory genes, and niche interactions governing the Root Apical Meristem (RAM) and root hair development.
- CO2: Analyze the cytological and molecular zoning of the Shoot Apical Meristem (SAM), vascular tissue differentiation, and environmental impacts on wood development.
- CO3: Interpret the molecular and genetic mechanisms driving phyllotaxy, stomatal/trichome differentiation, and the transition from vegetative to reproductive phases.
- CO4: Evaluate the genetic, biochemical, and hormonal cascades controlling anther, ovule, pollen-stigma interaction, and self-incompatibility systems.
- CO5: Demonstrate advanced microtechnique skills in structural staining, stomatal indexing, pollen viability testing, and tracking embryonic developments.

Mapping of CO with Bloom's taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual	CO1, CO4					
Conceptual		CO1, CO2				
Procedural				CO3		
Metacognitive					CO5	

Mapping of Course outcomes to Programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	AVERAGE
CO1	3	2	1	1	3	2	2	**2.0**
CO2	3	2	1	1	2	2	2	**1.9**
CO3	3	2	2	3	2	2	2	**2.3**

CO4	3	3	1	2	2	2	2	**2.1**
CO5	3	3	1	2	2	2	2	2.1

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

Modes of internal assessment

1. One internal examination (theory)
2. One internal examination (Lab)
3. Viva-voce
4. Group discussion
5. Home assignments

Attainment strategies of Cos:

1. Continuous evaluation through in and end-of-semester theory and practical examinations
2. Laboratory practices
3. Practical record book/field book
4. Seminar/group discussion

Unit 1: **08 classes**

Root development: Organization and regulation of root apical meristem (RAM), development and regulation of root hairs and lateral roots, quiescent centre, root-microbe interactions.

Unit 2: **15 classes**

Shoot development: Organization of shoot apical meristem (SAM), cytological and molecular analysis of SAM, Molecular mechanism of control of vascular tissue differentiation, secondary growth, wood development in relation to environmental factors; Leaf growth and determination of phyllotaxy, Molecular mechanism of differentiation of stomata & trichomes.

Unit 3: **10 classes**

Regulation of reproductive organ development: Transition from vegetative to reproductive phase, Molecular basis of flower development and its regulation

Unit 4: **12 classes**

Genetic and hormonal control of anther and ovule development, Recognition mechanisms and pollen hydration/germination,

Genetic, biochemical, and molecular basis of self-incompatibility. Mechanisms to overcome self-incompatibility

Lab activities: **15 classes**

1. Study of cytological zonation in SAM in sectioned and double-stained permanent slides of a suitable plant
2. Study the distribution of stomata in different plant species
3. Study of secondary growth by double staining method
4. Preparation and staining of T.S. (Transverse Section) of young, developing, and mature anthers.
5. Study of pollen tube development in the stigma

6. Pollen viability test
7. Examination of developmental stages of embryo sacs

Suggested Readings:

1. Beck, C. (2010). An Introduction to Plant Structure and Development. Cambridge University Press, 465pp.
2. Steeves, T.A. and Sussex, I.M. (1989). Patterns in plant development. Cambridge University Press, 405pp.
3. Inz´e, D. (Ed.) (2007). Cell Cycle Control and Plant Development, Blackwell Publishing Ltd. 394pp.
4. Whitelam, G.C. and Halliday, K.J. (2007). Light and Plant Development. Blackwell Publishing Ltd, 350pp.
5. Meyer, P. (Ed.) (2005). Plant Epigenetic. Blackwell Publishing Ltd. 281pp.
6. Leyser, O. and Day, S. (2003). Mechanism in Plant Development. Blackwell Publishing Ltd. 241pp.
7. Timmermans, M. (2010). Plant Development. Academic Press, 480pp.
8. Howell, S.J. (1998). Molecular Genetics of Plant Development. Cambridge University Press, 365pp.
9. Davies, P.J. (ed.) (2010). Plant Hormones: Biosynthesis, Signal Transduction, Action. Springer, Netherlands, 802pp.
10. Karp, J.G. (2007). Cell and Molecular Biology. John Wiley & Sons, USA.
11. Buchanan, B.B., Gruissem, W. and Jones, R.L. (2015). Biochemistry and Molecular Biology of Plants. Wiley Publisher, 1264pp.
12. Research and review articles on relevant topics

Semester-X

Title of the Course	**: Plant Omics**
Nature of the Course	**: Discipline Specific Core**
Course Code	**: DSC-V**
Total Credits	**: 04**
Distribution of Marks	**: 40+60=100**

Course Outcomes (COs)

CO1: Understand the foundational concepts of genomics, genome sequencing technologies, and the role of model organisms in plant biology.

CO2: Analyze gene and protein expression using modern transcriptomics and proteomics techniques, including RNA sequencing and mass spectrometry.

CO3: Evaluate metabolic profiles and ionomics data to identify biomarkers and correlate multi-omics data with plant phenomes.

CO4: Apply the principles of systems biology to model biochemical pathways, transcription networks, and cellular communication.

Learning Outcomes (LOs)

These focus on the practical and broader programmatic skills:

1) Demonstrate proficiency in retrieving, processing, and interpreting biological data from major omics databases.

2) Explain the underlying principles and applications of high-throughput analytical instruments (such as NGS, Microarrays, and NMR/MS) in plant sciences.

3) Design basic in-silico workflows to visualize biological networks and model enzymatic or genetic behaviors.

Mapping of CO with Bloom's Taxonomy

This matrix maps the cognitive dimensions to the course outcomes:

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual	CO1					
Conceptual		CO1			CO3	
Procedural			CO4	CO2		
Metacognitive						CO4

Mapping of Course Outcomes to Programme Outcomes (POs)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	AVERAGE
CO1	3	2	1	2	1	1	2	**1.7**
CO2	2	3	2	3	1	1	2	**2.0**
CO3	2	3	3	3	2	1	2	**2.3**
CO4	3	3	3	2	2	1	3	**2.4**
AVERAGE	**2.5**	**2.75**	**2.25**	**2.5**	**1.5**	**1.0**	**2.25**	**2.1**

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

Unit 1: Introduction to Genomics **09 classes**

Introduction to genomics, metagenomics, functional genomics. Model organisms in genomics (*A. thaliana, E. coli, C. elegans, S. cerevisiae*).

Unit-2: Genome sequencing **12 classes**

Methods for whole genome sequencing (shotgun & clone by clone), next generation sequencing, Genome sequencing projects (Human genome project, Arabidopsis genome project, Rice genome project).

Unit 3: Transcriptomics & Proteomics **12 classes**

Transcriptome and Transcriptome sequencing, gene expression studies by EST, microarray and RNA sequencing. Proteome, Protein Identification, quantification, characterization, structural and bioinformatics analysis. Applications of proteomics

Unit4: Metabolomics **12 classes**

Study of the metabolome, use of 1D/2D NMR and MS in metabolome analysis, multivariate analysis and identification of metabolite as biomarkers, study of ionome using inductively coupled plasma – mass spectroscopy (ICP-MS), correlating the data from genome, transcriptome, proteome, metabolome and ionome with phenome

Unit 5: Practical **15 classes**

1. Observation and study of the life cycle and phenotypic traits of model organisms (e.g., *Arabidopsis thaliana* and *Saccharomyces cerevisiae*) from supplied specimens or permanent slides.
2. Retrieval and alignment of specific gene sequences (e.g., from the Rice genome project or *Arabidopsis* genome project) using NCBI BLAST and TAIR.

3. In-silico visualization of 3D protein structures using tools like Chimera, PyMOL or RasMol, and primary protein sequence analysis using ExPASy.
4. Study of Metabolic Pathways in KEGG database.
5. Prediction of protein structures.
6. Interpretation of a provided microarray heatmap or a sample 1D NMR/MS mass spectrum to identify simple expression patterns or metabolites.
7. Plotting and analyzing Michaelis-Menten kinetics data using spreadsheet software to calculate V_{max} and K_m values.

SEMESTER X

Title of the Course : Advanced Plant Systematics and Conservation
Course Code : DSE-IV-A
Nature of the Course : Discipline Specific Elective
Total Credits : 04
Distribution of Marks : 40+60=100
Total classes : 60

COs:

CO1: Utilize molecular markers and DNA barcoding techniques to accurately identify plants and resolve cryptic taxa.

CO2: Perform sequence alignments and construct phylogenetic trees using bioinformatics software and statistical tools.

CO3: Evaluate the conservation status of species using IUCN criteria and propose effective in-situ and ex-situ conservation plans.

Learning Outcomes:

1. Apply molecular techniques and DNA barcoding to resolve plant taxonomic issues.
2. Utilize bioinformatics tools to process genetic data and construct phylogenetic trees.
3. Formulate conservation strategies for threatened plants using IUCN criteria and spatial data tools.

Mapping of CO with Bloom's taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual						
Conceptual					CO3	
Procedural			CO1	CO2		
Metacognitive						

Mapping of Course outcomes to Programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	AVERAGE
CO1	3	2	2	2	2	2	2	2.1
CO2	3	2	2	2	2	2	2	2.1

CO3	3	2	3	1	1	2	2	2.0
AVERAGE	3	2	2.3	1.7	1.7	2	2	**2.07**

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

MODES OF IN-SEMESTER ASSESSMENT:

- One Theory exam
- One Practical exam
- Group Discussion/Seminar/Viva/Assignments

Attainment strategy:

- Continuous evaluation through in and end semester theory examination
- In and end semester practical examination based on identification of supplied specimens.
- Submission of practical file with record of studied specimens
- Submission of collected specimens
- Viva-voce examination

Unit 1: Multidisciplinary Taxonomic Evidences: **12 classes**

Brief overview of classification principles. Sources of taxonomic characters: Morphology, Leaf architecture, Palynology, Anatomy and ultrastructure, Embryology, Cytology, Phytochemistry, and Serology. Serological techniques used in assessing relation between OTUs, and Techniques of Chemotaxonomy.

Unit 2: Molecular Taxonomy and Genomics: **12 classes**

Molecular tools in taxonomy: DNA Hybridisation, RFLP, RAPD, AFLP, and DNA sequencing. DNA Barcoding: PCR and PCR primer designing, molecular markers, Role of chloroplast and mitochondrial DNA in taxonomy, Process of DNA Barcoding, and DNA Barcode databases. Introduction to Phylogenomics and Next-Generation Sequencing (NGS).

Unit 3: Computational Taxonomy and Bioinformatics: **12 classes**

Computer applications in taxonomy: Numerical taxonomy and statistical tools in taxonomy. Construction of digital and computational taxonomic keys. Bioinformatics applications: Sequence alignment, FASTA, BLAST, and molecular phylogeny. Cladistics, Bayesian inference, and Maximum Likelihood in phylogeny construction.

Unit 4: Conservation Biology and Spatial Systematics: **09 classes**

IUCN Categories and criteria. Conservation of RET plants: in situ and ex situ conservation; Biosphere reserves, national parks, wildlife sanctuaries, botanical gardens, cryopreservation, Gene banks, and seed banks. GIS and GPS as tools of taxonomy.

Unit 5: Advanced Systematics Practical **15 classes**

- Application of BLAST and FASTA tools in molecular taxonomy for sequence retrieval and comparison.
- Molecular phylogenetic analysis: Constructing dendrograms/cladograms using digital sequence data.
- Classification of plants based on numerical taxonomic characters and Operational Taxonomic Units (OTUs).
- Demonstration of chemotaxonomic variation in plant families.
- Evaluation of molecular tools (interpreting RFLP/RAPD/AFLP gels or data) in solving taxonomic problems.
- Plant DNA Extraction, quantification, amplification using PCR
- Electrophoresis based separation/detection of genomic/amplicon DNA
- Retrieving sequences DNA sequences from chromatograms/raw sequence files
- Use of DNA Barcoding databases for plant identification.

SEMESTER X

Title of the Course : Cytogenetics and Crop Improvement-II (Advances in Mutation & Crop Improvement)

Course Code : DSE-III-B
Nature of the Course : Discipline Specific Elective
Total Credits : 04
Distribution of Marks : 40+60=100
Total classes : 60

Course outcomes

CO1: Evaluate fundamental cytogenetics and chromosome architecture by comparing prokaryotic and eukaryotic genome structures, specialized chromosomal features, cell division apparatuses, and non-Mendelian inheritance patterns.

CO2: Solve complex genetic mapping and population problems using principles of linkage, crossing over, interference, polygenic inheritance, multiple allelism, and Hardy–Weinberg equilibrium.

CO3: Differentiate mutational mechanisms across biological levels—from structural and numerical chromosomal aberrations to molecular DNA damage, repair mechanisms, and biochemical metabolic pathways.

CO4: Formulate tailored crop breeding strategies for self-pollinated, cross-pollinated, and vegetatively propagated plants, incorporating heterosis, distant hybridization, and biotic stress resistance.

CO5: Integrate modern molecular markers, tissue culture, and gene-editing tools (such as SSRs, SNPs, doubled haploidy, somatic hybridization, and CRISPR-Cas9) into conventional crop improvement programs.

CO6: Appraise major Indian crop breeding programs with specific emphasis on the evolutionary origin, taxonomic classification, key breeding objectives, and landmark varieties of wheat, rice, sugarcane, cotton, potato, and major pulses.

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual					CO1	
Conceptual			CO2	CO6		CO4
Procedural			CO5	CO3		
Metacognitive						

Mapping of Course outcomes to Programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	AVERAGE
CO1	3	2	1	1	3	2	2	**2.0**
CO2	3	2	1	1	2	2	2	**1.9**
CO3	3	2	2	3	2	2	2	**2.3**
CO4	3	3	1	2	2	2	2	**2.1**
CO5	3	3	3	2	2	2	2	
CO6	3	2	3	2	2	2	2	
AVERAGE	**3.0**	**2.8**	**1.8**	**1.8**	**2.5**	**2.0**	**2.0**	**2.1**

3 for highest correlation, 2 for moderate correlation, and 1 for lowest correlation

MODES OF IN-SEMESTER ASSESSMENT:

- One Theory exam
- One Practical exam
- Group Discussion/Seminar/Viva/Assignments

Attainment strategy:

- Continuous evaluation through in and end semester theory examination
- In and end semester practical examination based on identification of supplied specimens.
- Submission of practical file with record of studied specimens
- Submission of collected specimens
- Viva-voce examination

Unit1: **6 classes**

Genetic basis of plant breeding: Genetic consequence of hybridisation, quantitative inheritance, population structure, Hardy-Weinberg Equilibrium, combining ability, heritability, genetic advance, genetic base, choice of breeding methods, genetic diversity, germplasm conservation and Importance

Unit 2: Mutation: **8 classes**

(a) at chromosomal level: euploidy and aneuploidy, deletion, duplication, translocation and

cytogenetics and breeding behaviour of translocation heterozygote and deficiency, position effect, induction of polyploidy;

(b)at molecular level: Frame shift and substitution mutation, DNA damage and repair, Spontaneous and induced mutation; mutagens and their mode of action and (c) at biochemical level: One gene - one enzyme hypothesis, biochemical degradation of phenylalanine in man, biochemical mutation in Neurospora.

Unit3: **6 classes**

Genetic basis of plant breeding: Genetic consequence of hybridisation, quantitative inheritance, population structure, Hardy Weinburg Law, combining ability, heritability, genetic advance, genetic base, choice of breeding methods, germplasm activities and exploration.

Unit4: **6 classes**

Breeding procedure for self- pollinated, cross-pollinated and vegetatively propagated plants, mutation and ploidy breeding including haploidy in crop improvement; Heterosis, hypotheses, inbreeding depression ,estimation of heterosis, types of hybrids, development of hybrid seeds. Concept and utility of distant hybridization

Unit5: **6 classes**

Breeding for disease and insect resistance, Types of genetic resistance, mechanism of disease and insect resistances, factors or genes of resistance, source of resistance, breeding methods, advantage and limitations of resistance breeding.

Unit6: **7 classes**

In vitro technique in plant breeding: cell and tissue culture, aseptic methodologies, primary culture, cellline, cellclones, callusculture,soma clonalvariation ,micro-propagation, somatic embryogenesis, haploidy, protoplast fusion and somatic hybridization, transgenesis, artificial seeds,application and achievementsof in vitro techniques in plant breeding. CRISPR- 9 Cas9; Application of Gene Editing in Agriculture & Medicine.5

Unit7: **6 classes**

Breeding of wheat, rice, sugarcane, cotton, potato and major pulses in India with special reference to their origin, classification and production of improved varieties.

Lab activities

1. ApplicationofColchicineforchromosomedoublinginsuitableplantspecies.
2. C-Metaphase and counting of chromosomes, karyotype studies and preparation of idiograms .
3. Study of anaphasic separation; chromosomal breakage, laggard, chromatin

Bridge and unequal separation.

4. Floral biology study, techniques of emasculation, selfing and hybridization techniques.
5. Pollen studies-morphology,viability,artificial germination and storage,seed testing and use of mutagens.
6. Experiment on mutation and genetic markers

SEMESTER X

Title of the Course : Environmental and Applied Microbiology
Course Code : DSE-IV-C
Nature of the Course : Discipline Specific Elective
Total Credits : 04
Distribution of Marks : 40+60=100
Total Classes : 60

Course Outcomes (COs)

- CO1: Remember and understand fundamental principles of microbial ecology, biogeochemical cycles, food spoilage mechanisms, and industrial fermentation setups.
- CO2: Explain the role of plant-associated microbes, aerobiology, water sanitation protocols, and the pathogenic mechanisms of medical microbial systems.
- CO3: Apply standard quantitative protocols for assessing water pollution, food quality metrics, and enzyme tracking markers within agricultural soils.
- CO4: Analyze dynamic industrial production pathways, petroleum prospecting indicators, bioremediation methods, and plant stress alleviation dynamics.
- CO5: Evaluate structural variations in complex antimicrobial resistance mechanisms alongside diagnostic profiles for infectious bacterial and viral variants.

Mapping of CO with Bloom's taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual	CO1,					
Conceptual		CO1, CO2				
Procedural				CO3		
Metacognitive					CO4	CO5

Mapping of Course outcomes to Programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	AVERAGE
CO1	3	2	1	1	3	2	2	**2.0**
CO2	3	2	1	1	2	2	2	**1.9**
CO3	3	2	2	3	2	2	2	**2.3**

CO4	3	3	1	2	2	2	2	**2.1**
CO5	3	3	1	2	2	2	2	2.1

MODES OF IN-SEMESTER ASSESSMENT:

- One Theory exam
- One Practical exam
- Group Discussion/Seminar/Viva/Assignments

Attainment strategy:

- Continuous evaluation through in and end semester theory examination
- In and end semester practical examination based on identification of supplied specimens.
- Submission of practical file with record of studied specimens
- Submission of collected specimens
- Viva-voce examination

Unit: Microbial Ecology **12 classes**

The ecology of microorganisms in different environmental conditions; Role of microorganisms in biogeochemical cycles; Role of rhizosphere, phylloplane and endophytic microorganisms; Biochemistry of N2– fixation.

Aerobiology; Air sanitation, Microbiology in relation to water pollution; Coliform group and its importance in water pollution; Bacterial analysis of water (Detection of coliform group in water); Purification of water; waste water (sewage)treatments.

Biotransformation, Bioremediation, and Plant Stress Alleviation

Unit 2: Petroleum Microbiology **8 classes**

Microbial community in Petroleum, Utilization of petroleum by microorganisms; petroleum prospecting with the help of microorganisms; microbial oil recovery.

Unit 3: Food and Industrial Microbiology **15 classes**

Microbiology of milk and milk products; spoilage and preservation of foods;. Food produced (fermented foods) by microbes.

Importance of microorganisms in industry, Industrial process of Microbial fermentation of alcohol, citric acid and lactic acid; Industrial enzymes; foods from waste (single cell proteins); Manufacture of antibiotics in industry (Penicillin, Streptomycin). Biofertilizers and Biopesticides

Unit 4: Medical Microbiology **10 classes**

Bacterial toxins, Symptoms, pathogenicity, laboratory diagnoses, and control of the diseases caused by the following organisms: *Corynebacterium diphtheriae*, *Clostridium tetani*, *Vibrio cholerae, Mycobacterium tuberculosis*, Polio virus, Hepatitis virus. Antimicrobial resistance: causes and mechanisms

Lab activities **15 classes**

1. Microbial population of soil and rhizosphere
2. Microbial population of water
3. Coliform water testing (Microbial) – Presumptive, confirmed, completed

4. ONPG and MUG testing of water
5. Isolation of Lactic Acid Bacteria
6. Isolation of root nodule bacteria
7. Isolation of PGPR
8. Detection of heavy metal, pesticide and herbicide tolerant/degrading microbes
9. Microbial testing of milk
10. Enzymes in soil – Dehydrogenase, Phosphatase, Nitrate reductase
11. Detection of MDR microbes

Suggested readings

1. Microbiology by N.J. Pelczar, Jr. E.C.S.Chan and N.R. Krieg; Mac Graw Hill Book Company.
2. General Microbiology by R.Y.Stanier, M. Doudoroff and E.A. Adelberg; Mac Millan India.
3. Microbiology by L.M.Prescott,J.P.Harley and D.A.Klein . McGrawHill.
4. Text Book of Microbiology by R. Ananthanarayan and C.K. Joyaram Panikar . Orient Longman,Madras.
5. General Microbiology byC.B. Power and H.E. Daginawala ;Himalaya Publishing House,India.
6. A text book of Microbiology by R.C. Dubey and D.K. Maheswari., S.Chand& Co. Ltd.
7. Microbiology: An Introduction – G.J.Tortora, B.R. Funke and C.L.Case. Pearson Education
8. Microbiology by P.D.Sharma .RastogiPublications.
9. Bergey'smannual of Systematic Bacteriology, 2ndEdition.
10. Bergey'smannual of Determinitive Bacteriology, 9thEdition.
11. Molecular Virology by G.A.Knight . MC Graw Hill BookCompany.
12. General Virology by S. Luria and J.Darnoll.
13. Genes XI by B. Lewin , Oxford University Press ,India.
14. Petroleum Microbiology by R.M. Atlas , Mac Millan PublishingCompany.
15. Prescot and Dunn's Industrial Microbiology by G. Reed ; AVI, PublishingCompany.
16. Annual Review ofMicrobiology.
17. Annual Review ofBiochemistry.
18. Agricultural Microbiology by G. Rangaswami and D.J.Bagyaraj; PrenticeHall.

SEMESTER X

Title of the Course	**: APPLIED PLANT ECOLOGY**
Course Code	**: DSE-IV-D**
Nature of the Course	**: Discipline Specific Elective**
Total Credits	**: 04**
Distribution of Marks	**: 40+60=100**
Total Classes	**: 60**

Course Outcomes (COs)

- CO1: Recall and explain the physiological impacts of environmental pollution, deforestation, and ecosystem degradation on plant communities.
- CO2: Discuss the dynamics of multi-tier agroecosystem models and analyze management strategies for sustainable agriculture amidst global change variables.
- CO3: Apply standard quantitative field methods, phytochemical assays, and toxicological bioassays to assess ecological health indices.
- CO4: Analyze biosynthetic pathways of plant secondary metabolites and map the structural and ecological actions of key bioactive compounds.

- CO5: Evaluate mechanism-driven models of biological plant invasions and formulate ecological restoration frameworks for mining spoils, contaminated soils, and disturbed wetlands.

Mapping of CO with Bloom's taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual	CO1, CO4					
Conceptual		CO1, CO2				
Procedural				CO3		
Metacognitive					CO5	

Mapping of Course outcomes to Programme outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	AVERAGE
CO1	3	2	1	1	3	2	2	**2.0**
CO2	3	2	1	1	2	2	2	**1.9**
CO3	3	2	2	3	2	2	2	**2.3**
CO4	3	3	1	2	2	2	2	**2.1**
CO5	3	3	1	2	2	2	2	2.1

MODES OF IN-SEMESTER ASSESSMENT:

- One Theory exam
- One Practical exam
- Group Discussion/Seminar/Viva/Assignments

Attainment strategy:

- Continuous evaluation through in and end semester theory examination
- In and end semester practical examination based on identification of supplied specimens.
- Submission of practical file with record of studied specimens
- Submission of collected specimens
- Viva-voce examination

Unit 1: **10 classes**

Environmental pollution and plant ecology: vegetation responses to environmental pollution, phytoremediation of degraded environment. deforestation and environmental pollution; Conservation and management: state of affairs of the prevailing environmental stress upon various productive ecosystems, range management, forest management, soil conservation, conservation of endangered genetic resources.

Unit 2: **12 classes**

Agroecosystem management and sustainable agriculture: system approach in agriculture, mutually antagonistic nature of ecology and efficient agriculture; sustainable agriculture: complex agroecosystems- shifting agriculture, rotational fallow, home gardens, mixed arable live-stock farming, agri-silviculture, specialized cash crop systems, intercropping and crop rotation, integrated landscape management for cropping with 'Global Change', agriculture and globalization.

Unit 3: **13 classes**

Chemical ecology: Secondary metabolites, biosynthetic pathways (Shikimic acid, Mevalonic acid, and Malonic acid pathways), allelopathy and Kairopathy, biomagnifications and bioaccumulation of hazardous chemicals in food chains, heavy metals, and microplastics in terrestrial and aquatic ecosystems. Structural and functional aspects of certain bioactive compounds (curcumin, andrographolide, azadirachtin, reserpine, vasicine etc.), their

antioxidant and antimicrobial activity.

Unit 4: **10 classes**

Ecological Restoration Definitions and concept, reclamation, remediation, restoration and rehabilitation. Mechanisms of plant invasion, weed ecology. Disturbance: causes and impact on the structure and functioning of terrestrial and aquatic ecosystems. Restoration of degraded soils: restoration of contaminated soils and soil fertility, mine spoil restoration. Restoration projects (case studies).

Unit 5: Lab Course: **15 classes**

1. To study the allelopathic / kairopathic action of plants on associated plants.
2. Phytochemical extraction of certain MAPs and their antimicrobial and antioxidant activity study.
3. To study the PH, turbidity, temperature and light intensity in a fresh water system.
4. To study the root shoot ratio of plants growing in different habitats.
5. Estimation of chlorophyll content at various stages of growth of the plants/polluted and non-polluted areas.
6. Study of physicochemical parameters of water (temperature, pH, DO, dissolved CO2, conductivity, turbidity, Chlorine, total hardness, BOD, COD).
7. Bioassay methods in toxicology

SEMESTER X

Title of the Course :
Course Code : DSE-V
Nature of the Course : Discipline Specific Elective
Total Credits : 04
Distribution of Marks : 40+60=100
Total Classes : 60

Note: To be selected from SWAYAM in lieu of Dissertation

SEMESTER X

Title of the Course :
Course Code : DSE-VI
Nature of the Course : Discipline Specific Elective
Total Credits : 04
Distribution of Marks : 40+60=100
Total Classes : 60

Note: To be selected from SWAYAM in lieu of Dissertation