CRITERIA 1.1.3

Different UG And PG Programme, Sample of Courses With Highlight On Ethics / Gender / Human Values / Environment And Sustainability Aspects Is Presented.

Programme: B.Sc. Botany

1. ETHICS
2. GENDER
3. HUMAN VALUES
4. ENVIRONMENT AND SUSTAINIBILITY

Syllabus

For

B.Sc. Botany

(2018 onwards)

Department of Botany

Netaji Subhas University

Head
Department of Botany
Netaji Subhas University

Dean Academics
Netaji Subhas University
Jamshedpur, Jharkhand

Mapping of B.Sc. Botany Syllabus for Professional Ethics, Gender, Human Values, Environment, and Sustainability

Paper Code	Paper Name	Professional Ethics	Gender	Human Values	Environment	Sustainability
C-1	Algae and Microbiology				✓	✓
C-2	Biomolecules and Cell Biology					
AECC-1	Communicative English	✓	✓	✓		
C-3	Mycology and Phytopathology				✓	✓
C-4	Archegoniate				✓	✓
AECC-2	Environmental Science				✓	✓
C-5	Morphology and Anatomy				✓	
C-6	Economic Botany	✓	✓	✓	✓	✓
C-7	Basics of Genetics	✓				
SEC-1	IT Skill	✓				
C-8	Molecular Biology	✓				✓
C-9	Plant Ecology and Phytogeography				✓	✓
C-10	Plant Systematics				✓	
SEC-2	IT Skill	✓				
C-11	Reproductive Biology of Angiosperms		✓		✓	✓
C-12	Plant Physiology					✓
DSE-1	Natural Resource Management	✓	✓	✓	✓	✓
DSE-2	Project Work (Based on DSE)	✓			✓	✓
C-13	Plant Metabolism					✓
C-14	Plant Biotechnology	✓			✓	✓
DSE-3	Industrial and Environmental Microbiology	✓			✓	✓
DSE-4	Project Work	✓			✓	✓

Dean Academics
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NETAJI SUBHAS UNIVERSITY
Jamshedpur

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B.Sc. Botany Syllabus

Semester –I

COURSE	Code Of Papers	Name of Papers	Internal marks	External marks	Practical marks	Total Marks
Core Course	C-1	Algae and Microbiology	20	50	30	100
	C-2	Biomolecules and Cell Biology	20	50	30	100
	P-1	Practical based in C-1 & c-2				
AECC Ability Enhancement Compulsory Course	AECC-1	Communicative English /MIL	20	30	--	50
Generic Elective	GE-1	Chemistry	20	50	30	100
	GE-2	Zoology	20	50	30	100
		Practical-GE				
						450

Semester –II

COURSE	Code Of Papers	Name of Papers	Internal marks	External marks	Practical marks	Total Marks
Core Course	C-3	Mycology and Phytopathology	20	50	30	100
	C-4	Archegoniate	20	50	30	100
	P-2	Practical based on C-3 & C-4				
AECC Ability Enhancement Compulsory Course	AECC-2	Environmental Science	20	30	---	50
Generic Elective	GE-3	Chemistry	20	50	30	100
	GE-4	Zoology	20	50	30	100
		Practical-GE				
						450

Semester –III

COURSE	Code Of Papers	Name of Papers	Internal marks	External marks	Practical marks	Total Marks
Core Course	C-5	Morphology and Anatomy	20	50	30	100
	C-6	Economic Botany	20	50	30	100
	C-7	Basics of Genetics	20	50	30	100
	P-3	Practical based on C-5,C-6& C-7				
Skill Enhancement Course	SEC-1	IT Skill	15	25	10	50
Generic Elective	GE-5	Chemistry	20	50	30	100
	GE-6	Zoology	20	50	30	100
		Practical-GE				
						550

Semester –IV

COURSE	Code Of Papers	Name of Papers	Internal marks	External marks	Practical marks	Total Marks
Core Course	C-8	Molecular Biology	20	50	30	100
	C-9	Plant Ecology and Phytogeography	20	50	30	100
	C-10	Plant Systematics	20	50	30	100
	P-4	Practical based on C-8,C-9& C-10				
Skill Enhancement Course	SEC-2	IT Skill	15	35		50
Generic Elective	GE-7	Zoology	20	50	30	100
	GE-8	Chemistry	20	50	30	100
		Practical-GE				
						550

Semester –V

COURSE	Code Of Papers	Name of Papers	Internal marks	External marks	Practical marks	Total Marks
Core Course	C-11	Reproductive Biology of Angiosperms	20	50	30	100
	C-12	Plant Physiology	20	50	30	100
	P-5	Practical based on C-11& C-712				
Discipline specific Elective	DSE-1	Natural Resource Management	20	50	30	100
	DSE-2	Project work	----------			100
	P-6	Practical on DSE-1				30
						400

Semester –VI

COURSE	Code Of Papers	Name of Papers	Internal marks	External marks	Practical marks	Total Marks
Core Course	C-13	Plant Metabolism	20	50	30	100
	C-14	Plant Biotechnology	20	50	30	100
	P-7	Practical based on C-11 & C-12				
Discipline specific Elective	DSE-3	Industrial and Environmental Microbiology	20	50	30	100
	DSE-4	Project work	----------			100
	P-8	Practical on DSE-3				30
						400

SEMESTER	COURSE OPTED	COURSE NAME	Credit
1	Ability Enhancement Compulsory Course-I	English communications	2
	Core course-I	Algae and Microbiology	4
	Core Course-I Practical	CC-1	2
	Core course-II	Biomolecules and Cell Biology	4
	Core Course-II Practical	CC-2	2
	Generic Elective -1	GE-1 Zoology	4
	Generic Elective -2	GE-2 Chemistry	4
	Generic Elective Practical	GE-1& GE-2 Practical	2

SEMESTER	COURSE OPTED	COURSE NAME	Credit
2	Ability Enhancement Compulsory Course-II	Environmental Science	2
	Core course-III	Mycology and Phytopathology	4
	Core Course-III Practical	CC-III	2
	Core course-IV	Archegoniate	4
	Core Course-IV Practical	CC-IV	2
	Generic Elective -3	GE-3 Zoology	4
	Generic Elective -4	GE-4 Chemistry	4
	Generic Elective Practical	GE-3&GE-4 Practical	2

SEMESTER	COURSE OPTED	COURSE NAME	Credit
SEMESTER 3	Core course-V	Morphology and Anatomy	4
	Core Course-V Practical	CC-V	2
	Core course-VI	Economic Botany	4
	Core Course-VI Practical	CC-VI	2
	Core course-VII	Genetics	4
	Core Course-VII Practical	CC-VII	2
	Skill Enhancement Course-1	IT Skill	4
	Generic Elective -5	GE-5- Zoology	4
	Generic Elective -6	GE-6Chemistry	4
	Generic Elective Practical	GE-5&6 Practical	2

SEMESTER	COURSE OPTED	COURSE NAME	Credit
4	Core course-VIII	Molecular Biology	4
	Course-VIII Practical	CC-VIII	2
	Core course-IX	Plant Ecology and Phytogeography	4
	Course-IX Practical	CC-IX	2
	Core course-X	Plant Systematics	4
	Core Course- X Practical	CC-X	2
	Skill Enhancement Course-2	IT Skill	4
	Generic Elective -7	GE-7 Zoology	4
	Generic Elective -8	GE-8 Chemistry	4
	Generic Elective Practical	GE-7&8 Practical	2

SEMESTER	COURSE OPTED	COURSE NAME	Credit
5	Core course-XI	Reproductive Biology of Angiosperms	4
	Course- XI Practical	CC- XI	2
	Core course-XII	Plant Physiology	4
	Course- XII Practical	CC- XII	2
	Discipline specific Elective-1	Natural Resource Management	4
	DSE-1 practical	DSE-1	2
	Discipline specific Elective-2	Project work	2

SEMESTER	COURSE OPTED	COURSE NAME	Credit
6	Core course-XIII	Plant Metabolism	4
	Course- XIII Practical	CC- XIII	2
	Core course-XIV	Plant Biotechnology	4
	Course- XIV Practical	CC- XIV	2
	Discipline specific Elective-3	Industrial and Environmental Microbiology	4
	DSE-3practical	DSE-3	2
	Discipline specific Elective-4	Project work	2

Semester 1st

Core Course I: Algae and Microbiology

(Credits: Theory-4, Practical-2)

Course Objectives (COs):

The course aims to:

1. Understand the classification, structure, and characteristics of algae and microorganisms.
2. Study the morphology, life cycles, and reproduction of major algal groups.
3. Explore the ecological roles of algae and microorganisms in nutrient cycling and symbiotic relationships.
4. Understand microbial interactions, pathogenicity, and methods of microbial control.
5. Study the industrial applications of algae in food, biofuels, and wastewater treatment.

Theory

Unit 1: Introduction to microbial world

Microbial nutrition, growth and metabolism. Economic importance of viruses with reference to vaccine production, role in research, medicine and diagnostics, as causal organisms of plant diseases. Economic importance of bacteria with reference to their role in agriculture and industry (fermentation and medicine).

Unit 2: Viruses

Discovery, physiochemical and biological characteristics; classification (Baltimore), general structure with special reference to viroids and prions; replication (general account), DNA virus (T-phage), lytic and lysogenic cycle; RNA virus (TMV).

Unit 3: Bacteria

Discovery, general characteristics; Types-archaebacteria, eubacteria, wall-less forms (mycoplasma and spheroplasts); Cell structure; Nutritional types; Reproduction-vegetative, asexual and recombination (conjugation, transformation and transduction).

Unit 4: Algae

General characteristics; Ecology and distribution; range of thallus organization; Cell structure and components; cell wall, pigment system, reserve food (of only groups represented in the syllabus), flagella; methods of reproduction; Classification; criteria,

system of Fritsch, and evolutionary classification of Lee (only upto groups); Significant contributions of important phycologists. Role of algae in the environment, agriculture, biotechnology and industry.

Unit 5: Cyanophyta and Xanthophyta

Ecology and occurrence; Range of thallus organization; Cell structure; Reproduction, Morphology and life-cycle of Nostoc and Vaucheria.

Unit 6: Chlorophyta and Charophyta

General characteristics; Occurrence; Range of thallus organization; Cell structure; Reproduction. Morphology and life-cycles of Chlamydomonas, Volvox, Oedogonium, Chara.

Unit 7: Phaeophyta and Rhodophyta

Characteristics; Occurrence; Range of thallus organization; Cell structure; Reproduction. Morphology and life-cycles of Ectocarpus, Fucus and Polysiphonia.

Practical :

Microbiology

1. Electron micrographs/Models of viruses – T-Phage and TMV, Line drawings/ Photographs of Lytic and Lysogenic Cycle.
2. Types of Bacteria to be observed from temporary/permanent slides/photographs.
3. Gram staining.
4. Endospore staining with malachite green using the (endospores taken from soil bacteria).

Phycology

5. Study of vegetative and reproductive structures of Nostoc, , Volvox, Oedogonium, , Chara, Vaucheria, Ectocarpus, Fucus and Polysiphonia, through electron micrographs, temporary preparations and permanent slides.

Suggested Readings

1. Lee, R.E. (2008). Phycology, Cambridge University Press, Cambridge. 4th edition.
2. Wiley JM, Sherwood LM and Woolverton CJ. (2013) Prescott's Microbiology. 9th Edition. McGraw Hill International.
3. Kumar, H.D. (1999). Introductory Phycology. Affiliated East-West Press, Delhi.
4. Sahoo, D. (2000). Farming the ocean: seaweeds cultivation and utilization. Aravali International, New Delhi.
5. Campbell, N.A., Reece J.B., Urry L.A., Cain M.L., Wasserman S.A. Minorsky P.V., Jackson R.B. (2008). Biology, Pearson Benjamin Cummings, USA. 8th edition.
6. Pelczar, M.J. (2001) Microbiology, 5th edition, Tata McGraw-Hill Co, New Delhi.

Course Outcomes (COs)

CO1. Understand the Diversity and Classification of Algae and Microorganisms

CO2. Describe the Structure, Function, and Life Cycles

CO3. Understand economic importance of microbes and cryptogams.

CO 4. Analyze the Role of Microbes in Health and Disease.

CO5. Perform Laboratory Techniques in Microbiology and Phycology

Mapping of Course Outcomes and Program Outcomes:

Cos/Pos	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5
CO-1	2	2	3	3	2	2	2	1	-	1	-	1	2	1	1
CO-2	3	2	3	2	2	3	2	2	1	3	1	2	1	1	2
CO-3	2	1	2	1	1	1	2	1	1	2	1	1	3	3	2
CO-4	1	2	2	2	3	2	2	1	1	1	-	1	1	1	1
CO-5	2	3	2	1	3	1	1	1	-	1	1	1	2	3	3
Average	2	2	2.4	1.8	2.2	1.8	1.8	1.2	1	1.2	1	1.2	1	1	1.8

Legend:

3 - Strongly Correlated 2 - Moderately Correlated 1 - Slightly Correlated --No Correlation

Core Course II: Biomolecules and Cell Biology

(Credits: Theory-4, Practical2)

Course Objectives (COs):

The course aims to:

1. Understanding of the fundamental biochemical molecules and cellular structures that govern life processes.
2. Learn the structure, classification, and functions of carbohydrates, proteins, lipids, and nucleic acids.
3. Study the structure and functions of prokaryotic and eukaryotic cells.
4. Examine different types of cell signaling pathways, including receptor-mediated signaling and second messengers.
5. Explore the role of nucleic acids (DNA and RNA) in gene expression and regulation.

Theory:

Unit 1: Biomolecules

Types and significance of chemical bonds; Structure and properties of water; pH and buffers. Carbohydrates: Nomenclature and classification; Monosaccharides ; Disaccharides; Oligosaccharides and polysaccharides.

Lipids: Definition and major classes of storage and structural lipids; Fatty acids structure and functions; Essential fatty acids; Triacyl glycerols structure, functions and properties; Phosphoglycerides.

Proteins: Structure of amino acids; Levels of protein structure-primary, secondary, tertiary and quarternary; Protein denaturation and biological roles of proteins.

Nucleic acids: Structure of nitrogenous bases; Structure and function of nucleotides; Types of nucleic acids; Structure of A, B, Z types of DNA; Types of RNA; Structure of tRNA.

Unit 2: Bioenergenetics

Laws of thermodynamics, concept of free energy, endergonic and exergonic reactions, coupled reactions, redox reactions. ATP: structure, its role as an energy currency molecule.

Unit 3: Enzymes

Structure of enzyme: holoenzyme, apoenzyme, cofactors, coenzymes and prosthetic group; Classification of enzymes; Features of active site, substrate specificity, mechanism of action (activation energy, lock and key hypothesis, induced - fit theroy), Michaelis – Menten equation, enzyme inhibition and factors affecting enzyme activity.

Unit4: The cell

Cell as a unit of structure and function; Characteristics of prokaryotic and eukaryotic cells; Origin ofeukaryotic cell (Endosymbiotic theory).

Unit 5: Cell wall and plasma membrane

Chemistry, structure and function of Plant cell wall. Overview of membrane function; fluid mosaic model; Chemical composition of membranes; Membrane transport – Passive, active and facilitated transport, endocytosis and exocytosis.

Unit 6: Cell organelles

Nucleus: Structure-nuclear envelope, nuclear pore complex, nuclear lamina, molecular organization of chromatin; nucleolus. Cytoskeleton: Role and structure of microtubules, microfilaments and intermediary filament. Chloroplast, mitochondria and peroxisomes: Structural organization; Function; Semiautonomous nature of mitochondria and chloroplast.

Endomembrane system: Endoplasmic Reticulum – Structure, targeting and insertion of proteins in the ER, protein folding, processing; Smooth ER and lipid synthesis, export of proteins and lipids; Golgi Apparatus – organization, protein glycosylation, protein sorting and export from Golgi Apparatus; Lysosomes

Unit 7: Cell division

Phases of eukaryotic cell cycle, mitosis and meiosis; Regulation of cell cycle- checkpoints, role of protein kinases.

Practical

1. Qualitative tests for carbohydrates, reducing sugars, non-reducing sugars, lipids and proteins.
2. Study of plant cell structure with the help of epidermal peel mount of Onion/Rhoeo/Crinum.
3. Measurement of cell size by the technique of micrometry.
4. Study of cell and its organelles with the help of micrographs.
5. Study the phenomenon of plasmolysis and deplasmolysis.
6. Study different stages of mitosis and meiosis.

Suggested Reading:

1. Campbell, PN and Smith AD (2011) Biochemistry Illustrated, 4th ed., Published by Churchill Livingstone
2. Tymoczko JL, Berg JM and Stryer L (2012) Biochemistry: A short course, 2nd ed., W.H.Freeman
3. Berg JM, Tymoczko JL and Stryer L (2011) Biochemistry, W.H.Freeman and Company
4. Nelson DL and Cox MM (2008) Lehninger Principles of Biochemistry, 5th Edition., W.H. Freeman and Company

Course Outcomes (COs)

CO1. Understand the fluid mosaic model of biological membranes and the principles of membrane transport.

CO2. Analyze the mechanisms of diffusion, osmosis, active transport, endocytosis, and exocytosis.

CO3. Describe the stages of the cell cycle and the regulation of cell cycle checkpoints.

CO4. Understand enzyme kinetics, enzyme inhibition, and their role in metabolic pathways.

CO5. Compare and contrast mitosis and meiosis, emphasizing their roles in growth, reproduction, and genetic diversity.

Mapping of Course Outcomes and Program Outcomes:

Cos/Pos	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5
CO-1	2	2	3	3	2	2	2	1	-	1	-	1	1	1	1
CO-2	1	2	3	2	2	3	2	2	1	1	1	2	1	1	2
CO-3	2	1	2	1	1	1	2	1	1	2	1	1	1	1	2
CO-4	1	2	2	2	3	2	2	1	1	1	-	1	1	1	1
CO-5	2	1	2	1	1	1	1	-	-	1	1	1	-	-	-
Average	1.6	1.6	2.4	1.8	1.8	1.8	1.8	1.2	1	1.2	1	1.2	1	1	1.5

Semester- 2 nd

Mycology and Phytopathology (Credits: Theory-4, Practical-2)

Course Objectives (COs):

The course aims to:

- Understanding Fungal Diversity and Classification
- Examine the Ecological and Economic Importance of Fungi
- Analyze the mechanisms of plant disease development, including pathogen invasion, colonization, and disease cycles.
- Learn techniques for diagnosing plant diseases using microscopy, molecular tools, and serological methods.
- Explore recent developments in fungal biotechnology, biocontrol, and integrated disease management.

Theory

Unit 1: Introduction to true fungi

General characteristics; Affinities with plants and animals; Thallus organization; Cell wall composition; Nutrition; Classification.

Unit 2: Chytridiomycota and Zygomycota

Characteristic features; Ecology and significance; Thallus organisation; Reproduction; Life cycle with reference to Synchytrium, Rhizopus .

Unit 3: Ascomycota

General characteristics (asexual and sexual fruiting bodies); Ecology; Life cycle, Heterokaryosis and parasexuality; Life cycle and classification with reference to Saccharomyces, Aspergillus, Penicillium, Alternaria, Neurospora and Peziza.

Unit 4: Basidiomycota

General characteristics; Ecology; Life cycle and Classification with reference to black stem rust on wheat Puccinia (Physiological Specialization), loose and covered smut (symptoms only), Agaricus; Bioluminescence, Fairy Rings and Mushroom Cultivation.

Unit 5: Oomycota

General characteristics; Ecology; Life cycle and classification with reference to Phytophthora, Albugo

Unit 6: Symbiotic associations

Lichen – Occurrence; General characteristics; Growth forms and range of thallus organization; Nature of associations of algal and fungal partners; Reproduction; Mycorrhiza-Ectomycorrhiza, Endomycorrhiza and their significance.

Unit 7: Applied Mycology

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

Unit 8: Phytopathology

Terms and concepts; General symptoms; Geographical distribution of diseases; Etiology; Symptomology; Host-Pathogen relationships; Disease cycle and environmental relation; prevention and control of plant diseases, and role of quarantine.

Bacterial diseases – Citrus canker and angular leaf spot of cotton. Viral diseases – Tobacco Mosaic viruses, vein clearing. Fungal diseases – Early blight of potato, Black stem rust of wheat, White rust of crucifers.

Practical

1. Introduction to the world of fungi
2. Rhizopus: study of asexual stage from temporary mounts and sexual structures through permanent slides.
3. Aspergillus and Penicillium: study of asexual stage from temporary mounts.
4. Alternaria: Specimens/photographs and temporary mounts.
5. Agaricus: Specimens of button stage and full grown mushroom; sectioning of gills of Agaricus, fairy rings and bioluminescent mushrooms to be shown.
6. Lichens: Study of growth forms of lichens (crustose, foliose and fruticose) on different substrates.
7. Mycorrhizae: ectomycorrhiza and endomycorrhiza (Photographs)
8. Phytopathology: Herbarium specimens of bacterial diseases; Citrus Canker; Angular leaf spot of cotton, Viral diseases: TMV, Vein clearing, Fungal diseases: Early blight of potato, Black stem rust of wheat and White rust of crucifers.

Suggested Readings

1.Agrios, G.N. (1997) Plant Pathology, 4th edition, Academic Press, U.K.
2.Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996). Introductory Mycology, John Wiley & Sons (Asia) Singapore. 4th edition.

3.Webster, J. and Weber, R. (2007). Introduction to Fungi, Cambridge University Press, Cambridge. 3rd edition.
4.Sethi, I.K. and Walia, S.K. (2011). Text book of Fungi and Their Allies, Macmillan Publishers India Ltd.
5.Sharma, P.D. (2011). Plant Pathology, Rastogi Publication, Meerut, India.

Course Outcomes (COs)

CO1. Explain the Classification and general characters of Fungi.

CO2. Identify and describe fungal plant diseases.

CO3. Understand the fundamental concepts of plant pathology, including plant-microbe interactions.

CO4. Study factors affecting disease outbreaks and epidemiological patterns.

CO5.Study disease control methods, including cultural practices, biological control, chemical fungicides, and resistant crop varieties.

Mapping of Course Outcomes and Program Outcomes:

Cos/Pos	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5
CO-1	2	2	3	3	2	2	2	-	-	1	-	1	1	1	1
CO-2	1	2	3	2	2	3	2	1	1	1	1	2	1	1	2
CO-3	2	1	2	1	1	1	2	-	1	2	1	1	1	1	2
CO-4	1	2	2	2	3	2	2	1	1	1	-	1	1	1	1
CO-5	-	1	1	-	1	1	1	-	-	-	-	-	1	1	1
Average	1.6	1.6	2.4	1.8	1.8	1.8	1.8	1	1	1.2	1	1.2	1	1	2

Core Course IV: Archegoniate (Credits: Theory-4, Practical-2)

Course Objectives (COs):

The course aims to:

1. Evolution, diversity, structure, reproduction, and ecological significance of archegoniate plants.
2. Analyze the similarities and differences in life cycles, reproduction, and structural adaptations of bryophytes, pteridophytes, and gymnosperms.
3. Discuss the ecological significance of archegoniate plants in biodiversity, conservation, and ecosystem stability.

Theory

Unit 1: Introduction

Unifying features of archegoniates; Transition to land habit; Alternation of generations.

Unit 2: Bryophytes

General characteristics; Adaptations to land habit; Classification; Range of thallus organization.

Unit 3: Bryophytes

Classification (up to family), morphology, anatomy and reproduction of Riccia, Marchantia, , Anthoceros, Sphagnum and Funaria. Evolutionary trends in Riccia, Marchantia, Anthoceros and Funaria. Ecological and economic importance of bryophytes with special reference to Sphagnum.

Unit 4: Pteridophytes

General characteristics; Classification (up to family), morphology, anatomy and reproduction of Psilotum, Selaginella, Equisetum and Pteris . Apogamy, and apospory, heterospory andseed habit, telome theory, stelar evolution; Ecological and economic importance.

Unit 6: Gymnosperms

General characteristics, classification (up to family), morphology, anatomy and reproduction of Cycas, Pinus and Gnetum); Ecological and economic importance.

Practical

Permanent slide of:

1. Riccia – Morphology of thallus.
2. Marchantia- Morphology of thallus, whole mount of rhizoids & Scales, vertical section of thallus through Gemma cupvertical section of Antheridiophore, Archegoniophore.
3. Sphagnum- Morphology of plant, whole mount of leaf (permanent slide only).
4. Funaria- Morphology, antheridial and archegonial heads, capsule and protonema.
5. Selaginella- Morphology, transverse section of stem, whole mount of strobilus, whole mount of microsporophyll and megasporophyll , longitudinal section of strobilus
6. Equisetum- Morphology, strobilus, sporangiophore, rhizome
7. Cycas,/ Pinus - Morphology (coralloid roots, bulbil, leaf), microsporophyll,
8. Transverse section of coralloid root, transverse section of rachis, vertical section of leaflet, vertical section of microsporophyll.

Suggested Readings

1. Vashistha, P.C., Sinha, A.K., Kumar, A. (2010). Pteridophyta. S. Chand. Delhi, India.
2. Bhatnagar, S.P. & Moitra, A. (1996). Gymnosperms. New Age International (P) Ltd Publishers, New Delhi, India.
3. Parihar, N.S. (1991). An introduction to Embryophyta: Vol. I. Bryophyta. Central Book Depot. Allahabad.
4. Raven, P.H., Johnson, G.B., Losos, J.B., Singer, S.R. (2005). Biology. Tata McGraw Hill, Delhi.
5. Vanderpoorten, A. & Goffinet, B. (2009) Introduction to Bryophytes. Cambridge University Press.

Course Outcomes (COs)

CO1. Understand the phylogenetic relationships among bryophytes, pteridophytes, and gymnosperms.
CO2. Compare and contrast their life cycles, emphasizing alternation of generations.
CO 3. Understand structural and physiological adaptations that helped archegoniate plants survive on land.
CO 4. Understand the impact of climate change on archegoniate plant diversity and conservation strategies.

Mapping of Course Outcomes and Program Outcomes:

Cos/Pos	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5
CO-1	2	2	3	3	2	2	2	-	-	1	-	1	1	1	1
CO-2	1	2	3	2	2	3	2	1	1	1	1	2	1	1	2
CO-3	2	1	2	1	1	1	2	-	1	2	1	1	1	1	2
CO-4	1	2	2	2	3	2	2	1	1	1	-	1	1	1	1
Average	1.6	1.6	2.4	1.8	1.8	1.8	1.8	1	1	1.2	1	1.2	1	1	1.5

Semester-3rd

Core Course V: Anatomy of Angiosperms (Credits: Theory-4, Practical-2)

Course Objectives (COs):

The course aims to:

1. Learn about the structural organization of plant cells, tissues, and tissue systems.
2. Classify and describe the characteristics and functions of meristematic and permanent tissues.
3. Understand anatomical adaptations in xerophytes, hydrophytes, and mesophytes.
4. Understand the significance of plant anatomy in medicinal plant research and environmental adaptations.

Theory:

Unit 1: Introduction and scope of Plant Anatomy Applications in systematics, forensics and pharmacognosy.

Unit 2: Structure and Development of Plant Body : Internal organization of plant body: The three tissue systems, types of cells and tissues. Development of plant body: Polarity, Cyto differentiation and organogenesis during embryogenic development.

Unit 2: Tissues

Classification of tissues; Simple and complex tissues cytodifferentiation of tracheary elements and sieve elements; Pits and plasmodesmata; Hydathodes, cavities, lithocysts and laticifers.

Unit 3: Apical meristems

Evolution of concept of organization of shoot apex (Apical cell theory, Histogen theory, Tunica Corpus theory, continuing meristematic residue, cytohistological zonation); Types of vascular bundles;

Structure of dicot and monocot stem. Origin, development, arrangement and diversity in size and shape of leaves;

Structure of dicot and monocot leaf, Kranz anatomy.

Organization of root apex (Apical cell theory, Histogen theory, Korper-Kappe theory); Quiescent centre; Root cap; Structure of dicot and monocot root; Endodermis, exodermis and origin of lateral root.

Unit 4: Vascular Cambium and Wood

Structure, function and seasonal activity of cambium; Secondary growth in root and stem. Axially and radially oriented elements; Types of rays and axial parenchyma; Sapwood and heartwood; Early and late wood, tyloses; Development and composition of periderm.

Unit 5: Adaptive and Protective Systems

Epidermal tissue system, cuticle, epicuticular waxes, trichomes, stomata; Adcrustation and incrustation; Anatomical adaptations of xerophytes and hydrophytes.

Practical

1. Study of anatomical details through permanent slides/temporary stain mounts/ macerations/ museum specimens with the help of suitable examples.
2. Apical meristem of root, shoot and vascular cambium.
3. Root: monocot, dicot, secondary growth.
4. Stem: monocot, dicot - primary and secondary growth; periderm; lenticels.
5. Leaf: isobilateral, dorsiventral,.
6. Adaptive Anatomy: xerophytes, hydrophytes.

Suggested Readings

1. Dickison, W.C. (2000). Integrative Plant Anatomy. Harcourt Academic Press, USA.
2. Fahn, A. (1974). Plant Anatomy. Pergmon Press, USA.
3. Mauseth, J.D. (1988). Plant Anatomy. The Benjammin/Cummings Publisher, USA.
4. Evert, R.F. (2006) Esau's Plant Anatomy: Meristems, Cells, and Tissues of the Plant Body: Their Structure, Function and Development. John Wiley and Sons, Inc.

Course Outcome (Cos)

CO1. Brief about general characteristics and anatomy of root and stem.

CO2. Learn about the structural organization of plant cells, tissues, and tissue systems.

CO3. Classify and describe the characteristics and functions of meristematic and permanent tissues.

CO4. Understand anatomical adaptations in xerophytes, hydrophytes, and mesophytes.

CO 5. Utilize anatomical studies in taxonomy, paleobotany, and plant breeding.

Mapping of Course Outcomes and Program Outcomes:

Cos/Pos	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5
CO-1	2	3	3	2	2	2	2	1	2	1	1	1	1	1	1
CO-2	3	2	1	2	3	1	0	2	1	1	1	2	2	1	2
CO-3	2	1	1	1	1	1	2	1	1	1	1	1	1	2	2
CO4	1	2	2	1	1	1	1	1	1	1	1	0	1	1	1
CO-5	2	2	2	2	1	2	2	2	2	1	1	1	2	1	1
Average	2	2	1.8	1.6	1.6	1.4	1.4	1	1.4	1	1	1	1	1	1

Core Course VI: Economic Botany (Credits: Theory-4, Practical-2)

Course Objectives (COs):

The course aims to:

1. Understand the Scope and Importance of Economic Botany
2. Study the Economic Uses of Plant-Derived Products
3. Examine Plants Used in Agriculture and Industry
4. Explore Sustainable Utilization and Conservation of Plant Resources

Theory

Unit 1: Origin of Cultivated Plants ; Concept of Centres of Origin, their importance with reference to Vavilov's work. Crop domestication and loss of genetic diversity; evolution of new crops/varieties, importance of germplasm diversity.

Unit 2: Cereals - Wheat and Rice (origin, morphology, processing & uses); Brief account of millets.

Unit 3: Legumes Origin, morphology and uses of Chick pea, Pigeon pea and fodder legumes. Importance to man and ecosystem.

Unit 4: Sources of sugars and starches Morphology and processing of sugarcane, products and by-products of sugarcane industry. Potato – morphology, propagation & uses.

Unit 5: Spices Listing of important spices, their family and part used. Economic importance with special reference to fennel, saffron, clove and black pepper

Unit 6: Beverages - Tea, Coffee (morphology, processing & uses)

Unit 7: Sources of oils and fats General description, classification, extraction, their uses and health implications groundnut, linseed, soybean, mustard and coconut.

Essential Oils: General account, extraction methods, comparison with fatty oils & their uses.

Unit 8: Natural Rubber - Para-rubber: tapping, processing and uses.

Unit 9: Drug-yielding plants

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

Unit 10: Timber plants

General account with special reference to teak and pine.

Unit 11: Fibers

Classification based on the origin of fibres; Cotton, Coir and Jute (morphology, extraction and uses).

Practical

1. Cereals: Habit sketch, L. S/T.S. grain, starch grains of Rice, Wheat

2. Legumes: Soybean, Groundnut - habit, fruit, seed structure, micro-chemical tests).

3. Sources of sugars and starches: Sugarcane, Potato.

4. Spices: Black pepper, and Clove (habit and sections).

5. Beverages: Tea (plant specimen, tea leaves), Coffee (plant specimen, beans).

6. Sources of oils and fats: Coconut- Mustard–plant specimen, seeds; tests for fats in crushed seeds.

7. Essential oil-yielding plants: Habit sketch of Rosa and Eucalyptus (specimens/photographs).

8.Woods: Tectona, Pinus: Specimen, Section of young stem.

9. Fiber-yielding plants: Cotton, Jute (specimen,).

Suggested Readings

1.Kochhar, S.L. (2012). Economic Botany in Tropics, MacMillan & Co. New Delhi, India.

2.Wickens, G.E. (2001). Economic Botany: Principles & Practices. Kluwer Academic Publishers, The Netherlands.

3.Chrispeels, M.J. and Sadava, D.E. 1994 Plants, Genes and Agriculture. Jones & Bartlett Publishers.

Course Outcome (Cos)

CO1. Learn about the historical and cultural significance of plants in human civilization.

CO2. Explore the botanical sources, cultivation, and processing of economically valuable plant products.

CO3. Learn about the conservation of traditional plant knowledge and its role in biodiversity protection.

CO4. Analyze the impact of deforestation, overexploitation, and climate change on plant resources.

CO5. Explore the role of economic botany in food security, environmental sustainability, and global trade.

Mapping of Course Outcomes and Program Outcomes:

Cos/POs	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5
CO-1	2	3	3	2	2	2	2	1	-	1	1	1	1	1	1
CO-2	3	2	1	2	3	1	0	2	-	1	-	2	2	1	2
CO-3	2	1	1	1	1	1	2	1	2	1	1	1	1	2	2
CO4	1	2	2	1	1	1	1	0	-	1	-	0	1	1	1
CO-5	2	2	2	2	1	2	2	1	1	1	1	1	2	1	1
Average	2	2	1.8	1.6	1.6	1.4	1.4	1	1.5	1	1	1	1	1	1

Core Course VII: Genetics (Credits: Theory-4, Practical-2)

Course Objectives (COs):

The course aims to:

1. Understand the Basic Principles of Genetics
2. Analyze the Structure and Function of Genetic Material
3. Learn the Principles of Population and Evolutionary Genetics
4. Explore Applications of Genetics in Biotechnology and Medicine

Theory

Unit 1: Mendelian genetics and its extension

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

Unit 2: Extra chromosomal Inheritance

Chloroplast mutation: Mitochondrial mutations in yeast.

Unit 3: Linkage, crossing over and chromosome mapping Linkage and crossing over-Cytological basis of crossing over; Recombination frequency, two factor and three factor crosses; Interference and coincidence; Numericals based on gene mapping; Sex Linkage.

Unit 4: Variation in chromosome number and structure

Deletion, Duplication, Inversion, Translocation, Position effect, Euploidy and Aneuploidy

Unit 5: Gene mutations

Types of mutations; Molecular basis of Mutations; Mutagens – physical and chemical; Detection of mutations . Role of Transposons in mutation. DNA repair mechanisms.

Unit 6: Fine structure of gene

Classical vs molecular concepts of gene; Cis-Trans complementation test for functional allelism; Structure of Phage T4, rII Locus.

Unit 6. Population and Evolutionary Genetics

Allele frequencies, Genotype frequencies, Hardy-Weinberg Law, role of natural selection, mutation, genetic drift. Genetic variation and Speciation.

Practical

1. Meiosis through temporary squash preparation.
2. Mendel's laws through seed ratios. Laboratory exercises in probability and chi-square.
3. Blood Typing: ABO groups & Rh factor.
4. Study of aneuploidy: Down's, Klinefelter's and Turner's syndromes.
5. Study of human genetic traits: Sickle cell anemia, Albinism, red-green , Colour blindness,

Suggested Readings

1. Gardner, E.J., Simmons, M.J., Snustad, D.P. (1991). Principles of Genetics, John Wiley & sons, India. 8th edition.
2. Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics, John Wiley & Sons Inc., India. 5th edition.
3. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. Benjamin Cummings, U.S.A. 9th edition.
4. Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., Doebley, J. (2010). Introduction to Genetic Analysis. W. H. Freeman and Co., U.S.A. 10th edition.

Course Outcome (Cos)

CO1. Learn the concepts of heredity, variation, and the role of genes in inheritance.
CO2. Understand the structure, organization, and function of DNA and RNA.
CO3. Study chromosomal aberrations, mutations, and their impact on gene expression.
CO4. Understand genetic engineering, cloning, gene therapy, and genome editing techniques (CRISPR).
CO5. Understand Mendel's Law and solve Problem of genetics.

Mapping of Course Outcomes and Program Outcomes:

Cos/POs	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5
CO-1	2	3	3	2	2	2	2	-	-	1	-	1	1	1	1
CO-2	3	2	1	2	3	1	0	-	-	1	-	2	2	1	2
CO-3	2	1	1	1	1	1	2	-	-	1	-	1	1	2	2
CO4	1	2	2	1	1	1	1	-	-	1	-	0	1	1	1
CO-5	2	2	2	2	1	2	2	-	-	1	-	1	2	1	1
Average	2	2	1.8	1.6	1.6	1.4	1.4	-	-	1	-	1	1	1	1

Semester-4th

Core Course VIII: Molecular Biology (Credit: Theory; 4 Practical-2)

Course Objectives (COs):

The course aims to:

1. Understand the Structure and Function of Genetic Material
2. Learn the Mechanisms of Translation and Protein Synthesis
3. Understand Molecular Basis of Mutations and Genetic Disorders
4. Explore Molecular Techniques in Research and Biotechnology

Theory

Unit 1: Nucleic acids : Carriers of genetic information

Historical perspective; DNA as the carrier of genetic information (Griffith's, Hershey & Chase, Avery, McLeod & McCarty, Fraenkel-Conrat's experiment.

Unit 2. The Structures of DNA and RNA / Genetic Material

DNA Structure: Watson and Crick- historic perspective, DNA structure, Salient features of double helix, Types of DNA, Types of genetic material, denaturation and renaturation,; Organization of DNA- Prokaryotes, Viruses, Eukaryotes. RNA Structure Organelle DNA -mitochondria and chloroplast DNA. The Nucleosome Chromatin structure- Euchromatin, Heterochromatin- Constitutive and Facultative heterochromatin.

Unit 3: The replication of DNA

Chemistry of DNA synthesis; General principles – bidirectional, semi conservative and semi discontinuous replication, RNA priming; Various models of DNA replication, replication of linear ds-DNA, replication of the 5'end of linear chromosome; Enzymes involved in DNA replication.

Unit 4: Central dogma and genetic code

Key experiments establishing-The Central Dogma (Adaptor hypothesis and discovery of mRNA template), Genetic code (deciphering & salient features)

Unit 4: Transcription

Transcription in prokaryotes and eukaryotes. Principles of transcriptional regulation; Prokaryotes: Regulation of lactose metabolism and tryptophan synthesis in E.coli. Eukaryotes: transcription factors, heat shock proteins, steroids and peptide hormones; Gene silencing.

Unit 5: Processing and modification of RNA

Split genes-concept of introns and exons, removal of introns, spliceosome machinery, splicing pathways, group I and group II intron splicing, alternative splicing eukaryotic mRNA processing(5' cap, 3' polyA tail); Ribozymes; RNA editing and mRNA transport.

Unit 6: Translation

Ribosome structure and assembly, mRNA; Charging of tRNA, aminoacyl tRNA synthetases; Various steps in protein synthesis, proteins involved in initiation, elongation and termination of polypeptides; Fidelity of translation; Inhibitors of protein synthesis; Post-translational modifications of proteins.

Practical

1. Preparation of LB medium and raising E.Coli.
2. Study of DNA replication mechanisms through photographs.
3. Study of structures of prokaryotic RNA polymerase and eukaryotic RNA polymerase II through photographs.
4. Photographs establishing nucleic acid as genetic material.
5. Study of the following through photographs: Assembly of Spliceosome machinery; Splicing mechanism in group I & group II introns; Ribozyme and Alternative splicing.

Suggested Readings

1. Watson J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M., Losick, R. (2007). Molecular Biology of the Gene, Pearson Benjamin Cummings, CSHL Press, New York, U.S.A. 6th edition.
2. Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics. John Wiley and Sons Inc., U.S.A. 5th edition.
3. Russell, P. J. (2010). Genetics- A Molecular Approach. Benjamin Cummings, U.S.A. 3rd edition.
4. Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., Doebley, J. (2010). Introduction to Genetic Analysis. W. H. Freeman and Co., U.S.A. 10th edition.

Course Outcome (Cos)

CO1. Explain Structure and function of DNA

CO2. Understand Transcription and Translation in Eukaryotes.

CO3. Have experiential learning in advanced subjects of Molecular Biology

CO4. Learn about different types of mutations and their effects on gene function.

CO5. Understand the role of molecular biology in gene therapy, cancer research, and drug development.

Mapping of Course Outcomes and Program Outcomes:

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5
CO-1	3	1	2	1	1	1	1	1	1	-	1	1	1	1	2
CO-2	2	2	1	2	1	1	-	1	1	-	-		-		1
CO-3	2	2	2	1	-	-	1	1	1	-	1	1	1	2	1
CO-4	1	2	1	1	2	1	-	1	1	1	1	-	-		1
Average	2	1.8	1.5	1.3	1.3	1	1	1	1	1	1	1	1	1.5	1.3

Core Course IX: Plant Ecology and Phytogeography

(Credits: Theory-4, Practical-2)

Course Objectives (COs):

The course aims to:

1. Understand the Fundamentals of Plant Ecology
2. Examine Plant Adaptations to Environmental Conditions
3. Explore Phytogeography and Plant Distribution Patterns
4. Understand Conservation Strategies and Sustainable Management

Theory

Unit 1: Introduction

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

Unit 2: Soil Importance; Origin; Formation; Composition; Physical; Chemical and Biological components; Soil profile; Role of climate in soil development.

Unit 3: Water Importance: States of water in the environment; Atmospheric moisture; Precipitation types (rain, fog, snow, hail, dew); Hydrological Cycle; Water in soil; Water table.

Unit 4: Light, temperature, wind and fire Variations; adaptations of plants to their variation.

Unit 5: Biotic interactions - Trophic organization, basic source of energy, autotrophy, heterotrophy; symbiosis, commensalism, parasitism; food chains and webs; ecological pyramids; biomass, standing crop.

Unit 6: Population ecology - Characteristics and Dynamic . Ecological Speciation

Unit 7: Plant communities - Concept of ecological amplitude; Habitat and niche; Characters: analytical and synthetic; Ecotone and edge effect; Dynamics: succession – processes, types; climax concepts.

Unit 8: Ecosystems , Structure; Processes; Trophic organisation; Food chains and Food webs; Ecological pyramids.

Unit 9: Functional aspects of ecosystem - Principles and models of energy flow; Production and productivity; Ecological efficiencies; Biogeochemical cycles; Cycling of Carbon, Nitrogen and Phosphorus.

Unit 10: Phytogeography 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.

Practical

1. Study of instruments used to measure microclimatic variables: Soil thermometer, maximum and minimum thermometer, anemometer, psychrometer/hygrometer, rain gauge and lux meter.

2. Determination of pH of various soil and water samples

3. Determination of organic matter of different soil samples.

6. Determination of dissolved oxygen of water samples from polluted and unpolluted sources

7. (a). Study of morphological adaptations of hydrophytes and xerophytes .

(b). Study of biotic interactions of the following: Stem parasite (Cuscuta), Root parasite (Orobanche) Epiphytes, Predation (Insectivorous plants).

8. Determination of minimal quadrat size for the study of herbaceous vegetation in the college campus, by species area curve method (species to be listed).

9. Quantitative analysis of herbaceous vegetation in the college campus for frequency and comparison with Raunkiaer's frequency distribution law.

10. Quantitative analysis of herbaceous vegetation for density and abundance in the college campus.

11. 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.

Course Outcome (Cos)

CO1. Understand plant-environment interactions, including abiotic and biotic factors.

CO2. Understand morphological, physiological, and anatomical adaptations of plants in different ecosystems.

CO3. Understand biodiversity hotspots, conservation strategies, and ecological restoration.

CO4. Understand the effects of global climate change on plant ecology and distribution.

Mapping of Course Outcomes and Program Outcomes:

Cos/POs	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5
CO-1	3	1	2	1	1	1	1	1	1	-	1	1	1	1	2
CO-2	2	2	1	2	1	1	-	1	1	-	-		-		1
CO-3	2	2	2	1	-	-	1	1	1	-	1	1	1	2	1
CO-4	1	2	1	1	2	1	-	1	1	1	1	-	-		1
Average	2	1.8	1.5	1.3	1.3	1	1	1	1	1	1	1	1	1.5	1.3

Semester-5th

Core Course XI: Reproductive Biology of Angiosperms (Credits: Theory-4, Practical-2)

Course Objective

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

- Understand Flower Development
- Male and Female Gametophyte Development
- Fertilization and Embryogenesis
- Self-Incompatibility and Cross-Pollination

Theory

Unit 1: Introduction

History (contributions of G.B. Amici, W. Hofmeister, E. Strasburger, S.G. Nawaschin, P. Maheshwari, B.M. Johri, W.A. Jensen, J. Heslop-Harrison) and scope.

Unit 2: Reproductive development

Induction of flowering; flower as a modified determinate shoot. Flower development: genetic and molecular aspects.

Unit 3: Anther and pollen biology

Anther wall: Structure and functions, microsporogenesis, callose deposition and its significance. Microgametogenesis; Pollen wall structure, MGU (male germ unit) structure, NPC system; Palynology and scope (a brief account); Pollen wall proteins; Pollen viability, storage and germination; Abnormal features: Pseudomonads, polyads, massulae, pollinia.

Unit 4: Ovule

Structure; Types; Special structures–endothelium, obturator, aril, caruncle and hypostase; Female gametophyte– megasporogenesis (monosporic, bisporic and tetrasporic) and megagametogenesis (details of Polygonum type); Organization and ultrastructure of mature embryo sac.

Unit 5: Pollination and fertilization

Pollination types and significance; adaptations; structure of stigma and style; path of pollen tube in pistil; double fertilization.

Unit 6: Self incompatibility

Basic concepts (interspecific, intraspecific, homomorphic, heteromorphic, GSI and SSI);Methods to overcome self- incompatibility: mixed pollination, bud pollination, stub pollination; Intra-ovarian and in vitro pollination; Modification of stigma surface, parasexual hybridization; Cybrids, in vitro fertilization.

Unit 7: Embryo, Endosperm and Seed

Structure and types; General pattern of development of dicot and monocot embryo and endosperm; Suspensor: structure and functions; Embryo-endosperm relationship; Nutrition of embryo; Unusual features; Embryo development in Paeonia. Seed structure, importance and dispersal mechanisms

Units 8: Polyembryony and apomixis Introduction; Classification; Causes and applications.

Practical

1. Anther: Wall and its ontogeny; Tapetum (amoeboid and glandular); MMC, spore tetrads, uninucleate, bicelled and dehisced anther stages through slides/micrographs, male germ unit (MGU) through photographs and schematic representation.

3. Pollen grains: Fresh and acetolyzed showing ornamentation and aperture, psuedomonads, polyads, pollinia (slides/photographs,fresh material), ultrastructure of pollen wall(micrograph); Pollen viability: germination: Calculation of percentage germination.

4. Ovule: Types-anatropous, orthotropous, amphitropous/campylotropous, circinotropous, unitegmic, bitegmic; (permanent slides/specimens/photographs).

5. Female gametophyte through permanent slides/ photographs: Types, ultrastructure of mature egg apparatus.

6. Endosperm: Dissections of developing seeds for endosperm .

7. Embryogenesis: Study of development of dicot embryo through permanent slides.

Suggested Readings

1. Bhojwani, S.S. and Bhatnagar, S.P. (2011). The Embryology of Angiosperms, Vikas Publishing House. Delhi. 5th edition.

2. Shivanna, K.R. (2003). Pollen Biology and Biotechnology. Oxford and IBH Publishing Co. Pvt. Ltd. Delhi.

3. Raghavan, V. (2000). Developmental Biology of Flowering plants, Springer, Netherlands.

4. Johri, B.M. l (1984). Embryology of Angiosperms, Springer-Verlag, Netherlands.

Course Outcome (COs)

CO 1. Study of floral organogenesis, floral meristems, and genetic regulation of flower development.

CO2.Analysis of microsporogenesis, megasporogenesis, and gametophyte interactions.

CO3.Examination of double fertilization, zygote development, and early embryonic stages.

CO4.Study of post-fertilization changes, seed dormancy, and fruit dispersal strategies.

CO5.Integration of reproductive biology concepts into plant breeding, genetic modification, and biodiversity conservation.

Mapping of Course Outcomes and Program Outcomes:

Cos/POs	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5
CO-1	3	1	2	1	1	1	1	1	1	-	1	1	1	1	2
CO-2	2	2	1	2	1	1	-	1	1	-	-		-		1
CO-3	2	2	2	1	-	-	1	1	1	-	1	1	1	2	1
CO-4	1	2	1	1	2	1	-	1	1	1	1	-	-		1
CO-5	-	1	-	-	2	-	-	1	1	-	3	1	2	1	1
Average	2	1.6	1.5	1.2	1.5	1	1	1	1	1	1.5	1	1.3	1.3	1.2

Core Course XII: Plant Physiology

(Credits: Theory 4, Practical-2)

Course Objectives (COs):

The course aims to:

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

- Understand Photosynthesis and Respiration
- Explain Plant Growth and Development
- Understand Signal Transduction and Plant Responses
- Evaluate plant secondary metabolites and their ecological and pharmaceutical significance.

Theory

Water Potential and its components, water absorption by roots, aquaporins, pathway of

Unit 1: Plant-water relations

Water Potential and its components, water absorption by roots, a pathway of water movement, symplast, apoplast, transmembrane pathways, root pressure, guttation. Ascent of sap– cohesion-

tension theory.Transpiration and factors affecting transpiration, antitranspirants, mechanism of stomatal movement.

Unit 2: Mineral nutrition

Essential and beneficial elements, macro and micronutrients, methods of study and use of nutrient solutions, criteria for essentiality, mineral deficiency symptoms, roles of essential elements, chelating agents.

Unit 3: Nutrient Uptake

Soil as a nutrient reservoir, transport of ions across cell membrane, passive absorption, electrochemical gradient, facilitated diffusion, active absorption, role of ATP, carrier systems,proton ATPase pump and ion flux, uniport, co-transport, symport, antiport.

Unit 4: Translocation in the phloem

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

Unit 5: Plant growth regulators

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

Unit 6: Physiology of flowering

Photoperiodism, flowering stimulus, florigen concept, vernalization, seed dormancy. Unit 7: Phytochrome , crytochromes and phototropins

Discovery, chemical nature, role in photomorphogenesis, low energy responses (LER) and high irradiance responses (HIR), mode of action.

Practical

1. Determination of osmotic potential of plant cell sap by plasmolytic method.
2. Determination of water potential of given tissue (potato tuber) by weight method.
3. To study the phenomenon of seed germination

(effect of light). Demonstration experiments

1. To demonstrate suction due to transpiration.
2. Fruit ripening/Rooting from cuttings (Demonstration).
3. Bolting experiment/Avena coleptile bioassay (demonstration).

Suggested Readings

1. Hopkins, W.G. and Huner, A. (2008). Introduction to Plant Physiology. John Wiley and Sons.
U.S.A. 4th edition.

2. Taiz, L., Zeiger, E., MØller, I.M. and Murphy, A (2015). Plant Physiology and Development. Sinauer Associates Inc. USA. 6th edition.

3. Bajracharya D. (1999). Experiments in Plant Physiology-A Laboratory Manual. Narosa Publishing House, New Delhi.

Course Outcome (CO s)

CO1.Study of water absorption, transport, transpiration, and mechanisms of water conservation.

CO2.Examination of the biochemical pathways of photosynthesis, respiration, and energy metabolism.

CO3.Analysis of growth regulators (hormones), seed germination, dormancy, and flowering mechanisms.

CO4Study of signaling molecules, photoperiodism, circadian rhythms, and tropisms.

CO5.Integration of physiological principles in crop improvement, plant breeding, and biotechnology.

Mapping of Course Outcomes and Program Outcomes:

Cos/POs	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5
CO-1	3	1	2	1	1	1	1	1	1	-	1	1	1	1	2
CO-2	2	2	1	2	1	1	-	1	1	-	-		-		1
CO-3	2	2	2	1	-	-	1	1	-	-	1	1	1	2	1
CO-4	1	2	1	1	2	1	-	1	1	1	1	-	-		1
CO-5	-	1	-	-	1	-	-	-	1	-	3	1	2	1	1
Average	2	1.6	1.5	1.2	1.5	1	1	1	1	1	1.5	1	1.3	1.3	1.2

Semester-VI

Core Course XIII: Plant Metabolism (Credits: Theory-4, Practical-2)

Course Objectives (COs):

The course aims to:

1. Fundamentals of Plant Metabolism
2. Photosynthesis and Carbon Metabolism
3. Respiration and Energy Production
4. Evaluate Secondary Metabolites and Their Functions
5. Biotechnological Applications of Plant Metabolism

Theory

Unit 1: Concept of metabolism

Introduction, anabolic and catabolic pathways, regulation of metabolism, role of regulatory enzymes.

Unit 2: Carbon assimilation

Historical background, photosynthetic pigments, role of photosynthetic pigments (chlorophylls and accessory pigments), antenna molecules and reaction centres, photosynthetic electron transport, PSI, PSII, Q cycle, CO_2 reduction, photorespiration, C4pathways; Crassulacean acid metabolism; Factors affecting CO_2 reduction.

Unit 3: Carbohydrate metabolism - Synthesis and catabolism o sucrose and starch.

Unit 4: Carbon Oxidation

Glycolysis, fate of pyruvate, regulation of glycolysis, oxidative pentose phosphate pathway, oxidative decarboxylation of pyruvate, TCA cycle,amphibolic role, mitochondrial electron transport, oxidative phosphorylation, cyanide-resistant respiration, factors affecting respiration.

Unit 5: ATP-Synthesis

Mechanism of ATP synthesis, substrate level phosphorylation, ATP synthase, Boyers conformational model, Racker's experiment.

Unit 6: Lipid metabolism

Synthesis and breakdown of triglycerides, β-oxidation, glyoxylate cycle, gluconeogenesis and its role in mobilisation of lipids during seed germination .

Unit 7: Nitrogen metabolism

Nitrate assimilation, biological nitrogen fixation; Physiology and biochemistry of nitrogen fixation; Ammonia assimilation and transamination.

Unit 8: Mechanisms of signal transduction

Receptor-ligand interactions; Second messenger concept, Calcium calmodulin, MAP kinase cascade.

Practical

1. Chemical separation of photosynthetic pigments.
2. Experimental demonstration of Hill's reaction.
3. To study the effect of light intensity on the rate of photosynthesis.
4. To demonstrate activity of Nitrate reductase in germinating leaves of different plant sources.
5. To study the activity of lipases in germinating oilseeds and demonstrate mobilization of lipids during germination.

Suggested Readings

1. Hopkins, W.G. and Huner, A. (2008). Introduction to Plant Physiology. John Wiley and Sons. U.S.A. 4th edition.
2. Taiz, L., Zeiger, E., MØller, I.M. and Murphy, A (2015). Plant Physiology and Development. Sinauer Associates Inc. USA. 6th edition.
3. Harborne, J.B. (1973). Phytochemical Methods. John Wiley & Sons. New York.

Course Outcome (CO s)

CO1. Exploration of the light and dark reactions, carbon fixation pathways (C3, C4, CAM), and photorespiration.

CO2. Study of glycolysis, the citric acid cycle, oxidative phosphorylation, and ATP synthesis.

CO3.Analysis of growth regulators (hormones), seed germination, dormancy, and flowering mechanisms.

CO4 Investigation of metabolic responses to environmental stresses such as drought, salinity, and temperature fluctuations.

CO5. Application of metabolic engineering in crop improvement, biofuel production, and pharmaceutical development.

Mapping of Course Outcomes and Program Outcomes:

Cos	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5
CO-1	3	1	2	1	1	1	1	1	1	-	1	1	1	1	2
CO-2	2	2	1	2	1	1	-	1	1	-	-		-		1
CO-3	2	2	2	1	-	-	1	1	1	-	1	1	1	2	1
CO-4	1	2	1	1	2	1	-	1	1	1	1	-	-		1
CO-5	-	1	-	-	2	-	-	1	1	-	3	1	2	1	1
Average	2	1.6	1.5	1.2	1.5	1	1	1	1	1	1.5	1	1.3	1.3	1.2

Core Course XIV: Plant Biotechnology

(Credits: Theory-4, Practical-2)

Course Objectives (COs):

The course aims to:

1. Understand fundamental concepts, history, and applications of plant biotechnology.
2. Explain Plant Tissue Culture Techniques
3. Understand Genetic Engineering in Plants
4. Study Metabolic Engineering and Synthetic Biology

Theory

Unit 1: Plant Tissue Culture

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.

Unit 2: Recombinant DNA technology

Restriction Endonucleases; Restriction Mapping (Linear and Circular); Cloning Vectors: Prokaryotic (pUC 18 and pUC19, pBR322, Ti plasmid, BAC); Lambda phage, Cosmid, Shuttle vector; Eukaryotic Vectors (YAC).

Unit 3:Gene Cloning

Recombinant DNA, Bacterial Transformation and selection of recombinant clones, PCR mediated gene cloning; Gene Construct; construction of genomic and cDNA libraries, screening DNA libraries to obtain gene of interest by genetic selection; complementation, colony hybridization; PCR

Unit 4: Methods of gene transfer

Agrobacterium-mediated, Direct gene transfer by Electroporation, Microinjection, Microprojectile bombardment; Selection of transgenics– selectable marker and reporter genes

(Luciferase, GUS, GFP).

Unit 5: Applications of Biotechnology

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.

Practical

1. (a) Preparation of MS medium.

(b) Demonstration of in vitro sterilization and inoculation methods using leaf and nodal explants. etc.

2. Study of anther, embryo and endosperm culture, micropropagation, somatic embryogenesis.

3. Study of methods of gene transfer through photographs.

4. Study of steps of genetic engineering for production of Bt cotton, Golden rice, Flavr Savr tomato through photographs.

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.

Course Outcome (CO s)

CO1. Study of in vitro culture methods, micropropagation, somatic embryogenesis, and haploid production.

CO2. Exploration of recombinant DNA technology, gene cloning, and transformation techniques (Agrobacterium-mediated and direct gene transfer).

CO3. Study of engineered pathways for improving plant nutrition, stress tolerance, and secondary metabolite production.

CO4. Genetic modifications to enhance drought resistance, pest resistance, and disease resistance in crops.

CO5. Utilization of biotechnology in food security, biofuels, pharmaceuticals, and sustainable farming.

Mapping of Course Outcomes and Program Outcomes:

Cos/POs	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5
CO-1	3	1	2	1	1	1	1	1	1	-	1	1	1	1	2
CO-2	2	2	1	2	1	1	-	1	1	-	-		-		1
CO-3	2	2	2	1	-	-	1	1	1	-	1	1	1	2	1
CO-4	1	2	1	1	2	1	-	1	1	1	1	-	-		1
CO-5	-	1	-	-	2	-	-	1	1	-	3	1	2	1	1
Average	2	1.6	1.5	1.2	1.5	1	1	1	1	1	1.5	1	1.3	1.3	1.2

Discipline Specific Elective

Analytical Techniques in Plant Sciences

(Credits: Theory-4, Practical-2)

Course Objectives (COs):

The course aims to:

1. Introduce fundamental and advanced analytical techniques used in plant sciences.
2. Develop an understanding of the principles and applications of various instruments and biochemical techniques.
3. Equip students with the skills to analyze plant metabolites, genetic material, and physiological parameters.
4. Foster critical thinking and problem-solving abilities in experimental plant research.
5. Provide hands-on training in chromatography, spectrometry, molecular biology tools, and bioinformatics.

Theory

Unit 1: Imaging and related techniques

Principles of microscopy; Light microscopy; Fluorescence microscopy; Confocal microscopy; Use of fluorochromes: (a) Flow cytometry (FACS); (b) Applications of fluorescence microscopy: FISH, Transmission and Scanning electron microscopy .

Unit 2: Cell fractionation

Centrifugation: Differential and density gradient centrifugation, analytical centrifugation, ultracentrifugation.

Unit 3: Radioisotopes ; Use in biological research, auto-radiography, pulse chase experiment.

Unit 4: Spectrophotometry -Principle and its application in biological research.

Unit 5: Chromatography - Principle; Paper chromatography; Column chromatography, TLC, HPLC, Ion-exchange chromatography; Affinity chromatography.

Unit 6: Characterization of proteins and nucleic acids - Mass spectrometry; X-ray diffraction; Characterization of proteins and nucleic acids; Electrophoresis: AGE, PAGE, SDS- PAGE

Unit 7:Biostatistics

Statistics, data, population, samples, parameters; Representation of Data: TabularGraphical; Measures of central tendency: Arithmetic mean, mode, median; Measures of dispersion: Range, mean deviation, variation, standard deviation; Chi-square test for goodness of fit.

Practical

1. Study of Blotting techniques: Southern, Northern and Western, DNA fingerprinting, DNA sequencing, PCR through photographs.
2. Isolation of chloroplasts by differential centrifugation.
3. To separate chloroplast pigments by column chromatography.
4. Study of different microscopic techniques using photographs/micrographs .
5. Preparation of permanent slides (double staining).

Suggested Readings

1. Plummer, D.T. (1996). An Introduction to Practical Biochemistry. Tata McGraw-Hill Publishing Co. Ltd. New Delhi. 3rd edition.
2. Ruzin, S.E. (1999). Plant Microtechnique and Microscopy, Oxford University Press, New York. U.S.A.
3. Ausubel, F., Brent, R., Kingston, R. E., Moore, D.D., Seidman, J.G., Smith, J.A., Struhl, K. (1995). Short Protocols in Molecular Biology. John Wiley & Sons. 3rd edition.
4. Zar, J.H. (2012). Biostatistical Analysis. Pearson Publication. U.S.A. 4th edition.

Course Outcomes (COs):

CO1: Explain the principles and applications of analytical techniques used in plant sciences.

CO2: Apply spectroscopy and chromatography techniques for plant metabolite analysis.

CO3: Perform molecular biology techniques such as PCR, electrophoresis, and sequencing for plant genetic analysis.

CO4: Utilize bioinformatics tools for plant genome and proteome analysis.

CO5: Analyze plant physiological parameters using physiological and biochemical techniques.

CO6: Interpret experimental results and apply appropriate analytical methods for plant research problems.

Mapping of Course Outcomes and Program Outcomes:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO	PSO2	PSO3	PSO4	PSO5
CO1	3	2	2	2	1	1	-	-	-	-	-	-	1	-	2
CO2	3	3	3	3	2	1	-	-	-	-	-	1	-	-	1
CO3	3	3	3	3	2	2	1	-	-	-	-	-	1	1	1
CO4	2	3	3	3	3	2	1	1	-	-	1	-	-	1	1
CO5	3	2	3	3	2	2	-	-	-	-	-	-	2	1	1
CO6	3	3	3	3	3	3	2	1	1	1	-	-	1	0	0
Average	2.8	3	2.8	2.8	2.2	1.8	1.3	1	1	1	1	1	1.3	0.8	1

Discipline Specific

Elective

Bioinformatics

(Credits: Theory-4, Practical-2)

The course aims to:

1. Introduce the fundamental concepts and applications of bioinformatics in life sciences.
2. Familiarize students with biological databases, sequence alignment, and molecular modeling techniques.
3. Equip students with skills to analyze genomic, transcriptomic, and proteomic data.
4. Develop computational problem-solving abilities for biological data interpretation.
5. Train students in programming and machine learning approaches in bioinformatics.

Theory

Unit 1. Introduction to Bioinformatics

Introduction, Branches of Bioinformatics, Aim, Scope and Research areas of Bioinformatics.

Unit 2. Databases in Bioinformatics

Introduction, Biological Databases, Classification format of Biological Databases, Biological Database Retrieval System.

Unit 3. Biological Sequence Databases

National Center for Biotechnology Information (NCBI): Tools and Databases of NCBI, Database Retrieval Tool, Sequence Submission to NCBI, Basic local alignment search tool (BLAST), Nucleotide Database, Protein Database, Gene Expression Database.

EMBL Nucleotide Sequence Database (EMBL-Bank): Introduction, Sequence Retrieval, Sequence Submission to EMBL, Sequence analysis tools.

DNA Data Bank of Japan (DDBJ): Introduction, Resources at DDBJ, Data Submission at DDBJ. Protein Information Resource (PIR): About PIR, Resources of PIR, Databases of PIR, Data Retrieval in PIR. Swiss-Prot: Introduction and Salient Features.

Unit 4.

Introduction, Concept of Alignment, Multiple Sequence Alignment (MSA), MSA by CLUSTALW, Scoring Matrices, Percent Accepted Mutation (PAM), Blocks of Amino Acid Substitution Matrix (BLOSUM).

Unit 5. Molecular Phylogeny - Methods of Phylogeny, Software for Phylogenetic Analyses, Consistency of Molecular Phylogenetic Prediction.

Unit 6. Applications of Bioinformatics

Structural Bioinformatics in Drug Discovery, Quantitative structure-activity relationship (QSAR) techniques in Drug Design, Microbial genome applications, Crop improvement

Practical

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.

Suggested Readings

1. Ghosh Z. and Bibekanand M. (2008) Bioinformatics: Principles and Applications.

Oxford University Press.

2. Pevsner J. (2009) Bioinformatics and Functional Genomics. II Edition. Wiley Blackwell.

3. Campbell A. M., Heyer L. J. (2006) Discovering Genomics, Proteomics and Bioinformatics. II Edition. Benjamin Cummings.

Course Outcomes (COs):

After completing this course, students will be able to:

CO1: Explain key bioinformatics concepts, databases, and tools.

CO2: Perform sequence alignment, phylogenetic analysis, and molecular docking.

CO3: Analyze and interpret genomic, transcriptomic, and proteomic data.

CO4: Use computational tools for structural and functional annotation of biological sequences.

CO5: Apply programming and machine learning techniques for biological data analysis.

CO6: Develop bioinformatics pipelines and workflows for solving real-world biological problems.

Mapping of Course Outcomes and Program Outcomes:

Cos/POs	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5
CO-1	3	1	2	1	1	1	1	1	1	-	1	1	1	-	2
CO-2	2	2	1	2	1	1	-	1	1	-	-		-	-	1
CO-3	2	2	2	1	-	-	1	1	1	-	1	1	1	-	1
CO-4	1	2	1	1	2	1	-	1	1	1	1	-	-	1	1
CO-5	-	1	-	-	2	-	-	1	1	1	3	1	2	1	1
CO-6	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Average	1.8	1.5	1.4	1.2	1.4	1	1	1	1	1.4	1	1.3	1.2	1	1

Discipline Specific Elective

Stress Biology

(Credits: Theory 4, Practical 2)

Course Objectives (COs):

The course aims to:

1. Provide an understanding of biotic and abiotic stress factors affecting plant and animal systems.
2. Explore the physiological, biochemical, and molecular responses of organisms to stress.
3. Introduce stress adaptation, tolerance mechanisms, and signaling pathways.
4. Develop skills in experimental techniques for assessing stress responses.
5. Equip students with knowledge of stress mitigation strategies in agriculture and biotechnology.

Theory

Unit 1: Defining plant stress Acclimation and adaptation.

Unit 2: Environmental factors ; Water stress; Salinity stress, High light stress; Temperature stress; Hypersensitive reaction.

Pathogenesis– related (PR) proteins; Systemic acquired resistance; Mediation of insect and disease resistance by jasmonates.

Unit 3: Stress sensing mechanisms in plants Calcium modulation, Phospholipid signaling

Unit 4: Developmental and physiological mechanisms that protect plants against environmental stress Adaptation in plants; Changes in root: shoot ratio; Aerenchyna development; Osmotic adjustment; Compatible solute production.

Unit 5: Reactive oxygen species–Production and scavenging mechanisms.

Practical

1. Quantitative estimation of peroxidase activity in the seedlings in the absence and presence of salt stress.

2. Superoxide activity in seedlings in the absence and presence of salt stress.
3. Zymographic analysis of superoxide dismutase activity.
4. Quantitative estimation and zymographic analysis of glutathione reductase.
5. Estimation of superoxide anions.

Suggested Readings

1. Hopkins, W.G. and Huner, A. (2008). Introduction to Plant Physiology. John Wiley and Sons.

U.S.A. 4th edition.

2. Taiz, L., Zeiger, E., MØller, I.M. and Murphy, A (2015). Plant Physiology and Development. Sinauer Associates Inc. USA. 6th edition.

Course Outcomes (COs):

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

CO1: Explain different types of biotic and abiotic stress factors affecting biological systems.

CO2: Describe the physiological and biochemical responses of organisms under stress conditions.

CO3: Analyze molecular mechanisms involved in stress perception, signaling, and adaptation.

CO4: Apply techniques for assessing stress responses at physiological, biochemical, and molecular levels.

CO5: Evaluate stress tolerance strategies in plants and their applications in agriculture.

CO6: Develop solutions to mitigate stress impacts using biotechnological and agronomic approaches.

Mapping of Course Outcomes and Program Outcomes:

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	2	1	1	-	2	-	-	1	2	2	1		2
CO2	3	3	3	2	2	-	2	1	2	2	1	3	3	2	1
CO3	3	3	3	3	2	1	2	1	-	3	2	3	3	3	2
CO4	3	3	3	3	3	2	2	1	1	3	1	3	3	3	1
CO5	3	3	3	3	2	2	3	2	-	3	1	2	3	3	1
CO6	3	3	3	3	3	3	3	2	1	3	0	3	3	3	0
Average	3.0	3	2.8	2.5	2.2	2.0	2.3	1.4	1.3	2.5	1.2	2.7	2.7	2.8	1.2

Discipline Specific Elective

Plant Breeding

(Credits: Theory-4, Practical-2)

Course Objectives (COs):

The course aims to:

1. Introduce the principles and techniques of plant breeding for crop improvement.
2. Explain the genetic basis of plant breeding and the role of selection and hybridization.
3. Develop skills in conventional and molecular breeding approaches.
4. Familiarize students with biotechnological tools for crop improvement.
5. Equip students with knowledge of breeding for stress tolerance, disease resistance, and quality traits.

Theory

Unit 1: Plant Breeding

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 : Introduction, Centres of origin and domestication of crop plants, plant genetic resources; Acclimatization; Selection methods: For self pollinated, cross pollinated . Hybridization: For self, cross and vegetatively propagated plants – Procedure, advantages and limitations.

Unit 3: Quantitative inheritance

Concept, mechanism, examples of inheritance of Kernel colour in wheat, Skin colour in human beings. Monogenic vs polygenic Inheritance.

Unit 4: Inbreeding depression and heterosis History, genetic basis of inbreeding depression and heterosis; Applications.

Unit 5: Crop improvement and breeding Role of mutations; Polyploidy; Distant hybridization and role of biotechnology in crop improvement.

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.

Course Outcomes (COs):

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

CO1: Explain the fundamental concepts and significance of plant breeding in agriculture.

CO2: Describe various breeding methods, including selection, hybridization, and mutation breeding.

CO3: Apply conventional and molecular techniques for crop improvement.

CO4: Analyze the role of genetics and biotechnology in developing superior crop varieties.

CO5: Evaluate breeding strategies for disease resistance, stress tolerance, and yield enhancement.

CO6: Develop breeding programs integrating traditional and modern approaches for sustainable agriculture.

Mapping of Course Outcomes and Program Outcomes:

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	2	1	1	-	2	-	1		1	1	1		2
CO2	3	3	3	2	2	-	2	1	-	1	3	1	3	2	1
CO3	3	3	3	3	2	1	2	1	2	-	3	1	3	3	2
CO4	3	3	3	3	3	2	2	1	2	1	3	1	3	3	1
CO5	3	3	3	3	2	2	3	2	1	1	3	0	3	3	1
CO6	3	3	3	3	3	3	3	2	1	1	3	1	3	3	0
Average	3.0	3	2.8	2.5	2.2	2.0	2.3	1.4	1.4	1	2.7	0.8	2.7	2.8	1.2

Discipline Specific Elective

Natural Resource Management

(Credits: Theory-4, Practical-2)

Course Objectives (COs):

The course aims to:

1. Provide an understanding of the classification, conservation, and sustainable use of natural resources.
2. Explain the ecological and economic significance of biodiversity and ecosystems.
3. Develop knowledge of environmental policies, laws, and management strategies for resource conservation.
4. Equip students with skills to assess environmental challenges and develop sustainable solutions.
5. Foster awareness of climate change, pollution, and the role of technology in resource management.

Theory

Unit 1: Natural resources Definition and types.

Unit 2: Sustainable utilization ; Concept, approaches (economic, ecological and socio-cultural).

Unit 3: Land Utilization (agricultural, pastoral, horticultural, silvicultural); Soil degradation and management.

Unit 4: Water Fresh water (rivers, lakes, groundwater, aquifers, watershed); Marine; Estuarine; Wetlands; Threats and management strategies.

Unit 5: Biological Resources Biodiversity-definition and types; Significance; Threats; Management strategies; Bioprospecting; IPR; CBD; National Biodiversity Action Plan).

Unit 6: Forests Definition, Cover and its significance (with special reference to India); Major and minor Forest products; Depletion; Management.

Unit 7: Energy Renewable and non-renewable sources of energy

Unit 8: Contemporary practices in resource management EIA, GIS, Participatory Resource Appraisal, Ecological Footprint with emphasis on carbon footprint, Resource Accounting; Waste management.

Unit 9: National and international efforts in resource management and conservation

Practical

1.Estimation of solid waste generated by a domestic system (biodegradable and non biodegradable) and its impact on land degradation.

2. Collection of data on forest cover of specific area.

3. Measurement of dominance of woody species by DBH (diameter at breast height) method.

4. Calculation and analysis of ecological footprint.

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.

3. Rogers, P.P., Jalal, K.F. and Boyd, J.A. (2008). An Introduction to Sustainable Development. Prentice Hall of India Private Limited, New Delhi.

Course Outcomes (COs):

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

CO1: Explain the concepts and principles of natural resource management.
CO2: Identify various types of natural resources and their ecological and economic importance.
CO3: Analyze environmental challenges such as deforestation, soil degradation, and biodiversity loss.
CO4: Evaluate policies and strategies for sustainable management of land, water, and forests.
CO5: Apply remote sensing, GIS, and other technological tools for resource assessment and conservation.
CO6: Develop sustainable resource management plans considering climate change and global environmental issues.

Mapping of Course Outcomes and Program Outcomes:

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	2	2	1	1	3	2	-	2	1	-	1	1	2
CO2	3	3	3	3	2	1	3	3	1	3	2	2	3	2	1
CO3	1	3	3	2	2	2	3	3	-	1	3	3	3	3	2
CO4	3	3	3	3	3	2	3	3	2	3	2	3	1	3	1
CO5	2	3	3	3	2	3	3	3	2	3	3	3	3	2	1
CO6	3	3	3	3	3	3	3	3	3	3	3	3	1	3	-
Average	3.0	3	2.8	2.7	2.2	2.0	3.0	2.8	2.0	2.5	2.3	2.8	2.0	2.3	1.4

Discipline Specific Elective Horticultural

Practices and Post-Harvest Technology

(Credits: Theory-4, Practical-2)

Course Objectives (COs):

The course aims to:

1. Provide knowledge of post-harvest handling, storage, and processing of agricultural produce.
2. Explain the physiological and biochemical changes in crops after harvest.
3. Develop an understanding of packaging, transportation, and value addition of agricultural products.
4. Equip students with skills in post-harvest loss reduction and food preservation techniques.
5. Introduce modern technological advancements in post-harvest management and processing

Theory

Unit 1: Introduction

Scope and importance, Branches of horticulture; Role in rural economy and employment generation; Importance in food and nutritional security; Urban horticulture and ecotourism.

Unit 2: Ornamental plants

Types, classification (annuals, perennials, climbers and trees); Identification and salient features of some ornamental plant , sages, cacti and succulents . Ornamental flowering trees.

Unit 3: Fruit and vegetable crops

Production, origin and distribution; Description of plants and their economic products;

Management and marketing of vegetable and fruit crops; Identification of some fruits and vegetable varieties.

Unit 4: Horticultural techniques

Application of manure, fertilizers, nutrients and PGRs; Weed control; Biofertilizers, biopesticides; Irrigation methods (drip irrigation, surface irrigation, furrow and border irrigation); Hydroponics; Propagation Methods: asexual (grafting, cutting, layering, budding), sexual (seed propagation), Scope and limitations.

Unit 5: Landscaping and garden design

Planning and layout (parks and avenues); gardening traditions - Ancient Indian, European, Mughal and Japanese Gardens; Urban forestry; policies and practices.

Unit 6: Floriculture

Cut flowers, bonsai, commerce (market demand and supply); Importance of flower shows and exhibitions.

Unit 7: Post-harvest technology

Importance of post harvest technology in horticultural crops; Evaluation of quality traits; Harvesting and handling of fruits, vegetables and cut flowers; Principles, methods of preservation and processing; Methods of minimizing loses during storage and transportation; Food irradiation - advantages and disadvantages; food safety.

Unit 8: Disease control and management

Field and post-harvest diseases; Identification of deficiency symptoms; remedial measures and nutritional management practices; Crop sanitation; IPM strategies (genetic, biological and chemical methods for pest control); Quarantine practices; Identification of common diseases and pests of ornamentals, fruits and vegetable crops.

Unit 9: Horticultural crops - conservation and management

Documentation and conservation of germplasm; Role of micro propagation and tissue culture techniques; Varieties and cultivars of various horticultural crops; IPR issues; National, international and professional societies and sources of information on horticulture.

Practical: Field trip

Field visits to gardens, standing crop sites, nurseries, vegetable gardens and horticultural fields at IARI or other suitable locations.

Suggested Readings

1. Singh, D. & Manivannan, S. (2009). Genetic Resources of Horticultural Crops. Ridhi International, Delhi, India.
2. Swaminathan, M.S. and Kochhar, S.L. (2007). Groves of Beauty and Plenty: An Atlas of Major Flowering Trees in India. Macmillan Publishers, India.

Course Outcomes (COs):

Aims to:

CO1: Explain the principles of post-harvest handling, storage, and processing.

CO2: Identify physiological and biochemical changes affecting quality after harvest.

CO3: Analyze post-harvest losses and propose strategies to minimize them.

CO4: Apply food preservation techniques, including drying, refrigeration, and packaging.

CO5: Evaluate technologies used in post-harvest management and value addition.

Mapping of Course Outcomes and Program Outcomes:

Cos/Pos	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO10	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5
CO-1	2	3	3	2	2	2	2	1	-	2	1	-	1	1	1
CO-2	3	2	1	2	3	1	0	2	1	1	2	2	2	2	2
CO-3	2	1	1	1	1	1	2	1	1	2	1	-	1	2	1
CO-4	1	2	2	1	1	1	1	1	-	1	2	1	3	2	1
CO-5	3	2	3	2	1	2	2	2	1	2	1	-	1	3	2
Average	2.2	2	2	1.6	1.6	1.4	1.4	1.4	1	1.6	1.4	1.5	1.6	2.0	1.4

Discipline Specific Elective

Research Methodology

(Credit: Theory 4; Practical 2)

Course Objectives :

The course aims to:

1. Introduce fundamental concepts and principles of scientific research.
2. Develop an understanding of research design, data collection, and analysis techniques.
3. Equip students with skills for writing research proposals, reports, and scientific papers.
4. Familiarize students with ethical considerations and intellectual property rights in research.
5. Enhance problem-solving and critical thinking abilities through statistical and qualitative analysis.

Theory

Unit 1: Basic concepts of research

Research-definition and types of research (Descriptive vs analytical; applied vs fundamental; quantitative vs qualitative; conceptual vs emperical). Research methods vs methodology. Literature- review and its consolidation; Library research; field research; laboratory research.

Unit 2: General laboratory practices

Common calculations in botany laboratories. Understanding the details on the label of reagent bottles. Molarity and normality of common acids and bases.Preparation of solutions. Dilutions. Percentage solutions. Molar, molal and normal solutions.Technique of handling micropipettes; Knowledge about common toxic chemicals and safety measures in their handling.

Unit 3: Data collection and documentation of observations

Maintaining a laboratory record; Tabulation and generation of graphs. Imaging of Tissue specimens and application of scale bars. The art of field photography.

Unit 4: Overview of Biological Problems

History; Key biology research areas, Model organisms in biology (A Brief overview): Genetics, Physiology, Biochemistry, Molecular Biology, Cell Biology, Genomics, Proteomics-Transcriptional regulatory network.

Unit 5: Methods to study plant cell/tissue structure

Whole mounts, peel mounts, squash preparations, clearing, maceration and sectioning; Tissue

preparation: living vs fixed, physical vs chemical fixation, coagulating fixatives, non-coagulant fixatives; tissue dehydration using graded solvent series; Paraffin and plastic infiltration; Preparation of thin and ultrathin sections.

Unit 6: Plant microtechniques

Staining procedures, classification and chemistry of stains. Staining equipment. Reactive dyes and fluorochromes (including genetically engineered protein labeling with GFP and other tags). Cytogenetic techniques with squashed plant materials.

Unit 7: The art of scientific writing and its presentation

Numbers, units, abbreviations and nomenclature used in scientific writing. Writing references. Powerpoint presentation. Poster presentation. Scientific writing and ethics, Introduction to copyright- academic misconduct/plagiarism.

Practical

1. Experiments based on chemical calculations.
2. Plant microtechnique experiments.
3. The art of imaging of samples through microphotography and field photography.
4. Poster presentation on defined topics.
5. Technical writing on topics assigned.

Suggested Readings

1.Dawson, C. (2002). Practical research methods. UBS Publishers, New Delhi.

2.Stapleton, P., Yondeowei, A., Mukanyange, J., Houten, H. (1995). Scientific writing for agricultural research scientists – a training reference manual. West Africa Rice Development Association, Hong Kong.

3.Ruzin, S.E. (1999). Plant microtechnique and microscopy. Oxford University Press, New York, U.S.A.

Course Outcomes (COs):

Aims to:

CO1: Explain key concepts, principles, and types of research methodologies.

CO2: Design a research study, including problem identification, hypothesis formulation, and data collection methods.

CO3: Apply statistical tools and qualitative techniques for data analysis and interpretation.

CO4: Develop research proposals, scientific reports, and technical papers.

CO5: Evaluate ethical considerations, plagiarism, and intellectual property rights in research

Mapping of Course Outcomes and Program Outcomes:

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5
CO1	3	2	2	2	1	1	2	2	1	1	1	-	3	2	1
CO2	3	3	3	3	2	1	2	3	-	1	3	2	2	3	3
CO3	3	3	3	3	2	2	2	3	1	1	2	-	1	3	3
CO4	3	3	3	3	3	2	2	3	1	1	2	1	2	3	3
CO5	3	3	3	3	3	3	3	3	2	1	1	-	1	3	3
Average	3	2.8	2.8	2.8	2.2	1.8	2.2	2.8	1.25	1	1.8	1.5	1.8	2.8	2.6

Discipline Specific Elective

Industrial and Environmental Microbiology

(Credits: Theory-4, Practical-2)

Course Objectives (COs):

The course aims to:

1. Provide fundamental knowledge of industrial and environmental microbiology.
2. Explain the role of microorganisms in bioprocessing, fermentation, and bio-product formation.
3. Develop an understanding of microbial applications in environmental sustainability, including bioremediation and wastewater treatment.
4. Equip students with laboratory skills in microbial culturing, isolation, and industrial applications.
5. Foster awareness of the impact of microbes on industries, agriculture, and environmental conservation.

Theory

Unit 1: Scope of microbes in industry and environment

Unit 2: Bioreactors/Fermenters and fermentation processes Solid-state and liquid-state (stationary and submerged) fermentations; Batch and continuous fermentations.

Unit 3: Microbial production of industrial products Microorganisms involved, media, fermentation conditions, downstream processing and uses; Filtration, centrifugation, solvent extraction, precipitation and ultrafiltration, Enzyme: amylase or lipase activity, Organic acid (citric acid or glutamic acid), alcohol (Ethanol) and antibiotic (Penicillin)

Unit 4: Microbial enzymes of industrial interest and enzyme immobilization .Microorganisms for industrial applications and hands on screening microorganisms for casein hydrolysis; starch hydrolysis; cellulose hydrolysis; Methods of immobilization.

Unit 5: Microbes and quality of environment. Distribution of microbes in air; Isolation of microorganisms from soil, air and water.

Unit 6: Microbial flora of water. Water pollution, role of microbes in sewage and domestic waste water treatment systems. Determination of BOD, COD, TDS and TOC of water samples; Microorganisms as indicators of water quality.

Unit 7: Microbes in agriculture and remediation of contaminated soils. Biological fixation; Mycorrhizae; Bioremediation of contaminated soils. Isolation of root nodulating bacteria, arbuscular mycorrhizal colonization in plant roots.

Practical

1.Principles and functioning of instruments in microbiology laboratory

2.Hands on sterilization techniques and preparation of culture media.

3. A visit to any educational institute/ industry to see an industrial fermenter, and other downstream processing operations.

Suggested Readings

1.Pelzar, M.J. Jr., Chen E.C. S., Krieg, N.R. (2010). Microbiology: An application based approach. Tata McGraw Hill Education Pvt. Ltd., Delhi.

2.Tortora, G.J., Funke, B.R., Case. C.L. (2007). Microbiology. Pearson Benjamin Cummings, San Francisco, U.S.A. 9th edition.

Course Outcomes (COs):

Aims to:

CO1: Explain the principles and applications of industrial and environmental microbiology.

CO2: Describe microbial fermentation, bioprocessing, and their role in industrial product development.

CO3: Analyze microbial interactions in ecosystems and their impact on the environment.

CO4: Apply microbial technologies for bioremediation, wastewater treatment, and pollution control.

CO5: Evaluate the role of genetically modified microbes in industrial and environmental applications.

CO6: Develop biotechnological solutions for sustainable industrial and environmental management.

Mapping of Course Outcomes and Program Outcomes:

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	2	2	2	1	3	2	-	2	2	1	1	1	2
CO2	3	3	3	3	2	1	3	3	1	3	3	2	3	2	1
CO3	3	3	3	3	2	2	3	3	-	3	3	3	3	3	2
CO4	3	3	3	3	3	2	3	3	1	3	3	3	1	3	1
CO5	3	3	3	3	3	3	3	3	2	3	3	3	3	2	1
CO6	3	3	3	3	3	3	3	3	3	3	3	3	1	3	-
Avarage	3.0	2.8	2.8	2.8	2.5	2.0	3.0	2.8	1.8	2.8	2.8	2.5	2.0	2.3	1.4