Syllabus of B.Sc. Botany

Semester	Courses Opted	Course name	Credits
I	Ability Enhancement Compulsory Course-I	English /MILCommunications/Environmental Science	2
	Core Course-I	Algae and Microbiology (BOAM011)	4
	Core Course-I Lab	Algae and Microbiology Lab (BOAM6101)	2
	Core Course-II	Biomolecules and Cell Biology (BOBC0102)	4
	Core Course-II Lab	Biomolecules and Cell Biology Lab (BOBC6102)	2
	Generic Elective-I	Generic Elective-I(Any one) 1.Biodiversity(Microbes, Algae, Fungi and Archegoniatae) 2.Plant Anatomy and Embryology	4
	Generic Elective-I Lab/ Tutorial	GE-I- 1) Biodiversity(Microbes, Algae, Fungi and Archegoniatae) Lab 2) Plant Anatomy and Embryology Lab	2
		Total	**20**
II	Ability Enhancement Compulsory Course-II	English /MILCommunications/Environmental Science	2
	Core Course-III	Mycology and Phytopathology (BOMP0103)	4
	Core Course-III Lab	Mycology and Phytopathology-Lab (BOMP6103)	2
	Core Course- IV	Archegoniate (BOAR0104)	4
	Core Course-IV Lab	Archegoniate Lab (BOAR6104)	2
	Generic Elective –II	GE-II 3. Plant Ecology and Taxonomy	4
	Generic Elective –II Lab	Plant Ecology and Taxonomy Lab	2
		Total	**20**

III	Core Course – V	Morphology and Anatomy	4
	Core Course – V Lab	Morphology and Anatomy Lab	2
	Core Course – VI	Economic Botany	4
	Core Course – VI Lab	Economic Botany Lab	2
	Core Course – VII	Genetics	4
	Core Course – VII Lab	Genetics Lab	2
	Skill Enhancement Course-I	SEC-I(Any one) 1.Ethnobotany 2.Intellectual Property Rights	2
	Generic Elective –III	GE-III(Any one) 4.Plant Ph1ysiology and Metabolism 5.Environmental Biotechnology	4
	Generic Elective –III Lab	Generic Elective –III 4.Plant Ph1ysiology and Metabolism Lab 5.Environmental Biotechnology Lab	2
		Total	**26**
IV	Core Course – VIII	Molecular Biology	4
	Core Course – VIII Lab	Molecular Biology Lab	2
	Core Course – IX	Plant Ecology and Phytogeography	4
	Core Course – IX Lab	Plant Ecology and Phytogeography Lab	2
	Core Course – X	Plant Systematics	4
	Core Course – X Lab	Plant Systematics Lab	2
	Skill Enhancement Course-II	SEC-II (Any one) 3 Biofertilizers 4 Medicinal Botany	2
	Generic Elective –IV	GE-IV Economic Botany and Biotechnology	4
	Generic Elective –IV Lab	GE-IV Economic Botany and Biotechnology Lab	2
		Total	**26**
	Core Course – XI	Reproductive Biology of Angiosperms	4

V	Core Course – XI Lab	Reproductive Biology of Angiosperms Lab	2
	Core Course – XII	Plant Physiology	4
	Core Course – XII Lab	Plant Physiology Lab	2
	Discipline Specific Elective-I	DSE-I Analytical Techniques in Plant Science	4
	Discipline Specific Elective-I Lab	Analytical Techniques in Plant Science Lab	2
	Discipline Specific Elective-II	DSE-II Biostatistics	4
	Discipline Specific Elective-II Lab	Biostatistics Lab	2
		Total	**24**
VI	Core Course – XIII	Plant Metabolism	4
	Core Course – XIII Lab	Plant Metabolism Lab	2
	Core Course – XIV	Plant Biotechnology	4
	Core Course – XIV Lab	Plant Biotechnology Lab	2
	Discipline Specific Elective-III	DSE-III Industrial and Environmental Microbiology	4
	Discipline Specific Elective-III lab	Industrial and Environmental Microbiology Lab	2
	Discipline Specific Elective-IV	DSE-IV Bioinformatics	4
	Discipline Specific Elective-IV Lab	Bioinformatics Lab	2
		Total	**24**
		Grand Total	**140**

Syllabus (B.Sc)
Department of Botany, ADBU, Tapesia Gardens, Sonapur

PROGRAM OUTCOMES-UG COURSE

PO-1: **Critical Thinking**: Take informed actions after identifying the assumptions that frame our thinking and actions, checking out the degree to which these assumptions are accurate and valid, and looking at our ideas and decisions (intellectual, organizational, and personal) from different perspective.

PO-2: **Effective Communication**: Speak, read, write and listen clearly in person and through electronic media, and make meaning of the world by connecting people, ideas, books, media and technology.

PO-3: **Social Interaction**: Elicit views of others, mediate disagreements and help reach conclusions in group settings.

PO-4: **Effective Citizenship**: Demonstrate empathetic social concern and the ability to act with an informed awareness of issues and participate in civic life through volunteering.

PO-5: **Ethics**: Recognize different value systems including your own, understand the moral dimensions of your decisions, and accept responsibility for them.

PO-6: **Environment and Sustainability**: Understand the issues of environmental contexts and sustainable development.

PO-7: **Self-directed and Life-long Learning**: Acquire the ability to engage in independent and life-long learning in the broadest context socio-technological changes.

PROGRAMME SPECIFIC OUTCOMES (PSO)-B. Sc Botany

PSO1: Understand the principles of identification and classification of various plants groups and microbes according to their morphology, anatomy and reproductive biology

PSO-2: Understand the fundamental principles of life processes, biomolecules and genetic make-up

PSO-3: Measurement of biodiversity, threats and development of conservation strategies.

PSO-4: Familiarization with various classical and advanced laboratory techniques in plant biology

PSO-5: Development of rational personal and professional abilities through effective communicative skills

Courses offered in B.Sc

1.1 Algae and Microbiology
1.2 Algae and Microbiology Lab
1.3 Biomolecules and Cell Biology
1.4 Biomolecules and Cell Biology Lab
1.5 Biodiversity(Microbes, Algae, Fungi and Archegoniatae) (GE1)
1.6 Biodiversity(Microbes, Algae, Fungi and Archegoniatae) Lab(GE)
1.7 Plant Anatomy and Embryology (GE2)
1.8 Plant Anatomy and Embryology Lab (GE)
1.9 English Communication

2.1 Mycology and Phytopathology
2.2 Mycology and Phytopathology Lab
2.3 Archegoniate
2.4 Archegoniate Lab
2.5 Plant Ecology and Taxonomy (GE)
2.6 Plant Ecology and Taxonomy Lab (GE)

3.1 Morphology and Anatomy
3.2 Morphology and Anatomy Lab
3.3 Economic Botany
3.4 Economic Botany Lab
3.5 Genetics
3.6 Genetics Lab
3.7 Plant Physiology and Metabolism (GE1)
3.8 Plant Physiology and Metabolism Lab
3.9 Environmental Biotechnology (GE2)
3.10 Environmental Biotechnology Lab

3.11 Ethnobotany (Skill development 1)
3.12 Intellectual Property Rights (Skill development 2)

4.1 Molecular Biology
4.2 Molecular Biology Lab
4.3 Plant Ecology and Phytogeography
4.4 Plant Ecology and Phytogeography Lab
4.5 Plant Systematics
4.6 Plant Systematics Lab
4.7 Biofertilizers (Skill development 1)
4.8 Medicinal Botany (Skill development 2)
4.9 Economic Botany and Biotechnology (GE)
4.10 Economic Botany and Biotechnology Lab(GE)

5.1 Reproductive Biology of Angiosperms
5.2 Reproductive Biology of Angiosperms Lab
5.3 Plant Physiology
5.4 Plant Physiology Lab
5.5 Analytical Techniques in Plant Science (DSE1)
5.6 Analytical Techniques in Plant Science Lab
5.7 Biostatistics (DSE2)
5.8 Biostatistics Lab

6.1 Plant Metabolism
6.2 Plant Metabolism Lab
6.3 Plant Biotechnology
6.4 Plant Biotechnology Lab
6.5 Industrial and Environmental Microbiology (DSE1)

6.6 Industrial and Environmental Microbiology Lab
6.7 Bioinformatics (DSE2)
6.8 Bioinformatics Lab

Mapping of COs to PO/PSO

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
1.1	L	M	L	L	L	L	H	H	L		M	
1.2	M	L	L	L	L	L	H	M			M	
1.3	H								H			
1.4	H								H		M	
1.5	M			L		M	H	H	L			
1.6	M	L		L	L	M	H	H			H	
1.7	L	L		L			H	H				
1.8	M	L					H	H	H			
1.9		H										H
2.1	L	M	L	L	L	L	H	M	L		L	
2.2	M			L	L	L	H	M			M	
2.3	M	M	H	H	M	H	M	H	L			
2.4		L		L	M		H	H			H	
2.5	L	L	L	M		H	H			M	L	
2.6	M	L	L	M		H	L			M	H	
3.1	M		L				L	H				
3.2	M							H			L	
3.3	M			M		M	H	M		L		
3.4	M	L	L	M		M	H	M		L	L	
3.5	H		M		M		H		H		M	
3.6	M				M		H		H		H	
3.7	M	L		L	L	L	H	H	M		L	
3.8	M	L	L	L	L	L	H	L	M		M	
3.9	M			H	H	H	M			M	L	
3.10	M				M	M				M	M	
3.11	M		H	H	H			M		M		

3.12	H	H	M		H		H			L		
4.1	H				L				M		H	
4.2	H				L				M		H	
4.3	M		L	L	M	H	M	L	L	H	L	
4.4	M							L		H	H	
4.5			M	M	L	H	M	H				
4.6	H				M	H	M	H			H	
4.7			M	M		H	M	H			M	
4.8		H	H	L	M	L	M			H		
4.9	L	L	L	M	L	M	H	M		L		
4.10	M	L	L	L		M	H	M		L	L	
5.1	M		L				M	H	L		M	
5.2	M							L			M	
5.3	M					L			H		M	
5.4	M					L			H		M	
5.5	H		M		M		H		L		H	
5.6	H				L		H		M		H	
5.7	M	L			L		H			L	L	
5.8	M	L			L		H			L	L	
6.1	M				M		H		H			
6.2	M				L		H		H		H	
6.3	H				H	M				H	H	
6.4	H				H	M				H	H	
6.5	M	L	L	M	L	H	M	L		L	L	
6.6	M	L	L	M	M	H	M	L		H	M	
6.7	L	L			L		H		L			
6.8	M				L		H		L			

SEMESTER I

BOAM011: Algae And Microbiology

(4 Credits-60 Hours)

(4-0-0)

Course outcomes

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

CO-1: Understand different microorganisms and their importance (Understanding)

CO-2: Able to identify and characterize microorganisms (Applying)

CO-3: To assess the importance of microbial activities in food industry and therapeutics (Analysing)

CO-4: Able to identify beneficial and harmful microbes (Evaluating)

Syllabus:

Module I: Introduction to microbial world (7 Hours)

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).

Module II: Viruses(7 Hours)

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).

ModuleIII: Bacteria(7 Hours)

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).

Module IV:Algae (11 Hours)

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 (F.E. Fritsch, G.M. Smith, R.N. Singh, T.V. Desikachary, H.D. Kumar, M.O.P. Iyengar). Role of algae in the environment, agriculture, biotechnology and industry.

Module V:Cyanophyta and Xanthophyta(8 Hours)

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

ModuleVI:Chlorophyta and Charophyta(8 Hours)

Chlorophyta and Charophyta General characteristics; Occurrence; Range of thallus organization; Cell structure; Reproduction. Morphology and life-cycles of Chlamydomonas, Volvox, Oedogonium, Coleochaete, Chara. Evolutionary significance of Prochloron.

Module VII:Phaeophyta and Rhodophyta(12 Hours)

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

Mapping:

	Module-1	Module-2	Module-3	Module-4	Module-5	Module-6	Module-7
CO-1	M	H	H	H	L		
CO-2	L	M	M	M	H	H	H
CO-3	M			H		L	
CO-4	L	L	L	L	H	M	M

BOAM6101: Algae And Microbiology LAB

(2 Credits: 30 hrs)

(0-0-2)

Course outcomes

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

CO-1: Differentiate between cell shapes and structures of microorganisms (Applying).

CO-2: Able to understand reproduction and multiplication processes in microbes (Understanding).

CO-3: Utilize and create basic identification techniques for microbes (Creating).

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. Electron micrographs of bacteria, binary fission, endospore, conjugation, root Nodule.
3. Gram staining.
4. Endospore staining with malachite green using the (endospores taken from soil bacteria).

Phycology

1. Study of vegetative and reproductive structures of Nostoc, Chlamydomonas (electron micrographs), Volvox, Oedogonium,Coleochaete, Chara, Vaucheria, Ectocarpus, Fucus and Polysiphonia, Procholoron through electron micrographs, temporary preparations and permanent slides.

Mapping:

	Practical-1	Practical-2	Practical-3	Practical-4	Practical-5
CO-1	L	H	M	M	M
CO-2		M	L	M	H
CO-3		M	L		H

Suggested Readings

1. Lee, R.E. (2008). Phycology, Cambridgehe University Press, Cambridge. 4th edition. 2.Wiley JM, Sherwood LM and Woolverton CJ. (2013) Prescott's Microbiology. 9th Edition. McGraw Hill International.
2. Kumar, H.D. (1999). Introductory Phycology. Affiliated East-West Press, Delhi.
3. Sahoo, D. (2000). Farming the ocean: seaweeds cultivation and utilization. Aravali International, New Delhi.

4. 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. ll
5. Pelczar, M.J. (2001) Microbiology, 5th edition, Tata McGraw-Hill Co, New Delhi.

BOBC0102: Biomolecules And Cell Biology

(4 Credits-60 Hours)

(4-0-0)

Course outcomes

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

1)To recall the properties and economic importance of enzymes (Remembering).

2)To memorize the general characteristics of carbohydrates, proteins, nucleic acids and lipids and how they are imported/exported to various organelles (Remembering).

3)To acquire comprehensive knowledge on the general structure of proteins (Understanding).

4)To interpret the basics of mode of actions of enzymes (Understanding).

5) To understand the importance of cell cycle and its regulation in controlling diseases (Understanding).

Module I: Biomolecules (20 Hours)

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; Triacylglycerols 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.

Module II: Bioenergenetics (4 Hours)

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

Module III: Enzymes (6 Hours)

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.

Module IV: The cell (4 Hours)

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

Module V: Cell wall and plasma membrane (4 Hours)

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.

Module VI: Cell organelles (16 Hours)

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

Module VII: Cell division (6 Hours)

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

Mapping of COs to Syllabus

	Module 1	Module 2	Module 3	Module 4	Module 5	Module 6	Module 7

CO 1	-	-	H	-	-	-	-
CO 2	H	-	-	L	-	M	-
CO 3	H	-	-	-	-	L	-
CO 4	-	-	H	-	-	-	-
CO 5	-	-	-	-	-	-	H

BOBC6102: Biomolecules And Cell Biology LAB

(2 Credits: 30 hrs)

(0-0-2)

Course outcomes

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

1)To recall the properties of carbohydrates, reducing sugars, non-reducing sugars, lipids and proteins (Remembering).

2)To memorize the common tests of carbohydrates, proteins, nucleic acids and lipids and their classification (Remembering).

3)To acquire comprehensive knowledge on the logic behind the cell structure and functions (Understanding).

4)To comprehend the basics of cell structure (Understanding).

Practicals:

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. Demonstration of the phenomenon of protoplasmic streaming in Hydrilla leaf.
4. Measurement of cell size by the technique of micrometry.
5. Counting the cells per unit volume with the help of haemocytometer. (Yeast/pollen grains).
6. Study of cell and its organelles with the help of electron micrographs.

7. Cytochemical staining of : DNA- Feulgen and cell wall in the epidermal peel of onion using Periodic Schiff's (PAS) staining technique.
8. Study the phenomenon of plasmolysis and deplasmolysis.
9. Study the effect of organic solvent and temperature on membrane permeability.
10. Study different stages of mitosis and meiosis.

Mapping of COs to Syllabus

	CO1	CO2	CO3	CO4
Prac 1	H	H	-	-
Prac 2	-	-	-	-
Prac 3	-	-	-	-
Prac 4	-	-	-	-
Pract 5	-	-	-	-
Prac 6	-	-	-	-
Prac 7	-	-	-	-

Prac 8	-	-	H	M
Prac 9	-	-	M	L
Prac 10	-	-	L	H

Suggested Readings

1. Campbell, MK (2012) Biochemistry, 7th ed., Published by Cengage Learning
2. Campbell, PN and Smith AD (2011) Biochemistry Illustrated, 4th ed., Published by Churchill Livingstone
3. Tymoczko JL, Berg JM and Stryer L (2012) Biochemistry: A short course, 2nd ed., W.H.Freeman
4. Berg JM, Tymoczko JL and Stryer L (2011) Biochemistry, W.H.Freeman and Company
5. Nelson DL and Cox MM (2008) Lehninger Principles of Biochemistry, 5th Edition., W.H. Freeman and Company.
6. Karp, G. (2010). Cell Biology, John Wiley & Sons, U.S.A. 6th edition.
7. Hardin, J., Becker, G., Skliensmith, L.J. (2012). Becker's World of the Cell, Pearson Education Inc. U.S.A. 8th edition.
8. Cooper, G.M. and Hausman, R.E. (2009) The Cell: A Molecular Approach. 5th edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA. 17
9. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009) The World of the Cell. 7th edition. Pearson Benjamin Cummings Publishing, San Francisco

Generic Elective

Biodiversity (Microbes, Algae, Fungi and Archegoniate)
(4Credits: 60 Hrs)
(4-0-0)

Course outcomes

1. Summarize viruses with respect to their types, replication, life-cycle, reproduction and economic importance (Understanding)

2. Illustrate the classification, morphology, anatomy and economic importance of algae (Understanding)
3. Compare fungi, lichens and mycorrhiza (Understanding)
4. Interpret the classification, morphology, anatomy, reproduction and economic importance of archegoniates (Understanding)

Module I: Microbes (10 Hrs)

Viruses – Discovery, general structure, replication (general account), DNA virus (T-phage); Lytic and lysogenic cycle, RNA virus (TMV); Economic importance; Bacteria –Discovery, General characteristics and cell structure; Reproduction – vegetative, asexual and recombination (conjugation, transformation and transduction); Economic importance.

Module II: Algae (12 Hrs)

General characteristics; Ecology and distribution; Range of thallus organization and reproduction; Classification of algae; Morphology and life - cycles of the following: Nostoc, Chlamydomonas, Oedogonium, Vaucheria, Fucus, Polysiphonia . Economic importance of algae.

Module III: Fungi (12 Hrs)

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 of Rhizopus (Zygomycota) Penicillium,Alternaria (Ascomycota), Puccinia, Agaricus (Basidiomycota); Symbiotic Associations - Lichens: General account, reproduction and significance; Mycorrhiza: ectomycorrhiza andendomycorrhiza and their significance.

Module IV: Introduction to Archegoniate (2 Hrs)

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

Module V: Bryophytes (10 Hrs)

General characteristics, adaptations to land habit, Classification, Range of thallus organization.Classification (up to family), morphology, anatomy and reproduction of Marchantia and Funaria.(Developmental details not to be included).Ecology and economic importance of bryophytes with special mention of Sphagnum.

Module VI: Pteridophytes (8 Hrs)

General characteristics, classification, Early land plants (Cooksonia and Rhynia). Classification (up to family), morphology, anatomy and reproduction of Selaginella, Equisetum and Pteris.(Developmental details not to be included).Heterospory and seed habit, stellar evolution.Ecological and economical importance of Pteridophytes.

Module VII: Gymnosperms (6 Hrs)

General characteristics, classification: Classification (up to family), morphology, anatomy and reproduction of Cycas and Pinus.(Developmental details not to be included).Ecological and economical importance.

Mapping of Cos to Syllabus

	Module I	Module II	Module III	Module IV	Module V	Module VI	Module VII
CO1	H						
CO2		H					
CO3			H				
CO4				M	H	H	H

Biodiversity (Microbes, Algae, Fungi and Archegoniate) Lab (2Credits: 30 hrs)
(0-0-2)

Course outcomes

1. Interpret bacteria and viruses (Understanding)
2. Dissect the steps involved in gram staining (Analyzing).
3. Illustrate the unique features of algae and fungi (Understanding).
4. Compare lichens with mycorrhiza (Understanding).
5. Interpret the distinguishing characters of bryophytes, pteridophytes and gymnosperms (Understanding)

Practicals:

1. EMs/Models of viruses –T- Phage and TMV, Line drawing/Photograph of Lytic andLysogenic Cycle.
2. Types of Bacteria from temporary/permanent slides/photographs; EM bacterium; Binary Fission; Conjugation; Structure of root nodule.
3. Gram staining

4. Study of vegetative and reproductive structures of Nostoc, Chlamydomonas (electron micrographs), Oedogonium, Vaucheria, Fucus* and Polysiphonia through temporary preparations and permanent slides. (* Fucus - Specimen and permanent slides)
5. Rhizopus and Penicillium : Asexual stage from temporary mounts and sexual structuresthrough permanent slides.
6. Alternaria: Specimens/photographs and tease mounts.
7. Puccinia : Herbarium specimens of Black Stem Rust of Wheat and infected Barberryleaves; section/tease mounts of spores on Wheat and permanent slides of both the hosts.
8. Agaricus: Specimens of button stage and full grown mushroom; Sectioning of gills of Agaricus.
9. Lichens: Study of growth forms of lichens (crustose, foliose and fruticose)
10. Mycorrhiza: ecto mycorrhiza and endo mycorrhiza (Photographs)
11. Marchantia- morphology of thallus, w.m. rhizoids and scales, v.s. thallus through gemma cup, w.m. gemmae (all temporary slides), v.s. antheridiophore, archegoniophore, l.s. sporophyte (all permanent slides).
12. Funaria- morphology, w.m. leaf, rhizoids, operculum, peristome, annulus, spores(temporary slides); permanent slides showing antheridial and archegonial heads, l.s. capsule and protonema.
13. Selaginella- morphology, w.m. leaf with ligule, t.s. stem, w.m. strobilus,
w.m.microsporophyll and megasporophyll (temporary slides), l.s. strobilus (permanent slide).
14. Equisetum- morphology, t.s. internode, l.s. strobilus, t.s. strobilus, w.m.
sporangiophore,w.m. spores (wet and dry)(temporary slides); t.s rhizome (permanent slide).
15. Pteris- morphology, t.s. rachis, v.s. sporophyll, w.m. sporangium, w.m. spores(temporary slides), t.s. rhizome, w.m. prothallus with sex organs and young sporophyte (permanent slide).
16. Cycas- morphology (coralloid roots, bulbil, leaf), t.s. coralloid root, t.s. rachis, v.s. leaflet,v.s. microsporophyll, w.m. spores (temporary slides), l.s. ovule, t.s. root (permanent slide).
17. Pinus- morphology (long and dwarf shoots, w.m. dwarf shoot, male and female), w.m.dwarf shoot, t.s. needle, t.s. stem, , l.s./t.s. male cone, w.m. microsporophyll, w.m. microspores (temporary slides), l.s. female cone, t.l.s. &r.l.s. stem (permanent slide).

Mapping of Cos to Syllabus

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
CO1	H	H	M														
CO2			H														

CO3				H	H	H	H	H									
CO4									H	H							
CO5											H	H	H	H	H	H	H

Suggested Readings

1. Kumar, H.D. (1999). Introductory Phycology. Affiliated East - West. Press Pvt. Ltd. Delhi. 2nd edition.
2. Tortora, G.J., Funke, B.R., Case, C.L. (2010). Microbiology: An Introduction, Pearson Benjamin Cummings, U.S.A. 10th edition.
3. Sethi, I.K. and Walia, S.K. (2011). Text book of Fungi & Their Allies, MacMillan Publishers Pvt. Ltd., Delhi.
4. Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996). Introductory Mycology, John Wiley and Sons (Asia), Singapore. 4th edition.
5. Raven, P.H., Johnson, G.B., Losos, J.B., Singer, S.R., (2005). Biology. Tata McGraw Hill, Delhi, India.
6. Vashishta, P.C., Sinha, A.K., Kumar, A., (2010). Pteridophyta, S. Chand. Delhi, India.
7. Bhatnagar, S.P. and Moitra, A. (1996). Gymnosperms. New Age International (P) Ltd Publishers, New Delhi, India.
8. Parihar, N.S. (1991). An introduction to Embryophyta. Vol. I. Bryophyta. Central Book Depot, Allahabad.

Plant Anatomy and Embryology
(4 Credits: 60 Hrs)
(4-0-0)

Course outcomes

1. Classify meristematic tissues and permanent tissues (Understanding)
2. Compare dicots with monocots and also illustrate the adaptive and protective structures present in plants (Understanding)
3. Explain secondary growth in dicots (Understanding)
4. Outline the unique features of a flower and also explain pollination and fertilization (Understanding)
5. Compare embryo with endosperm and apomixes with polyembryony (Understanding)

Module I: Meristematic and permanent tissues (8 Hrs)

Root and shoot apical meristems; Simple and complex tissues.

Module II: Organs (4 Hrs)

Structure of dicot and monocot root stem and leaf.

Module III: Secondary Growth (8 Hrs)
Vascular cambium – structure and function, seasonal activity. Secondary growth in root and stem, Wood (heartwood and sapwood).

Module IV: Adaptive and protective systems (8 Hrs)
Epidermis, cuticle, stomata; General account of adaptations in xerophytes and hydrophytes.

Module V: Structural organization of flower (8 Hrs)
Structure of anther and pollen; Structure and types of ovules; Types of embryo sacs, organization and ultrastructure of mature embryo sac.

Module VI: Pollination and fertilization (8 Hrs)
Pollination mechanisms and adaptations; Double fertilization; Seed -
structure appendages and dispersal mechanisms.

Module VII: Embryo and endosperm (8 Hrs)
Endosperm types, structure and functions; Dicot and monocot embryo; Embryo endosperm relationship.

Module VIII: Apomixis and polyembryony (8 Hrs)
Definition, types and Practical applications

Mapping of Cos to Syllabus

	Module I	Module II	Module III	Module IV	Module V	Module VI	Module VII	Module VIII
CO1	H							
CO2		H		H				
CO3			H					

CO4					H	H		
CO5							H	H

Plant Anatomy and Embryology Lab
(2Credits: 30 hrs)
(0-0-2)

Course outcomes

1. Classify meristems and tissue (Understanding)
2. Outline dicots and monots with respect to their stem, roots and leaves (Understanding)
3. Interpret the adaptive structures in plants (Understanding)
4. Illustrate anther structure and explain pollination types and seed dispersal mechanisms (Understanding)
5. Classify the different types of ovules and also demonstrate the female gametophyte its structure and development (Understanding)
6. Plan the dissection of embryo or endosperm from seeds and experiment with seed germination (Applying)

Practicals:

1. Study of meristems through permanent slides and photographs.
2. Tissues (parenchyma, collenchyma and sclerenchyma); Macerated xylary elements, Phloem (Permanent slides, photographs)
3. Stem: Monocot: Zea mays; Dicot: Helianthus; Secondary: Helianthus
(only Permanent lides).
4. Root: Monocot: Zea mays; Dicot: Helianthus; Secondary: Helianthus (only Permanent lides).
5. Leaf: Dicot and Monocot leaf (only Permanent slides).
6. Adaptive anatomy: Xerophyte (Nerium leaf); Hydrophyte (Hydrilla stem).
7. Structure of anther (young and mature), tapetum (amoeboid and secretory) (Permanent lides).
8. Types of ovules: anatropous, orthotropous, circinotropous, amphitropous/ campylotropous.
9. Female gametophyte: Polygonum (monosporic) type of Embryo sac Development (Permanent slides/photographs).
10. Ultrastructure of mature egg apparatus cells through electron micrographs.
11. Pollination types and seed dispersal mechanisms (including appendages, aril, caruncle) Photographs and specimens).
12. Dissection of embryo/endosperm from developing seeds.

13. Calculation of percentage of germinated pollen in a given medium.

Mapping of Cos to Syllabus

	1	2	3	4	5	6	7	8	9	10	11	12	13
CO1	H	H											
CO2			H	H	H								
CO3						H							
CO4							H				H		
CO5								H	H	H			
CO6												H	H

Suggested Readings

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

EGEC0107: ENGLISH COMMUNICATION

(2 Credits- 30 Hours)

Course Outcomes:

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

CO1: The students will be able to *identity* the purpose of language as a means of communication. (Remembering)

CO2: The students will be able to *differentiate*between personal communication,social interactions and professional communication. (Understanding)

CO3: The students will be able to *apply* theoretical as well as practical norms and skills for effective communication during group discussion and personal interviews. (Applying)

CO4: The students will be able to *analyse* a creative composition in terms of the theoretical and practical paradigms of effective communication.(Analysing)

CO5: The students will be able to *assess* and *interpret* the secrets of effective communication. (Evaluating)

CO6: The students will be able to *compose* and *modify* creative compositions to ascertain effective communication among readers. (Creating)

Syllabus:

Module I: Introduction

Theory of Communication, Types and modes of Communication

Module II: Language of Communication

Verbal and Non-verbal (Spoken and Written) Personal, Social and BusinessBarriers and Strategies, Intra-personal, Inter-personal and Group communication

Module III: Speaking Skills

Monologue, Dialogue, Group Discussion Effective Communication/ Mis-Communication, Interview, PublicSpeech

Module IV: Reading and Understanding

Close Reading, Comprehension, Summary, Paraphrasing, Analysis andInterpretationTranslation (from Indian language to English and vice-versa) Literary/KnowledgeTexts

Module V: Writing Skills

Documenting, Report Writing, Making notes, Letter writing

Suggested Readings:

1. *Fluency in English* - Part II, Oxford University Press, 2006.

2. *Business English*, Pearson, 2008.

3. *Language, Literature and Creativity*, Orient Blackswan, 2013.

4. *Language through Literature* (forthcoming) ed. Dr. Gauri Mishra, Dr Ranjana

Kaul,DrBrati Biswas, 2017.

SEMESTER II

BOMP0103: Mycology And Phytopathology

(4 Credits-60 Hours)

(4-0-0)

Course Outcomes

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

CO-1: Able to tell and name different fungi, their classification process/criteria (Remembering).

CO-2: Able to explain fungal cell organization; illustrate their reproduction mechanisms (Understanding).

CO-3: Make use of the knowledge gained to solve important fungal and other related diseases in plants (Applying).

CO-4: Determine the application of fungi in industries and agriculture (Evaluate).

Syllabus:

Module I: Introduction to true fungi (6 Hours)

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

Module II: Chytridiomycota and Zygomycota (5 Hours)

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

Module III: Ascomycota (10 Hours)

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.

Module IV: Basidiomycota (8 Hours)

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.

Module V: Allied Fungi (3 Hours)

General characteristics; Status of Slime molds, Classification; Occurrence; Types of plasmodia; Types of fruiting bodies.

Module VI: Oomycota (4 Hours)

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

Module VII: Symbiotic associations (4 Hours)

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.

Module VIII: Applied Mycology (10 Hours)

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.

Module IX: Phytopathology (10 Hours)

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.

	Module-1	Module-2	Module-3	Module-4	Module-5	Module-6	Module-7	Module-8	Module-9
CO-1	L	M	H	H	H	H	L	M	
CO-2	M	H	H	H	H	H	L	M	
CO-3	L	L	L	L	L	L	L	M	H
CO-4			M	H			M	H	L

BOMP6103: Mycology And Phytopathology LAB

(2 Credits: 30 hrs)

(0-0-2)

Course outcomes

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

CO-1: Able to recall the general structure of fungi and show their reproductive structures (Remembering).

CO-2: Able to demonstrate thallus structure of different classes of fungi (Understanding).

CO-3: Examine the methods of reproduction in fungi (Analyzing).

CO-4: Able to formulate control measures of deadly plant pathogens and also develop plans for preparation of herbarium (Creating).

Practicals:

1. Introduction to the world of fungi (Unicellular, coenocytic/septate mycelium, ascocarps&basidiocarps).
2. Rhizopus: study of asexual stage from temporary mounts and sexual structures through permanent slides.
3. Aspergillus and Penicillium: study of asexual stage from temporary mounts. Study of Sexual stage from permanent slides/photographs.
4. Peziza: sectioning through ascocarp.
5. Alternaria: Specimens/photographs and temporary mounts.
6. Puccinia: Herbarium specimens of Black Stem Rust of Wheat and infected Barberry leaves; sections/ mounts of spores on wheat and permanent slides of both the hosts.
7. Agaricus: Specimens of button stage and full grown mushroom; sectioning of gills of Agaricus, fairy rings and bioluminescent mushrooms to be shown.
8. Study of phaneroplasmodium from actual specimens and /or photograph. Study of Stemonitis sporangia.
9. Albugo: Study of symptoms of plants infected with Albugo; asexual phase study through section/ temporary mounts and sexual structures through permanent slides.
10. Lichens: Study of growth forms of lichens (crustose, foliose and fruticose) on different substrates. Study of thallus and reproductive structures (soredia and apothecium) through permanent slides. Mycorrhizae: ectomycorrhiza and endomycorrhiza (Photographs)
11. 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.

Mapping:

	Practical-1	Practical-2	Practical-3	Practical-4	Practical-5	Practical-6	Practical-7	Practical-8	Practical-9	Practical-10	Practical-11
CO-1	M	H	M	M	L			L	M	M	
CO-2	H				L		M			M	
CO-3	L	H	M	L		L	M	M			L
CO-4						M			L		H

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.

BOAR0104: Archegoniate

(4 Credits-60 Hours)

(4-0-0)

Course outcomes

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

1. Recall the unique features of archegoniate (Remembering)
2. Summarize the different land habits and alternation of generation in archegoniates (Understanding)
3. Classify the different archegoniates and demonstrate their morphology, anatomy and reproduction (Understanding)
4. Illustrate the economic importance of bryophytes, pteridophytes and gymnosperms (Understanding)

Syllabus:

Module I: Introduction (2 hours)

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

Module II: Bryophytes (18 hours)

General characteristics; Adaptations to land habit; Classification; Range of thallus organization.Classification (up to family).*Riccia, Marchantia, Pellia, Porella, Anthoceros, Sphagnum and Funaria*; Reproduction and evolutionary trends in Riccia, Marchantia, Anthoceros and Funaria (developmental stages not included).

Module III: Pteridophytes (18hours)

General characteristics, classification, early land plants (*Cooksonia* and *Rhynia*). Classification (up to family), morphology, anatomy and reproduction of *Psilotum*, *Selaginella*, *Equisetum* and *Pteris*. (Developmental details not to be included).Apogamy, and apospory, heterospory and seed habit, telome theory, stellar evolution.

Module IV: Gymnosperms (18 hours)

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

Module V: Economic Importance (4 hours)

Ecological and economic importance of bryophytes with special reference to *Sphagnum*. Ecological and economic importance of pteridophytes and gymnosperms.

Mapping of Cos to Syllabus

	Module I	Module II	Module III	Module IV	Module V
CO1	M	L	L	L	
CO2	H				
CO3		H	H	H	
CO4					H

BOAR6104: Archegoniate LAB

(2 Credits: 30 hrs)

(0-0-2)

Course outcomes

1. Infer the various morphological, anatomical and reproductive features of important bryophytes (Understanding)
2. Interpret the various morphological, anatomical and reproductive features of important pteridophytes (Understanding)
3. Demonstrate the various morphological, anatomical and reproductive features of important gymnosperms (Understanding)
4. Develop the art of preparing slides of various archegoniate specimens and identifying them under the microscope (Applying)
5. Identify different bryophytes, pteridophytes and gymnosperms in their natural habitat (Applying)

Practicals:

1. ***Riccia*** – Study of morphology of thallus.

2. ***Marchantia***- Study of morphology of thallus, whole mount of rhizoids & Scales, vertical section of thallus through Gemma cup, whole mount of Gemmae (all temporary slides), vertical section of Antheridiophore, Archegoniophore, longitudinal section of Sporophyte (all permanent slides).

3. ***Anthoceros***- Study of morphology of thallus, dissection of sporophyte (to show stomata, spores,pseudoelaters, columella) (temporary slide), vertical section of thallus (permanent slide).

4. ***Pellia, Porella***- Study of these specimen through permanent slides.

5. ***Sphagnum***- Study of morphology of plant, whole mount of leaf (permanent slide only).

6. ***Funaria***- Study of morphology, whole mount of leaf, rhizoids, operculum, peristome, annulus, spores (temporary slides); permanent slides showing antheridial and archegonial heads, longitudinal section of capsule and protonema.

7. ***Psilotum***- Study of specimen, transverse section of synangium (permanent slide).

8. ***Selaginella***- Study of morphology, whole mount of leaf with ligule, transverse section of stem, whole mount of strobilus, whole mount of microsporophyll and megasporophyll (temporary slides), longitudinal section of strobilus (permanent slide).

9. ***Equisetum***- Study of morphology, transverse section of internode, longitudinal section ofstrobilus, transverse section of strobilus, whole mount of sporangiophore, whole mount of spores (wet and dry) (temporary slide), transverse section of rhizome (permanent slide).

10. ***Pteris***- To study the morphology, transverse section of rachis, vertical section of sporophyll, wholemount of sporangium, whole mount of spores (temporary slides), transverse section of rhizome, whole mount of prothallus with sex organs and young sporophyte (permanent slide).

11. ***Cycas***- To study the morphology (coralloid roots, bulbil, leaf), whole mount of microsporophyll,transverse section of coralloid root, transverse section of rachis, vertical section of leaflet, vertical section of microsporophyll, whole mount of spores (temporary slides), longitudinal section of ovule, transverse section of root (permanent slide).

12. ***Pinus***- To study the morphology (long and dwarf shoots, whole mount of dwarf shoot, male and female cones), transverse section of Needle, transverse section of stem, longitudinal section of /transverse section of male cone, whole mount of microsporophyll, whole mount of Microspores (temporary slides), longitudinal section of female cone, tangential longitudinal section and radial longitudinal sections stem (permanent slide).

13. ***Gnetum***- Study of morphology (stem, male & female cones), transverse section of stem, vertical section of ovule (permanent slide)

14. **Botanical excursion.**

Mapping of Cos to Syllabus

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	L	H	H	H	H	H								
CO2							H	H	H	H				
CO3											H	H	H	
CO4	M	M	M		M	M	M	M	M	M	M	M	M	
CO5														H

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. Vander-Poorteri 2009 Introduction to Bryophytes. COP

Generic elective

Plant Ecology and Taxonomy

(4 Credits: 60 Hrs)

(4-0-0)

Course Outcomes

1. Summarize ecology and its various factors (Understanding)
2. Interpret community and ecosystem (Understanding)
3. Rephrase the geographical distribution of plants (Understanding)

4. Outline the identification, classification and nomenclature of plants as well as explain taxonomic identification and hierarchy (Understanding)
5. Demonstrate the applied aspects of plant taxonomy (Understanding)
6. Interpret botanical nomenclature and classification and also compare biometrics, numerical taxonomy and cladistics (Understanding)

Syllabus:

Module I: Introduction (2 Hrs)

Module II: Ecological factors (10 Hrs)
Soil: Origin, formation, composition, soil profile. Water: States of water in the environment, precipitation types. Light and temperature: Variation Optimal and limiting factors; Shelford law of tolerance. Adaptation of hydrophytes and xerophytes.

Module III: Plant communities (6 Hrs)
Characters; Ecotone and edge effect; Succession; Processes and types.

Module IV: Ecosystem (8 Hrs)
Structure; energy flow trophic organisation; Food chains and food webs, Ecological pyramids production and productivity; Biogeochemical cycling; Cycling of carbon, nitrogen and Phosphorous.

Module V: Phytogeography (4 Hrs)
Principle biogeographical zones; Endemism.

Module VI: Introduction to plant taxonomy (2 Hrs)
Identification, Classification, Nomenclature.

Module VII Identification (4 Hrs)

Functions of Herbarium, important herbaria and botanical gardens of the world and India; Documentation: Flora, Keys: single access and multi-
access.

Module VIII: Taxonomic evidences from palynology, cytology, phytochemistry and molecular data (6 Hrs)

Module IX: Taxonomic hierarchy (2 Hrs)
Ranks, categories and taxonomic groups.

Module X: Botanical nomenclature (6 Hrs)
Principles and rules (ICN); ranks and names; binominal system, typification, author citation, valid publication, rejection of names, principle of priority and its limitations.

Module XI Classification (6 Hrs)
Types of classification-artificial, natural and phylogenetic. Bentham and Hooker (upto series), Engler and Prantl (upto series).

Module XII: Biometrics, numerical taxonomy and cladistics (4 Hrs)
Characters; variations; OTUs, character weighting and coding; cluster analysis; phenograms, cladograms (definitions and differences).

Mapping of Cos to Syllabus

	Module I	Module II	Module III	Module IV	Module V	Module VI	Module VII	Module VIII	Module IX	Module X	Module XI	Module XII
CO1	H	H										
CO2			H	H								
CO3					H							
CO4						H	H		H			
CO5								H				

CO6										H	H	H

Plant Ecology and Taxonomy Lab
(2Credits: 30 hrs)
(0-0-2)

Course Outcomes

1. Interpret the working principle of basic equipments used in ecological research (Understanding)
2. Infer the physiochemical characteristics of soil and water (Understanding)
3. Compare hydrophytes with xerophytes (Understanding)
4. Explain ecosystem structure (Understanding)
5. Summarize angiosperms (Understanding)
6. Utilize their knowledge on plant taxonomy to prepare herbarium (Applying)

Practicals:

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, and analysis of two soil samples for carbonates, chlorides, nitrates, sulphates, organic matter and base deficiency by rapid field test.
3. Comparison of bulk density, porosity and rate of infiltration of water in soil of three habitats.
4. (a) Study of morphological adaptations of hydrophytes and xerophytes (four each).(b)Study of biotic interactions of the following: Stem parasite (Cuscuta), Root parasite(Orobanche), Epiphytes, Predation (Insectivorous plants)
5. Determination of minimal quadrat size for the study of herbaceous vegetation in the college campus by species area curve method. (species to be listed)
6. Quantitative analysis of herbaceous vegetation in the college campus for frequency and comparison with Raunkiaer's frequency distribution law
7. Study of vegetative and floral characters of the following families (Description, V.S. flower, section of ovary, floral diagram/s, floral formula/e and systematic position according to Bentham & Hooker's system of classification):Brassicaceae –Brassica, Alyssum / Iberis; Asteraceae -

Sonchus/Launaea, Vernonia/Ageratum, Eclipta/Tridax; Solanaceae -
Solanum nigrum, Withania; Lamiaceae -Salvia, Ocimum, Liliaceae Asphodelus / Lilium / Allium.
8. Mounting of a properly dried and pressed specimen of any wild plant with herbarium label (to be submitted in the record book).

Mapping of Cos to Syllabus

	1	2	3	4	5	6	7	8
CO1	H							
CO2		H	H					
CO3				H				
CO4					H	H		
CO5							H	
CO6								H

Suggested Readings

1. Kormondy, E.J. (1996). Concepts of Ecology. Prentice Hall, U.S.A. 4th edition.
2. Sharma, P.D. (2010) Ecology and Environment. Rastogi Publications, Meerut, India. 8th edition.
3. Simpson, M.G. (2006). Plant Systematics. Elsevier Academic Press, San Diego, CA, U.S.A.
4. Singh, G. (2012). Plant Systematics: Theory and Practice. Oxford & IBH Pvt. Ltd., New Delhi. 3rd edition.

SEMESTER III

Morphology and Anatomy
(4 Credits: 60 Hrs)
(4-0-0)

Course Outcomes

1. Develop an understanding of concepts and fundamentals of plant anatomy (Understanding)
2. Examine the internal anatomy of plant systems and organs (Remembering)
3. Comprehend the concepts of organization and development of shoot and root apices (Understanding)
4. Examine the structure and role of cambium (Analyzing)
5. Studying the various concepts of wood and dendrochronology (Analyzing)
6. Evaluate the adaptive and protective systems of plants (Evaluating)
7. Evaluate the secretory systems in plants (Evaluating)

Module I Introduction and Scope of Plant anatomy (2 Hrs)

Applications in systematics, forensics and pharmacognosy

Module II Tissues (12 Hrs)

Classification of tissues; Simple and complex tissues (no phylogeny); cytodifferentiation of tracheary elements and sieve elements;Pits and plasmodesmata; Wall ingrowths and transfer cells, adcrustation and incrustation, Ergastic substances.

Module III Stem (8 Hrs)

Organization of shoot apex (Apical cell theory, Histogen theory, Tunica Corpus theory, continuing meristematic residue, cytohistological zonation); Types of vascular bundles; Structureof dicot and monocot stem.

Module IV Leaf (4 Hrs)
Structure of dicot and monocot leaf, Kranz anatomy.

Module V Root (6 Hrs)
Organization of root apex (Apical cell theory, Histogen theory, Korper- Kappe theory);
Quiescentcentre; Root cap; Structure of dicot and monocot root; Endodermis, exodermis and
origin of lateral root.

Module VI Vascular Cambium (6 Hrs)
Structure, function and seasonal activity of cambium; Secondary growth in root and stem.

Module VII Wood (8 Hrs)
Axially and radially oriented elements; Types of rays and axial parenchyma; Cyclic aspects and reaction wood; Sapwood and heartwood; Ring and diffuse porous wood; Early and late wood,
tyloses; Dendrochronology.

Module VIII Periderm (3 Hrs)
Development and composition of periderm, rhytidome and lenticels.

Module IX Adaptive and Protective Systems (8 Hrs)
Epidermal tissue system, cuticle, epicuticular waxes, trichomes
(uni - and multicellular, glandular and nonglandular, two examples of each), stomata (classification); Adcrustation and incrustation; Anatomical adaptations of xerophytes and hydrophytes.

Module X Secretory System (3 Hrs)
Hydathodes, cavities, lithocysts and laticifers.

Mapping of COs to Syllabus

	Module 1	Module 2	Module 3	Module 4	Module 5	Module 6	Module 7	Module 8	Module 9	Module 10
CO1	**H**	**H**	**H**	**M**						
CO2		**H**	**H**	**H**	**M**	**M**				
CO3					**H**					
CO4						**H**		**H**		
CO5							**H**			
CO6									**H**	
CO7		**L**								**H**

Morphology and Anatomy Lab
(2Credits: 30 hrs)
(0-0-2)
Course Outcomes

1. Prepare permanent slides, temporary stain mounts, macerations and museum specimens (Creating)
2. Gain the knowledge about apical meristem of root, shoot and vascular system (Understanding)
3. Apprehend the ideas of the distribution and types of tissues (Understanding)
4. Gain an understanding on secondary growth and wood anatomy in plants (Applying)
5. Scrutinize the different aspects of plant adaptations (Analyzing)
6. Estimate the importance of plant secretory systems (Evaluating)

Practicals:

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. Distribution and types of parenchyma, collenchyma and sclerenchyma.

4. Xylem: Tracheary elements- tracheids, vessel elements; thickenings; perforation plates; xylem fibres.
5. Wood: ring porous; diffuse porous; tyloses; heart-and sapwood.
6. Phloem: Sieve tubes-sieve plates; companion cells; phloem fibres.
7. Epidermal system: cell types, stomata types; trichomes: non-glandular and glandular.
8. Root: monocot, dicot, secondary growth.
9. Stem: monocot, dicot.- primary and secondary growth; periderm; lenticels.
10. Leaf: isobilateral, dorsiventral, C4 leaves (Kranz anatomy).
11. Adaptive Anatomy: xerophytes, hydrophytes.
12. Secretory tissues: cavities, lithocysts and laticifers.

Mapping of COs to Syllabus

	Module 1	Module 2	Module 3	Module 4	Module 5	Module 6	Module 7	Module 8	Module 9	Module 10	Module 11	Module 12
CO1	**H**											
CO2		**H**	**M**	**L**		**L**						
CO3			**H**	**M**		**L**	**H**					**M**
CO4				**L**	**H**	**L**		**H**	**H**			
CO5							**L**		**L**	**H**	**H**	**L**
CO6							**M**					**H**

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. Esau, K. (1977). Anatomy of Seed Plants. John Wiley & Sons, Inc., Delhi.

Economic Botany

(4Credit: 60 Hrs)
(4-0-0)

Course Outcomes

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

CO1: Tell the concept of origin of crops, crop domestication, evolution of new crops (Remembering)
CO2: Perceive the ideas of different economically useful crops (Understanding)
CO3: Execute the concepts developed in the class in their daily activities (Applying)
CO4: Survey the uses of economically important plants (Analyzing)
CO5: Modify and improve processing methods and techniques for essential oils and other useful crops (Creating)

Syllabus:

Module I: Origin of Cultivated Plants (6 Hrs)

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 diversty.

Module II Cereals (6 Hrs)

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

Module III Legumes (4 Hrs)

General account, importance to man and ecosystem.

Module IV Sugars & Starches (4 Hrs)

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

Module V: Spices (6 Hrs)

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

Module VI: Beverages (4 Hrs)

Tea, Coffee (morphology, processing & uses)

Module VII: Oils & Fats (8 Hrs)
General description, classification, extraction, their uses and health implications groundnut, coconut, linseed and Brassica and Coconut (Botanical name, family & uses)

Module VIII: Essential Oils (4 Hrs)
General account, extraction methods, comparison with fatty oils & their uses.

Module IX: Natural Rubber (3 Hrs)
Para-rubber: tapping, processing and uses.

Module X: Drug-yielding plants (4 Hrs)
Therapeutic and habit-forming drugs with special reference to Cinchona, Digitalis, Papaver and Cannabis.

Module XI: Tobacco (4 Hrs)
Tobacco (Morphology, processing, uses and health hazards)

Module XII: Timber plants (3 Hrs)
General account with special reference to teak and pine.

Module XIII: Fibres (4 Hrs)
Classification based on the origin of fibres, Cotton and Jute (morphology, extraction and uses).

Mapping:

	Module-1	Module-2	Module-3	Module-4	Module-5	Module-6	Module-7	Module-8	Module-9	Module-10	Module-11	Module-12	Module-13
CO-1	H	M	L	L	L	L	L	L	L	L	L	L	L
CO-2		M	M	H	M	M	M	M	M	M	M	M	M
CO-3		L	M	L	M	H	M	H	M		M		M

CO-4	**M**					**L**	**M**	**H**	**M**		**M**		**M**

Economic Botany Lab
(2Credits: 30hrs)
(0-0-2)

Course Outcomes

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

CO-1: Recollect the morphology and anatomy of various economically important plants (Remembering)
CO-2: Explain the economic importance of crop plants (Understanding)
CO-3: Execute various micro-chemical tests of cereals, legumes, sugars and starches (Applying)
CO-4: Able to carry out qualitative and quantitative checking of crop plant products (Evaluating)

Practicals:

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: Soya bean, Groundnut, (habit, fruit, seed structure, micro-chemical tests).
3. Sugars & 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. Spices: Black pepper, Fennel and Clove (habit and sections).
5. Beverages: Tea (plant specimen, tea leaves), Coffee (plant specimen, beans).
6. Oils & Fats: Coconut-T.S. Nut, Mustard–plant specimen, seeds; tests for fats in crushedseeds.
7. Essential oil-yielding plants: Habit sketch of Rosa, Vetiveria, Santalum and Eucalyptus (specimens/photographs).
8. Rubber: specimen, photograph/model of tapping, samples of rubber products.
9. Drug-yielding plants: Specimens of Digitalis, Papaver and Cannabis.
10. Tobacco : specimen and products of Tobacco.
11. Woods: Tectona, Pinus: Specimen, Section of young stem.
12. Fibre-yielding plants: Cotton (specimen, whole mount of seed to show lint and fuzz; whole

mount of fibre and test for cellulose), Jute (specimen, transverse section of stem, test for lignin on transverse section of stem and fibre).

Mapping:

	Practical-1	Practical2	Practical3	Practical4	Practical5	Practical6	Practical7	Practical8	Practical9	Practical10	Practical11	Practical-12
CO-1	M	H	M	L	M	M	M	M	M	M	L	M
CO-2	H	H	H	M	M	H	M	L	M	M	M	M
CO-3	M	M	M			H		L				M
CO-4	H	H	H	L	L	L	L			L		H

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. (2003). Plants, Genes and Agriculture. Jones & Bartlett Publishers.

Genetics
(4 Credits: 60 Hrs)
(4-0-0)

Course Outcomes

1. Summarize the concepts of Mendelian genetics (Understanding)
2. Infer the ideas behind extrachromosomal inheritance, linkage and crossing over (Understanding)
3. Explain numerical and structural chromosomal aberrations (Understanding)
4. Compare the various genetic mutations and explain DNA repair (Understanding)
5. Demonstrate the fine structure of the gene including complementation test (Understanding)
6. Rephrase the Hardy Weinberg Law (Understanding)
7. Solve numericals based on genetics (Applying)

Syllabus:

Module I: Mendelian genetics and its extension (16 Hrs)

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

Module II: Extrachromosomal Inheritance (6 Hrs)

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

Module III: Linkage, crossing over and chromosome mapping (12 Hrs)

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

Module IV: Variation in chromosome number and structure (8 Hrs)

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

Module V: Gene mutations (6 Hrs)

Types of mutations; Molecular basis of Mutations; Mutagens – physical and chemical (Base analogs, deaminating, alkylating and intercalating agents); Detection of mutations: ClB method.Role of Transposons in mutation. DNA repair mechanisms.

Module VI: Fine structure of gene (6 Hrs)

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

Module VII. Population and Evolutionary Genetics (6 Hrs)

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

Mapping of COs to Syllabus

	Module I	Module II	Module III	Module IV	Module V	Module VI	Module VII
CO1	H						
CO2		H	H				
CO3				H			
CO4					H		
CO5						H	
CO6							H
CO7	M		M	L			M

Genetics Lab
(2Credits: 30hrs)
(0-0-2)

Course Outcomes
1. Experiment with meiosis through slide prepartion (Applying)
2. Solve problems related to Mendel's laws, probability and chi-square analysis (Applying)
3. Examine test cross data for chromosome mapping (Analyzing)
4. Analyze pedigree charts (Analyzing)
5. Demonstrate incomplete dominance and gene interaction (Evaluating)
6. Interpret blood typing and human genetic disorders (Understanding)
7. Summarize the various chromosomal aberrations and human genetic traits (Understanding)

Practicals:

1. Meiosis through temporary squash preparation.
2. Mendel's laws through seed ratios. Laboratory exercises in probability and chi-square analysis.
3. Chromosome mapping using test cross data.
4. Pedigree analysis for dominant and recessive autosomal and sex linked traits.
5. Incomplete dominance and gene interaction through seed ratios (9:7, 9:6:1, 13:3, 15:1, 12:3:1, 9:3:4)
6. Blood Typing: ABO groups & Rh factor.
7. Study of aneuploidy: Down's, Klinefelter's and Turner's syndromes.
8. Photographs/Permanent Slides showing Translocation Ring, Laggards and Inversion Bridge.
9. Study of human genetic traits: Sickle cell anemia, XerodermaPigmentosum, Albinism, red-green Colour blindness, Widow's peak, Rolling of tongue, Hitchhiker's thumb and Attached ear lobe.

Mapping of COs to Syllabus

	1	2	3	4	5	6	7	8	9
CO1	H								
CO2		H							
CO3			H						
CO4				H					
CO5					H				
CO6						M	M		
CO7								M	M

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. (2012). Concepts of Genetics. Benjamin Cummings, U.S.A. 10th 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.

Generic Papers
Plant Physiology and Metabolism
(4Credits: 60 Hrs)
(4-0-0)

Course outcomes

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

CO-1: Recall the concepts of transportation mechanism and photosynthesis in plants (Remembering).
CO-2: Explain about enzymes and various metabolism mechanisms in plants (Understanding).
CO-3: Classify any given plants into various categories (Analysing).
CO-4: Evaluate plant growth characteristics through acquired knowledge (Evaluating).

Syllabus:

Module I: Plant-water relations (8 Hrs)

Importance of water, water potential and its components; Transpiration and its significance; Factors affecting transpiration; Root pressure and guttation.

Module II: Mineral nutrition s (8 Hrs)

Essential elements, macro and micronutrients; Criteria of essentiality of elements; Role of essential elements; Transport of ions across cell membrane, active and passive transport, carriers, channels and pumps.

Module III: Translocation in phloem. (6 Hrs)

Composition of phloem sap, girdling experiment; Pressure flow model; Phloem loading and unloading

Module IV: Photosynthesis (12 Hrs)

Photosynthetic Pigments (Chl a, b, xanthophylls, carotene); Photosystem I and II, reaction center, antenna molecules; Electron transport and mechanism of ATP synthesis; C3, C4 and CAM pathways of carbon fixation; Photorespiration.

ModuleV: Respiration (6 Hrs)
Glycolysis, anaerobic respiration, TCA cycle; Oxidative phosphorylation, Glyoxylate, Oxidative Pentose Phosphate Pathway.

ModuleVI: Enzymes (4 Hrs)
Structure and properties; Mechanism of enzyme catalysis and enzyme inhibition.

ModuleVII: Nitrogen metabolism (4 Hrs)
Biological nitrogen fixation; Nitrate and ammonia assimilation.

Module VIII: Plant growth regulators (6 Hrs)
Discovery and physiological roles of auxins, gibberellins, cytokinins, ABA, ethylene.

Module IX: Plant response to light and temperature (6 Hrs)
Photoperiodism (SDP, LDP, Day neutral plants); Phytochrome (discovery and structure), red and far red light responses on photomorphogenesis; Vernalization.

Mapping:

	Module-1	Module-2	Module-3	Module-4	Module-5	Module-6	Module-7	Module-8	Module-9
CO-1	H	H	H	H	M	L	M		L
CO-2	M	M	M	M	H	H	M	L	L
CO-3	L			H			L		M
CO-4	L	L	M	L	L		L	H	M

Plant Physiology and Metabolism Lab
(2Credits: 30hrs)
(0-0-2)

Course outcomes

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

CO-1: Illustrate various metabolic processes in plants (Understanding).

CO-2: Determine the role of enzymes and growth regulators in plants (Evaluating)

CO-3: Develop experiments using various techniques (Creating)

Practicals:

1. Determination of osmotic potential of plant cell sap by plasmolytic method.
2. To study the effect of two environmental factors (light and wind) on transpiration by excised twig.
3. Calculation of stomatal index and stomatal frequency of a mesophyte and a xerophyte.
4. Demonstration of Hill reaction.
5. Demonstrate the activity of catalase and study the effect of pH and enzyme concentration.
6. To study the effect of light intensity and bicarbonate concentration on O2 evolution in photosynthesis.
7. Comparison of the rate of respiration in any two parts of a plant.
8. Separation of amino acids by paper chromatography.

Demonstration experiments (any four)

1. Bolting.
2. Effect of auxins on rooting.
3. Suction due to transpiration.
4. R.Q.
5. Respiration in roots.

	Practical-1	Practical2	Practical3	Practical4	Practical5	Practical6	Practical7	Practical8	Practical9	Practical10
CO-1	M	M	L	H	M	H	L			
CO-2					H	L	M	L	H	H
CO-3	M	M	M	M	M	L	L	H	H	H

Suggested Readings

1. Taiz, L., Zeiger, E., MØller, I.M. and Murphy, A (2015). Plant Physiology and Development. Sinauer Associates Inc. USA. 6th edition.
2. Hopkins, W.G., Huner, N.P., (2009). Introduction to Plant Physiology. John Wiley & Sons, U.S.A. 4th Edition.
3. Bajracharya, D., (1999). Experiments in Plant Physiology- A Laboratory Manual. Narosa Publishing House, New Delhi. 48

Environmental Biotechnology

(4Credits: 60 Hrs)

(4-0-0)

Course Outcomes

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

CO1: Recall the basic knowledge of environment, its policies and how to protect it (Remembering)

CO2: Understand the concept of environmental hazards and how bioremediation helps in cleansing it (Understanding)

CO3: Analyse the basic concept of sustainable development (Analyzing)

CO4: Assess the various ways of microbial treatment to make the environment pollution free (Evaluating)

Syllabus:

Module I: Environment (4 Hrs)

Environment - basic concepts and issues, global environmental problems - ozone depletion, UV-B, greenhouse effect and acid rain due to anthropogenic activities, their impact and biotechnological approaches for management.

Module II: Atmospheric Stratification (6 Hrs)

An overview of atmosphere, hydrosphere, lithosphere and anthrosphere - environmental problems.Environmental pollution - types of pollution, sources of pollution, measurement of pollution, methods of measurement of pollution, fate of pollutants in the environment, Bioconcentration, bio/geomagnification.

Module III: Microbial Treatment (8 Hrs)

Microbiology of waste water treatment, aerobic process - activated sludge, oxidation ponds, trickling filter, towers, rotating discs, rotating drums, oxidation ditch. Anaerobic process - anaerobic digestion, anaerobic filters, up-flow anaerobic sludge blanket reactors. Treatment schemes for waste waters of dairy, distillery, tannery, sugar and antibiotic industries.

Module IV: Antropogenic Factors and its Bioremediation (10 Hrs)

Xenobiotic compounds - organic (chlorinated hydrocarbons, substituted simple aromatic compounds, polyaromatic hydrocarbons, pesticides, surfactants) and inorganic (metals, radionuclides, phosphates, nitrates). Bioremediation of xenobiotics in environment - ecological consideration, decay behavior and degradative plasmids, molecular techniques in bioremediation.

Module V: Biohazardous Substance (6 Hrs)

Role of immobilized cells/enzymes in treatment of toxic compounds. Biopesticides, bioreactors, bioleaching, biomining, biosensors, biotechniques for air pollution abatement and odour control.

Module VI: Sustainable Development (8 Hrs)

Sustainable Development: Economics and Environment: Economic growth, Gross National Productivity and the quality of life, Tragedy of Commons, Economics of Pollution control, Cost-benefit and cost effectiveness analysis, WTO and Environment, Corporate Social Responsibility, Environmental awareness and Education; Environmental Ethics.

Module VII: **Laws for Environment Protection (6 Hrs)**

International Legislations, Policies for Environmental Protection: Stockholm Conference (1972) and its declaration, WCED (1983) and Brundtland Report (1987), Rio Earth Summit-UNCED (1992) and its declaration, Montreal Protocol - 1987, Basel Convention (1989), Kyoto Protocol- 1997, Ramsar Convention 1971.

Module VIII: **Policies for Environment Protection (6 Hrs)**

National Legislations, Policies for Pollution Management: Salient features of Wild life protection act 1972, Water Pollution (Prevention and Control) Act-1974, Forest conservation act 1980, Air Pollution (Prevention and Control) Act-1981, National Environmental Policy - 2006, Central and State Pollution Control Boards: Constitution and power.

Module IX: **Public Participation for Environmental Protection (6 Hrs)**

Public Participation for Environmental Protection: Environmental movement and people's participation with special references to Gandhamardan, Chilika and Narmada Bachao Andolan, Chipko and Silent valley Movement; Women and Environmental Protection, Role of NGO in bringing environmental awareness and education in the society.

Mapping of COs to Syllabus

	Module 1	Module 2	Module 3	Module 4	Module 5	Module 6	Module 7	Module 8	Module 9
CO 1	-	-		-	-	-	L	H	M
CO 2		-	-	M	H	-	-		
CO 3	-	-	-	-	-	H	-		
CO 4	-	-	H	M	-	-	-		

Environmental Biotechnology
(2Credits: 30hrs)
(0-0-2)
Course Outcomes
At the end of this course, student will be able to:
CO1: Understanding the basic knowledge about DO, salinity, pH, chloride, total hardness, alkalinity, acidity, nitrate, calcium, Magnesium and phosphorus (Remembering)
CO2: Grasp the idea about Gravimetric analysis-Total solid, dissolved solid, suspended solid in an effluent (Understanding)
CO3: Utilize the concepts of DO, salinity, pH, chloride, total hardness, alkalinity, acidity, nitrate, calcium, Magnesium and phosphorus in analyzing soil and water (Applying)
CO4: Scrutinize the concepts of gravimetric analysis (Analyzing)

Practicals:

1. Water/Soil analysis - DO, salinity, pH, chloride, total hardness, alkalinity, acidity, nitrate, calcium, Magnesium and phosphorus.
2. 2. Gravimetric analysis-Total solid, dissolved solid, suspended solid in an effluent.
3. 3. Microbial assessment of air (open plate and air sample) and water.

Mapping of COs to Syllabus

	Prac1	Prac2	Prac3
CO 1	H	-	
CO 2		H	-
CO 3	H	-	-
CO 4	-	-	H

Suggested Readings

1. Waste water engineering - treatment, disposal and reuse, Metcalf and Eddy Inc., Tata McGraw Hill, New Delhi.
2. Environmental Chemistry, AK. De, Wiley Eastern Ltd, New Delhi.
3. Introduction to Biodeterioration, D.Allsopp and K.J. Seal, ELBS / Edward Arnold.
4. Bioremidation, Baaker, KH and Herson D.S., 1994. Mc.GrawHill Inc, NewYork.
5. Industrial and Environmental Biotechnology - Nuzhat Ahmed, Fouad M. Qureshi and Obaid Y. Khan, _2006. Horizon Press.
6. Environmental Molecular Biology, Paul. A, Rochelle, 2001.Horizon Press.
7. Environmental Protection and Laws by Jadhav and Bhosale, V.M.Himalaya publ. House 13. Biodiversity Assessment and Conservation by PC Trivedi, Agrobios

Skill Enhancement Course

Ethnobotany
(2Credits: 30 Hrs)
(2-0-0)

Course Outcomes

1. Demonstrate the concept, scope and objectives of ethnobotany with reference to tribal lifestyle (Understanding)
2. Interpret different ethnobotanical methodologies (Understanding)
3. Examine the role of various plants in traditional and modern medicine (Analyzing)
4. Infer the legal aspects of ethnobotany (Understanding)

Syllabus:

Module I: Ethnobotany (6Hrs)

Introduction, concept, scope and objectives; Ethnobotany as an interdisciplinary science. The relevance of ethnobotany in the present context; Major and minor ethnic groups or Tribals of India, and their life styles. Plants used by the tribals: a) Food plants b) intoxicants and beverages c) Resins and oils and miscellaneous uses.

Module II: Methodology of Ethnobotanical studies (6 Hrs)

a) Field work b) Herbarium c) Ancient Literature d) Archaeological findings e) temples and sacred places.

Module III: Role of ethnobotany in modern Medicine (10 Hrs)

Medico-ethnobotanical sources in India;Significance of the following plants in ethno botanical practices (along with their habitat and morphology) a) *Azadiractha indica* b) *Ocimum sanctum* c) *Vitex negundo*. d) *Gloriosa superba* e) *Tribulus terrestris* f) *Pongamia pinnata* g) *Cassia auriculata* h) *Indigofera tinctoria*. Role of ethnobotany in modern medicine with special example *Rauvolfia sepentina, Trichopus zeylanicus, Artemisia,Withania*. Role of ethnic groups in conservation of plant genetic resources.Endangered taxa and forest management (participatory forest management).

Module IV: Ethnobotany and legal aspects (8 Hrs)

Ethnobotany as a tool to protect interests of ethnic groups. Sharing of wealth concept with few examples from India. Biopiracy, Intellectual Property Rights and Traditional Knowledge.

Mapping of COs to Syllabus

	Module I	Module II	Module III	Module IV
CO1	H			
CO2		H		
CO3			H	
CO4				H

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)

Skill Enhancement Course

Intellectual Property Rights
(2Credits: 30 hrs)
(2-0-0)
Course Outcomes
1. Interpret IPR and its philosophy (Understanding)
2. Summarize copyrights and related rights and industrial property rights like designs, trademarks, patents and geographical indications (Understanding)

3. Infer the importance of protecting traditional knowledge (Understanding)
4. Explain the necessity to protect plant varieties (Understanding)
5. Summarize the roles of information technology and biotechnology in the field of IPR (Understanding)
6. Utilize the concepts of intellectual property rights in safeguarding innovations, products etc in future (Applying)

Syllabus:

Module I: Introduction to intellectual property right (IPR) (2 Hrs)

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

Module II : Patents (3 Hrs)

Objectives, Rights, Patent Act 1970 and its amendments. Procedure of obtaining patents, Working of patents. Infringement.

Module III: Copyrights (3 Hrs)

Introduction, Works protected under copyright law, Rights, Transfer of Copyright, Infringement.

Module IV: Trademarks (3 Hrs)

Objectives, Types, Rights, Protection of goodwill, Infringement, Passing off, Defences, Domain name.

Module V: Geographical Indications (3 Hrs)

Objectives, Justification, International Position, Multilateral Treaties, National Level, Indian Position.

Module VI: Protection of Traditional Knowledge (4 Hrs)

Objective, Concept of Traditional Knowledge, Holders, Issues concerning, Bio-Prospecting and Bio-Piracy, Alternative ways, Protectability, needfor a Sui-Generis regime, Traditional Knowledge on the International Arena, at WTO, at National level, Traditional Knowledge Digital Library.

Module VII: Industrial Designs (2 Hrs)

Objectives, Rights, Assignments, Infringements, Defences of Design Infringement

Module VIII: Protection of Plant Varieties (2 Hrs)

Plant Varieties Protection-Objectives, Justification, International Position, Plant varieties protection in India. Rights of farmers, Breeders and Researchers. National gene bank, Benefit sharing.Protection of Plant Varieties and Farmers' Rights Act, 2001.

Module IX:Information Technology Related Intellectual Property Rights (4 Hrs)

Computer Software and Intellectual Property, Database and Data Protection, Protection of Semi-conductor chips, Domain Name Protection

Module X: Biotechnology and Intellectual Property Rights. (4 Hrs)

Patenting Biotech Inventions: Objective, Applications, Concept of Novelty, Concept of inventive step, Microorganisms, Moral Issues

Mapping of COs to Syllabus

	Module I	Module II	Module III	Module IV	Module V	Module VI	Module VII	Module VIII	Module IX	Module X
CO1	H									
CO2		H	H	H	H		H			
CO3						H				
CO4								H		
CO5									H	H
CO6		H	M			M	M		L	L

Suggested Readings

1. N.S. Gopalakrishnan & T.G. Agitha, (2009) Principles of Intellectual Property Eastern Book Company, Lucknow.
2. Kerly's Law of Trade Marks and Trade Names (14th Edition) Thomson, Sweet & Maxweel.
3. Ajit Parulekar and Sarita D' Souza, (2006) Indian Patents Law – Legal & Business Implications; Macmillan India Ltd.

4. B.L.Wadehra (2000) Law Relating to Patents, Trade Marks, Copyright, Designs & Geographical Indications; Universal law Publishing Pvt. Ltd., India.
5. P. Narayanan (2010) Law of Copyright and Industrial Designs; Eastern law House, Delhi.

SEMESTER IV

Molecular Biology
(4 Credits: 60 Hrs)
(3-1-0)

Course Outcomes

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

CO1: Recall the various experiments proving DNA to be the carrier of genetic information (Remembering)

CO2: Perceive of structure of DNA and RNA and also central dogma and genetic code (Understanding)

CO3: Understand the concepts of mechanism of transcription in prokaryotes and eukaryotes for practical purpose (Understanding)

CO4: Inspect the concept of the processing and modification of RNA (Analyzing).

Syllabus:

Module I: Nucleic acids : Carriers of genetic information (4 Hrs)

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

Module II. The Structures of DNA and RNA / Genetic Material (10 Hrs)

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

Module III:The replication of DNA (10 Hrs)

Chemistry of DNA synthesis (Kornberg's discovery); General principles – bidirectional, Semiconservative and semi discontinuous replication, RNA priming; Various models of DNA replication, including rolling circle, θ (theta) mode of replication, replication of linear ds-DNA, replication of the 5'end of linear chromosome; Enzymes involved in DNA replication.

Module IV: Central dogma and genetic code (2 Hrs)

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

Module V: Mechanism of Transcription (10 Hrs)

Transcription in prokaryotes; Transcription in eukaryotes

Module VI: Processing and modification of RNA (8 Hrs)
Split genes-concept of introns and exons, removal of introns, spliceosome machinery, splicing pathways, group I & group II intron splicing, alternative splicing eukaryotic mRNA processing(5' cap, 3' poly A tail); Ribozymes, exon shuffling; RNA editing and mRNA transport.

Module VII: Translation (Prokaryotes and eukaryotes) (8 Hrs)
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.

Module VIII: Regulation of transcription in prokaryotes and eukaryotes (8 Hrs)
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.

Mapping of COs to Syllabus

	Module 1	Module 2	Module 3	Module 4	Module 5	Module 6	Module 7	Module 8
CO 1	H	M	L	-	-	-	-	-
CO 2		-	-	H	-	-	-	
CO 3	-	-	-	-	H	-	-	M
CO 4	-	-	-	-	-	H	-	

Molecular Biology Lab
(2Credits: 30hrs)

(0-0-2)

Course Outcomes

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

CO1: Recall the basic knowledge on DNA to isolate and purify it (Remembering)

CO2: Grasp the procedure to purify and estimate DNA and also its various replication mechanisms (Understanding)

CO3: Understand the concepts on transcription in studying prokaryotic and eukaryotic RNA polymerases (Understanding)

CO4: Prepare LB medium for growing bacterial cultures (Creating)

Practicals:

1. Preparation of LB medium and raising E.Coli.
2. Isolation of genomic DNA from E.Coli.
3. DNA isolation from cauliflower head.
4. DNA estimation by diphenylamine reagent/UV Spectrophotometry.
5. Study of DNA replication mechanisms through photographs (Rolling circle, Theta replication and semi-discontinuous replication).
6. Study of structures of prokaryotic RNA polymerase and eukaryotic RNA polymerase II through photographs.
7. Photographs establishing nucleic acid as genetic material (Messelson and Stahl's, Avery et al, Griffith's, Hershey & Chase's and Fraenkel & Conrat's experiments)
8. Study of the following through photographs: Assembly of Spliceosome machinery; Splicing mechanism in group I & group II introns; Ribozyme and Alternative splicing.

Mapping of COs to Syllabus

	CO1	CO2	CO3	CO4
Prac 1	-	-	-	H
Prac 2	H	-	-	-

Prac 3	M	-	-	-
Prac 4	-	H	-	-
Pract 5	-	M	-	-
Prac 6	-	-	H	-
Prac 7	-	-	-	-
Prac 8	-	-	M	-

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. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. Benjamin Cummings. U.S.A. 9th edition.
4. Russell, P. J. (2010). Genetics- A Molecular Approach. Benjamin Cummings, U.S.A. 3rd edition.
5. 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.

Plant Ecology and Phytogeography

(4 Credits: 60 Hrs)

(3-1-0)

Course Outcomes

1. Recollect the concepts of ecology of individual, population, community and ecosystem (Remembering)

2. Perceive the basic knowledge of biotic and abiotic factors of environment their interaction, ecosystem and its functional aspects (Understanding)
3. Inspect the ideas on ecosystem and its functional aspects (Analyzing)
4. Utilize the concepts of population dynamics and community succession in understanding the composition of a particular area (Applying)
5. Check their knowledge on phytogeography (Evaluating)

Syllabus:

Module I: Introduction (4 Hrs)

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

Module II: Soil (8 Hrs)

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

Module III: Water (4 Hrs)

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

Module IV: Light, temperature, wind and fire (6 Hrs)

Variations; adaptations of plants to their variation.

Module V: Biotic interactions (2 Hrs)

Host-Pathogen interaction

Module VI: Population ecology (4 Hrs)

Characteristics and Dynamics .Ecological Speciation

Module VII: Plant communities (8 Hrs)
Concept of ecological amplitude; Habitat and niche; Characters: analytical and synthetic; Ecotone and edge effect; Dynamics: succession – processes, types; climax concepts.

Module VIII: Ecosystems (4 Hrs)
Structure; Processes; Trophic organisation; Food chains and Food webs; Ecological pyramids.

Module IX: Functional aspects of ecosystem (8 Hrs)

Principles and models of energy flow; Production and productivity; Ecological efficiencies; Biogeochemical cycles; Cycling of Carbon, Nitrogen and Phosphorus.

Module X: Phytogeography (12 Hrs)
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.

Mapping of COs to Syllabus

	Module 1	Module 2	Module 3	Module 4	Module 5	Module 6	Module 7	Module 8	Module 9	Module 10
CO1	H					H	H	H		
CO2		H	H	H	H					
CO3						L	L	M	H	
CO4						H	H	L	L	
CO5								L		H

Plant Ecology and Phytogeography Lab
(2Credits: 30hrs)
(0-0-2)

Course Outcomes

1. Recall their basic knowledge on ecology in order to use instruments to measure microclimatic variables (Remembering)
2. Perceive the concepts of various physico-chemical properties of soil and water (Understanding)
3. Estimate the dissolved oxygen of water samples from polluted and unpolluted sources (Evaluating)
4. Utilize their knowledge to demonstrate and calculate the plant communities (Applying)
5. Fabricate the concepts of ecology and inculcating these ideas in their young minds through field visits (Creating)

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 (pH meter, universal indicator/Lovi Bond comparator and pH paper)
3. Analysis for carbonates, chlorides, nitrates, sulphates, organic matter and base deficiency from two soil samples by rapid field tests.
4. Determination of organic matter of different soil samples by Walkley & Black rapid titration method.
5. Comparison of bulk density, porosity and rate of infiltration of water in soils of three habitats.
6. Determination of dissolved oxygen of water samples from polluted and unpolluted sources.
7. (a). Study of morphological adaptations of hydrophytes and xerophytes (four each).
(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.

Mapping of COs to Syllabus

	Module 1	Module 2	Module 3	Module 4	Module 5	Module 6	Module 7	Module 8	Module 9	Module 10	Module 11
CO1	**H**	**L**									
CO2	**L**	**L**	**H**	**L**	**M**	**L**					
CO3						**H**					
CO4							**H**	**H**	**H**	**H**	
CO5							**L**	**L**	**L**	**L**	**H**

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.
5. Kormondy, E.J. (1996). Concepts of ecology. PHI Learning Pvt. Ltd., Delhi, India. 4th edition.

Plant Systematics

(4Credits: 60 hrs)

(3-1-0)

Course outcomes

1. Summarize the concepts of plant identification, classification, nomenclature and biosystematics (Understanding)
2. Outline taxonomic identification and hierachy (Understanding)
3. Infer systematics as an interdisciplinary science (Understanding)
4. Summarize botanical nomenclature and various systems of classification (Understanding)
5. Explain biometrics, numerical taxonomy and cladistics (Understanding)
6. Summarize the phylogeny in angiosperms (Understanding)

Syllabus:

Module I: Introduction to Plant Systematics. (2 Hrs)

Plant identification, Classification, Nomenclature; Biosystematics

Module II: Identification (6 Hrs)
Field inventory; Functions of Herbarium; Important herbaria and botanical gardens of the worldand India; Virtual herbarium; E-flora; Documentation: Flora, Monographs, Journals; Keys: Single access and Multi-access

Module III: Systematics-an interdisciplinary science (6 Hrs)
Evidence from palynology, cytology, phytochemistry and molecular data.

Module IV: Taxonomic hierarchy (6 Hrs)
Concept of taxa (family, genus, species); Categories and taxonomic hierarchy; Species concept (taxonomic, biological, evolutionary).

Module V: Botanical nomenclature (10 Hrs)
Principles and rules (ICN); Ranks and names; Typification, author citation, valid publication, rejection of names, principle of priority and its limitations; Names of hybrids.

Module VI: Systems of classification (10 Hrs)
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.

Module VII: Biometrics, numerical taxonomy and cladistics (8 Hrs)
Characters; Variations; OTUs, character weighting and coding; cluster analysis; Phenograms, cladograms (definitions and differences).

Module VIII: Phylogeny of Angiosperms (12 Hrs)
Terms and concepts (primitive and advanced, homology and analogy, parallelism and convergence, monophyly, Paraphyly, polyphyly and clades).origin& evolution of angiosperms; co - evolution of angiosperms and animals; methods of illustrating evolutionary relationship (phylogenetic tree, cladogram).

Mapping of COs to Syllabus

	Module I	Module II	Module III	Module IV	Module V	Module VI	Module VII	Module VIII
CO1	H	M	M		M			
CO2		H		H				
CO3			H					
CO4					H	H		
CO5							H	
CO6								H

Plant Systematics Lab
(2Credits: 30hrs)
(0-0-2)

Course outcomes

1. Interpret the vegetative characters and systematic position of various angiospermic plants (Understanding)
2. Utilize their knowledge on angiosperms to study the floral characters through slide preparation (Applying)
3. Apply the ideas of plant taxonomy and systematics in identifying different plant specimens in their natural habitat (Applying)
4. Develop the art of preparing herbarium of plant specimens (Creating)

Practicals:

1. Study of vegetative and floral characters of the following families (Description, V.S. flower, section of ovary, floral diagram/s, floral formula/e and systematic position according to Bentham & Hooker's system of classification):Ranunculaceae - Ranunculus, Delphinium Brassicaceae -Brassica, Alyssum / Iberis Myrtaceae - Eucalyptus, Callistemon Umbelliferae - Coriandrum /Anethum / Foeniculum Asteraceae - Sonchus/Launaea, Vernonia/Ageratum, Eclipta/Tridax Solanaceae - Solanum nigrum/Withania Lamiaceae - Salvia/Ocimum Euphorbiaceae - Euphorbia hirta/E.milii, Jatropha
Liliaceae - Asphodelus/Lilium/Allium Poaceae - Triticum/Hordeum/Avena

2. Field visit (local) – Subject to grant of funds from the university.
3. Mounting of a properly dried and pressed specimen of any wild plant with herbarium label (to be submitted in the record book).

Mapping of COs to Syllabus

	1	2	3
CO1	H		
CO2	H		
CO3		H	
CO4			H

Suggested Readings

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

Generic Papers

Economic Botany and Plant Biotechnology
***(4Credits: 60 Hrs*)**
(4-0-0)

Course Outcomes

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

CO1: Tell the concept of origin of crops, and evolution of new crops (Remembering)
CO2: Perceive the ideas of different economically useful crops and their products processing (Understanding)
CO3: Apply the knowledge of plant tissue culture and DNA technologies in producing disease free plants (Applying)
CO4: Generate ideas and techniques on hybridoma technology and disease diagnosis (Creating)

Syllabus:

Module I: Origin of Cultivated Plants (4 Hrs)
Concept of centres of origin, their importance with reference to Vavilov's work.

Module II: Cereals (4 Hrs)
Wheat -Origin, morphology, uses

Module III: Legumes(6 Hrs)
General account with special reference to Gram and soybean

Module IV: Spices (6 Hrs)
General account with special reference to clove and black pepper (Botanical name, family, part used, morphology and uses).

Module V: Beverages (4 Hrs)
Tea (morphology, processing, uses)

Module VI: Oils and Fats (4 Hrs)
General description with special reference to groundnut

Module VII: Fibre Yielding Plants (4 Hrs)
General 4description with special reference to Cotton (Botanical name, family, part used, morphology and uses)

Module VIII: Introduction to biotechnology (2 Hrs)

Module IX: Plant tissue culture (8 Hrs)
Micropropagation ; haploid production through androgenesis and gynogenesis; brief account of embryo and endosperm culture with their applications

Module X: Recombinant DNA Techniques (18 Hrs)
Blotting techniques: Northern, Southern and Western Blotting, DNA Fingerprinting; Molecular DNA markers i.e. RAPD, RFLP, SNPs; DNA sequencing, PCR and Reverse Transcriptase-PCR. Hybridoma and monoclonal antibodies, ELISA and Immunodetection Molecular diagnosis of human disease, Human gene Therapy

Mapping:

	Module-1	Module-2	Module-3	Module-4	Module-5	Module-6	Module-7	Module-8	Module-9	Module-10
CO-1	H	M	M	M	L	L	L			
CO-2		M	M	M	M	L	H			
CO-3								L	H	H
CO-4								L	M	H

Economic Botany and Plant Biotechnology Lab
(2Credits: 30hrs)
(0-0-2)
Course Outcomes
At the end of this course, student will be able to:

CO1: Recall the basic knowledge about economically important plants and plant tissue culture (Remembering)
CO2: Explain the working principle of plant tissue culture methods and molecular biology equipments (Understanding)
CO3: Apply and build advanced protocols for plant tissue culture and quality test of plant products (Applying)

Practicals:
1. Study of economically important plants: Wheat, Gram, Soybean, Black pepper, Clove

Tea, Cotton, Groundnut through specimens, sections and microchemical tests
2. Familiarization with basic equipments in tissue culture.
3. Study through photographs: Anther culture, somatic embryogenesis, endosperm and embryo culture; micropropagation.
4. Study of molecular techniques: PCR, Blotting techniques, AGE and PAGE.

	Practical-1	Practical 2	Practical 3	Practical 4
CO-1	H	L	M	
CO-2		H	L	M
CO-3	L	M		H

Suggested Readings

1. Kochhar, S.L. (2011). Economic Botany in the Tropics, MacMillan Publishers India Ltd., New Delhi. 4th edition.
2. Bhojwani, S.S. and Razdan, M.K., (1996). Plant Tissue Culture: Theory and Practice. Elsevier Science Amsterdam. The Netherlands.
3. Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington.

Skill Enhancement Course

Biofertilizers
(2Credits: 30 hrs)
(2-0-0)

Course Outcomes

At the end of this course, student will be able to:
CO1: Recollect their knowledge on the role of microbes in producing biofertilizers (Remembering)
CO2: Perceive the concept of the various components of biological organisms used as biofertilizer (Azospirillum, cyanobacteria, VAM) (Understanding)
CO3: Use the idea of organic farming in the field (Applying)
CO4: Survey the various ways of generating biofertilizers (Analyzing)

Syllabus:

Module I: (4 Hrs)

General account about the microbes used as biofertilizer – Rhizobium – isolation, identification, mass multiplication, carrier based inoculants, Actinorrhizal symbiosis.

Module II: (8 Hrs)

Azospirillum: isolation and mass multiplication – carrier based inoculant, associative effect of different microorganisms.*Azotobacter*: classification, characteristics – crop response to *Azotobacter* inoculum, maintenance and mass multiplication.

Module III: (4 Hrs)

Cyanobacteria (blue green algae), *Azolla* and *Anabaena azollae* association, nitrogen fixation, factors affecting growth, blue green algae and *Azolla* in rice cultivation.

Module IV: (8 Hrs)

Mycorrhizal association, types of mycorrhizal association, taxonomy, occurrence and
distribution, phosphorus nutrition, growth and yield – colonization of VAM – isolation and inoculum production of VAM, and its influence on growth and yield of crop plants.

Module V: (6 Hrs)

Organic farming – Green manuring and organic fertilizers, Recycling of biodegradable municipal, agricultural and Industrial wastes – biocompost making methods, types and method of vermicomposting – field Application.

Mapping of COs to Syllabus

	Module 1	Module 2	Module 3	Module 4	Module 5
CO 1	H	M	L	-	-

CO 2	M	-	-	L	H
CO 3	-	-	-	-	H
CO 4	H	-	-	-	-

Suggested Readings

1. Dubey, R.C., 2005 A Text book of Biotechnology S.Chand & Co, New Delhi.
2. Kumaresan, V. 2005, Biotechnology, Saras Publications, New Delhi.
3. John Jothi Prakash, E. 2004. Outlines of Plant Biotechnology. Emkay -Publication, New Delhi.
4. Sathe, T.V. 2004 Vermiculture and Organic Farming. Daya publishers.
5. Subha Rao, N.S. 2000, Soil Microbiology, Oxford & IBH Publishers, New _Delhi.
6. Vayas,S.C, Vayas, S. and Modi, H.A. 1998 Bio-fertilizers and organic _Farming Akta Prakashan, Nadiad 55

Medicinal Botany
***(2Credits: 30 Hrs*)**
(2-0-0)
(2-0-0)

Course Outcomes

1. Interpret age-old systems of medicine (Understanding)
2. Infer the importance of conserving endangered and endemic medicinal plants (Understanding)
3. Make use of traditional and folk medicine for the betterment of the society (Applying)

Syllabus:

Module I: (10 Hrs)

History, Scope and Importance of Medicinal Plants. Indigenous Medicinal Sciences; Definitionand Scope-Ayurveda: History, origin, panchamahabhutas, saptadhatu and tridosha concepts, Rasayana, plants used in ayurvedic treatments, Siddha: Origin of Siddha

medicinal systems, Basis of Siddha system, plants used in Siddha medicine. Unani: History, concept: Umoor-e- tabiya, tumors treatments/ therapy, polyherbal formulations.

Module II: (10 Hrs)

Conservation of endangered and endemic medicinal plants. Definition: endemic and endangered medicinal plants, Red list criteria; In situ conservation: Biosphere reserves, sacred groves, National Parks; *Ex situ* conservation: Botanic Gardens, Ethnomedicinal plant Gardens. Propagation of Medicinal Plants: Objectives of the nursery, its classification, important components of a nursery, sowing, pricking, use of green house for nursery production, propagation through cuttings, layering, grafting and budding

Module III: (10 Hrs)

Ethnobotany and Folk medicines. Definition; Ethnobotany in India: Methods to study ethnobotany; Applications of Ethnobotany: National interacts, Palaeo-ethnobotany. folk medicines of ethnobotany, ethnomedicine, ethnoecology, ethnic communities of India. Application of natural products to certain diseases- Jaundice, cardiac, infertility, diabetics, Blood pressure and skin diseases

Mapping of COs to Syllabus

	Module I	Module II	Module III
CO1	H		
CO2		H	
CO3			H

Suggested Readings:

1. Trivedi P C, 2006. Medicinal Plants: Ethnobotanical Approach, Agrobios, India.
2. Purohit and Vyas, 2008. Medicinal Plant Cultivation: A Scientific Approach, 2nd edn.
Agrobios, India

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SEMESTER-V

Reproductive Biology of Angiosperms

(4 Credits: 60 Hrs)

(4-0-0).

Course Outcomes

1. Define and tell the basic ideas of anther, ovule, endosperm, embryo and seed (Remembering)
2. Demonstrate and explain concepts of pollen biology, pollination and fertilization, self-incompatibility (Understanding).
3. Plan and develop protocols for studying pollination, fertilization and embryogenesis (Applying)
4. Categorize and distinguish different reproductive mechanisms in Angiosperm (Analyzing)
5. Compare and evaluate methods of pollination and self-incompatibility in plants (Evaluating)
6. Design and improve protocols for transformation (Creating)

Module I: Introduction (2 hours)
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.

Module II: Anther (4 hours)
Anther wall: Structure and functions, microsporogenesis, callose deposition and its significance.

Module III: Pollen biology (8 hours)
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.

Module IV: Ovule (8 hours)
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.

Module V: Pollination and fertilization (6 hours)

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

Module VI: Self incompatibility (8 hours)
Basic concepts (interspecific, intraspecific, homomorphic, heteromorphic, GSI and SSI); Methods to overcome self- incompatibility: mixed pollination, bud pollination, stub pollination; Intraovarian and *in vitro* pollination; Modification of stigma surface, parasexual hybridization; Cybrids, *in vitro* fertilization.

Module VII: Endosperm (4 hours)
Types, development, structure and functions.

Module VIII: Embryo (6 hours)
Six types of Embryogeny; General pattern of development of dicot and monocot embryo; Suspensor: structure and functions; Embryo-endosperm relationship; Nutrition of embryo; Unusual features; Embryo development in *Paeonia*.

Module IX: Seed (4 hours)
Structure, importance and dispersal mechanisms

Module X: Polyembryony and apomixes (6 hours)
Introduction; Classification; Causes and applications.

Module XI: Germline transformation (4 hours)
Pollen grain and ovules through pollen tube pathway method/ *Agrobacterium*/ electrofusion/ floral dip/biolistic.

Mapping of COs to Syllabus

	Module 1	Module 2	Module 3	Module 4	Module 5	Module 6	Module 7	Module 8	Module 9	Module 10	Module 11
CO1	M	M	M	M			M	M	M		
CO2			H		H	H					
CO3			L		H	L	L	M		M	

CO4		**L**	**L**	**L**	**H**	**H**	**H**	**L**	**L**	**M**	
CO5					**H**	**H**					
CO6										**L**	**H**

Reproductive Biology of Angiosperms Lab
(2 Credits: 30 Hrs)
(0-0-2)
Course Outcomes

1. Tell and show various reproductive parts of Angiosperm (Remembering)
2. Develop pollen viability test and calculation of germination percentage (Applying)
3. Examine various types of ovule, the female gametophyte and intra-ovarian pollination (Evaluating)
4. Explain and infer endosperm and embryogenesis (Understanding).
5. Dissect developing seeds to determine stages of growth (Analyzing)
6. Develop or modify protocols for analysis of seed germination, pollination and embryogenesis (Creating)

Practicals:

1. Anther: Wall and its ontogeny; Tapetum (amoeboid and glandular); MMC, spore tetrads, uninucleate, bicelled and dehisced anther stages through slides/micrographs, male germ unit (MGU) through photographs and schematic representation.
2. Pollen grains: Fresh and acetolyzed showing ornamentation and aperture, psuedomonads, polyads, pollinia (slides/photographs,fresh material), ultrastructure of pollen wall (micrograph); Pollen viability: Tetrazolium test.germination: Calculation of percentage germination in different media using hanging drop method.
3. Ovule: Types-anatropous, orthotropous, amphitropous/campylotropous, circinotropous, unitegmic, bitegmic; Tenuinucellate and crassinucellate; Special structures: Endothelium, obturator, hypostase, caruncle and aril (permanent slides/specimens/photographs).
4. Female gametophyte through permanent slides/ photographs: Types, ultrastructure of mature egg apparatus.
5. Intra-ovarian pollination; Test tube pollination through photographs.
6. Endosperm: Dissections of developing seeds for endosperm with free-nuclear haustoria.

7. Embryogenesis: Study of development of dicot embryo through permanent slides; dissection of developing seeds for embryos at various developmental stages; Study of suspensor through electron micrographs.

Mapping of COs to Syllabus

	Module 1	Module 2	Module 3	Module 4	Module 5	Module 6	Module 7
CO1	**H**	**H**					
CO2		**H**					
CO3			**H**	**H**	**H**		
CO4						**H**	**H**
CO5						**H**	
CO6					**M**	**M**	**H**

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.

Plant Physiology
(4 Credits: 60 Hrs)
(4-0-0)
Course outcomes

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

CO1: Recall nutrient uptake and translocation in plants (Remembering)

CO2: Explain concepts of plant water relation and mineral nutrition. (Understanding).

CO3: Understand the models for diffusion and translocation studies (Applying)

CO4: Analyse the functions of growth regulators (Analyzing)

CO5: Formulate methods to test actions of Plant Growth Regulators in vitro/in vivo (Creating)

Syllabus:

Module I: Plant water relationship (10 hours)

Water Potential and its components, water absorption by roots, aquaporins, 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.

Module II: Mineral nutrition (8 hours)

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.

Module III: Nutrient Uptake (8 hours)

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.

Module IV: Translocation in the phloem (8 hours)

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

Module V: Plant growth regulators (14 hours)

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

Module VI: Physiology of flowering (6 hours)

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

Module VII: Phytochrome (6 hours)

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

Mapping of COs to Syllabus

	Module 1	Module 2	Module 3	Module 4	Module 5	Module 6	Module 7
CO 1	-	-	H	M	-	-	-
CO 2	H	M	L	-	-	-	-
CO 3	-	-	-	H	-	-	-
CO 4	-	-	-	-	H	-	-
CO 5	-	-	-	-	H	-	-

Plant Physiology Lab

(2 Credits: 30 Hrs)

(0-0-2)

Course outcomes

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

CO1: Memorize the basic concept of transpiration and stomata (Remembering)

CO2: Understand the concepts of osmotic potential and water potential (Understanding).

CO3: Understand the basics of seed germination, amylase activity and the effect of different concentrations of plant growth hormones like IAA. (Applying)

CO4: Examine suction pressure due to transpiration, fruit ripening or rooting from cuttings and bolting

Practicals:

1. Determination of osmotic potential of plant cell sap by plasmolytic method.
2. Determination of water potential of given tissue (potato tuber) by weight method.
3. Study of the effect of wind velocity and light on the rate of transpiration in excised twig/leaf.
4. Calculation of stomatal index and stomatal frequency from the two surfaces of leaves of a mesophyte and xerophyte.
5. To calculate the area of an open stoma and percentage of leaf area open through stomata in a mesophyte and xerophyte (both surfaces).
6. To study the phenomenon of seed germination (effect of light).
7. To study the effect of different concentrations of IAA on *Avena* coleoptile elongation (IAA Bioassay).
8. To study the induction of amylase activity in germinating barley grains.

Demonstration experiments

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

Mapping of COs to Syllabus

	CO1	CO2	CO3	CO4
Prac 1	-	H	-	-
Prac 2		M	-	H
Prac 3	M	-	-	-
Prac 4	-	-	-	-
Pract 5	H	-	-	-

Prac 6	-	-	H	-
Prac 7	-	-	L	-
Prac 8	-	-	M	-

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.

Analytical Techniques in Plant Sciences
(4 Credits: 60 Hrs)
(4-0-0)

Course outcomes

1. Interpret various microscopic techniques (Understanding)
2. Compare the different centrifugation techniques (Understanding)
3. Apply radioisotopes and spectrophotometry in biological research (Applying)
4. Illustrate the various chromatographic and molecular techniques (Understanding)
5. Utilize the knowledge of biostatistics in solving related problems (Applying)

Syllabus:

Module I: Imaging and related techniques (15 hours)

Principles of microscopy; Light microscopy; Fluorescence microscopy; Confocal microscopy; Use of fluorochromes: (a) Flow cytometry (FACS); (b) Applications of fluorescence microscopy: Chromosome banding, FISH, chromosome painting; Transmission and Scanning electron microscopy – sample preparation for electron microscopy, cryofixation, negative staining, shadow casting, freeze fracture, freeze etching.

Module II: Cell fractionation (8 hours)
Centrifugation: Differential and density gradient centrifugation, sucrose density gradient, CsCl2gradient, analytical centrifugation, ultracentrifugation, marker enzymes.

Module III: Radioisotopes (4 hours)
Use in biological research, auto-radiography, pulse chase experiment.

Module IV: Spectrophotometry (4 hours)
Principle and its application in biological research.

Module V: Chromatography (8 hours)
Principle; Paper chromatography; Column chromatography, TLC, GLC, HPLC, Ion-exchange chromatography; Molecular sieve chromatography; Affinity chromatography.

Module VI: Characterization of proteins and nucleic acids (6 hours)
Mass spectrometry; X-ray diffraction; X-ray crystallography; Characterization of proteins and nucleic acids; Electrophoresis: AGE, PAGE, SDS-PAGE.

Module VII: Biostatistics (15 hours)
Statistics, data, population, samples, parameters; Representation of Data: Tabular, Graphical; Measures of central tendency: Arithmetic mean, mode, median; Measures of dispersion: Range, mean deviation, variation, standard deviation; Chi-square test for goodness of fit.

Mapping of COs to Syllabus

	Module I	Module II	Module III	Module IV	Module V	Module VI	Module VII
CO1	H						

CO2		H					
CO3			H	H			
CO4					H	H	
CO5							H

Analytical Techniques in Plant Sciences Lab

(2 Credits: 30 Hrs)

(0-0-2)

Course outcomes

1. Infer the various blotting techniques as well as PCR (Understanding)
2. Experiment with ELISA and also utilize paper chromatography and TLC to separate sugars and nitrogenous bases (Applying)
3. Make use of centrifugation and chromatographic techniques for chloroplast isolation and separation (Applying)
4. Apply various biochemical and molecular techniques for protein estimation and separation (Applying)
5. Apply molecular techniques for separation of DNA markers (Applying)
6. Compare different microscopic techniques (Applying)
7. Construct permanent slides (Creating)

Practicals:

1. Study of Blotting techniques: Southern, Northern and Western, DNA fingerprinting, DNA sequencing, PCR through photographs.
2. Demonstration of ELISA.
3. To separate nitrogenous bases by paper chromatography.
4. To separate sugars by thin layer chromatography.
5. Isolation of chloroplasts by differential centrifugation.
6. To separate chloroplast pigments by column chromatography.
7. To estimate protein concentration through Lowry's methods.
8. To separate proteins using PAGE.
9. To separation DNA (marker) using AGE.
10. Study of different microscopic techniques using photographs/micrographs (freeze fracture, freeze etching, negative staining, positive staining, fluorescence and FISH).

11. Preparation of permanent slides (double staining).

Mapping of COs to Syllabus

	1	2	3	4	5	6	7	8	9	10	11
CO1	H										
CO2		H	H	H							
CO3					H	H					
CO4							H	H			
CO5									H		
CO6										H	
CO7											H

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.

Biostatistics
(4 Credits: 60 Hrs)
(4-0-0)
Course outcomes

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

CO-1: Define basic terminologies in Biostatistics (Remembering).
CO-2: Explain the concepts of biostatistics and its use in biology (Understanding).
CO-3: Apply the statistics tools for data analysis (Applying)

CO-4: Design sampling methods to generate significant data (Creating).

Syllabus:

Module I: Introduction (12 hours)

Biostatistics - definition - statistical methods - basic principles. Variables - measurements, functions, limitations and uses of statistics.

Module II: Collection of data (12 hours)

Collection of data primary and secondary - types and methods of data collection procedures - merits and demerits. Classification - tabulation and presentation of data - sampling methods.

Module III: Measures of central tendency (14 hours)

Measures of central tendency - mean, median, mode, geometric mean - merits & demerits. Measures of dispersion - range, standard deviation, mean deviation, quartile deviation -merits and demerits; Co- efficient of variations.

Module IV: Correlation & Regression (12 hours)

Correlation - types and methods of correlation, regression, simple regression equation, fitting prediction, similarities and dissimilarities of correlation and regression.

Module V: Statistical inference (10 hours)

Statistical inference - hypothesis - simple hypothesis - student 't' test - chi square test.

Mapping:

	Module-1	Module-2	Module-3	Module-4	Module-5
CO-1	H	H	H	H	H
CO-2	H	H	H	H	H
CO-3	M	M	H	H	H
CO-4	L	M	H	H	H

Biostatistics Lab

(2 Credits: 30 Hrs)

(0-0-2)

Course outcomes

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

CO-1: Tell the definitions of various statistical terms 9Remembering

CO-2: Make use of statistical calculations for data interpretation (Applying)

CO-3: Analyze any given biological data to see their accuracy and importance (Analysing)

Practicals:

1) Calculation of mean, standard deviation and standard error
2) Calculation of correlation coefficient values and finding out the probability
3) Calculation of 'F' value and finding out the probability value for the F value.

Mapping:

	Module-1	Module-2	Module-3
CO-1	H	H	H
CO-2	H	H	H
CO-3	H	H	H

Suggested Readings

1. Biostatistic, Danniel, W.W., 1987.New York, John Wiley Sons.
2. An introduction to Biostatistics, 3rd edition, Sundarrao, P.S.S and Richards, J. Christian Medical College, Vellore
3. Statistical Analysis of epidemiological data, Selvin, S., 1991. New York University Press.
4. Statistics for Biology, Boston, Bishop, O.N. Houghton, Mifflin.

5. The Principles of scientific research, Freedman, P. New York, Pergamon Press.
6. Statistics for Biologists, Campbell, R.C., 1998.Cambridge University Press.

SEMESTER-VI

Plant Metabolism

(4 Credits: 60 Hrs)

(4-0-0)

Course outcomes

1. Interpret the ideas of metabolism (Understanding)

2. Summarize photosynthesis and the different pathways involved (Understanding)
3. Explain carbohydrate metabolism (Understanding)
4. Rephrase respiration and the different pathways involved (Understanding)
5. Explain the mechanisms of ATP synthesis and compare oxidative, substrate-level and photophosphorylation (Understanding)
6. Outline lipid and nitrogen metabolism (Understanding)
7. Demonstrate signal transduction (Understanding)

Syllabus:

Module I: Concept of metabolism (6 hours)

Introduction, anabolic and catabolic pathways, regulation of metabolism, role of regulatory enzymes (allosteric ,covalent modulation and Isozymes).

Module II: Carbon assimilation (14 hours)

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

Module III: Carbohydrate metabolism (2 hours)

Synthesis and catabolism of sucrose and starch.

Module IV: Carbon Oxidation (10 hours)

Glycolysis, fate of pyruvate, regulation of glycolysis, oxidative pentose phosphate pathway, oxidative decarboxylation of pyruvate, regulation of PDH, NADH shuttle; TCA cycle, amphibolic role, anaplerotic reactions, regulation of the cycle, mitochondrial electron transport, oxidative phosphorylation, cyanide-resistant respiration, factors affecting respiration.

Module V: ATP-Synthesis (8 hours)

Mechanism of ATP synthesis, substrate level phosphorylation, chemiosmotic mechanism (oxidative and photophosphorylation), ATP synthase, Boyers conformational model, Racker’s experiment, Jagendorf’s experiment; role of uncouplers.

Module VI: Lipid metabolism (8 hours)
Synthesis and breakdown of triglycerides, β-oxidation, glyoxylate cycle, gluconeogenesis and its role in mobilisation of lipids during seed germination, α oxidation.

Module VII: Nitrogen metabolism (8 hours)
Nitrate assimilation, biological nitrogen fixation (examples of legumes and non-legumes); Physiology and biochemistry of nitrogen fixation; Ammonia assimilation and transamination.

Module VIII: Mechanisms of signal transduction (4 hours)
Calcium, phospholipids, cGMP, NO.

Mapping of COs to Syllabus

	Module I	Module II	Module III	Module IV	Module V	Module VI	Module VII	Module VIII
CO1	H	L	L	L		L	L	
CO2		H						
CO3			H					
CO4				H				
CO5					H			
CO6						H	H	
CO7								H

Plant Metabolism Lab
(2 Credits: 30 Hrs)
(0-0-2)

Course outcomes
1. Utilize the knowledge to separate photosynthetic pigments (Applying)
2. Demonstrate Hill's reaction (Understanding).

3. Interpret the effects of light and carbon dioxide on respiration and compare the rate of respiration in various plant materials (Understanding)
4. Demonstrate nitrate reductase activity (Understanding)
5. Infer the activity of lipases (Understanding)
6. Demonstrate the fluorescence and absorption spectrum of photosynthetic pigments (Understanding)

Practicals:

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. Effect of carbon dioxide on the rate of photosynthesis.
5. To compare the rate of respiration in different parts of a plant.
6. To demonstrate activity of Nitrate Reductase in germinationg leaves of different plant sources.
7. To study the activity of lipases in germinating oilseeds and demonstrate mobilization of lipids during germination.
8. Demonstration of fluorescence by isolated chlorophyll pigments.
9. Demonstration of absorption spectrum of photosynthetic pigments.

Mapping of COs to Syllabus

	1	2	3	4	5	6	7	8	9
CO1	H								
CO2		H							
CO3			H	H	H				
CO4						H			
CO5							H		
CO6								H	H

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.

Plant Biotechnology
(4 Credits: 60 Hrs)
(4-0-0)
Course outcomes
At the end of this course, student will be able to:
CO1: Memorize the various concepts of plant tissue culture (Remembering)

CO2: Explain Plant tissue culture & recombinant DNA Technology (Understanding).

CO3: Apply basic knowledge in plant tissue and modern techniques of micropropagation in their future research works (Applying)

CO4: Develop/improve protocols for better transgenic products (Creating)

Syllabus:
Module I: Plant Tissue Culture (16 hours)
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, virus elimination, secondary metabolite production, haploids, triploids and hybrids; Cryopreservation; Germplasm Conservation).

Module II: Recombinant DNA technology (30 hours)
Restriction Endonucleases (History, Types I-IV, biological role and application); Restriction Mapping (Linear and Circular); Cloning Vectors: Prokaryotic (pUC 18 and pUC19, pBR322, Ti plasmid, BAC); Lambda phage, M13 phagemid, Cosmid, Shuttle vector; Eukaryotic Vectors (YAC and briefly PAC, MAC, HAC).Gene Cloning (Recombinant DNA, Bacterial Transformation and selection of recombinant clones, PCR-mediated gene cloning); Gene Construct; construction of genomic and cDNA libraries, screening DNA libraries to obtain gene of interest by genetic selection; complementation, colony hybridization; Probes-oligonucleotide, heterologous, PCR; 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).

Module III: Applications of Biotechnology (14 hours)

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.

Mapping of COs to Syllabus

	Module 1	Module 2	Module 3
CO 1	H	-	-
CO 2	H	M	-
CO 3	H	-	M
CO 4	-	-	H

Plant Biotechnology Lab

(2 Credits: 30 Hrs)

(0-0-2)

Course outcomes

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

CO1: Study various media used in Plant tissue culture Laboratory (Remembering)

CO2: Explain/demonstrate different molecular biology techniques in tissue culture (Understanding).

CO3: Analyze modern DNA techniques used in plant improvement (Analyzing)

CO4: Evaluate and compare techniques in plant tissue culture (Evaluating)

Practicals:

1. (a) Preparation of MS medium.

(b) Demonstration of *in vitro* sterilization and inoculation methods using leaf and nodal explants of tobacco, *Datura*, *Brassica* etc.

2. Study of anther, embryo and endosperm culture, micropropagation, somatic embryogenesis & artificial seeds through photographs.

3. Isolation of protoplasts.

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.

Mapping of COs to Syllabus

	CO1	CO2	CO3	CO4
Prac 1	H	-	-	H
Prac 2	-	-	-	M
Prac 3	-	-	-	L
Prac 4	-	-	-	-
Pract 5	-	L	H	-
Prac 6	-	H	M	-
Prac 7	-	M	-	-

Prac 8	-	-	-	-

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.

Industrial and Environmental Microbiology
(4 Credits: 60 Hrs)
(4-0-0)

Course outcomes

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

CO1: Tell the basics of bioreactors and fermentation process (Remembering)
CO2: Explain the role of microbes in industry, agriculture and environment (Understanding).
CO3: Select suitable microbes for solving some environmental problems (Applying)
CO4: Compare various fermentation techniques applied in industry (Analyzing)
CO5: Assess and evaluate pollutants in environment (Evaluating)
CO6: Develop methods for fermentation (Creating)

Syllabus

Module I: Scope of microbes in industry and environment (6 hours)

Module II: Bioreactors/Fermenters and fermentation processes (12 hours)
Solid-state and liquid-state (stationary and submerged) fermentations; Batch and continuous fermentations. Components of a typical bioreactor, Types of bioreactors-laboratory, pilotscale and production fermenters; Constantly stirred tank fermenter, tower fermenter, fixed bed and fluidized bed bioreactors and air-lift fermenter. A visit to any educational institute/ industry to see an industrial fermenter, and other downstream processing operations.

Module III: Microbial production of industrial products (12 hours)
Microorganisms involved, media, fermentation conditions, downstream processing and uses; Filtration, centrifugation, cell disruption, solvent extraction, precipitation and ultrafiltration, lyophilization, spray drying; Hands on microbial fermentations for the production and estimation (qualitative and quantitative) of Enzyme: amylase or lipase activity, Organic acid (citric acid or glutamic acid), alcohol (Ethanol) and antibiotic (Penicillin).

Module IV: Microbial enzymes of industrial interest and enzyme immobilization (8 hours)
Microorganisms for industrial applications_and hands on screening microorganisms for casein hydrolysis; starch hydrolysis; cellulose hydrolysis. Methods of immobilization, advantages and applications of immobilization, large scale applications of immobilized enzymes (glucose isomerase and penicillin acylase).

Module V: Microbes and quality of environment (6 hours)
Distribution of microbes in air; Isolation of microorganisms from soil, air and water.

Module VI: Microbial flora of water (8 hours)
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, check coliform and fecal coliform in water samples.

Module VII: Microbes in agriculture and remediation of contaminated soils (8 hours)
Biological fixation; Mycorrhizae; Bioremediation of contaminated soils. Isolation of root nodulating bacteria, arbuscular mycorrhizal colonization in plant roots.

	Module-1	Module-2	Module-3	Module-4	Module-5	Module-6	Module-7

CO-1	**L**	**H**	**H**	**M**			
CO-2	**L**	**M**	**H**	**H**	**L**	**H**	**H**
CO-3		**L**	**M**	**M**	**L**	**H**	**H**
CO-4	**L**	**M**	**H**	**H**			
CO-5	**L**			**L**	**H**	**H**	**M**
CO-6	**L**	**H**	**H**	**M**			

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Industrial and Environmental Microbiology Lab
(2 Credits: 30 Hrs)
(0-0-2)
Course outcomes
At the end of this course, student will be able to:

CO1: Tell the principles of laboratory instruments (Remembering)
CO2: Explain different sterilization techniques and culture media preparation (Understanding).
CO3: Apply sterilization techniques in laboratory (Applying)
CO4: Compare and select best sterilization methods (Evaluating)

Practicals:
1.Principles and functioning of instruments in microbiology laboratory
2.Hands on sterilization techniques and preparation of culture media.
Mapping:

	Practical-1	**Practica-2**
CO-1	**H**	**M**
CO-2	**M**	**H**
CO-3	**M**	**H**
CO-4	**L**	**H**

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.

Biostatistics
(4 Credits: 60 Hrs)
(4-0-0)

Course outcomes

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

CO-1: Tell the basic terminologies in Bioinformatics (Remembering)
CO-2: Explain various databases and applications of Bioinformatics in science (Understanding)
CO-3: Apply the knowledge gain in data mining from databases (Applying)
CO-4: Interpret biological data or information accurately (Evaluating)
CO-5: Predict biomolecule structures and functions (Creating)

Module I: Introduction to Bioinformatics (5 hours)

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

Module II: Databases in Bioinformatics (5 hours)

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

Module III: Biological Sequence Databases (25 hours)

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.

Module IV: Sequence Alignments (10 hours)
Introduction, Concept of Alignment, Multiple Sequence Alignment (MSA), MSA by CLUSTALW, Scoring Matrices, Percent Accepted Mutation (PAM), Blocks of Amino Acid Substitution Matrix (BLOSUM).

Module V: Molecular Phylogeny (8 hours)
Methods of Phylogeny, Software for Phylogenetic Analyses, Consistency of Molecular Phylogenetic Prediction.

Module VI: Applications of Bioinformatics (7 hours)
Structural Bioinformatics in Drug Discovery, Quantitative structure-activity relationship (QSAR) techniques in Drug Design, Microbial genome applications, Crop improvement.

Mapping:

	Module-1	Module-2	Module-3	Module-4	Module-5	Module-6
CO-1	H	H	H	H	H	H
CO-2	H	H	H	H	H	H
CO-3	L	H	H	H	M	L
CO-4	L	M	H	H	M	L
CO-5	L	M	M	M	M	H

Bioinformatics Lab
(2 Credits: 30 Hrs)
(0-0-2)

Course outcomes
At the end of this course, student will be able to:

CO-1: Classify about different nucleic acid and protein databases (Understanding).
CO-2: Utilize bioinformatics tools in scientific experiments (Applying)

CO-3: Construct phylogenetic tree of biological informations (Creating)

Practicals:

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.

Mapping:

	Practical-1	Practical-2	Practical-3	Practical-4	Practical-5
CO-1	H	H	H	H	H
CO-2	H	H	H	H	H
CO-3	H	H	H	H	H

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.