



Centurion
UNIVERSITY
Shaping Lives...
Empowering Communities...

M.Sc. Botany Syllabus

(Two Years Programme)

School of Applied Sciences
Centurion University of Technology
& Management

2025-26

DEPARTMENT OF BOTANY

M.Sc. Botany Two Year Programme Course Structure 2025-26

Basket I - Core Courses					
Sl. No.	Code	Subject Name	T-P-Pr	Credits	Level
SEMESTER – I					
1.	CUTM1431	Systematics and Diversity of Plants	3-1-0	4	6
2.	CUTM1437	Cell and Molecular Biology	3-1-0	4	6
3.	CUTM4549	Advanced Microbiology	3-1-0	4	6
4.	CUTM1433	Biochemistry and Enzyme Technology	3-1-0	4	6
5.	CUTM1430	Developmental Biology and Phytotomy	3-1-0	4	6
SEMESTER – II					
6.	CUTM1416	Pharmacognosy and Phytochemistry	3-1-0	4	6
7.	CUTM1428	Plant Physiology and Metabolism	3-1-0	4	6
8.	CUTM1438	Bioanalytical Techniques	3-1-0	4	6
9.	CUTM1439	Plant Biotechnology	3-1-0	4	6
	CUTM1440	Plant Breeding and Genetics	3-1-0	4	6
SEMESTER – III					
10.	CUTM1441	Plant Genomics	3-1-0	4	6.5
11.	CUTM 4114	Computational Biology and Data Analysis	3-1-0	4	6.5
12.	CUTM 2378	Research Methodology and IPR	2-0-2	1*4	-
SEMESTER – IV					
13.	CUTM1434	Advances in Plant Ecology	3-1-0	4	6.5
14.	CUTM2495	Advanced Separation Technologies and Downstream Processing	3-1-0	4	6.5
Total			14*4=56		
Basket II (Specialization)				24	
Skill				04	
Grand Total				84	

SEMESTER – I

CUTM1431: Systematics and Diversity of Plants

Subject Name	Code	Type of course	T-P-Pr(Credit)
Systematics and Diversity of Plants	CUTM1431	Theory + practice	3-1-0(04)

Course objectives

- To understand the various aspects of plant nomenclature and classification
- To understand the salient features of angiosperm families with special reference to sexual characters
- To understand the diversity, reproduction and economic importance of lower plants

Course outcome

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

Cos	Course outcomes
CO1	Learn the basic principles of plant classification with emphasis on modern tools of taxonomy for plant identification and nomenclature
CO2	Understand the classification and conservation of angiosperm plants and the theoretical knowledge on diversity of the plant kingdom
CO3	Build the knowledge about the systematic position of genera, species and families
CO4	Know the function of algal biomass, cultivation, production and utilization, and their environmental impacts
CO5	Interpret the morphological characters of selected plants and can identify different families

Course Outcome to Program Outcome Mapping

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PSO1	PSO2	PSO3
CO1	2	3	3	3		2	2	2		2	3	3	1	2	2	3
CO2	2	3	3	2	1	2	3	3		3	2	2	1	2	2	3
CO3	2	2	3	2		2	3	3		3	3	1	1	2	2	3
CO4	2	2	3	2			3	2		3	2	1	1	2	2	2
CO5	1	2	2	1			1	1		1	1	1	1		2	2

(High-3, Medium-2, Low-1)

Course Content

Module I

Approaches to plant systematic: Principles of Plant Classification with emphasis modern tools of taxonomy: Taxonomy as a synthetic discipline, Modern tools of Taxonomy (Cytotaxonomy, Chemotaxonomy, Numerical Taxonomy, Molecular taxonomy, The Species Concept, Taxonomy hierarchy, species, ICBN, Herbarium preparation, preservation and digitalization, Botanical garden of local, National and International level.

Module II

Systems of classification: Systems of classification: Artificial (Linnaeus), Natural (Bentham and Hooker); Phylogenetic (Hutchinson) and Modern (Cronquist) systems, relevance of taxonomy to conservation; Angiosperm Phylogenetic Group: Brief outline of APG-I (1998), APG-II (2003), APG-III- (2009), APG-IV(2016); Principles of conservation, extinctions, environmental status of plants based on IUCN

Module III

Salient features of plant families: Salient features of following families: Monocotyledons: Orchidaceae, Liliaceae, Palmae, Cyperaceae, Araceae, and Poaceae; Dicotyledon: Ranunculaceae, Magnoliaceae, Malvaceae, Rutaceae, Leguminosae, Solanaceae, Cucurbitaceae, Fabaceae, Brassicaceae, Compositae, Asclepiadaceae, Euphorbiaceae

Module IV

Algae: Marine, Freshwater and Terrestrial algae, Classification, Food reserve, Pigment and Thallus organization of algae, Life cycles, salient features and reproduction in Prochlorophyta, Chlorophyta, Life cycles, salient features and reproduction in Bacillariophyta, Xanthophyta, Dinophyta, Phaeophyta and Rhodophyta, Algal biomass production and utilization, algal blooms and their environmental impacts, Seaweed cultivation and utilization.

Lichens: Nature of the relationship between algae and fungi in Lichens, Classification of Lichens, Reproduction and economic importance.

Module V

Bryophyta: Morphology, structure, reproduction and life history, Distribution,

classification, general account of Marchantiales, Jungermaniales, Anthoceratales, Sphagnales, Funariales and Polytrichales & Ecological importance.

Module VI

Pteridophyta: Morphology, anatomy and reproduction; classification, Evolution of stele; heterospory and origin of seed habit, General account of Psilopsida, Lycopsida, Sphenopsida and Pteropsida

Module VII

Gymnosperms: General characteristic features of Gymnosperms, Classification of Gymnosperms and their distribution in India, Phylogeny and Economic importance of Gymnosperms, General account of Cycadales, Coniferales and Gnetales.

Practice

1. Demonstration of the utility of secondary metabolites in the taxonomy of some appropriate genera
2. Acquaintance with flora of local region, preparation of field notes and arrange according to Bentham and Hooker system of classification.
3. Morphological characterization of selected families of dicots and monocots and identification up to families
4. Study of morphology and reproductive structures of algae belonging to different classes through permanent microscopic slide preparations and preserved specimens.
5. Study of temporary & permanent preparation for microscope observation of external and internal features of vegetative and reproductive structure of important genera of Bryophytes
6. T.S. and L.S of vegetative and reproductive organs of important species of Pteridophytes and Gymnosperms.

Text Books:

1. Naik. V.N. (1999), Taxonomy of Angiosperms, Tata-MacGraw-Hill Pub. Co. Ltd.
2. Samuel Jones, (1987), Plant Systematics, Mc-Graw-Hill Company
3. Sivarajan, V.V, (1991), Introduction to the Principles of Plant Taxonomy, Oxford and IBH, N. Delhi
4. Sambamurthy, A. V. S. S. (2005), Taxonomy of Angiosperms, I K International Publishing House Pvt. Ltd.

5. Paria, N. D. (2022). Plant Taxonomy & Biodiversity. Santra Publication
6. Bhatnagar A. K., Kapoor, Rupam. (2020). Plant Diversity in India, I K International Publishing House

Reference Books:

1. Heywood, V.H. and Moore, D. M. (1984). Current Concepts in Plant Taxonomy. Academic press, London.
2. Stace, C. A. (1989). Plant taxonomy and Biosystematics. Edward Arnold, London.
3. Takhtajan, A. L. (1997). Diversity and Classification of Flowering Plants. Columbia University Press, NY.
4. Woodland, D.W. (1991). Contemporary plant systematics. Prentice-Hall, New Jersey, USA
5. Sneath, R. H. A and R. R. Sokal (1973), Numerical Taxonomy, W. H. Freeman and Company, San Francisco.

CUTM1437: Cell and Molecular Biology

Subject Name	Code	Type of course	T-P-Pr(Credit)
Cell and Molecular Biology	CUTM1437	Theory + practice	3-1-0(04)

Course objectives

- To explore biological membranes, cytoskeleton, cell division, intercellular communication, and the nucleus, focusing on the structure, function, and interactions of cellular components.
- To study the mechanisms of DNA replication, transcription, RNA processing, and translation, including regulation and post-translational modifications, to understand gene expression and protein synthesis.
- To analyse protein structure, function, and evolution, enzyme catalysis, and protein engineering to comprehend the principles of protein folding, stability, and the creation of novel proteins through various techniques.

Course outcome

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

Cos	Course outcomes
CO1	Recall the fundamental components of biological membranes and their roles in cellular function along with basic molecular process of cell.
CO2	Understand the mechanisms behind DNA replication, transcription, and translation in both prokaryotic and eukaryotic systems
CO3	Apply laboratory techniques such as PCR, gel electrophoresis, and enzyme assays to explore molecular and cellular processes.
CO4	Analyse the structure-function relationships of proteins and enzymes, their biochemical reactions.
CO5	Evaluate experimental data on cell signalling pathways and gene expression regulation, and cellular responses to various stimuli.

Course Outcome to Program Outcome Mapping

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2		3			1				1	2	2	2	2
CO2	3	3		3			1					2	2	2	2
CO3	3	1		3	3		2		2			2	3	3	3
CO4	3	2		3	3		2		2			3	3	3	3
CO5	3	3		2			1		2			2	3	3	3

(High-3, Medium-2, Low-1)

Course Content

Module I

Biological Membranes and Transport of Biomolecules: Structure of biological membranes: Cell wall (Prokaryotic versus eukaryotic); Plasma membrane: Composition of PM, Mobility and fluidity of membrane proteins; Dynamic nature of membrane; Permeability of pure phospholipids; Membrane Trafficking (Pumps, channels, transporters); Membrane transport: Active transport and passive transport; Endocytosis (Phagocytosis, receptor-mediated endocytosis).

Module II

Cytoskeleton, Cell motility and Cell division: Structure and organization of actin filaments: assembly and disassembly of actin filaments, organization of actin filaments, association of actin filaments with the plasma membrane, Intermediate filaments: assembly of intermediate filaments, intracellular organization of intermediate filaments, the microtubule: structure and dynamic organization of microtubules

Eukaryotic cell division: Mitosis and Meiosis, Cell death and cell renewal: Programmed cell death. Cell cycle and its regulation, cell cycle check points.

Module III

Intercellular communication: Extracellular matrix, cell adhesion and roles of different adhesion molecules, cell-matrix interactions, Cell-Cell interactions (Adhesion Junctions, Tight Junctions, Gap junctions, Plasmodesmata),

Signaling molecules and their receptors, modes of cell signaling, Cell surface receptors, G Protein- coupled receptors. Receptor protein tyrosine kinases, cytokine receptors, Pathways of Intracellular signal transduction, second messengers, bacterial and plant two- component systems.

Module IV

Nucleus Nuclear organization, traffic between the nucleus and the cytoplasm, chromosomes, Chromatin organization (DNA packaging); Lampbrush chromosome; Polytene chromosome; Telocentric chromosome, euchromatin and heterochromatin, The Nucleolus.

Replication, Protein-Nucleic Acid Interactions and Transcription: Prokaryotic and

eukaryotic DNA replication: DNA polymerases, replisome, primase, telomerase, inhibitors of replication. DNA synthesis by reverse transcription.

Module V

Prokaryotic transcription mechanisms, Prokaryotic transcriptional regulation (Operon concept), Eukaryotic transcription –core promoter and general transcription factors (GTFs), Eukaryotic transcription–activating transcription factors and enhancers, Post-Transcriptional Control of Gene Expression.

Module VI

RNA Processing: RNA-processing, mRNA export. Post transcriptional modification and: RNA splicing, spliceosome, RNA editing, Genetic code. Regulation of gene expression in prokaryotes and eukaryotes: role of chromatin in regulating gene expression and gene silencing.

Module VII

Translation and Protein sorting: Translation: Protein synthesis, post-translational modifications: Glycosylation, Phosphorylation, Ubiquitination, Inhibitors of transcription and translation.

Protein sorting and Targeting: Co translational targeting and post translational targeting. Protein targeting to Mitochondria, Chloroplast, Endoplasmic reticulum, Peroxisome and Plasma membrane.

Practice

1. Temporary and permanent mounts of mitosis and meiosis
2. Permanent mount of giant chromosomes (Lampbrush chromosomes)
3. Isolation of genomic DNA
4. DNA quantification using gel electrophoresis and spectroscopy
5. DNA amplification using PCR
6. *In silico* membrane-receptor and ligand interaction studies

Text Books:

1. Geoffrey M. Cooper, Robert E. Hausman (2023). The Cell: A Molecular Approach. 9th edition, ASM Press, Washington D.C.
2. Robertis, De and Robertis Lea, Febiger. (2017). Cell and molecular biology 8th Edition

Reference Books:

1. Molecular Biology of the Cell Alberts, B., et al. 6th Revised. Taylor & Francis; 2014 ISBN 978-0-8153-4432-2 (hard), 978-0-8153-4524-4
2. Essential Cell Biology Alberts, B., et al. 4th Revised. Garland; 2013 ISBN 9780815344544
3. Lewin's Genes XI Krebs, J.E. et al. Jones & Bartlett; 2018 ISBN 9781284104493
4. Molecular Cell Biology Lodish H. et al. 8th ed. W. H. Freeman and Company; 2016 ISBN 9781464183393.
5. <https://www.sciencedirect.com/science/article/pii/S0022283620300905>

Advanced Microbiology

Subject Name	Code	Type of course	T-P-Pr(Credit)
Advanced Microbiology	CUTM4549	Theory + practice	3-1-0(04)

Course objectives

<ul style="list-style-type: none"> • To know various Culture media and their applications and also understand various physical and chemical means of sterilization. • To perform routine culture handling tasks safely and effectively • To know the various physical and chemical growth requirements of microbes and get equipped with various methods of microbes culture techniques and their role in various industry

Course outcomes

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

COs	Course outcomes
CO1	Learn the basic concepts of microbiology, classification of common microbes, genetic diversity of microbes
CO2	Understand the structure, replication, life cycle, their transmission, culture of microbes, and host pathogen interactions.
CO3	Identify the microbes, industrial application; application of important microorganisms in agriculture, cosmetics, and pharmaceutical industries, growth kinetics, and different metabolic process (photosynthesis, respiratory metabolism of microbes
CO4	Categorize important diseases caused by bacteria, protozoa and virus, emergence of multiple-drug resistance strains, interpretation of molecular markers
CO5	Adopt the methods of food preservation, microbiological legal standards of selected food and milk products, bioreactors, and genome mapping

Course Outcome to Program Outcome Mapping

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3						2	2					2	3	2
CO2	3	3	3	3	1	1		2					3	3	3
CO3	3	2	3	2	2	2		3		2	2	2	3	3	3
CO4		3	3	3	3		3	3		2		2	3	2	
CO5	3	3	3	3	2	2	3	3	2	2	2		3	2	2

(High-3, Medium-2, Low-1)

Course Content

Module I

Classification of Bacteria: Introduction to micro-organisms, Classification of bacteria (Phylogenetic system of classification, Bergey's manual), metabolic groups of bacteria.

Structure of Bacteria: Ultra structure of bacterial cell and cell wall. Nutrition of bacteria: modes of nutrition, nutritional types, growth characteristics, reproduction and genetic recombination: binary fission, resting structure, conjugation, transformation and transduction; mechanism of antibacterial action.

Module II

Classification of Virus: Classification of viruses; Structural and genetic diversity of viruses

Virus: Structure, plant and animal viruses, nature and transmission, lytic and lysogenic cycle, genome organization (TMV, CMV, CAMV and Gemini viruses), isolation and purification, detection, identification and economic importance; bacteriophages, viroids, prions, viruses in cancer

Module III

Microbial culture methods: Culture media (types, Different culturing Technique), Isolation, purification, growth, maintenance and preservation of microbes, axenic and synchronous culture, batch and continuous culture

Module IV

Microbial Physiology and Metabolism: Growth Kinetics, Growth cycle, Logistic growth equation, Measurement and growth monitoring in culture, Factor affecting growth; Photosynthetic pigments, Paths of carbon and electron in bacterial photosynthesis; Fermentation, Respiratory metabolism, Embden-Meyerhoff pathway, Entner-Doudroff pathway, Pasteur Effect.

Module V

Applications of microbes in agriculture and industry: Agriculturally important microorganisms, Bio fertilizers, bio pesticides, mycorrhizae, industry (alcoholic beverages, citric acid, penicillin production), environment (pollution indicator and control), and genetic

engineering

Food Microbiology: Microbial toxins produced in food items, Probiotics and prebiotics; Methods of food preservation, Microbiological legal standards of selected food and milk products

Module VI

Medical Microbiology: Host pathogen interactions, important plant diseases caused by bacteria, protozoa, virus; Antibiotics: Definition, phenomenon of antibiotics, and mode of action, biochemical mechanisms of resistance development, multiple-drug resistance

Module VII

Microbial genetics: Genetic regulation: Operon concept (Lac, Trp operon), Genetic mapping: Genome mapping of *E. coli*, Molecular markers in genome analysis.

Bioprocess technology and Engineering: Fermenter design and growth processes, types of bioreactors

Practice

1. Introduction, operation, precautions and use of common microbiology laboratory instruments: Incubator, Hot air oven, Autoclave, Laminar air flow hood and use of common laboratory glass wares (Test tubes, culture tubes, petri plates, and inoculating needles (wire loop, stab needles).
2. Preparation of culture media for bacterial cultivation (Nutrient agar/broth, MacConkey's agar) and sterilization of media and glasswares.
3. Isolation of bacteria by different culture methods (Streak, pour and spread plate method).
4. Preparation of bacterial smear and different staining methods (Gram's staining, Acid-fast staining).
5. Preparation of antibiotic disc and antibiotic sensitivity test.
6. Detection of microorganisms in air, soil and water by standard plate count method.

Text Books:

1. Dubey R C. (2023). A Textbook of Microbiology. 5th Edition, S Chand & Company.
2. Singh, R.P. Microbiology. 2020-2021 edition
3. Dubey R. C. Maheswari, D. K. (2022). A Textbook of Microbiology. 5th Edition. S.

Chand and Company.

4. Dubey R. C. Maheswari D. K. (2023). Practice Microbiology. S. Chand.

Reference Books:

1. Pelczar, Michale J. Jr., Chan E.C.S., Krieg Noel R. (2023). Microbiology, 5th Ed, Affiliated East-West Press Private Limited, G-1/16, Ansari Road, New Delhi 110002
2. Prescott, L. M., Harley, J. P. and Klen, D. A. (1999). Microbiology, 7thEd., McGraw-Hill, New York.
3. Agrios, G. N. (2005). Plant Pathology, 5th Ed, Elsevier Academic press, USA

CUTM1433: Biochemistry and Enzyme Technology

Subject Name	Code	Type of course	T-P-Pr(Credit)
Biochemistry and Enzyme Technology	CUTM1433	Theory + practice	3-1-0(04)

Course objectives

- To introduce the organic structure of living systems such as biomolecules like carbohydrates, proteins, lipids, and nucleic acids
- To provide knowledge relevant to the plant biochemistry and enzymology principles and enzyme kinetics.
- To learn techniques employed in enzymes purification and characterization and applications of enzyme technology.

Course outcome

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

Cos	Course outcomes
CO1	Learn comprehensive theoretical knowledge on biomolecules, bioenergetics principals
CO2	Predict the structure and function of proteins, their types, modification and functions.
CO3	Determine the chemical structures of carbohydrate, nucleosides, nucleotides and lipids, circulating lipids and inflammatory lipid mediators etc
CO4	Illustrate the purification, characterization and estimation of enzymes processes. enzyme kinetics calculations
CO5	Evaluate and apply biochemical calculation for enzyme kinetics and application of enzymes.

Course Outcome to Program Outcome Mapping

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2			1		1	2				2	2	2	3
CO2	3	2	1			2				1		2	3	3	3
CO3	3	2		1				1		2		2	2	3	3
CO4	3	3		3	2			2					3	3	3

CO5	1	3		3	3					1	2	2	3	3	3
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(High-3, Medium-2, Low-1)

Course Content

Module I

Essential Biochemistry and Bioenergetics: Structure of atoms and molecules, chemical bonds; Stabilizing interactions (thermodynamics of folding, conformational entropy, charge interaction, Vander wall force, hydrophobic effect, disulfide bonds, prosthetic group, ion binding protein stability); pH, buffer, acid base equilibria; Water and it's interaction; Biological thermodynamics, enthalpy and entropy, standard free energy, concept and calculation; Biological energy transducer, cellular energy currency.

Module II

Biochemistry of Proteins: Building block of proteins, amino acids: Classification, structure and properties, amino acids (genetically coded, rare genetically coded, modified), dissociation constant, isoelectric point; Protein structure (primary, secondary, tertiary and quaternary), protein denaturation and renaturation; Dynamics of protein structure (globular, fibrous), chaperon concept; Protein folding; Ramachandran plot; Motifs and domains in proteins; Super secondary structure of protein (motif) like helix turn helix, helix loop helix, Zn finger, lucine zipper proteins, etc. and their function; Specialized secondary structure protein structure (TMV, hemoglobin, myoglobin, collagen, RuBisCo).

Module III

Biochemistry of Nucleic Acid: Structure, types, models and stability of nucleic acids (DNA/RNA); Primary and secondary structure of nucleic acids, alternate secondary structure: hairpin, cruciform, triple helix, G-quadrates, etc.; Denaturation, T_m value; Protein DNA interaction

Module IV

Carbohydrate: Structure, types and nomenclature: mono, di, and polysaccharides; Suitability in the context of their different functions, cellular structure, energy storage; Glycosylation of other biomolecules - glycoproteins and glycolipids

Module V

Biochemistry of Lipid: Classification, structure, properties and functions of fatty acid;

Essential fatty acids, fats, phospholipids, sphingolipids, cerebrosides, steroids, lipoproteins;
Membrane protein; Plant biofuel

Vitamins and Antioxidants: Structure and functions of vitamins; Source of phytochemicals;
Natural Antioxidants

Module VI

Enzymology: Characteristics, classification (IUB); Mechanism of enzyme action; Coenzymes and its role in enzyme action; Enzyme kinetics: Michaelis-Menten equation and Briggs-Haldane, Lineweaver-burk, Eadie-hofstee modification; Determination of K_m , competitive, non-competitive and un-competitive inhibition of enzymes; Mechanism of action of chymotrypsin and ribonuclease; Regulation of enzyme activity (covalent modification, feedback regulation and allosteric control); Extraction, assay and purification of enzymes.

Module VII

Industrial biochemistry: Industrial enzymes – production & applications; Biofuel: production of biomethane and bioethanol from agro-food wastes/microalgae

Enzyme immobilization: Definition and scope, Techniques of Immobilization;

Nanobiocatalysts: Introduction to nanobiocatalysis, synthesis and applications in different Industry.

Practice

1. Quantitative estimation of proteins (Biuret, Lowry, BCA and Bradford methods)
2. Quantitative estimation of carbohydrates/nucleic acid
3. Determination of unknown concentration of vitamin C
4. Effects of pH, temperature, and substrate concentration on enzyme activity
5. Synthesis of plant based nanoparticle
6. Bio-diesel production from biomass and its characterization

Text Books:

1. Donald Voet, Judith G. Voet, Biochemistry, Wiley, 4th edition (2011)
2. David L. Nelson; Michael M. Cox, Lehninger Principles of Biochemistry, W. H freeman and Company (2021)
3. Satyanarayana, U. and Chakrapani, U, Biochemistry, Elsevier, 6th edition (2021)

Reference Books:

1. Trevor Palmer, Philip L. Bonner- Enzymes_ Biochemistry, Biotechnology, Clinical

Chemistry-Woodhead Publishing – 2nd edition 2007

2. Leskovacs V. Comprehensive enzyme kinetics, Kluwer- 1st edition 2003

CUTM1430: Developmental Biology and Phytotomy

Subject Name	Code	Type of course	T-P-Pr(Credit)
Developmental Biology and Phytotomy	CUTM1430	Theory + practice	3-1-0(04)

Course objectives

- To know the relationship between the internal structure, function, taxonomy, physiology, ecology and developmental genetics of the organism.
- To know the evolutionary history and taxonomic variation of vascular plant anatomy
- To understand the morphology and development of reproductive parts

Course outcome

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

Cos	Course outcomes
CO1	Define and remember the internal structure, tissues involved in developmental stages of plants
CO2	Understand about the secondary growth, gametophyte development, molecular mechanisms of fruit and seed development.
CO3	Identify different plants by studying the anatomical features and make use of the knowledge for studying the deviations
CO4	Analyse the gametogenesis and pollen-pistil interaction mechanisms
CO5	Determine the pollen viability and differential behaviour of sperms

Course Outcome to Program Outcome Mapping

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	2	2		1	2	2		2	1	1	1	2	2
CO2	2	2	1	1		1	2	1		2	2	1	1	1	2
CO3	1	1	1	1		2	1	1		2	1	1	1	2	2
CO4	3	2	2	2		2	2	2		2	1	1	1	2	2
CO5	3	3	2	2		2	2	2		2	1	1	1	2	2

(High-3, Medium-2, Low-1)

Course Content

Module I

Introduction and importance of Plant Anatomy: Importance in plant development, taxonomy and identification, ecology and pharmacognosy.

Tissues: Simple tissues, complex tissues and their function; Secondary xylem, secondary phloem in angiosperms and gymnosperms (conifers), structure and functions; Meristematic tissue: Structure, classification, distribution and function.

Module II

Secondary growth: Secondary growth in stem and root; Anomalous secondary growth in dicot and monocot stems; Cambial types: Vascular cambium and phellogen, structure and functions, cambial activity in grafting and wound healing

Module III

Wood Structure and anatomy: Macro and micro structure and composition, chemical composition and properties of wood, bark and bark products

Wood parenchyma: Apo tracheal and Para tracheal parenchyma; Hard wood anatomy, organization of wood, sap wood, heard wood; Axial Parenchyma fibers and ray parenchyma and their value in wood identification'; Nodal anatomy.

Module IV

Shoot development: Shoot systems and its derivatives, Theories of organization of meristem in stem.

Root development: Root systems and its derivatives, Theories of organization of meristem in root, Quiescent center, Coordination of shoot and root development; Root-shoot transition, Ontogeny and phylogeny of vessels.

Leaf Development: Ontogeny of dorsiventral leaf, arrangement of leaves (Phyllotaxy)

Module V

Modes of Flower Development: Meristem tissue in flower development, genetic control of flower development.

Anther: Anther wall, endothelium, middle layer, tapetum, tapetum-Structure, types and function **Microsporogenesis:** Pollen tetrad development and Pollen wall proteins, Pollen

viability and Storage, Male gametophyte development, Differential behavior of sperms.

Module VI

Megasporogenesis: Female gametophyte development, Organization of the embryo sac and different types of it. Pollination-pollination mechanism, biotic and abiotic pollination and floral attractants

Pollen-pistil interaction: The Stigma-Types and structure, stigmatic exudates, style transmitting tissue, canal cell.

Post pollination events: stigma receptivity (recognition and rejection reaction) pollen adhesion, pollen hydration, pollen germination and pollen tube growth and guide, sexual incompatibility (both homorphic and heteromorphic), Double fertilization and In vitro fertilization

Module VII

Methods of in Vitro Fertilization: Anther culture, Intra-ovarian pollination, Gynogenesis.

Endosperm development and differentiation: Types of endosperms, ruminant endosperm

Embryogenesis: Embryo development in dicot and monocot, polyembryony; apomixes, agamospermy and parthenocarpy

Fruit Biology: Development and diversity of fruit dispersal

Practice

1. Study of anatomical details through permanent slides preparation
2. T.S of plants showing secondary growth
3. T. S of plants showing anomalous secondary growth
4. T.S of anthers of angiospermic plants
5. Pollen viability
6. T.S of ovary of flower showing placentation

Text Books:

1. Pandey S N, Ajanta Chadha (2009) Plant Anatomy and Embryology, Vikas Publishing House
2. Raghavan, V. (1999). Developmental Biology of Flowering Plants. Springer-Verlag, New York
3. Bhojwani, S. S., Bhatnagar, S. P. and Dantu, P.K. (2014). The Embryology of Angiosperms. Vikas Publishing House, New Delhi.

Reference Books:

1. Eames. A. J .and Macdaniels, L.H,1947, An Introduction to Plant Anatomy, McGraw-Hill, N. Y and London.
2. Easu, K,2017 Esau's Plant Anatomy: Meristems Cells and Tissues of the Plant Body Their Structure Function And Development, 3Rd Edn by Evert R.F., Wiley India.
3. Richard Crang , Sheila Lyons-Sobaski , Robert Wise,2018, Plant Anatomy, A Concept-Based Approach to the Structure of Seed Plants, Springer, 978-3-319-77208-0

SEMESTER – II

CUTM1416: Pharmacognosy and Phytochemistry

Subject Name	Code	Type of course	T-P-Pr (Credit)
Pharmacognosy and Phytochemistry	CUTM1416	Theory + practice	3-1-0

Course objectives

- This course is very critical in imbibing the knowledge of Medicinal and Aromatic Plants.
- Through this course student will understand the importance of Phytochemistry which actually added therapeutic value to the Medicinal Plants.
- This course enables analytical thinking of students which will help them in deducing and isolation of the vital phytochemical compounds.

Course outcome

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

COs	Course outcomes
CO1	Acquire the knowledge about the commercial medicinal and aromatic plants, cultivation, conservation, yield and cost benefit analysis and marketing strategies
CO2	Understand the techniques of extraction, isolation of phytoconstituents from selected medicinal plants.
CO3	Identify the important therapeutic classes of compounds
CO4	Analyse different phytocompounds through phytochemical analysis of selected medicinal plants.
CO5	Estimate about the importance of crude drugs and quality control methods for authenticity of crude drugs

Course Outcome to Program Outcome Mapping

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PSO1	PSO2	PSO3
CO1	3	3	2	2			2	2		3	2	2	3	3	3	3
CO2	3	3	3	3	1	2	3	3		3	2	3	2	3	3	3
CO3	3	3	3	3	1	1	3	3		3	3	3	2	3	3	3
CO4	3	3	3	3	1	1	3	3		3	3	3	2	3	3	3
CO5	3	3	3	3	1	2	3	3		3	3	3	2	3	3	3

(High-3, Medium-2, Low-1)

Course Content

Module I

Concept note on commercial medicinal and aromatic plants (MAPs); Collection, cultivation and trade of MAPs; Relationship between conservation sites and richness of MAPs; Commercial MAPs of India; Promoting medicinal plants cultivation as a tool for biodiversity conservation. Yield assessment and cost-benefit analysis; Role of National Medicinal Plant Board (NMPB) in Promotion of MAPs; Marketing of Medicinal Plants: Challenges and Strategies.

Module II

Methods of extraction, isolation and characterization of natural products; Various separation techniques used for isolation of natural products; Biosynthetic pathways; Primary metabolites, their examples; Secondary metabolites, various classes of secondary metabolites (e.g. Alkaloids, glycosides, tannins, lignans, saponins, lipids, flavonoids, coumarins etc.).

Module III

Important therapeutic classes: Anti-diabetics, hepatoprotectives, immunomodulators, nutraceuticals, natural products for gynecological disorders, anti-cancer, anti-viral (mainly anti-HIV), adaptogens etc.

Module IV

Phytochemistry of Neem: General chemical class and identification tests, specific tests for markers, special reference to alkaloids (nimbin, nimbolide etc.).

Phytochemistry of Brahmi: General chemical class and identification tests, specific tests for markers, special reference to bitters (bacosides).

Phytochemistry of Turmeric: General chemical class and identification tests, specific tests for markers, special reference to phenols (curcuminoids).

Phytochemistry of *Withania somnifera*: General chemical class and identification tests, specific tests for markers, special reference to steroids (withanolides).

Module V

Phytochemistry of *Andrographis paniculata*: General chemical class and identification tests, specific tests for markers, special reference to bitters (andrographolides).

Phytochemistry of Ginger: General chemical class and identification tests, specific tests for

markers, special reference to phenols (gingerols).

Phytochemistry of Garlic: General chemical class and identification tests, specific tests for markers, special reference to phenols (allicin);

Phytochemistry of *Terminalia arjuna*: General chemical class and identification tests, specific tests for markers, special reference to triterpenes (arjunolic acid)

Module VI

Introduction: Definition, history, scope of pharmacognosy in indigenous system of medicine.

Sources of drugs: Biological, marine, mineral and modern techniques like plant tissue cultures as sources of drugs; Classification of drugs and natural origin: Alphabetical, morphological, taxonomical, chemical and pharmacological classification of drugs; Demand and supply of crude drugs and their regulations with reference to trade and biodiversity

Module VII

Quality control and drug evaluation: Adulteration; Significance of Pharmacopoeia standards; Detection of adulteration by organoleptic, macroscopic and microscopic methods for detection of adulteration.

Practice

1. Preparation of extracts of Herbs by successive solvent extraction method to record the percentage yield.
2. Detection of Phytoconstituents such as i) Alkaloids, ii) Steroids, Triterpenoids and their glycosides and Saponins iii) Flavonoids and their glycosides iv) Anthracene glycosides v) Coumarins vi) Tannins.
3. Antimicrobial activity of some selected medicinal plants and antibiotics.
4. Isolation and Purification of the following natural products: (a) Piperine from Black Pepper, (b) Caffeine from Tea Powder, (c) Eugenol from Clove oil.
5. Extraction and estimation of volatile oils by Clevenger's method (Hydrodistillation method).
6. TLC fingerprint profiles of the following medicinal plants with special emphasis on their marker compounds: (a) *Withania somnifera*, (b) *Bacopa monnieri*, (c) *Curcuma longa*.

Reference Books:

1. Biren Shah and A.K. Seth. (2020). Textbook of Pharmacognosy and Phytochemistry. CBS Publishers and Distributors Pvt. Ltd; 2nd edition
2. Jarald, Edwin E. and Edwin Jarald Sheeja (2018). Text book of Pharmacognosy and Phytochemistry, CBS Publisher.
3. William C. E (2009). Trease and Evans Pharmacognosy.

Practice Books:

1. Raphael Ikan (2013). Natural Products: A laboratory guide, Academic Press.
2. C.K. Kokate (2019). Pharmacognosy. Nirali Prakashan Publisher
3. Vinod Rangari (2019). Pharmacognosy and Phytochemistry. Career Publications; 4th edition.
4. Krishnaswamy N. R. (2021). Chemistry of Natural Products: A Laboratory Handbook. Universities Press (India) Private Limited.

CUTM1428: Plant Physiology and Metabolism

Subject Name	Code	Type of course	T-P-Pr(Credit)
Plant Physiology and Metabolism	CUTM1428	Theory + practice	3-1-0

Course objectives

<ul style="list-style-type: none"> To understand the structure and function of light harvesting complexes and the mechanisms of electron transport system To understand the uptake, transport, and translocation of water, ions, solutes, and macromolecules. To analyse sensory photobiology, and mechanisms of action of phytochromes, cryptochromes, phototropins, glycolytic pathway, fermentation, and the TCA cycle
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Course outcome

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

Cos	Course outcomes
CO1	Recollect the concept and mechanisms of photosynthesis and photophosphorylation.
CO2	Understand the mechanisms of water and mechanisms of loading and unloading of photo assimilates, sensory photobiology and stress physiology.
CO3	Articulate the mechanisms of cellular respiration, oxidative phosphorylation and lipid metabolism in plant.
CO4	Analyse the concepts of hormone receptors, signal transduction, gene expression in plant responses, sensory photobiology of plants, and roles of photo-pigments.
CO5	Interpret the oxidative stress, reactive oxygen species (ROS) and the role of antioxidant enzymes in different stress condition in plant.

Course Outcome to Program Outcome Mapping

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	3	1	1	1	2	2		2	1	1	1	2	3
CO2	3	2	2	2	1	1	2	3		2	2	1	1	2	3
CO3	3	3	2	3	1	2	3	3		3	2	2	1	3	3
CO4	3	3	3	3	2	2	3	3		3	3	2	2	3	3
CO5	3	3	3	3	2	2	3	3		3	3	3	2	3	3

(High-3, Medium-2, Low-1)

Course Content

Module I

Photosynthesis - Light harvesting complexes; Red drop and Emerson's enhancement effect. Photolysis of water, photophosphorylation, mechanisms of electron transport; Hill Reaction, photoprotective mechanisms; CO₂ fixation-C₃, C₄ and CAM pathways. Chlororespiration: The relation between Photosynthesis, respiration and Chlororespiration. Regulation of C₃ pathway.

Module II

Solute transport and photoassimilate translocation – uptake, transport and translocation of water, ions, solutes and macromolecules from soil, through cells, across membranes, through xylem and phloem; transpiration; mechanisms of loading and unloading of photo assimilates.

Module III

Plant growth regulator and Elicitors: Physiological effect and mechanism of action of Auxin, Gibberellin, Cytokinin, Ethylene, Abscisic acid, Jasmonic acid, Salicylic acid, Brassinosteroid, Strigolactones, hormone receptor, Signal transduction and Gene expression; Programmed cell death; Sensory photobiology: Structure, function and mechanisms of action of phytochromes, cryptochromes and phototropins; stomatal movement; photoperiodism and biological clocks.

Module IV

Stress Physiology: Plant responses to biotic and abiotic stress, mechanisms of biotic and abiotic stress tolerance, water deficit and drought resistance, salinity stress, metal toxicity, freezing and heat stress, oxidative stress. Metabolism: reactive oxygen species (ROS), antioxidant enzymes: catalase, peroxidases, superoxide dismutase, glutathione transferase, glutathione reductase, Halliwell–Asada cycle.

Module V

Cellular Respiration: Glycolysis, Fermentation, TCA cycle and their regulation. Pentose phosphate path ways, alternate oxidase. Shuttle system: Malate - Aspartate shuttle and Glycerol phosphate shuttle. Factor affecting respiration. Gluconeogenesis and its regulation.

Module VI

Oxidative phosphorylation: Mitochondrial electron transport, Chemiosmotic mechanism, ATP-Synthesis: Mechanism of ATP synthesis, Substrate level phosphorylation, oxidative phosphorylation, ATP synthase, Boyers conformational model, Racker's experiment, role of uncouplers. Inhibitors of oxidative phosphorylation.

Module VII

Lipid metabolism: Fatty acid biosynthesis, synthesis of membrane lipids, storage lipids and their catabolism. α and β -oxidation of fatty acid. Glyoxalate cycle. Nitrogen fixation & Metabolism: Biological Nitrogen fixation, asymbiotic and symbiotic Nitrogen fixation, nodule formation, Nod and Nif genes their regulation and function, mechanism of nitrate uptake and reduction, ammonium transport and assimilation.

Practice

1. Isolation of chloroplast and measurement of electron transport activity
2. Comparative study of photosynthetic pigment in C₃ and C₄ plant, grown in light and shade condition
3. Extraction of pigments from leaves and preparation of absorption spectra for chlorophyll and carotenoids
4. To compare chlorophyll content in juvenile and matured leaves
5. Estimation of relative leaf water contents in stress and control plant condition
6. Accumulation of proline content comparison in stress and control plant condition

Text Books:

1. Satyanarayana, U. and Chakrapani, U. (2013), Biochemistry, Elsevier
2. Buchanan, Gruissem and Russell (2015). Biochemistry and molecular biology of plants, Willy Blackwell

Reference Books:

1. Taiz, L., Zeiger, E., Mller, I. M. and Murphy, A (2018), Plant Physiology and Development. Sinauer Associates Inc. USA. 6th edition.

CUTM1438: Bioanalytical Techniques

Subject Name	Code	Type of course	T-P-Pr(Credit)
Bioanalytical Techniques	CUTM1438	Theory + practice	3-1-0(04)

Course objectives

<ul style="list-style-type: none"> • To develop the skill to understand the theory and practice of bioanalytical techniques • To provide scientific understanding of analytical techniques and detailed implementation of results • To understand different types of data using appropriate statistical software

Course outcome

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

COs	Course outcomes
CO1	Learn different staining procedures and visualization techniques, Laws of absorption of light, Beer-Lambert's Law, Isotopes and Nature of radioactivity.
CO2	Demonstrate principles of various analytical techniques for quantification of biochemical compounds
CO3	Utilize different instruments for conducting the research work
CO4	Analyze different phyto-constituents using different instruments
CO5	Interpret the results of different techniques

Course Outcome to Program Outcome Mapping

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	1	2	2	1			1		3	3	1
CO2	3	3	2	2	2			1	1	1		2	3	3	2
CO3	3	3		3	3	3	2	1					3	3	3
CO4	3	3		3	2			1			2	1	3	3	2
CO5	3	1	3	1	2	3	1			1		3	3	3	2

(High-3, Medium-2, Low-1)

Course Content

Module-1

Microscopic techniques: Visualization of cells and sub-cellular components by light microscopy and fluorescent microscope, resolving powers of different microscopes, Electron microscope, Scanning and transmission microscopes, fixation and staining techniques for EM, Scanning probe microscopes: AFM and STM.

Module II

Spectroscopic techniques: Laws of absorption of light, Beer-Lambert's Law, Absorption spectra, Measurement of absorption of light, Factors affecting the absorption properties of chromophores, Ultraviolet-visible absorption spectroscopy: Principle, Instrumentation and application, AAS Fluorescence spectrophotometry: Principle, Instrumentation and application, Mass spectroscopy: Principle, Instrumentation and application, FTIR.

Module III

Centrifugation techniques: Basic principles of sedimentation, Types of centrifuges, Types of rotors, Preparative centrifugation (Differential & density gradient), Analytical ultracentrifugation.

Module IV

Radio labelling Techniques: Isotopes and Nature of radioactivity, Radioactive decay, Radioisotopes used in Biology, Detection and measurement of radioactivity, Carbon dating, Geiger-Muller counting and liquid scintillation Counting, Safety guidelines related to Radio labelling techniques.

Immuno-techniques: Antibody generation, Detection of molecules using ELISA, RIA, immunoprecipitation, FISH and GISH.

Module V

Chromatographic techniques: Principles of chromatography (Adsorption and Partition chromatography); Planar chromatography (Paper and Thin-layer chromatography); Column chromatography; Gas chromatography; Gel permeation chromatography, Ion exchange chromatography, Affinity chromatography, HPLC, HPTLC, FPLC.

Module VI

Electrophoretic techniques: General principles, Electrophoresis of nucleic acids (Agarose gel, pulse- field), Electrophoresis of proteins (SDS-PAGE, native gels) isoelectric focusing and two-dimensional gels, Blotting Techniques-Southern, northern, Western blotting, Dot blotting.

PCR Variants: qPCR, RT-PCR, and Multiplexing for Genomic Profiling. Sequencer: NGS Platforms, Nanopore sequencer.

Module VII

Electrophysiological methods: Electrocardiogram (ECG), Positron emission tomography (PET), Magnetic resonance imaging (MRI), Flow cytometry, Nuclear magnetic resonance (NMR)

Practice

1. To study and gain expertise on differential and cytological staining techniques.
2. Quantification of biomolecules using UV-vis Spectrophotometer
3. Detection of antigen/antibodies using ELISA
4. To separate different macromolecules using centrifugation.
5. To separate the phytochemicals by different chromatographic techniques.
6. To study the separation of Protein by SDS PAGE

Text Books:

1. Keith Wilson and John Walker (2018) Principles and techniques of biochemistry and molecular biology. 7th. Edition, Cambridge University Press, Cambridge, UK.
2. Voet D and Voet J Biochemistry, 4th Edition. (2020). John Wiley and Sons. New Jersey, USA

Reference Books:

1. Wilson K and Walker J (2018) Principles and techniques of biochemistry and molecular biology. 7th Edition, Cambridge University Press, Cambridge, UK.
2. Rodney F Boyer (2019) Biochemistry laboratory: modern theory and techniques. 2nd Edition, Pearson Prentice Hall, Boston, USA.

CUTM1439: Plant Biotechnology

Subject Name	Code	Type of course	T-P-Pr(Credit)
Plant Biotechnology	CUTM1439	Theory + practice	3-1-0(04)

Course objectives

- To understand the basics of tissue culture, its practices and apply knowledge of cellular differentiation and totipotency in plant tissue culture and regeneration.
- To learn the principles of vector-mediated gene transfer and Agrobacterium-mediated genetic transformation in plants, and to optimize protocols for gene transfer.
- To develop and apply genetic engineering techniques, for improved plant variety development and to design edible vaccines and long-shelf-life plants.

Course outcome

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

Cos	Course outcomes
CO1	Learn to propagate plants through plant tissue culture, conduct research, develop disease-free germplasm and advance agricultural and horticultural practices
CO2	Understand different genetic manipulation techniques, to create genetically modified plants, enhance crop traits, and address agricultural challenges
CO3	Make use of the enhanced agricultural practices, introducing a variety of gene transfer techniques for development of an improved variety
CO4	Discover the knowledge and skills in designing, developing, and evaluating genetically modified plants for enhanced disease resistance
CO5	Evaluate the gene function, mechanisms and skills to manipulate gene expression in plants using RNA interference (RNAi)

Course Outcome to Program Outcome Mapping

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	1	2		1	2		1	2	2	3	3	
CO2	3	3	2	2	2		1	3		2	2	3	3	3	
CO3	3	3	3	3	3	1	2	2	2	3	2	3	3	3	2
CO4	3	3	3	2	3	1	2	2	2	3	3	3	3	3	3
CO5	3	2	2	2	3		2	2	2	3	3	3	3	3	2

(High-3, Medium-2, Low-1)

Course Content

Module I

Basics of Plant Tissue Culture: History, scope, concept of cellular differentiation and Totipotency, Cell culture media and sterilization techniques, Callus culture, nodal and tip culture, Protoplast and Embryo culture, Embryo culture and embryo rescue, protoplast isolation, culture and plant regeneration

Module II

Applications of Plant Tissue Culture: Somatic embryogenesis, Soma clonal variation and crop improvement, germplasm conservation, Production of Secondary metabolites through Tissue culture, Industrial applications.

Module III

Recombinant DNA technology: Genomic DNA & plasmid DNA isolation and purification, construction of recombinant DNA and expression cassettes, Transformation (mobilization of vectors into competent bacteria), selection, screening and analysis of recombinant clones, genomic DNA and cDNA libraries.

Module IV

Genetic Engineering in Plants: Vector mediated Gene transfer, Molecular basis of crown gall and hairy root diseases, features of Ti and Ri plasmids, mechanism of T-DNA transfer, role of virulence genes, vectors based on PTi & PRi, binary and co-integrate vectors, optimized protocols for Agrobacterium-mediated genetic transformation, physical and chemical methods of gene transfer.

Module V

Methods of Gene transfer in plants: Direct gene transfer methods (particle bombardment/micro projectile / biolistic, electroporation, microinjection, liposome mediated, silicon carbide fibers), chemical methods (PEG - mediated, calcium phosphate co-precipitation), transgenic monocots and dicots via direct gene transfer, in plant transformation. Integration and fate of transgene, precision of transgene integration by site-specific.

Module VI

Applications of Genetic Engineering: Transgenic plants for disease resistance, nutritional

improvement, herbicide tolerance, Long shelf life, edible vaccines.

Module VII

Gene silencing in plants: Antisense RNA technology: Antisense RNA, construction of antisense vectors, applications of antisense technology. Gene silencing: causes (DNA methylation, homology-dependent suppression by antisense gene), strategies for avoiding gene silencing, methods of inducing gene silencing and its application. Regulatory RNA molecules (si RNA and miRNA), RNAi technology and its applications in plants. CRISPR/Cas technology and its applications in plants.

Practice

1. Preparation of tissue culture media
2. Direct organogenesis: Shoot tip culture
3. Protoplast isolation
4. Micro propagation of plants
5. *Agrobacterium tumefaciens* mediated transformation of tobacco leaves
6. Demonstration of biolistic method of gene transfer through photographs

Text Books:

1. Satyanarayana, U. (2020), Biotechnology, Elsevier
2. Jocelyn E. Krebs, Elliott S. Goldstein, Stephen T. Kilpatrick (2017). Lewin's Genes XII.
3. Jeremy W. Dale , Malcolm von Schantz , Nicholas Plant (2011). From Genes to Genomes: Concepts and Applications of DNA Technology

Reference Books:

1. Liebler, D.C. Introduction to Proteomics: Tools for the New Biology. Human Press, Totowa NJ. 2002.
2. Richard J. Reece. Analysis of Genes and Genomes. 2003

CUTM1440: Plant Breeding and Genetics

Subject Name	Code	Type of course	T-P-Pr (Credit)
Plant Breeding and Genetics	CUTM1440	Theory+ practice	3-1-0 (04)

Course Objectives

- To understand the basic concepts of genetics and develop their analytical, quantitative and problem solving skills from classical to molecular genetics.
- To provide insight into structure and functions of chromosomes, chromosome mapping, polyploidy and cytogenetic aspects of crop evolution.
- To impart theoretical knowledge and practical skills about plant breeding objectives, modes of reproduction and genetic consequences, breeding methods for crop improvement.

Course outcome

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

COs	Course outcomes
CO1	Learn about the chemical basis of heredity, molecular marker system in plant, basic of populations and genetic drift.
CO2	Understand the basics of chromosome structure, aberrations, cytoplasmic inheritance and occurrence of cytogenetic abnormalities and DNA damage and repair mechanisms.
CO3	Acquire knowledge on conventional and advance breeding methods in development of an improved plant variety.
CO4	Examine and evaluate conventional plant breeding methods for different pollination systems and vegetatively propagated crops.
CO5	Utilize the molecular and cytogenetic tools, including marker-assisted selection, for genetic improvement of crops.

Course Outcome to Program Outcome Mapping

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	1	2	3		1	2	1	1	2	2	3	1	1
CO2	3	2	1	3	2		1	1	1	2	2	3	3	2	2
CO3	3	3	3	3	3		2	1	2	2	3	3	3	2	3
CO4	2	2	3	3	3	1	2	2	2	3	3	3	3	1	2
CO5	3	3	3	3	3		2	1	2	3	3	3	2	3	3

(High-3, Medium-2, Low-1)

Course Content

Module I

Gene concept: Allelism and fine structure of gene; Mendelism and deviation of Mendelian ratios, epistasis, linkage and crossing over, Incomplete and complete linkage.

Module II

Genome mapping: Sex-linked inheritance; Nuclear and cytoplasmic genome organization; Maternal effect, genome imprinting, two-point cross, three-point test cross and chromosome mapping, tetrad analysis, extra chromosomal inheritance; Cytoplasmic male sterility.

Module III

Chromosomal aberrations: Structural aberration: Duplication, deficiency, inversion and translocations heterozygotes: Numerical **chromosome aberrations: Aneuploids:** trisomics and monosomics; **Euploids:** Autopolyploids, allopolyploids, role polyploidy in speciation with reference to *triticum* and *brassica*; Polyploids, haploids, aneuploids and their utility; Chromosome variation and evolution.

Module IV

Population genetics – Populations, Gene pool, Gene frequency; Hardy-Weinberg Law; concepts and rate of change in gene frequency through natural selection, migration and random genetic drift

Module V

Mutagenesis: DNA damage and repair mechanisms, Spontaneous and induced mutations and their molecular mechanisms, physical and chemical mutagens, transposable elements and mechanism of transposition.

Module VI

Introduction to plant breeding: Natural breeding systems in plants, genetic diversity in plant breeding; Conventional breeding methods for self, cross-pollinated and vegetative propagated crop plants.

Module VII

Tools in plant breeding: Heterosis breeding; polyploidy and haploid breeding; Cytogenetic tools in plant breeding, Genetic crossing, Molecular markers-RAPD, ISSR, SSR, SNPs, Bulk-segregate analysis, Back- cross breeding. Marker Assisted selection – Foreground and background selection – MAS for major and minor genes – Marker assisted pyramiding

Practice

1. Study of chromosome mapping with point test cross data.
2. Karyotyping using photographs
3. Disease and Pest Resistance Screening
4. Demonstration of cross hybridization process in selected plant species.

5. To amplify the supplied DNA sample by using random amplified polymorphic DNA(RAPD) and inter simple sequence repeat (ISSR) markers.
6. To amplify the supplied DNA sample using SSR markers

Text Books:

1. H.K. Chaudhari, **Plant Breeding: Classical to Modern"**(2019)
2. C. Neal Stewart Jr. Plant Biotechnology and Genetics: Principles, Techniques, and Applications (2016)
3. B.D. Singh. Plant Breeding: Principles and Methods (2015).

Reference Books:

1. Lewin, B. (2014). Gene VIII. Person-Prentice Hall, London.
2. Pierce, B. A. (2006). Genetics: A Conceptual Approach. W. H. Freeman, New York.
3. George Acquaaah, "Principles of Plant Genetics and Breeding". Wiley Blackwell.

SEMESTER – III

CUTM1441 Plant Genomics

Course Title	Course Code	Type of course	Course Credit (T-P-Pr)
Plant Genomics	CUTM 1441	Theory+ practice	3+1+0 (04)

Course objectives

<ul style="list-style-type: none"> • To understand and apply advanced techniques in genomics, including genome organization, mapping, and sequencing, with genome analysis tools. • To gain comprehensive knowledge in comparative genomics, transcriptomics, proteomics, and metabolomics • To know the cutting-edge technologies for genetic and protein sequencing, and metabolite profiling
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Course outcomes

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

COs	Course outcomes
CO1	Remember about the concepts of genome organization and mapping of genomes, extra-chromosomal DNA
CO2	Know details about the genome sequencing methods, traditional chemical and enzymatic techniques, next-generation sequencing technologies, and Human Genome Project
CO3	Explore about the genome sequence in development of improved plant variety, whole genome comparisons and phylogenetic analysis to classify organisms.
CO4	Apply different advance techniques such as 16S rRNA typing/sequencing for identification and classification of organisms
CO5	Evaluate the efficacy of approaches like transcriptomics, proteomics and metabolomics for characterisation of a particular trait.

Course Outcome to Program Outcome Mapping

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	1		2				2	2			3	2
CO2	3	3	2	2	1	3	2	2	3	3	3	1	2	3	3
CO3	3	2	3	1	1	3	2	3	3	3	3	2	2	3	3
CO4	3	3	3	2	3	0	2	2		3	1			2	3
CO5	3	2	2		1	2	3		2	3	2			3	2

(High-3, Medium-2, Low-1)

Course Content

Module I

Genome Diversity and Extra-chromosomal DNA: Introduction to genomics, Brief overview of prokaryotic and eukaryotic genome organization, Extra-chromosomal DNA: bacterial plasmids, Mitochondrial and chloroplast genomes.

Module II

Genome mapping: Physical and genetic mapping

Genetic mapping: linkage analysis, Choice of mapping populations, Markers for genetic mapping, Physical Mapping: Tools and techniques used for physical mapping, Cytogenetic Mapping Techniques

Module III

Genome Sequencing strategies: Chemical (Maxim and Gilbert's degradation method) and enzymatic (Sanger's dideoxy synthetic method) methods of DNA sequencing; Genome sequencing strategies- Whole genome, clone-by-clone and hybrid approaches.

Genome sequencing methods/technologies: Next generation sequencing technologies- 454, Illumina, ABI SOLiD, single molecule and nanopore sequencing. Human Genome Sequencing Project, Genome sequencing projects for plants (Rice, Arabidopsis).

Module IV

Comparative genomics: Whole genome comparison; Tandem and segmental duplication; DNA based phylogenetic trees; Identification and classification of organisms using 16S rRNA typing/sequencing.

Module V

Transcriptomics: Global gene expression strategies- Northern blotting, Serial Analysis of Gene Expression (SAGE), Massively Parallel Signature Sequencing (MPSS), Microarray-construction of microarrays – genomic arrays, cDNA arrays and oligo arrays, Transcriptome profiling.

Module VI

Proteomics: Protein interactions; DNA – protein Interactions, yeast two-hybrid systems; affinity tagging, pathway building. 2D-PAGE, isoelectric focusing, mass spectrometry, MALDI-TOF, LC-MS; Proteome databases; Protein sequencing: N-terminal sequencing-

Ninhydrin test, Sanger's method, Edman degradation; C-terminal sequencing-types of reducing agents; functional protein microarrays

Module VII

Metabolomics: Introduction to metabolomics: Metabolome, Metabolite profiling, Metabolome fingerprinting, Role of Biomarker in metabolomics, Techniques for metabolome analysis.

Practice

1. Demonstration of genetic mapping.
2. Demonstration of web tools for genome analysis
3. Phylogenetic analysis using genomic tools
4. RNA isolation from supplied plant sample.
5. Protein separation using SDS-PAGE (Demonstration through virtual labs)
6. Isolation of secondary metabolites using Soxhlet apparatus.

Text Books

1. Brown, T. A. (2023). *Genome VIII*. Garland Science. ISBN: 9780815345973.
2. Stacey, G. (Ed.). (2020). *Genetics and Genomics of Soybean*. Springer.

Reference Books

1. "Plant Genomics: Methods and Protocols" edited by Jan Bartoš and Jaroslav Doležel (2021)
2. Buchanan B, Gruissem G, and Jones R Biochemistry and Molecular Biology of Plants, American Society of Plant Physiologists, USA, 2000.

CUTM 4114 Computational Biology and Data Analysis

Subject Name	Code	Type of course	T-P-Pr (Credit)
Computational Biology and Data Analysis	CUTM 4114	Theory+ practice	3-1-0 (04)

Course objectives

- To ensure students gain a foundational understanding of computational biology and its role in modern biological research.
- To provide hands-on experience with computational tools commonly used in biology.
- To study the case studies, or research assignments by using computational approaches to analyse biological data.

Course outcome

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

COs	Course outcomes
CO1	Understand the nature, key concepts and scope of computational biology and bioinformatics in modern biological research for understanding the algorithms.
CO2	Apply the knowledge to retrieve biological data, and know the sequence alignment techniques using computational tools.
CO3	Analyse whole genome sequencing, gene prediction, NGS data, Insilco drug design, and molecular dynamics simulations in drug discovery research.
CO4	Demonstrate the programming language like Bio python for computational biology tasks, like sequence manipulation, alignment, and structural analysis.
CO5	Employ bio-statistical methods to analyse and interpret biological data.

Course Outcome to Program Outcome Mapping

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	1	2		2	1	-	1	2	3	3	1	1
CO2	3	3	3	3	3	1	2	2	1	2	2	3	3	3	2
CO3	3	3	3	3	3	1	2	2	1	3	3	3	3	3	3
CO4	3	3	2	2	3		1	1	1	1	2	3	2	3	1
CO5	3	3	2	2	3	1	2	1	1	1	3	3	3	2	3

(High-3, Medium-2, Low-1)

Course Content

Module I

Introduction to Computational Biology and Bioinformatics: Nature and scope of Computational Biology and Bioinformatics, Basic algorithms in Computational Biology, Introduction to sequence alignment (only general ideas, not algorithm) - Local and global, pair wise and multiple, BLAST.

Module II

Biological Databases: Overview of biological databases, Types of Biological data- Genomic DNA, cDNA, rDNA, ESTs, GSSs; primary, secondary, functional, composite, structural classification of databases, Nucleotide, Protein Sequence Databases, Literature Databases, Sequence motifs Databases, Composite Databases, Genome Databases, Genome Browsers, Bioinformatics Database search engines: -Text-based search engines (Entrez). Data access, retrieval and submission.

Module III

Sequence Alignments: Local alignment, Global alignment, Scoring matrices - PAM, BLOSUM, Gaps and penalties, Dot plots. Dynamic programming approach: Needleman and Wunsch Algorithm, Smith and Waterman Algorithm, Hidden Markov Model, Multiple sequence alignment, Alignment, tree building and tree evaluation, Comparison and application of Unweighted Pair Group Method with Arithmetic Mean (UPGMA), Neighbor Joining (NJ), Software for Phylogenetic analysis.

Module IV

Whole Genome Assembly and challenges, Sequencing and analysis of large genomes, Gene prediction, Functional annotation, Functional genomics case studies, visualization tools such as PyMol. NGS data analysis, Concept of Big data analysis

Module V

In silico Drug Design: In silico Drug Design: Basic Concepts, importance and application; Molecular force fields and energy minimization; Molecular Dynamics Simulation methods; Methods of Insilico Drug Design: structure and ligand-based drug design approach.

Module VI

Biopython and its application in Computational Biology: Biopython: Introduction, important features and application of bio python in computational biology; Create a simple sequence in Biopython for DNA, RNA and Protein Alphabets; Sequence Alignment Tools in Biopython; PDB Module of Biopython

Module VII

Bio statistical Methods: Data, Types of Data and data Visualization, Data arrangement, data normalization, Tabulation, Sampling methods, concept of Parametric and non-parametric statistics, Measures of central tendency: Mean, Mode & Median, Measures of dispersion: Mean deviations, coefficient of variance (CV), Standard deviations; Student t-test and paired t-test; chi square test; Probability distribution (normal, binominal and poison distributions), Simple Correlation and Regression, Analysis of variance (ANOVA): one way and two-way classification

Practice

1. Demonstration of biological databases: NCBI, EMBL, Swissprot/TrEMBL, UniProt and ExPaSy tool.
2. Pairwise Sequence Alignment using BLAST and Multiple Sequence Alignment with CLUSTAL W
3. Phylogenetic analysis using Online and MEGA software
4. Identification of gene characteristics and Genome visualization using Genome Viewer
5. Molecular docking and Visualization by PyMol
6. Calculate the Mean Median Mode, Standard deviation from the supplied data set in R Statistical tools.

Text book:

1. Bioinformatics: Sequence and Genome Analysis by Mount D., 2014, Cold Spring Harbor Laboratory Press, New York.
2. Biological Sequence Analysis: Probabilistic models of protein and Nucleic acids by Durbin et al., 2007, Cambridge University Press.
3. A Bioinformatics Guide for Molecular Biologists, Edited by Sarah Aerni, Pivotal Software, Inc.; Marina Sirota, Systems Medicine, Stanford University © 2014 • 328 pp, illus. (64 4C, 26 B&W), index Hardcover • ISBN 978-1-936113-22-4

Reference book:

1. Fundamentals of Bioinformatics. S. Harisha, I. K. International Pvt Ltd, 30 Dec 2013 - Science
2. Bioinformatics: Sequence and Genome Analysis by Mount D., 2006, Cold Spring Harbor Laboratory Press, New York

CUTM 2378: Research Methodology and IPR

Code	Subject Name	Type of course	T-P-Pr (Credit)
CUTM 2378	Research Methodology and IPR	Theory + Project	(2-0-2)

Course objectives

- To develop an appropriate framework for various research designs and techniques
- To identify various sources of information for literature review and data collection
- To make expertise in academic writing and patenting

Course outcome

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

COs	Course outcomes
CO1	Know about the elementary research methodology and significance of research
CO2	Understand the scientific writing skills, plagiarism, impact factor, citation index of standard journals and importance of publications
CO3	Acquire knowledge on web browsing for gathering scientific data, PowerPoint making, scientific poster preparation and presentation skills including computing skills required for scientific research
CO4	Utilize the knowledge on intellectual property, trademarks, copyright, plant variety protection and farmers' rights
CO5	Decide about the types of patents and able to compile the patent application forms

Course Outcome to Program Outcome Mapping

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3		3		3	3	1					2	2	3	1
CO2	3	2		2	3						1	1	1	1	2
CO3	3		1		1	1	2					3	2	3	2
CO4	2		1	1		3						2	3	1	3
CO5	2	1		1	2	1	1					1	3	3	2

Course Content

Module 1

Elementary Research Methodology: Research Concept, Objectives, characteristics, Steps and Significance of Research, Arbitrary and Scientific Research, Research approaches. Types of research: Historical, Descriptive, Analytical, Case Study, Quantitative vs. qualitative, Conceptual, Empirical Action Research, Research Methods Vs Methodology. Research Problems: Selection and definition of the research problems, formulating a research problem, identifying variables and Constructing hypothesis; Choosing a mentor, lab and research question; maintaining a lab notebook; Selection of problems - stages in the execution of

research

Module II

Academic Writing and Presentation: Technical writing skills - types of reports; layout of a formal report; standard of Journal (Impact Factor, Citation Index), Scientific writing skills - importance of communicating science; problems while writing a scientific document; plagiarism, software for plagiarism; scientific publication writing: elements of a scientific paper including abstract, introduction, materials & methods, results, discussion, references; drafting titles and framing abstracts; publishing scientific papers - peer review process and problems, recent developments such as open access and non-blind review; characteristics of effective technical communication; scientific presentations; ethical issues; scientific misconduct.

Module III

Scientific communication skills: Concept of effective communication- setting clear goals for communication; determining outcomes and results; barriers to effective communication; non-verbal communication- importance of body language, power of effective listening; Presentation skills - formal presentation skills; preparing and presenting using over-head projector, PowerPoint; defending interrogation; scientific poster preparation & presentation; participating in group discussions; Computing skills for scientific research - web browsing for information search.

Module IV

Introduction to IPR: Introduction to intellectual property; types of IP: patents, trademarks, copyright & related rights, industrial design, traditional knowledge, geographical indications, protection of new GMOs; IP as a factor in R&D; IPs of relevance to biotechnology and few case studies; plant variety protection and farmer's rights.

Module V

Types of Patents: Basics of patents: types of patents; Indian Patent Act 1970; recent amendments; WIPO Treaties; Budapest Treaty; Patent Cooperation Treaty (PCT) and implications; filing of a patent application; role of a Country Patent Office; precautions before patenting-disclosure/non-disclosure - patent application- forms and guidelines including those of National Bio-diversity Authority (NBA) and other regulatory bodies, fee structure, time frames; types of patent applications: provisional and complete specifications.

Projects

1. Write a review article and submit to a journal
2. Write a book chapter/ book for publishing
3. Write an original article for a journal

Text Books:

1. Kothari C R (2016) Research Methodology: Methods and Techniques, New Age Pvt Ltd.
2. Ganbawale R M, (2017) Biostatistics and Research Methodology, New Central Book Agency
3. Sinha, S. C. and Dhiman, A. K. (2002).Research Methodology, Ess Ess Publications
2 volumes

Reference Books:

1. Geoffrey Marczyk, David DeMatteo, David Festinger (2005). Essentials of Research Design and Methodology, John Wiley & Sons, Inc.
2. Carol Ellison (2010) McGraw-Hill's Concise Guide to Writing Research Papers, McGraw-Hill
3. Trochim, W. M. K., (2005). Research Methods: the concise knowledge base, Atomic Dog Publishing. 270p.
4. Wadehra, B.L. (2000). Law relating to patents, trademarks, copyright designs and geographical indications. Universal Law Publishing.
5. Neuman, W.L. (2008). Social research methods: Qualitative and quantitative approaches, Pearson Education

SEMESTER – IV

CUTM1434: Advances in Plant Ecology

Subject Name	Code	Type of course	T-P-Pr(Credit)
Advances in Plant Ecology	CUTM1434	Theory + practice	3-1-0(04)

Course objectives

- To know and understand the concept of ecology.
- To describe bio geochemistry, energy flow, biodiversity and their response to climate change.
- To develop a broad range of knowledge about biological activity of toxic substance.

Course outcome

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

COs	Course outcomes
CO1	Learn the knowledge on ecology and ecosystems
CO2	Understand different biogeochemical cycles, population characteristics, natural resources, environmental pollution, principles of toxicology and concepts and components of biodiversity
CO3	Apply the knowledge on biodiversity conservation, solid waste management and remote sensing in forest community
CO4	Analyse the various organic pollutants in various ecosystem
CO5	Evaluate different water quality parameters, bio concentration factor and quantitative structure activity relationship

Course Outcome to Program Outcome Mapping

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	3	2	1	2	3	1	3	2	2	3	2	1
CO2	3	3	3	2	2	1	1	3	2	3	2	3	3	3	1
CO3	3	3	3	3	3	1	2	3	2	3	2	3	3	3	2
CO4	3	3	3	2	3		1	3	2	3	1	3	2	3	2
CO5	3	3	2	2	2	1	2	3	3	3	2	3	2	2	3

(High-3, Medium-2, Low-1)

Course Content

Module I

Ecosystem and Population Ecology: Introduction to Ecology, Evolution of Ecology, Ecosystems and its different components, Trophic levels, energy flow pathways and ecological efficiencies, Gaia hypothesis, global bio-geochemical cycles of C, N, P, & S, ecosystem stability. Population Ecology: Characteristics of population: Distribution and size, factors affecting population size, Life history strategies, r and K selection, Concept of meta population, types and dynamics in meta population.

Module II

New perspective to Natural resources: Natural Resources, Types of natural resources, Forest resources, use and over-exploitation, deforestation, timber extraction, mining and dams (Case Studies); Silent valley Movement, Application of Remote Sensing in Forest Community; Prospects of alternate energy sources, Renewables.

Module III

Introduction to Air Pollution and its Management: An introduction to environmental pollution and its control, Concepts of Air Pollution, Natural and anthropogenic sources, primary and secondary pollutants; Indian National Ambient Air Quality Standards; Effect of **Air pollution:** Acid rain, Photochemical Smog, Ozone layer depletion and Global warming. Concepts on Noise Pollution: Introduction and Effect.

Module IV

Biological treatment of Waste Water: An introductory concept to water pollution; Storm water, types (fresh water aquifer and marine); Sources of water pollution; Effect of water pollution; Measurement of water quality parameters such as DO, BOD, pH and EC and Microbiological analysis – MPN

Module V

Biotechnology for solid waste Management: Soil Pollution: Types and sources and Control. Degradation of pesticides and synthetic fertilizer. Aspects of Phytoremediation, Solid and Hazardous Waste Management, Solid waste characteristics and its Disposal techniques, Fuel pellets, Refuse derived fuels.

Module VI

Principles of Toxicology: Toxicology: Principles of toxicology, Dose, uptake and retention, dose-response relationships and Quantal response. Aquatic Bioassay test: Chronic and Acute toxicity, Approach for Sub acute test and Biosensors, Bioaccumulation: Character of Xenobiotics, Concept of Bio magnification and Bioaccumulation; Bio concentration Factor. Quantitative structure activity relationship, the process of toxicant uptake, factors affecting bioaccumulation and measurement of it; Biodegradation of organic pollutants: Biodegradation of halogenated carbon compound, polycyclic compound; Pesticides and detergents.

Module VII

Modern trends in Biodiversity: Concepts and components of biodiversity, Biodiversity indices, Biodiversity losses, Abroad view on: In-situ conservation and Ex-situ conservation Megadiversity zones and biodiversity hotspots, National and global red data lists, International effort for conservation of Biodiversity. Intellectual Property Rights, Patent protection and Biopiracy and Bioprospecting

Practice

1. Quantifying the demographic features in an ecosystem through population size and density.
2. Determination of importance value index of species in a plant community.
3. Determination of Dissolved Oxygen of water by Winkler's method.
4. Determination of pH and Conductivity of Soil.
5. Antibiotic susceptibility test in microorganism
6. Analysis of different biodiversity indices

Texts Books:

1. Kumar, H. D. and S. P. Adhikary (2006). A Text Book on Environmental Engineering. India Tech Publishing, New Delhi.
2. Pradipta Kumar Mohapatra (2006). A Text Book of Environmental Biotechnology, I. K Publishing House, New Delhi
3. Chapman, J. L. and Reiss, M. J. (1998). Ecology: Principles and Applications. Cambridge University Press, UK
4. Cunningham, W. P. and Cunningham, M. A. (2004). Principles of Environment Science. Enquiry and Applications. 2nd Edition. Tata McGraw Hill, New Delhi

Reference Books:

1. E. P. Odum (1996). Fundamentals of Ecology, Nataraj Publisher, Dehra Dun
2. Hill, M. K. (1997). Understanding Environmental Pollution. Cambridge University Press, U K.
3. Mason, C. F. (1991). Biology of Fresh Water Pollution. Longman, New York
4. Crawley, M., Crawley, J., Crawley, M. (1997) Plant ecology, 2nd edition, Wiley-Blackwell.
5. Peter, D. Stiling (2018), Ecology, Pearson Education (US), 9780139156533
6. Thomas M. Smith, Robert Leo Smith, (2014), Elements of Ecology ,Pearson Education India.

CUTM2495: Advanced Separation Technologies and Downstream Processing

Subject Name	Code	Type of course	T-P-Pr(Credit)
Advanced Separation Technologies and Downstream Processing	CUTM2495	Theory + practice	2-0-2(04)

Course objectives

- To understand the fundamental principles of extraction processes of medicinal plants.
- To understand the principles and applications of supercritical fluid extraction (SFE) and ultrasound extraction (sonication) in downstream processing.
- To analyse the concept of green extraction and the phytonics process.

Course outcome

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

Cos	Course outcomes
CO1	Learn the principles and techniques of extraction of medicinal plant parts.
CO2	Understand the difference between maceration, percolation, infusion, decoction, and hot continuous extraction techniques.
CO3	Judge the characteristics of target compounds and source materials for extraction.
CO4	Analyse the utilization of enzymes for extracting bioactive compounds in downstream process.
CO5	Evaluate the molecular distillation process in separating volatile and non-volatile compounds, and know the supercritical fluid extraction (SFE) and ultrasound extraction (sonication).

Course Outcome to Program Outcome Mapping

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	3	3	3	3	2	2	3	3	3	3	3	2
CO2	3	3	3	3	3	3	3	3	1	3	3	3	3	3	3
CO3	3	3	2	3	3	3	3	3	2	3	3	3	3	3	3
CO4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

(High-3, Medium-2, Low-1)

Course Content

Module-I

Introduction to extraction of medicinal plants, General principles and mechanisms involved in crude drug extraction; Factors affecting the choice of extraction process; Parameters for selecting an appropriate extraction method; Steps involved in the extraction (Size reduction, Extraction, Filtration, Concentration, and Drying).

Module-II

General techniques in methods of extraction: Maceration, Infusion, Digestion, Decoction and Hot Continuous Extraction Techniques.

Module-III

Extraction methods for Essential Oil: Hydro distillation, Water and steam distillation, direct steam distillation, Supercritical fluid extraction.

Module-IV

Aqueous alcoholic extraction by fermentation, Microwave assisted extraction, Molecular distillation, Counter-current extraction.

Module-V

Advanced separation technique: Phytonics Process of extraction, Ultrasound Extraction (Sonication).

Project

Extraction of volatile oil and phyto-constituents from different plant parts using suitable methods.

Reference Books:

1. C.K Kokate & A.P Purohit & S.B Gokhale. Pharmacognosy (2023). 58th Edition, Nirali Prakashan
2. Extraction methods for preparation of bioactive plant extracts: A comparative study (Lambert Academic Publishing)
3. Jong Seong Kang & Narendra Singh Yadav (2022). Isolation and Analysis of Characteristic Compounds from Herbal and Plant Extracts

Practice Books:

1. Das, Anup Kumar (2015) Essentials of Botanical Extraction, International Ed, Academic Press