Centurion UNIVERSITY

Shaping Lives...
Empowering Communities...

M.Sc. Botany Syllabus

(Two Years Programme)

School of Applied Sciences

Centurion University of Technology & Management

2024-25

M.Sc. Botany
(Two-year Programme)
Course Structure-2024

Basket I (Core Courses)				
Sl. No.	**Code**	**Subject Name**	**T-P-P**	**Credits**
1.	CUTM1416	Pharmacognosy and Phytochemistry	3-1-0	04
2.	CUTM 2494	Herbal Cosmetics Technology	2-0-2	04
3.	CUTM 1428	Plant Physiology and Metabolism	3-1-0	04
4.	CUTM 1430	Developmental Biology and Phytotomy	3-1-0	04
5.	CUTM 1431	Systematics and Diversity of Plants	3-1-0	04
6.	CUTM 2495	Advanced Separation Technologies and Downstream Processing	2-0-2	04
7.	CUTM 1433	Biochemistry and Enzyme Technology	3-1-0	04
8.	CUTM 1434	Advances In Plant Ecology	3-1-0	04
9.	CUTM 4114	Computational Biology and Data Analysis	3-1-0	04
10.	CUTM 1436	Microbiology	3-1-0	04
11.	CUTM 1437	Cell and Molecular Biology	3-1-0	04
12.	CUTM 1438	Bioanalytical Techniques	3-1-0	04
13.	CUTM 1439	Plant Biotechnology	3-1-0	04
14.	CUTM 1440	Plant Breeding and Genetics	3-1-0	04
15.	CUTM 1441	Plant Genomics	3-1-0	**04**
16.	CUTM 2378	Research Methodology and IPR	2-0-2	04
				64
Basket II (Domain /Skill Courses)				**32**
Total				**96**

CUTM1416: Pharmcognosy and Phytochemistry

Subject Name	Code	Type of course	T-P-Pr (Credit)
Pharmcognosy and phytochemistry	CUTM1416	Theory+Practice	**(3-1-0)** (04)

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	PS03
CO1	3	3	2	1			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**

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 gynaecological 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.);
Photochemistry 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.

Practical

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 glylosides and Saponins iii) Flavonoids and their glycosides iv) Anthracene Glycosides v) Coumarins vi) Tannins by chemical tests and TLC methods.

3. Antimicrobial activity of some selected medicinal plants and antibiotics.
4. Isolation and Purification of following natural products, (a)Piperine form Black Pepper, (b)Caffeine from Tea Powder, (c) Eugenol from Clove oil. Isolation of natural products by column chromatography.
5. Extraction and estimation of volatile oils by Clevenger's method (Hydro distillation method).
6. TLC figure print profiles of following medicinal plants with special emphasis on their marker compounds, (a) *Withania somnifera*, (b) *Bacopa monnieri*, (c) *Curcuma longa*, (d) *Glycyrrhiza glabra*

Text Books:

1. Kalia, A.N. (2018). Textbook of Industrial Pharmacognosy. S Chand Publisher.
2. Ashutosh Kar. (2017). Pharmacognosy and Pharmaco Biotechnology. Nirali Prakashan Publisher.
3. C.K A and Purohit, A.P (2019). Pharmacognosy Kokate. Nirali Prakashan Publisher.

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). Textbook of Pharmacognosy and Phytochemistry. CBS Publisher.
3. William C. E (2009). Trease and Evans Pharmacognosy.

Practical 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.

CUTM 2494: Herbal Cosmetics Technology

Subject Name	Code	Type of course	T-P-Pr (Credit)
Herbal Cosmetic Technology	CUTM 2494	Theory+ project	2-0-2 (04)

Course objectives

- To gain knowledge of basic understanding of common herbal drugs, Indian cosmetics industry and the quality of raw materials
- To learn the manufacturing process of the cosmetic products
- To understand the quality assurance in Herbal Drug Industry and concept of TQM, GLP and ISO-9000

Course outcome

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

COs	Course outcomes
CO1	**Learn** about different types of herbal cosmetics having impact on beautification and therapeutic value
CO2	**Understand** the types of raw materials used in cosmetics industries, concept of TQM, GLP, ISO-9000 and quality audit of herbal industries
CO3	**Identify** the common herbs used in making different cosmetics
CO4	**Prepare** different herbal cosmetics formulations

CO5	**Evaluate** the prepared herbal formulations

Course Outcome to Program Outcome Mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PSO1	PSO2	PS03
CO1	2	2	3	3	1	3	2	1	0	3	3	2	2	3	3	3
CO2	2	2	3	3	1	3	3	2	0	3	3	3	2	3	2	3
CO3	2	2	3	3	1	3	3	1	0	3	3	3	2	3	3	3
CO4	2	2	3	3	1	3	3	1	0	3	3	3	3	3	3	3
CO5	3	2	3	3	1	3	3	1	0	3	3	3	3	3	2	3

***High-3, Medium-2, Low-1**

Module-I

Introduction to herbal cosmetics, their advantages, Types of herbal cosmetics, Study of common drugs used in cosmetics. Indian cosmetic industry and scope of herbal cosmetic in market.

Module-II

Types of raw materials used in cosmetics: i) Water, ii) preservatives, iii) humectants, iv) surfactant, v) oil, fat and waxes, vi) perfumes, vii) colors. Facial cosmetics: cleansing creams, Emollients, Moisturizers (cold cream, moisturizing cream, night cream), Bleaches, Sunscreen and anti-sunburn preparations.

Module-III

Make-up preparations: Face powder, Lipstick, Rouge (red powder for cheeks), Eye makeup (mascara, eye shadow, eye liner, eye brow pencil), Nail Preparations. Hair care product: Hair dressings, hair cleanser, hair dying agent, antidandruff agent, hair tonic/hair nourisher, hair tonic, hair conditioners, hair oil. hair colorants (Chemicals and Botanicals used as colorants). Common herbs used in hair cosmetics.

Module-IV

Oral hygiene product: Tooth paste, tooth powder, mouth wash, gargles, dentifrice. Other types of cosmetics: Deodorant, Bath & Shower Products (Soaps, Shampoo), Antiperspirants.

Module-V

Study of some formulations used in various preparations (complexion lotion, cleansing cream, face scrub, face packs/face masks, nail cream, shampoos, deodorants and powders).

Quality assurance in Herbal Drug Industry: Concept of TQM, GLP, ISO-9000, Quality audit, Suppliers' audits and approval, Auditing of Storage area, Weighing areas, Production area

Project

Preparation and evaluation of different herbal formulations (face powder, cream, lotion, shampoo etc).

Text Books:

1. Jhade Neeraj, Vaibhav, Usman (2020). Textbook of Herbal Cosmetics, S Vikas and Company
2. Himadri Panda. (2021). Herbal Cosmetics Handbook, Asia Pacific Business Press Inc.
3. Tara E. Gottschalck and John E. Bailey. (2008). International Cosmetic Ingredient Dictionary and Handbook, 12th Edition. The Personal Care Products Council.
4. Ramya Keber, B. A Textbook on Herbal Cosmetic Technology, Pritam Publications, India

Reference Books:

1. Handbook of Cosmetic Science and Technology –edited by Andre O. Barel et al., Publisher: Informa Healthcare.
2. Mitch L. Schlossman (2009). The Chemistry and Manufacture of Cosmetics, 4th Edition, Allured Publishing Corporation
3. Eiri Board (2015). Herbal Cosmetics & Beauty Products, Engineers India Research Institute

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 (04)

Course objectives

- 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, including the structure, function, and mechanisms of action of phytochromes, cryptochromes, and phototropins and to explore glycolysis, fermentation, and the TCA cycle, along with their regulation.

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	**Apply** the knowledge on the mechanisms of cellular respiration, oxidative phosphorylation and lipid metabolism in plant.
CO4	**Analyse** the concepts of hormone receptors, signal transduction, and gene expression in plant responses, sensory photobiology of plants, roles of photo-pigments in various physiological processes
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	PO13	PSO1	PSO2	PS03
CO1	3	2	3	1	1	1	2	2		2	1	1	1	2	3	3

CO2	3	2	2	2	1	1	2	3		2	2	1	1	2	3	3
CO3	3	3	2	3	1	2	3	3		3	2	2	1	3	3	3
CO4	3	3	3	3	2	2	3	3		3	3	2	2	3	3	3
CO5	3	3	3	3	2	2	3	3		3	3	3	2	3	3	3

***High-3, Medium-2, Low-1**

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 & Elicitors: Physiological effect & mechanism of action of Auxin, Gibberellin, Cytokinin, Ethylene, Abscisic acid, Jasmonic acid, Salicylic acid, Brassinosteroid, Strigolactones, hormone receptor, Signal transduction & 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. Glyoxalatecyle. 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.

Practical

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 conditio

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.

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

- The student will be able to know the relationship between the internal structure, function, taxonomy, physiology, ecology and developmental genetics of the organism.
- Evolutionary history and taxonomic variation of vascular plant anatomy
- They will understand the morphology and development of reproductive parts

Course outcome

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

Gained Knowledge about wood structure and shoot development.

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	PO13	PSO1	PSO2	PS03
CO1	3	1	2	2		1	2	2		2	1	1	1	2	2	2
CO2	2	2	1	1		1	2	1		2	2	1	1	1	2	2
CO3	1	1	1	1		2	1	1		2	1	1	1	2	2	2
CO4	3	2	2	2		2	2	2		2	1	1	1	2	2	2
CO5	3	3	2	2		2	2	2		2	1	1	1	2	2	2

***High-3, Medium-2, Low-1**

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 phellegen, 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

Megasporogensis: 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 hetermorphic), 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, ruminate endosperm

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

Fruit Biology: Development and diversity of fruit dispersal

Practical

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. Wood Sample Preparation for Microscopic Analysis
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, McGrow- Hill, N.Y and London.
2. Easu, K,2017 Esaus 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

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 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 plant kingdom
CO3	**Build** the knowledge about the systematic position of generas, 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	PS03
CO1	2	2	3	2	2	1	2	1		2	2	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**

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 Phylogenic Group: Brief outline of APG - I (1998), APG - II (2003), APG - III - (2009), AGP-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, CyperaceaeAraceae, and Poaceae; Dicotyledon: Ranunculaceae, Magnoliaceae, Malvaceae, Rutaceae, Leguminosae, Solanaceae, Cucurbitaceae, Fabaceae, Brassicaceae, Compositae, Asclepediaceae, 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.

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

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

Module VI

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

Practical

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 upto 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. Sambamurty, 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 Franssco.

CUTM 2495: Advanced Separation Technologies and Downstream Processing

Subject Name	Code	Type of course	T-P-Pr (Credit)
Advanced Separation Technologies and Downstream Processing	CUTM 2495	Theory+ practice	2-0-2 (04)

Course objectives

- To understand the fundamental principles of extraction processes, particularly in the context of medicinal plants.
- To understand the principles and applications of supercritical fluid extraction (SFE) and ultrasound extraction (sonication) in the context of downstream processing.
- To analyse the concept of green extraction and the Phytonics Process as environmentally friendly approaches

Course outcome

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

Cos	Course outcomes
CO1	**Learn** the principles of general methods of extraction and to understand the fundamentals of medicinal plant extraction techniques.
CO2	**Understand** the differentiate between maceration, percolation, infusion, decoction, and hot continuous extraction techniques for medicinal plant extraction.
CO3	**Apply** the knowledge on evaluation the characteristics of target compounds and source materials to select appropriate extraction methods.
CO4	**Analyse** the knowledge and understanding on utilizing enzymes for the extraction of bioactive compounds and understand their benefits in downstream processing.
CO5	**Evaluate** the principles and applications of molecular distillation in separating volatile and non-volatile compounds and able to apply the knowledge on the principles of supercritical fluid extraction (SFE) and ultrasound extraction (sonication) for the extraction of specific compounds and can pursue higher studies to get employability opportunity

Course Outcome to Program Outcome Mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PSO1	PSO2	PS03
CO1	3	3	2	3	3	3	3	2	2	3	3	3	3	3	2	3
CO2	3	3	3	3	3	3	3	3	1	3	3	3	3	3	3	3
CO3	3	3	2	3	3	3	3	3	2	3	3	3	3	3	3	3
CO4	3	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	3

***High-3, Medium-2, Low-1**

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

Advance 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

Reference Practical Books:

Essentials of Botanical Extraction-Principles and Applications: by Mandal SC et al., 2015, Elsevier Inc.

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 mainly dealing with biomolecules like carbohydrates, proteins, lipids, and nucleic acids laying the foundation for other advanced courses like physiology, cell biology, molecular biology, and immunology
- To provide knowledge relevant to the plant biochemistry and enzymology principles including fundamental properties of enzymes, enzyme catalytic mechanisms and enzyme kinetics
- To learn techniques employed in enzymes purification and characterization as well as applications of enzyme technology in food, medical, and household industries

Course outcome

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

Cos	Course outcomes
CO1	**Learn** comprehensive theoretical knowledge on the kingdoms of biomolecules, bioenergetics principals that are the prerequisites and consequences of physiological phenomenon for further manipulations.
CO2	Know **details** about the structure and function of proteins, their types, modification and functions.
CO3	**Construct** the chemical structures of carbohydrate, nucleosides, nucleotides and lipids, circulating lipids and inflammatory lipid mediators etc
CO4	**Demonstrating** the purification, characterization and estimation of enzymes processes. The biochemical calculation for enzyme kinetics will be discover and cane use in plotting graphs based on kinetics data
CO5	**Evaluate** and apply biochemical calculation for enzyme kinetics. Compare methods for production, purification, characterization and immobilization of enzymes. And their application in industry.

Course Outcome to Program Outcome Mapping:

COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PO13**	**PSO1**	**PSO2**	**PS03**
CO1	3	3	3	2	1	1	2	1		1	1	1	2	2	3	3
CO2	3	3	3	3	1	2	3	1		2	1	2	3	3	3	3
CO3	3	3	3	3	3	3	3	3	3	2	2	2	2	3	3	3
CO4	3	3	3	3	3	2	3	2	3	3	2	3	3	3	3	3
CO5	3	3	3	3	3	2	2	3	2	3	2	3	3	3	3	3

***High-3, Medium-2, Low-1**

Module I

Essential Biochemistry and Bioenergetics: Structure of atoms and molecules, chemical bonds, Stabilizing Interactions (thermodynamics of folding, conformational entropy, charge charge interaction, Vander wall force, hydrophobic effect, disulfide bonds, prosthetic group, ion binding protein stability), pH, buffer, Acid Base Equilibria, Water; Biological Thermodynamics, Enthalpy and Entropy, Standard Free Energy Concept and Calculation, Biological Energy transducer Cellular energy currency, Energy rich compounds

Module II

Biochemistry of Protein: Building Block of Proteins**:** Chemical Properties of Proteins, common plant Protein Sources, Protein Databases; Amino acids (genetically coded, Rare genetically coded, modified), Dissociation constant, Isoelectric point, Assay of Amino acids, protein denaturation and renaturation; Prions; Structural Organization: Structural organization of Protein (different models), Dynamics of Protein Structure (globular, Fibrous), chaperon concept; Ramachandran Plot. Specialized Secondary

Structure protein structure (TMV, Hemoglobin, Myoglobin, collagen, Carboxypeptidase, RuBisCo); Domain and Motifs: Motifs, domains, Models, Functional relationship between domains and function of proteins, super secondary structures of proteins Classification of proteins based on the structures like Zn finger, lucine zipper proteins etc

Module III

Biochemistry of Nucleic Acid, Carbohydrates: Nucleic Acid: Structure, Models and Stability of Nucleic Acids (DNA/RNA), Nucleotide Databases; Primary and Secondary Structure, Alternate Secondary Structure: Hairpin, Cruciform, triple Helix, G-quadrates etc. Denaturation, Tm value, Protein DNA interaction

Carbohydrate: Structure types and Nomenclature, Structure Function Relationship Carbohydrate Databases.

Module IV

Biochemistry of Lipid, Vitamins, and Antioxidants: 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 phytovitamins, Natural Antioxidants

Module V

Enzymology: Overview of enzyme: Chemical Nature, Characteristics, Classification (IUB), Nomenclature, Enzyme conformation, Active Sites, Ribozyme, isozymes, multi enzyme complex

Enzyme kinetics: MichelisMenten equation, Treatment of Data (Briggs-Haldane, lineweaver-burk, Eadie-hofstee, cornish-bowden, Van Slyke-Cullen behavior) Enzyme inhibitiion, Significance of Km. Kcat,Vm; Single substrate, bi substrate, multi substrate reaction, Significance and Evaluation of activation energy;

Mechanism of enzyme action: Enzyme catalytic reaction mechanism, chymotrypsin, lysozyme, Serine protease, Alcohol dehydrogenase, carboxypeptidase, Co enzymes and its role in Enzyme action (NAD+/NADP+, FAD, lipoic acid, thiamine pyrophosphate, tetrahydrofolate, biotin, pyridoxal phosphate, B12 etc.); Allosteric enzyme and its mechanism

Enzyme catalysis: Acid-base catalysis, covalent catalysis, metal ion catalysis, proximity, orientation effect, site directed mutagenesis of enzyme.

Module VI

Enzyme Technology: Enzyme Purification, Assay, Large Scale production of Enzyme; Enzyme Immobilization (kinetics), enzyme reactor; Biotransformation, Nobel Enzyme; Scope of enzyme technology in medicine, Detergents, Food and breverage industry, Leather Industry, Textile industry etc).

Module VII

Industrial Biochemistry: Industrial Enzymes – production & applications,

Biofuel**:** production of biomethane and bioethanol from agro-food wastes/Microalgae; Nutritional profiling of agricultural products; Biopolymer, Microbial polysaccharides; Dextrans. Polyhydroxyalkanoates, Polyhydroxybutyrate (PHB), Biodegradable plastics

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. Extraction and Preparation of Protein lysates

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

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.
- Describe bio geochemistry, energy flow, biodiversity and their response to climate change.
- 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	PO13	PSO1	PSO2	PS03
CO1	3	3	3	2	2	2	3	3		3	3	2	2	3	3	3
CO2	2	2	3	2	1	1	2	3		3	3	2	2	3	3	3
CO3	2	3	3	2	1	1	3	3		3	3	3	2	3	3	3
CO4	2	2	3	2	1	1	3	3		3	3	2	2	3	3	3

CO5	3	3	3	3	3	1	3	3		3	3	3	2	3	3	3

***High-3, Medium-2, Low-1**

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 biogeochemical 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, A broad 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

Practical

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:

7. Kumar, H. D. and S.P. Adhikary (2006). A Text Book on Environmental Engineering. India Tech Publishing, New Delhi.
8. Pradipta kumar Mohapatra (2006). A textbook of Enviornmental Biotechnology, I. K Publishing house, New Delhi
9. Chapman, J. L. and Reiss, M. J. (1998). Ecology: Principles and Applications. Cambridge University Press, UK
10. 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, DehraDun
2. Hill, M. K. (1997). Understanding Environmental Pollution. Cambridge University Press, UK.
3. Mason, C. F. (1991). Biology ofFreshwater 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.

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 what computational biology is and its role in modern biological research.
- To provide hands-on experience with computational tools commonly used in biology, such as BLAST for sequence alignment, molecular modelling software, and data visualization tools.
- To case studies, or research assignments where they use computational approaches to analyse biological data and draw meaningful conclusions.

Course outcome

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

COs	Course outcomes
CO1	**Learn about** the nature and scope of computational biology and bioinformatics in modern biological research and Identify scenarios where these algorithms are applied to analyze biological data.
CO2	**Understanding** the strategies of biological databases, data retrieval, and sequence alignment techniques, enabling them to effectively analyse and interpret biological data for research and application in computational biology and bioinformatics.
CO3	**Make use of** advanced knowledge and skills in whole genome assembly, gene prediction, functional genomics, NGS data analysis, Insilco drug design, molecular dynamics simulations, and structure-based drug design, enabling them to contribute effectively to genomics and drug discovery research, while also understanding the challenges of big data analysis in these fields.

CO4	**Discovering** the programming language like Biopython for computational biology tasks, including sequence manipulation, alignment, and structural analysis. They will be equipped to apply Biopython effectively in bioinformatics research and data analysis.
CO5	**Evaluations** the foundations in bio statistical methods, enabling them to effectively analyse biological data, performs hypothesis testing, and interpret statistical results. They will also have the capability to apply various statistical techniques to address research questions in the field of computational biology and bioinformatics.

Course Outcome to Program Outcome Mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PSO1	PSO2	PS03
CO1	3	3	2	3	3	3	3	3	2	3	2	3	3	3	3	3
CO2	3	3	2	3	3	3	3	3	2	3	2	3	3	3	3	3
CO3	3	3	2	3	3	3	3	3	2	3	2	3	3	3	3	3
CO4	3	3	2	3	3	2	3	3	2	3	2	3	3	3	3	3
CO5	3	3	2	3	3	3	3	3	2	3	2	3	3	3	3	3

***High-3, Medium-2, Low-1**

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), Neighbour 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

Insilico Drug Design: Insilico 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 biopython 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 SpringHarbor Laboratory Press, New York.
2. Biological Sequence Analysis: Probabilistic models of protein and Nucleicacids 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 books

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 SpringHarbor Laboratory Press, New York

CUTM1436: Microbiology

Subject Name	Code	Type of course	T-P-Pr (Credit)
Microbiology	CUTM1436	Theory+ practice	3-1-0 (04)

Course objectives

- 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, structural and genetic diversity of microbes
CO2	**Understand** the transmission, replication, life cycle, growth kinetics, and different metabolic process (photosynthesis, respiration, fermentation) of microbes, mode of actions of antibiotics, microbial toxins, probiotics and prebiotics, host pathogen interactions, genetic regulation and genetic mapping
CO3	**Identify** the microbes, culturing techniques, industrial application, **solving** of problems related to waste water management, degradation of oils, pesticides, toxic chemicals bioleaching, bioremediation etc. by applying acquired knowledge; application of important microorganisms in agriculture, cosmetics, and pharmaceutical industries
CO4	**Categorize** important diseases caused by bacteria, protozoa and virus, emergence of multiple-drug resistance strains, interpretation of molecular markers; growth monitoring in culture
CO5	**Adopt** the methods of food preservation, microbiological legal standards of selected food and milk products, mass cultivation, single cell protein, microbial enzymes, novel medicines from microbes fermenter design, bioreactors, and maintenance of industrial microorganisms.

Course Outcome to Program Outcome Mapping:

COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PO13**	**PSO1**	**PSO2**	**PS03**
CO1	2	2	3	2		1	1	2		2	2	2	2	2	2	3
CO2	3	3	2	2		1	2	3		2	3	1	2	2	2	3
CO3	3	3	3	2		1	3	2			3	1	2	2	2	3
CO4	3	3	1	2		2	3	2		2	3	2	2	2	2	3
CO5	3	3	3	2		2	3	2		1	3	2	2	2	2	3

***High-3, Medium-2, Low-1**

Module I

Bacteria and virus: Classification, taxonomy, cataloguing virus to ICTV and ICNV; Structural and genetic diversity of viruses; Transmission and Replication; Prions, Viriods, Anti-viral agents, and Vaccines; Bacterial Classification (phonetic, genetic and phyllogenetic); Bergey's manual of systematic bacteriology; Classification, Identification and Culturing Technique of cyanobacteria; Industrial Application, Cyanotoxins.

Module II

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

Module III

Environmental Microbiology & Wastewater Management: Microbes and quality of environment, Bio-transformations, Microbes in waste water management; Microbial degradation of pesticides, toxic chemicals, oil; Bioleaching, bioremediation.

Module IV

Agricultural and food Microbiology: Agriculturally important microorganisms, Mycorrhizae, Microbial mineralization, Microbial toxins, Biological control; Microbial toxins produced in food items, Probiotics and prebiotics, Methods of food preservation, Microbiological legal standards of selected food and milk products.

Module V

Medical Microbiology: Host pathogen interactions, Pathogenicity of bacteria invasiveness and toxigenicity, Constitutive and inducible host defence mechanism, Important diseases caused by bacteria, protozoa, virus; Antibiotics: Definition, phenomenon of antibiotics, Chemical and biochemical modification of antibiotic structures, assay and Mode of action, Biochemical mechanisms of resistance development, Multiple-drug resistance.

Module VI

Industrial Microbiology: Cyanobacterial Biotechnology: Application as nutraceuticals, pharmaceuticals, cosmetic, bio fertilizer; application as biofuel, CO_2 sequestration and pollution control, Mass cultivation, Single cell protein

Microbial enzymes: Sources, Large scale production, recovery; Microbial enzymes of industrial interest, Novel medicines from microbes, Biotechnological application of Microbial enzyme, Use of Microbes in Biotechnology.

Bioprocess technology and Engineering: Culture media (types, Different culturing Technique, Media formulation, Preservation of Microbes, Fermenter design and growth processes; Bioreactors, and Membrane Bio reactors, analysis of different bioreactors, stability of microbial reactors, specialized bioreactors; Isolation, preservation, and Maintenance of Industrial Microorganisms.

Module VII

Microbial genetics: Lytic and Lysogenic cycle, Conjugation, Transduction, Recombination; Genetic regulation: Operon concept (*Lac, Trp.*), Genetic mapping: Genome mapping of E. *coli*, QTL Mapping. Molecular markers in genome analysis, RAPD, RFLP, AFLP, FISH and GISH.

Practical

1. Working principles and operations of basic equipment of microbiological laboratory.
2. Microbial culture media preparation and sterilization techniques.
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). Practical 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, 7th Ed., McGraw-Hill, New York.
3. Agrios, G. N. (2005). Plant Pathology, 5th Ed, Elsevier Academic press, USA

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

- Explore biological membranes, cytoskeleton, cell division, intercellular communication, and the nucleus, focusing on the structure, function, and interactions of cellular components.
- Study the mechanisms of DNA replication, transcription, RNA processing, and translation, including regulation and post-translational modifications, to understand gene expression and protein synthesis.
- 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, understanding how these molecules catalyze biochemical reactions and are regulated within the cell.
CO5	**Evaluate** experimental data on cell signalling pathways and gene expression regulation, forming conclusions about cellular responses to various stimuli.

Course Outcome to Program Outcome Mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PSO1	PSO2	PS03
CO1	3	3	2	3		2	3	2		2	3	1	2	2	2	3
CO2	2	2	2	3		2	1	2		2	3	1	2	2	2	1
CO3	3	3	3	3	3	2	3	1	2	3	3	2	3	3	3	3
CO4	3	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	3

***High-3, Medium-2, Low-1**

Module I

Biological Membranes and Transport of Biomolecules: Structure of biological membranes: Cell wall (Prokaryotic versus eukaryotic), the plasma membrane, Membrane proteins, Mobility of membrane proteins, Membrane biogenesis: Cell wall and cell membrane biogenesis, Cell-Cell and cell-matrix interactions: Extracellular matrix and cell-matrix interactions (Matrix structural proteins, Matrix Polysaccharides; Matrix adhesion proteins), Cell-Cell interactions (Adhesion Junctions, Tight Junctions, Gap junctions, Plasmodesmata), Membrane Trafficking (Pumps, channels, transporters): Ions channels, Active transport driven by ATP hydrolysis, Active transport driven by Ion gradients, Passive transport, Facilitated 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, stem cells and maintenance of adult tissues. Cell cycle and its regulation and check points.

Module III

Intercellular communication and the Nucleus: 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, the cAMP Pathway, cGMP, Nuclear organization, traffic between the nucleus and the cytoplasm, chromosomes, Chromatin organization (DNA packaging), Lampbrush chromosome, Polytene chromosome, telocentric chromosome, Inter-phase chromatin, Euchromatin and Heterochromatin, karyotype and its significance, the Nucleolus.

Module IV

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, 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 V

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

Module VI

Protein Structure, Function and Evolution: Unique principles of protein structure and molecular machines (primary, secondary, tertiary, quaternary structures), Study of protein structures (circulsardichorism, X-ray crystallography and cryo electron microscopy), How proteins have evolved and how analysis of protein structure can help us to understand the evolutionary relationships between different proteins and their function.

Module VII

Enzyme Catalysis and Protein Engineering: How the peptide and protein structures discussed in the preceding module can assume functions, Enzyme catalysis, mechanism and kinetics, Co-operative (allosteric) molecular basis of metabolic regulation, Principles of protein folding and stability, Protein engineering and mechanistic enzymology–how to create novel, functional proteins, by rational design, semi-rational approaches, and by directed evolution.

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. *Insilico* 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 Rev ed. Taylor & Francis; 2014 ISBN 978-0-8153-4432-2 (hard), 978-0-8153-4524-4
2. Essential Cell Biology Alberts, B., et al. 4th Rev ed. Garland; 2013 ISBN 9780815344544
3. Lewin's Genes XII 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

CUTM1438: Bio analytical Techniques

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

Course objectives

- 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	PO13	PSO1	PSO2	PS03
CO1	3	3	3	3	3	3	2	1	2	2	3	3	3	3	1	1

CO2	3	3	3	3	3	3	2	1	2	2	3	3	3	3	2	3
CO3	3	3	3	3	3	3	2	1	2	2	3	3	3	3	2	3
CO4	3	3	3	3	3	3	2	1	2	2	3	3	3	3	2	3
CO5	3	3	3	3	3	3	2	1	2	2	3	3	3	3	2	3

***High-3, Medium-2, Low-1**

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, Fluorescence spectrophotometry: Principle, Instrumentation and application, Mass spectroscopy: Principle, Instrumentation and application.

Module III

Radiolabeling 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 Radiolabeling techniques.

Immunotechniques: Antibody generation, Detection of molecules using ELISA, RIA, immunoprecipitation, FISH and GISH.

Module IV

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

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

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.

Module VII

Electrophysiological methods: Electrocardiogram (ECG), Positron emission tomography (PET), Magnetic resonance imaging (MRI), Flow cytometry,Nuclear magnetic resonance, Biostatistics: Measures of central tendency and dispersal; Sampling distribution; Regression and Correlation; t-test; Analysis of variance; Chi-square test.

Practical

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 phytocompounds 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:

3. Wilson K and Walker J (2018) Principles and techniques of biochemistry and molecular biology.7thEdition, Cambridge University Press, Cambridge, UK.
4. 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, 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, with advanced knowledge in introducing foreign DNA into plant by utilizing a variety of gene transfer techniques for development of an improved variety
CO4	**Discovering** the knowledge and skills in designing, developing, and evaluating genetically modified plants for enhanced disease resistance
CO5	**Evaluating** the gene function, mechanisms and skills to manipulate gene expression using techniques like RNA interference (RNAi) in plants.

Course Outcome to Program Outcome Mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PSO1	PSO2	PS03

CO1	3	2	2	3	3	3	2	2	3	3	2	3	3	3	3	3
CO2	3	2	2	3	3	3	3	3	2	3	3	3	3	3	3	3
CO3	2	3	2	3	3	3	2	3	3	3	1	3	3	3	3	3
CO4	2	3	2	3	3	3	3	3	3	3	3	3	3	3	3	3
CO5	2	3	2	3	3	3	3	3	3	3	3	3	3	3	3	3

***High-3, Medium-2, Low-1**

Module I

Basics of 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, Somaclonal 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 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.
Practice 5: *Agrobacterium tumefaciens* mediated transformation of tobacco leaves

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.

Practical

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 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	**Compare** the cellular and molecular mechanisms of gene mutation and new strategies to overcome like gene pyramiding and Marker Assisted selection (MAS).
CO5	**Explain** about the important tools and techniques in plant breeding and crop improvement.

Course Outcome to Program Outcome Mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PSO1	PSO2	PS03
CO1	3	2	1	2	0	1	1	1		1	1	2	1	1	2	2
CO2	2	3	2	2	0	2	2	2		2	1	2	1	1	2	2
CO3	3	3	3	3	3	2	3	3	3	3	2	3	2	3	3	3
CO4	3	3	1	3	3	1	3	3	3	3	2	3	3	3	3	3
CO5	3	3	1	3	3	1	3	3	3	3	2	3	3	3	3	3

***High-3, Medium-2, Low-1**

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

Practical

1. Study of chromosome mapping with point test crosses 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 Acquaah, "Principles of Plant Genetics and Breeding ". Wiley Blackwell.

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

- To understand and apply advanced techniques in genomics, including genome organization, mapping, and sequencing, with practical experience in genome analysis tools.
- To gain comprehensive knowledge in comparative genomics, transcriptomics, proteomics, and metabolomics, enabling them to analyse gene expression, protein interactions, and metabolic profiles.
- To know the skills to utilize cutting-edge technologies for genetic and protein sequencing, and metabolite profiling, essential for research and applications in biotechnology and molecular biology.

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, including the structure of prokaryotic and eukaryotic genomes, extra-chromosomal DNA, and the techniques used for genetic and physical mapping.
CO2	**Know details about** the strategies in genome sequencing methods, including traditional chemical and enzymatic techniques, as well as next-generation sequencing technologies, with insights into significant sequencing projects such as the Human Genome Project.
CO3	**Explore** about the genome sequence in development of improved plant variety as well as whole genome comparisons and phylogenetic analysis to classify organisms.
CO4	**Blueprint** the knowledge on different advance techniques including sequencing like Identification and classification of organisms using 16S rRNA typing/sequencing.
CO5	**Evaluating** the efficacy of different approaches like transcriptomics, proteomics and metabolomics for characterisation of a particular trait using advanced techniques such as DEG, 2D-PAGE, mass spectrometry, and functional protein microarrays.

Course Outcome to Program Outcome Mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PSO1	PSO2	PS03
CO1	3	3	2	3	3	3	3	2	1	2	2	3	3	3	3	3
CO2	3	3	3	3	3	3	3	2	2	2	2	3	3	3	3	3
CO3	3	3	1	3	3	3	3	2	3	3	3	3	3	3	3	3
CO4	3	3	1	3	3	3	3	2	3	3	2	3	3	3	3	3
CO5	2	3	1	3	3	3	3	2	3	2	2	3	3	3	3	3

***High-3, Medium-2, Low-1**

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.

Practical

1. Isolation of plasmid DNA from the supplied bacterial sample
2. Restriction digestion of the plasmid DNA by the help of restriction endonuclease enzyme
3. Elution of a specific DNA fragment from the PCR amplified sample separated on an agarose gel.

4. To clone the eluted DNA fragment into suitable plasmid vector
5. RNA Isolation from plant leaf sample
6. Protein separation using SDS-PAGE (Demonstration through virtual labs)

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 2378: Research Methodology and IPR

Subject Name	Code	Type of course	T-P-Pr (Credit)
Research Methodology and IPR	CUTM 2378	Theory+Project	(2-0-2) (04)

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

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 CR (2016) Research Methodology: Methods and Techniques, New Age Pvt Ltd
2. Ganbawale RM, (2017) Bioststistics 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 ConcisevGuide to WritingvResearch 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