School of Applied Sciences

Centurion University of Technology & Management

M.Sc. (Botany) Syllabus

(Two years Programme)

2021

M. Sc. Botany
(Two year Programme)
Course Structure-2020

Basket I (Core Courses)				
Sl. No.	**Code**	**Subject Name**	**T-P-P**	**Credits**
1.	CUTM1416	Pharmcognosy and phytochemistry	3-1-0	04
2.	CUTM1427	Herbal Cosmetic Technology	3-0-1	04
3.	CUTM 1428	Plant Physiology and Metabolism	3-1-0	04
4.	CUTM 1429	Good Manufacturing Practices-Herbal Industry	3-1-0	04
5.	CUTM 1430	Developmental Biology and Phytotomy	3-1-0	04
6.	CUTM 1431	Systematics and Diversity of Plants	3-1-0	04
7.	CUTM 1432	Advanced Separation Technologies and Downstream Processing	2-2-0	04
8.	CUTM 1433	Biochemistry and Enzyme Technology	3-1-0	04
9.	CUTM 1434	Advances In Plant Ecology	3-1-0	04
10.	CUTM 1435	Computational Biology	3-1-0	04
11.	CUTM 1436	Microbiology	3-1-0	04
12.	CUTM 1437	Cell and Molecular Biology	3-1-0	04
13.	CUTM 1438	Bioanalytical Techniques	3-1-0	04
14.	CUTM 1439	Plant Biotechnology	3-1-0	04
15.	CUTM 1440	Plant Breeding and Genetics	3-1-0	04
16.	CUTM 1441	Plant Genomics	3-1-0	**64**
Basket II (DomainCourses)				**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)

Objective

- 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

COs	Course outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	Acquire the knowledge about secondary metabolites apart from learning about phytochemistry of significant medicinal plants	PO1-3, PO2-3, PO3-3, PO4-2, PO6-2
CO2	Acquire and demonstrate competency in laboratory safety and in routine laboratory skills to do sensitive R&D experiments in future.	PO1-3, PO2-3, PO3-3, PO4-3, PO5-2

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 *Withaniasomnifera*: General chemical class and identification tests, specific tests for markers, special reference to steroids (withanolides), Phytochemistry of *Andrographispaniculata*: 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** *Terminaliaarjuna***:** General chemical class and identification tests, specific tests for markers, special reference to triterpenes (arjunolic acid)

Module V

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; Adulteration
Quality control and drug evaluation: Significance of Pharmacopoeia standards; Detection of adulteration by organoleptic, macroscopic and microscopic methods
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) Extraction and estimation of volatile oils by Clevenger's method (Hydro distillation method).
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)TLC figure print profiles of following medicinal plants with special emphasis on their marker compounds, (a) Withaniasomnifera, (b) Bacopamonnieri, (c) Curcuma longa, (d) Glycyrrhizaglabra

Text Books:

1. Textbook of Industrial Pharmacognosy, Kalia, A.N
2. Pharmacognosy and Pharmaco biotechnology AshutoshKar
3. PharmacognosyKokate, C.K A and Purohit, A.P

Reference Books:

1. E-content: www.nmpb.nic.in/
2. Textbook of Pharmacognosy and PhytochemistryJarald, Edwin E. and Edwin JaraldSheeja
3. Trease and Evans Pharmacognosy, Evans, W.C.

Practical
Natural Products: Aa laboratory guide by Raphael Ikan, Academic Press.
Pharmacognosy by C.K. Kokate , Publisher: NiraliPrakashan
Pharmacognosy by Trease& Evans
Pharmacognosy&Phytochemistry by VinodRangari
Chemistry of Natural Products: A Laboratory Handbookh by Krishnaswamy NR.

CUTM1427: Herbal Cosmetic Technology

Subject Name	Code	Type of course	T-P-Pj(Credit)
Herbal Cosmetic Technology	CUTM1427	Theory+ practice	3-0-1 (04)

Objective

- This is a skill course which will help students in preparation of cosmetic products.
- This course will elucidate the formulations in detail such that can innovate new products of similar health care objectives.

Course outcome

COs	Course outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	Acquire the knowledge about the manufacturing of the cosmetic products and their impact on beautification and therapeutic value	PO1-3, PO2-3, PO3-3, PO4-2, PO6-2
CO2	Acquire and demonstrate competency in laboratory safety and in routine laboratory skills to do sensitive R&D experiments in future.	PO1-3, PO2-3, PO3-3, PO4-3, PO5-2

Module I

Introduction to cosmetics- Skin, Hair and Nail Structure & function-Botanicals in Cosmetics

Module II

Cosmetics Ingredients & Nomenclature-Emulsions-Creams & Lotions-Face washes & Face Masks-Shaving Preparations-Sunscreens- Antiperspirant and Deodorants.

Project:
1. Preparation of herbal shaving cream
2. Preparation of herbal face wash

Module III

Make-up preparations: Eye area makeup; Lip care preparations; Nail Preparations; Soaps: Bath and Shower Products-Shampoo and Hair conditioner's-Hair Oils and Hair Sprays, -Gels in Hair and Skin Care products; Toothpastes; Mouthwashes

Project:
3. Preparation of herbal shampoo
4. Preparation of Herbal Hair Oil
5. Preparation of Hair Spray using Essential oils

Module IV

Fragrances-Toxicology in Cosmetics-Rheology fundamentals and application in cosmetic formulations-Claims support: Principles and Practice-Cosmetic product Packaging-Consumer testing &Evaluation

Text Books:

1. Textbook of Herbal Cosmetics Paperback: Vimaladevi M.
2. Herbal Cosmetics Handbook- by H Panda
3. International Cosmetic Ingredient Dictionary and Handbook- by The Personal Care Products Council.

Reference Books:

1. Handbook of Cosmetic Science and Technology –edited by Andre O. Barel et al., Publisher: Informa Healthcare.
2. The Chemistry and Manufacture of Cosmetics-edited by Mitchell L. Schlossman, Allured Publishing Corporation
3. Harry's Cosmeticology: edited by Meyer R. Rosen

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)

Objective

- Students will learn the basic knowledge of stress adaptations in biological systems.
- They will learn molecular understanding of primary and secondary metabolic process.

Course outcome

COs	Course outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	Acquire knowledge in various physiological processes occur in plants. Learn about the response of plants to various biotic and abiotic stresses	PO1-3, PO2-3, PO3-3, PO4-2
CO2	.Gain the ability to conduct research, pursue lifelong learning and provide solutions to public issues related to agriculture.	PO1-3, PO2-3, PO3-3, PO7-3, PO9-2
CO4	Conduct the experimental work on complex plant physiological process including design of experiments, analysis and interpretation of data leading to publication	PO1-3, PO2-3, PO4-3, PO7-3, PO9-2

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.Photorespiration.Regulation of C3 pathway.

Practice:

1. Isolation of chloroplast and measurement of electron transport activity

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 photoassimilates.

Practice:
2. Comparative study of photosynthetic pigment in C3 and C4 plant, grown in light and shade condition

ModuleIII

Plant growth regulator & Elicitors: Physiological effect & mechanism of action of Auxin, Gibberellin, Cytokinin, Ethylene, Abscisic acid, Jasmonic acid & Salicylic acid, 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.

Practice:
3. To study qualitative and quantitative characters of plant community by quadrat method.

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.

Practice:
4. Extraction of pigments from leaves and preparation of absorption spectra for chlorophyll and carotenoids.

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.

Practice:
5. To compare chlorophyll content in juvenile and matured leaves

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.

Practice:
6. Preparation of standard curve for quantification of protein, carbohydrate and reducing sugar.

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.

Text Books:

1. Devlin, R. N. and Witham, F. H. (1983). Plant Physiology. CBS Publishers, Delhi.
2. Bhattacharya D. (1999). Experiments in Plant Physiology- A Laboratory Manual. Narosa Publishing House, New Delhi.
3. Pandey and Sinha (1987)., Plant Physiology, Vikas Publishing House.
4. Satyanarayana, U. and Chakrapani, U.(2013), Biochemistry, Elsevier

Reference Books:

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

CUTM1429: Good Manufacturing Practices-Herbal Industry

Subject Name	Code	Type of course	T-P-Pr (Credit)
Good Manufacturing Practices-Herbal Industry	CUTM1429	Theory+ practice	**(3-1-0)**(04)

Objective

- To provide knowledge on GMP s and elucidating their impact on production quality.
- To introduce the concept of quality standards in terms of ISO-9000 and quality audit.
- To enlighten the issues in relevance to Hazard analysis and critical points.

Course outcome

COs	Course outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	Learn the necessity of GMP's	PO1-3, PO2-3, PO4-2
CO2	Students will know how to maintain the quality through the audits and allow them to maintain homogenous quality throughout the production line	PO1-3, PO2-3, PO4-2

Module I

Guidelines for the manufacture of herbal medicines: Quality assurance in the manufacture of herbal medicines, Good manufacturing practice for herbal medicines, Airlock, Clean area, Critical operation, cross-contamination, Calibration, Pipe work, light fittings, ventilation points, other services like Sanitation and hygiene.

Module II

Qualification: Contract production and analysis, Self-inspection, Personnel, Training, Personal hygiene, Premises, Equipment, Materials, Documentation, Batch number (or lot number), Batch records, In-process control, Intermediate product, Master formula, SOP, OCP, HIRA, Good practices in production, Packaging, Packaging material, Qualification, Good practices in quality control.

Module III

Validation: Introduction, Basic concepts, types and stages of validation, validation master plan (VMP), equipment validation; Concept of URS, DQ, IQ, OQ and PQ and process-types; Prospective, concurrent and retrospective validation & revalidation.

Module IV

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, Intermediate and bulk products and finished products, HACCP in traditional system of medicine.

Text Books:

1. Good Manufacturing Practices for pharmaceutical products. In: WHO Expert Committee on Specifications for Pharmaceutical Preparations. Twenty second report. Geneva, World Health Organization, 1992, Annex 1 (WHO Technical Report Series, No. 823).
2. Validation of analytical procedures used in the examination of pharmaceutical materials. In: WHO Expert Committee on Specifications for Pharmaceutical Preparations. Thirty-second report. Geneva, World Health Organization, 1992, Annex 5 (WHO Technical Report Series, No. 823).
3. General guidelines for methodologies on research and evaluation of traditional medicine. Geneva, World Health Organization, 2000.
4. Quality control methods for medicinal plant materials. Geneva, World Health Organization, 1998.

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)

Objective

- 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

COs	Course outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	Acquire an insight in to the internal structure, tissues involved in developmental stages of plants, molecular mechanisms of fruit and seed development.	PO1-3, PO2-3, PO3-3, PO4-2
CO2	Gain the ability to conduct research and provide solutions to public issues related to agriculture.	PO1-3, PO2-3, PO4-2
CO4	Able to know different types cells in plant growth and metabolism and can pursue higher studies and thereby get employment opportunity	PO1-3, PO2-3, PO4-3, PO7-3, PO9-2
CO5	Help in developing analytical skill for identification of plants	PO1-3, PO2-3, PO3-3, PO4-2,PO5-3

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

Practice:

1. Study of anatomical details through permanent slides preparation

ModuleII

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

Practice:

2. T.S of plants showing secondary growth
3. T.S of plants showing anomalous secondary growth

Module III

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

Wood parenchyma: Apotracheal and paratracheal parenchyma; Hard wood anatomy, organisation of wood, sap wood, heard wood; Axial Parenchyma fibres and ray parenchyma and their value in wood identification'; Nodal anatomy.

Practice:

4. Wood Sample Preparation for Microscopic Analysis

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, Quiscent 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

Practice:

5. Pollen Viability
6. T.S of ovary of flower showing placentation

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

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,1965 Plant Anatomy.Wiley N.W.

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)

Objective

- To understand the various aspects of plant nomenclature and classification
- To understand the classical and modern trends of Angiosperm taxonomy
- To understand the salient features of angiosperm families with special reference to sexual characters
- To have comprehensive knowledge on lower plants
- To understand the diversity, reproduction and economic importance of lower plants

Course outcome

COs	Course outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	Gain comprehensive theoretical knowledge on diversity of plant kingdom with focus on Algae, Fungi, Bryophytes, Pteridophytes, Gymnosperms and Lichen	PO1-3, PO2-3, PO4-2,PO6-1
CO2	Students will know the technique of plant identification of indigenous and wild angiosperm plants and acquire the basic skills on the plant taxonomy	PO1-3, PO2-3, PO4-2,PO8-3
CO3	Provide life-long learning process to identify the plants and pursue higher studies and able to get job in National organization	PO1-3, PO2-3, PO6-2,PO7-1

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.

Practice:

1. Demonstration of the utility of secondary metabolites in the taxonomy of some appropriate genera

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

Practice:

2. Acquaintance with flora of local region, preparation of field notes and arrange according to Bentham and Hooker system of classification.

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

Practice:

3. Morphological characterization of selected families of dicots and monocots and identification upto families

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.

Practice:

4**.** Study of morphology and reproductive structures of algae belonging to different classes through permanent microscopic slide preparations and preserved specimens.

Module V

Bryophyta: Morphology, structure, reproduction and life history, Distribution, classification, general account of Marchantiales, Jungermaniales, Anthoceratales, Sphagnales, Funariales and Polytrichales& Ecological importance

Practice:

5. Study of temporary & permanent preparation for microscope observation of external and internal features of vegetative and reproductive structure of important genera of Bryophytes

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, Classificationof 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.

Practice:

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.

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,SanFranssco.

CUTM1432: Advanced Separation Technologies and Downstream Processing

Subject Name	Code	Type of course	T-P-Pr (Credit)
Advanced Separation Technologies and Downstream Processing	CUTM1432	Theory+ practice	3-1-0 (04)

Objective

The student will be able to know

- To improve their knowledge in Extraction Technology which is a valuable skill. To familiarize with different advanced extraction techniques developed to date
- To improve the existing practical knowledge of students in extraction technology.
- To introduce more sophisticated and sensitive extraction techniques such as Super critical Fluid Extraction and Microwave assisted extraction techniques.

Course outcome

COs	Course outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	Gain comprehensive theoretical knowledge on different extraction techniques	PO1-3, PO2-3, PO3-3,PO4-3,PO6-2
CO2	Students can perform specific extraction technique of different herbal materials	PO1-2, PO2-3, PO3-3,PO4-3,PO6-2
CO3	Provide life-long learning process and hands on training on advanced instruments which will enable them to perform well at industrial level	PO1-3, PO2-3, PO3-2,PO4-3,PO6-2

Module I

Introduction to extraction of Medicinal Plants-General Methods of Extraction -Steps Involved in the Extraction.Maceration, Percolation and Infusion Techniques for the Extraction-Decoction and Hot Continuous Extraction Techniques.

Module II

Selecting an appropriate extraction method, Extraction methods for Essential Oil-Counter-current Extraction-Aqueous Alcoholic Extraction by Fermentation- Microwave assisted Extraction- Pressurized extraction techniques.

Module III

Enzyme extraction, Molecular Distillation. Supercritical Fluid Extraction-Ultrasound Extraction (Sonication)

Module IV

Subcritical Fluid Extraction Green Extraction-Phytonics Process-Extraction Process Design and Optimization Using Design of Experimental Approach (DOE).

Practical

1. Super Critical Fluid Extraction of Pepper
2. Super Critical Fluid Extraction of Turmeric
3. Separation of essential oil by SCF technique Clove oil
4. Separation of essential oil by SCF technique Zinger oil
5. Preparation of water extract of Amla fruit by Microwave assisted extraction.

Text Books:

1. Essentials of Botanical Extraction-Principles and Applications: by Mandal SC et al., 2015, Elsevier Inc
2. Extraction technologies for medicinal and aromatic plants, International centre for science and high technology. Edited by Sukhdev Swami Handa, SumanPreet Singh Khanuja, Gennaro Longo, DevDutt Rakesh., 2008, ICS-UNIDO.

Reference Books:

1. 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)

Objective

- This course provides the theory and knowledge relevant to the plant biochemistry and enzymology principles including fundamental properties of enzymes, enzyme catalytic mechanisms and enzyme kinetics.
- Techniques employed in enzymes purification and characterization is also emphasized in this course.
- Students will also be introduced to the theory as well as applications of enzyme technology in food, medical, and household industries.
- Finally, this course serves to provide an awareness of the current and possible future applications of

enzyme technologies

Course outcome

COs	Course outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	Gain comprehensive theoretical knowledge on the kingdoms of biomolecules, bioenergetics principals that are the prerequisites and consequences of physiological phenomenon for further manipulations.	PO1-3, PO2-2,PO4-3,PO5-2
CO2	Learn the purification, characterization and estimation of enzymes. Apply biochemical calculation for enzyme kinetics and can plot graphs based on kinetics data	PO1-3, PO2-3,PO4-3,PO5-3

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

Practice:

1. Quantitative estimation of proteins(Biuret, Lowry, BCA and Bradford methods)

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.

Practice:

2. Quantitative estimation of Carbohydrates/Nucleic Acid

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

Practice:

3. Determination of Unknown Concentration of Vitamin C

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.

Practice:

4. Effects of pH, Temperature, and Substrate Concentration on enzyme activity

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).

Practice:

5. Isolation and purification of enzyme/proteins

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:

6. Bio-diesel production from Biomass and its Characterization

Text Books:

1. Donald Voet, Judith G. Voet,Biochemistry, Wiley
2. David L. Nelson; Michael M. Cox,Lehninger Principles of Biochemistry, W.H freeman and Company
3. Satyanarayana, U. and Chakrapani, U,Biochemistry, Elsevier
4. Murray, Darryl K. Granner, Peter A. Mayes,Harper's Illustrated Biochemistry, Tata McGraw hill

Reference Books:

1. Trevor Palmer, Philip L. Bonner - Enzymes_ Biochemistry, Biotechnology, Clinical Chemistry-Woodhead Publishing
2. Leskovacs V. Comprehensive enzyme kinetics, Kluwer
3. LemuelWingard, Applied Biochemistry and Bioengineering. Enzyme Technology, Elsevier Science
4. Robert_Rastall_Novel_Enzyme_Technology_for_Food, Woodhead Publishing

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)

Objective

- 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.
- Students will gain an overview of contemporary pollution issues.
- Students will gain competency to understand the conservation biology.

Course outcome

COs	Course outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	Gain the knowledge of advanced topics in plant ecology and develop a scientific understanding of Ecology, Ecosystem and its principles	PO1-3, PO2-2,PO3-1, PO7-1
CO2	Knowledge gained can be applied to field and laboratory. It will be helpful in conservation, ecological consultancy and research.	PO1-2, PO2-3, PO4-3, PO3-1, PO7-2
CO4	Evaluate the environment pollution issues and the processes that influences their source, pathways and receptors	PO1-2, PO2-3, PO4-3, PO3-1, PO7-2,PO8-2
CO7	Be able to understand the ecological context in which a particular species may have evolved, or a specific ecological process takes place	PO1-2, PO2-3, PO4-3, PO3-1, PO7-3,PO8-2

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.

Practice:
1. Practice on Nitrogen Cycle.

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, Wind, Geothermal energy, and Nuclear energy.

Practice:
2. Determination of Importance value index of species in a plant community.

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

Practice:

3. Determination of Dissolved Oxygen of water by Winkler's method.

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.

Practice:

4. Determination of pH and Conductivity of Soil.

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.

Practice:

5. Antibiotic Susceptibility Test in Microorganism

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

Practice:

6. Calculating 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. PradiptakumarMohapatra(2006). A textbook of EnviornmentalBiotechnology,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, 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.

CUTM1435: Computational Biology

Subject Name	Code	Type of course	T-P-Pr (Credit)
Computational Biology	CUTM1435	Theory+ practice	3-1-0 (04)

Objective

- Introduce students to the field of computational biology.
- To make them realize the importance of insilico databases and computational tools to understand biology in a better way.

Course outcome

COs	Course outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	Acquire the knowledge relevant to various areas of basic concepts and application of Computational Biology	PO1-3, PO2-3, PO3-3,PO4-3, PO5-2
CO2	Learn and able to employ various computational tools for modern day research	PO1-3, PO2-3, PO3-3, PO4-3, PO5-3
CO3	Learn In silico design solutions for complex scientific data base models	PO1-3, PO2-3, PO3-2,PO4-3, PO5-3, PO6-2
CO4	Acquire competency to design the experiment to analyses the protein structure and interpretation of data leading to publication	PO1-3, PO2-3, PO3-2,PO4-3, PO5-3, PO6-2,PO9-2
CO5	To be familiar with the modern computational and experimental tools for structural modeling of proteins and prediction analysis	PO1-3, PO2-3, PO3-2,PO4-3, PO5-3, PO6-2,PO9-2

Module I

Computational Biology Fundamentals and Biological Databases: Computational Biology: Basic Concepts, importance and application
Biological Databases: Classification and different types of Biological Database; DNA and Protein sequence analysis, Pairwise and multiple sequence alignment;Protein structural analysis, protein structure modeling and prediction
Practice:

1. Demonstration and Retrieving data from web resources: EMBL, GenBank, ENTREZ

Module II

Database Management Systems and Its Application in Computational Biology: Database Management Systems: Basic Concepts, importance and application; Database Models, relational database; SQL; Data mining: Fundamentals, Classification and applications of data mining

Module III

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.

Practice:

2. Structure based drug design: Molecular docking using Biovia

Module IV

Systems and Synthetic biology: Systems and Synthetic Biology: Basic Concepts, importance and application; Systems Modeling; Formulating and Simulating Network Models in Biology; Potential Hazards of Synthetic Biology

Practice:

3. Mathematical modeling and simulating of Biochemical network

Module V

Algorithms in Computational Biology: Algorithms in Computational Biology: Algorithms and complexity, biological versus computer algorithms; Recursive algorithms, iterative versus recursive algorithms; Overview of algorithm design techniques: Dynamic programming; Markov Chains and Hidden Markov Models: Concept and application in computational biology.

Practice:

4. Pairwise Sequence Alignment using BLAST
5. Aligning Multiple Sequences with CLUSTAL W

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

Practice:

6.Align nucleotide/protein sequences using tools available in biopython

Module VII

Biojava and It's application in Computational Biology: Biojava: Introduction, importance and application of Biojava to computational biology; Protein structure module of Biojava and its use in manipulating structure of protein; Genome and sequencing module of biojava and its application for analyzing sequence data; Biojava alignment module and its application for pairwise and multiple sequence alignment

Text Books:

1. Introduction to bioinformatics by Teresa K. Attwood, David J. Parry-Smith,1999,Pearson Education.
2. Arthur M.Lesk, Introduction to Bioinformatics, Oxford University Press, New Delhi, 2003.
3. D.Higgins and W.Taylor (Eds), Bioinformatics-Sequence, Structure anddatabanks, Oxford University Press, New Delhi, 2000.

Reference Books:

1. Bioinformatics: Sequence and Genome Analysis by Mount D., 2004, 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. Bioinformatics- a practical guide to the analysis of Genes and Proteins byBaxevanis,A.D. and Francis Ouellellette, B.F., 1998, John Wiley & Sons, UK.

CUTM1436: Microbiology

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

Objective

- To know various Culture media and their applications and also understand various physical and chemical means of sterilization.
- Master aseptic techniques and be able 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 outcome

COs	Course outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	Acquire, articulate, retain and knowledge relevant to various areas of Microbiology particularly the interactions between viruses, bacteria and the host immune system	PO1-3, PO2-3, PO3-2,PO7-3, PO5-2
CO2	Acquire and demonstrate competency in laboratory safety and in routine and specialized microbiological laboratory skills	PO1-3, PO2-3, PO3-3, PO4-3, PO5-2,PO7-3
CO5	Acquire competency applicable to microbiological research or clinical methods, including accurately reporting observations and analysis	PO1-3, PO2-3, PO7-2, PO8-2, PO9-2
CO8	Student will be instilled with values of professional ethics and be made ready to contribute to society as responsible individuals.	PO1-3, PO2-3, PO3-2, PO5-2,PO6-2

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 (phenetic, genetic and phyllogenetic); Bergeys manual of systematic bacteriology; Classification, Identification and Culturing Technique of cyanobacteria; Industrial Application, Cyanotoxins.

Practice:

1. Preparation of bacterial smear and staining – Gram's, Acid-fast, Staining of bacterial spores flagella, capsule, spirochaetes
2. Isolation, purification, identification and biomass production of cyanobacteria

Module II

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.

Practice:

3. Methods for measurement of bacterial growth by haemocytometer and spectrophptometer

Module III

Environmental Microbiology & Wastewater Management: Microbes and quality of environment, Biotransformations, 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, Biologicalcontrol.Microbial toxins produced in food items, Probiotics and prebiotics, Methods of food preservation, Microbiological legal standards of selected food and milk products.

4.Qualitative analysis of Milk and milk products; Microbiological analysis of food products; Detection of bacteria in milk by Standard plate count

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.

Practice:

5.Antibiotic sensitivity test disc preparation; Antibiotic sensitivity test – Kirby – Bauer, Stoke's; MIC determination by filter paper disc assay

Module VI

Industrial Microbiology: Cyanobacterial Biotechnology: Application as nutraceuticals, pharmaceuticals, cosmetic, biofertilizer; 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, Biotechnologial 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.

Practice:

6.Preparation of different microbial culture media

Module VII

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

Text Books:

1. Mehrotra, R. S. and Aneja, R. S. (1998). An Introduction to Mycology, New Age International, New Delhi

2. Alexopoulus, C. J., Mims, C. W. and Blackwel, M. (1996). Introductory Mycology, John Wiley, New York.
3. Kumar, H. D. (1988). Introductory Phycology. East-West Press, New Delhi.
4. Maloy, S. R., Cronan, J. E. Jr. and Freifielder, D. (2008). Microbial Genetics, 2nd Ed. Norosa, New Delhi.

Reference Books

1. Prescott, L. M., Harley, J. P. and Klen, D. A. (1999). Microbiology, 7th Ed., McGraw-Hill, New York.
2. Pelczar, Jr., M. J., Chan E.C.S. and Krieg, N. R. (2005). Microbiology, 5th Ed, Tata McGraw-Hill, New Delhi.
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)

Objective

- The student will be able to know the cell biology of all major groups of organisms, including microorganisms, plants and animals
- How genome organization differs in the major groups of organisms
- The complex interactions between nucleus and cytoplasm that determine how cells function
- Basic concepts of how cells become specialized into different types in complex organisms
- How the cytoskeleton is organized and its role in cellular function

Course outcome

COs	Course outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	Gain an understanding of chemical nature of biological macromolecules and molecular processes that occur in and between cells	PO1-3,PO2-3, PO3-2, PO4-3,PO5-2
CO2	Learn current experimental approaches in cell biology and molecular biology such as extraction of DNA from the agarose gel and amplification of DNA using Polymerase Chain Reaction.	PO1-3,PO2-3, PO3-2, PO4-3,PO5-2
CO4	Can investigate protein and nucleic acid in the samples and can pursue higher studies to get employability opportunity	PO1-3, PO2-3, PO4-3, PO5-2
CO5	Acquire the computational skill in relation with In-silico membrane-receptor and ligand interaction studies	PO1-3, PO2-3, PO4-2, PO5-2

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).

Practice: 1. Glucose uptake assay

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.

Practice: 2. Plasmid isolation (miniprep).

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.

Practice: 3. Extraction of DNA from the fish fins.

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.

Practice: 4. Visualization of DNA by performing agarose gel electrophoresis and extraction of DNA from the agarose gel.

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.

Practice: 5. DNA amplification using Polymerase Chain Reaction (PCR).

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: 6. *Insilico* membrane-receptor and ligand interaction studies using DISCOVERY STUDIO (BIOVIA).

Text Books:

1. Geoffrey M. Cooper, Robert E. Hausman (Boston University). The Cell: A Molecular Approach. ASM Press, Washington D.C. Fourth edition.
2. Cell and molecular biology Robertis, De and Robertis Lea and Febiger. Eighth 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: Bioanalytical Techniques

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

Objective

- This course is introduced to bridge the gap between academics, research and industry.
- This course begins with a review of basic bio analytical technique and an introduction to general terminologies.
- This course contains bio analytical techniques along with their theory, working principal, common instrumentation and possible applications. This course will be equally beneficial to various scientific areas.
- Students will be exposed to various biological techniques and their applications in identification, isolation of different biological molecules.

Course outcome

COs	Course outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	Acquire knowledge on the principle of molecular techniques	PO1-3,PO2-3, PO3-2, PO4-2,PO5-2
CO2	Learn current application of various instruments regarding molecular techniques for the improvement of trait	PO1-3,PO2-3, PO3-3, PO4-3,PO5-3
CO3	Use of the knowledge for designing a project for research and execute it	PO1-2,PO2-3, PO3-3, PO4-3,PO5-3

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.

Practice: 1.To study and gain expertise on differential and cytological staining techniques.

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.

Practice: 2 Demonstration of UV-vis Spectrophotometer.

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.

Practice:
3. To separate proteins on the basis of their size and charge

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

Practice:
4**.** To separate the amino acids in a mixture by thin layer chromatography.
5. Purification of immunoglobulins by affinity chromatography

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.

Practice:
6. To study the separation of DNA by agarose gel electrophoresis

Module VII

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

Text Books:

1. Keith Wilson and John Walker (2009)Principles and techniques of biochemistry and molecular biology.7th Edition,Cambridge University Press, Cambridge, UK.

Reference Books:

1. Wilson K and Walker J (2009)Principles and techniques of biochemistry and molecular biology.7thEdition,Cambridge University Press, Cambridge, UK.
2. Voet D and Voet J Biochemistry, 4th Edition. (2010). John Wiley and Sons. New Jersey, USA
3. Rodney F Boyer(2012) Biochemistry laboratory: modern theory and techniques.2nd Edition, Pearson Prentice Hall, Boston,USA.
4. R. Katoch(2011) Analytical techniques in biochemistry and molecular biology,Springer, New York.

CUTM1439: Plant Biotechnology

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

Objective

The student will be able to know

- To understand the basics principles of plant sciences and molecular biology and their integration towards trait improvement in plants.
- To have a thorough knowledge of laboratory techniques used in plant biotechnology.
- To understand the industrial applications of biotechnology in developing new products.
  To undertake research in plant biotechnology

Course outcome

COs	Course outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	Understand the concepts and techniques of plant biotechnology and their applications in crop plants.	PO1-3, PO2-3, PO3-2, PO4-3, PO7-2
CO2	Laboratory skills on integrative approach for	PO1-3, PO2-3, PO3-3, PO4-3, PO7-2

	biotechnological experiments specifically on basic, techniques in micro-propagation and can get job opportunities in agribusiness, private companies, industries, universities and research laboratories	
CO3	Design of experiments for complex scientific problems towards research in the field of conservation of plant species and can pursue higher studies	PO1-3, PO2-3, PO3-3, PO4-3, PO7-3
CO7	Experimental skills to conserve plants for sustainability	PO1-3, PO2-3, PO3-3, PO4-2, PO7-3

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

Practice:
1. Preparation of tissue culture media
2. Direct Organogenesis: Shoot tip culture

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.

Practice:

3. Micropogation techniques

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.

Practice: 4. DNA isolation and purification

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. Callus induction
6. Agrobacterium mediated gene transfer in plants

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.

Text Books:

1. Glick, B. R. and Pasternak (2003). Molecular Biotechnology: Principles and Applications of Recombinant DNA. ASM Press, Washington, D. C., USA.
2. Kyte, L. and Kleyn, J. (1996). Plants from Test Tube to: an Introduction to Micro propagation, 3rd Ed. Timber press, Port land, USA.

Reference Book:

Pollard, W. J. and Walker (1990).Plant Cell and Tissue Culture Vol VI. Humana press Clifton, USA.

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)

Objective

- This course examines the application of genetic principles to plant improvement. Topics include breeding objectives, mating systems, selection, testing and germplasm maintenance of horticultural and crop plants

Course outcome

COs	Course outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	Understand the sources and types of genetic variation and explain their importance for plant improvement	PO1-3, PO2-3, PO3-3, PO4-3, PO5-2, PO7-2
CO2	Laboratory skills to carry out specific plant breeding activities such as selection of parental germ-plasm, conservation and recording of phenotypic variation and selection among progeny relevant to plant breeding	PO1-3, PO2-3, PO3-3, PO4-2, PO5-2, PO7-2

Module I Genetics:

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

Practice:
1. Study of chromosome mapping with point test crosses data.

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.

Practice:
2. Induction of Polyploidy by Colchicine.

Module IV

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 V

Protein engineering: Protein engineering and site directed mutagenesis; In vitro mutagenesis and deletion techniques, gene knock out in bacterial and eukaryotic organisms.

Module VI
Introduction to breeding techniques: Breeding methods for self & Cross pollinated crops; Self-incompatibility and male sterility in crop plants;
Selection: Pureline & mass selection; Line, pedigree, bulk method; Single seed descent and multiline method.
Practice:
3. Demonstration of pedigree analysis.
4. Studying the pollen grain size and germination in various crops - preparation of temporary and permanent slides.

M**odule VII**

Special breeding techniques: Hybrid breeding and genetic basis of heterosis;Ideotype breeding; Mutation breeding;Molecular breeding (Marker assisted selection and Gene Pyramiding); Genomics Assisted breeding; QTL mapping, Genome wide association studies.
Practice:
5. Learning technique in hybrid seed production using male sterility in field crop.
6. Demonstration of mutation breeding.

Text Books

1. Chopra VL. 2004. Plant Breeding. Oxford & IBH.
2. Gupta SK. 2005. Practical Plant Breeding.Agribios.

Reference Book:

1. Lewin, B. (2004). 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.
4. Allard RW. 1981. Principles of Plant Breeding. John Wiley & Sons.

CUTM1441: Plant Genomics

Subject Name	Code	Type of course	T-P-Pr (Credit)
Plant Genomics	CUTM1441	Theory+ practice	3-1-0 (04)

Objective

The student will be able to know

- Deciphering the genetic makeup and protein population in an organism are among the elementary approaches in biological sciences.
- To provide an understanding in genomics and proteomics and, the different approaches and techniques employed in these fundamental fields of study.

Course outcome

COs	Course outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	Understand various omics approaches and their role in understanding plant function	PO1-3, PO2-3, PO3-3, PO4-2, PO5-2
CO2	Experiments to understand plant function	PO1-3, PO2-3, PO4-2, PO5-2
CO3	Analyze the information from plant genomic research and recognize its potential applications in crop improvement	PO1-3, PO2-3, PO3-3, PO4-2, PO5-3
CO4	Design and develop experiments to understand and manipulate plant function	PO1-3, PO2-3, PO3-3, PO4-2, PO5-2

Module I: Basics of Genomics

Introduction to genomics, Brief overview of prokaryotic and eukaryotic genome organization, Extra-chromosomal DNA: bacterial plasmids, Extra-chromosomal DNA: mitochondria and chloroplast

Practice: 1. Demonstration of Polymerase chain reaction (PCR)

Module II: Genome mapping

Genetic and physical mapping, Markers for genetic mapping, FISH technique in gene mapping, comparative gene mapping
Practice: 2. Demonstration of gene mapping

Module III: Genome sequencing projects

Human Genome Project, Genome sequencing projects for microbes, Genome sequencing projects for plants and animals, Accessing and retrieving genome project information from the web
Practice: 3. Demonstration of web tools for genome analysis

Module IV: Comparative genomics:

Identification and classification of organisms using 16SrRNA typing/sequencing, Identification and classification of organisms using SNPs, Use of genomes to understand evolution of eukaryotes, track emerging diseases and design new drugs, Determining gene location in genome sequence.

Practice: 4. Phylogenetic analysis using genomic tools

Module V: Proteomics

Introduction to proteomics, Proteomics technologies- 2D-PAGE, isoelectric focusing, Mass spectrometry, MALDI-TOF, Yeast 2-hybrid system, Proteome databases.
Practice: 5. Demonstration of 2D-PAGE gel

Module VI: Functional genomics and proteomics

Transcriptome analysis for identification and functional annotation of gene, Gene function- forward and reverse genetics, Protein chips and functional proteomics, Clinical and biomedical applications of proteomics; Introduction to metabolomics,metagenomics and systems biology.

Module VII: Emerging Technologies

Introduction to gene editing, ZFNs & TALENs, CRISPR/Cas System, Case studies of gene editing for crop improvement
Practice: 6. Demonstration of gene cloning

Text books

1. Twyman, R.M. Principles of Proteomics. BIOS Scientific Publisher, New York. 2004.
2. Singer M and Berg P Genes and Genomes: A Changing Perspective; University ScienceBooks, CA, USA, 1991.

Reference Books

1. Liebler, D.C. Introduction to Proteomics: Tools for the New Biology. Human Press, Totowa NJ. 2002.
2. Buchanan B, Gruissem G, and Jones R Biochemistry and Molecular Biology of Plants, American Society of Plant Physiologists, USA, 2000.
3. Hammes GD. Spectroscopy for the Biological Sciences; Wiley Interscience, USA, 2005.