

Syllabus Book
for
2 Years Postgraduate Programme
M.Sc. Biotechnology



Centurion
UNIVERSITY

Shaping Lives...
Empowering Communities...

School of Biotechnology

Centurion University of Technology and Management

India's First and Best Skill University



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Constituent Campuses

Bhubaneswar | Paralakhemundi | Rayagada | Bolangir | Chattarpur | Balasore

Programme Educational Objectives (PEOs)

PEO-01	To develop advanced technical skills in applied biotechnology to contribute to scientific discovery and problem-solving.
PEO-02	To get equipped for careers in research institutions, biotech industries, academia, or doctoral studies, with strong communication and leadership skills.
PEO-03	To integrate ethical, regulatory, and policy considerations into their scientific work to promote responsible and sustainable biotechnological applications.

Programme Specific Outcomes (PSOs)

PSO-1	Application of Advanced Biotechnology Techniques: Graduates will acquire the ability to apply advanced molecular, cellular, and computational techniques in fields such as genetic engineering, proteomics, genomics, and synthetic biology to address challenges in agriculture, healthcare, industry, and environmental sustainability
PSO-2	Translational Research and Innovation: Graduates will demonstrate the capability to translate biotechnological research into innovative products, processes, and services, particularly in areas such as biopharmaceuticals, biofuels, diagnostics, and sustainable agriculture, fostering entrepreneurial ventures and industrial growth.
PSO-3	Problem-Solving in Specialized Domains: Graduates will develop expertise in solving complex biological and industrial problems by integrating interdisciplinary knowledge of biotechnology, bioinformatics, and systems biology, with a focus on addressing contemporary challenges like climate change, disease management, and food security.

Programme Outcomes (POs)

PO-01	Disciplinary Knowledge: Graduates will gain in-depth knowledge of biotechnology concepts, including molecular biology, genetic engineering, microbiology, biochemistry, and bioinformatics, with an emphasis on their interdisciplinary applications in research, industry, and societal problem-solving.
PO-02	Analytical Skills: Graduates will develop the ability to design, conduct, and analyze experiments using modern biotechnological tools and techniques, enabling them to address complex biological questions and provide innovative solutions to real-world challenges.
PO-03	Design /development of solutions: Design solution for biotechnological problems and design system component of processes that meet the desired needs with appropriate consideration for the public health and safety, and the cultural, societal and the environmental considerations.
PO-04	Communication: Communicate effectively on complex activities with the committee and with society at large, such as, being able to comprehend and write affective reports and design documentation, make effective presentations in Biotechnology.
PO-05	Environment and sustainability: Graduates will understand and apply biotechnological approaches to address environmental sustainability, public health, food security, and other societal issues while minimizing ecological footprints.
PO-06	Innovation and Entrepreneurship: Graduates will acquire entrepreneurial skills and the ability to identify opportunities for innovation in the biotechnology industry, focusing on product development, commercialization, and creating start-ups aligned with sustainable development goals.
PO-07	Ethics and Professional Responsibility: Graduates will exhibit a strong understanding of professional ethics, bioethics, and intellectual property rights, ensuring responsible conduct in research, industry, and community engagements.
PO-08	Lifelong Learning and Adaptability: Graduates will cultivate a mindset for continuous learning, staying updated with advances in biotechnology and related fields, and adapting to evolving technologies and global trends.

Academic Regulations for 2 Years Postgraduate Programme

School of Biotechnology

Centurion University of Technology and Management

2023

1. Introduction

This Programme provides flexibility to students to choose a single discipline or a combination of disciplines/ streams as an academic career path. The Programme envisages a competency-based, multi-disciplinary, holistic academic programme with a creative combination of disciplines/ skills/ Domain/ Research of study with multiple entry and exit options.

The curriculum emphasizes a flexible combination of a wide range of courses with a focus on analytical and critical thinking, computational skills, use of cutting-edge technology, innovation, creativity, experiential learning including the development of a competency-based skilling ecosystem and holistic development of students leading to specific career prospects.

The university follows a dynamic curriculum development approach. Hence, it reserves the rights to revise / modify the syllabus, structure, credits etc. as deemed fit.

2. Objective

- To provide basic and advanced knowledge on principles of biotechnology, as well as current research and development.
- To develop technical skills in areas such as plant, animal, microbial, and medical biotechnology and to use high throughput biological lab equipments.
- To conduct research and develop research ideas. They also learn how to perform biotechnological research independently or in collaboration with others
- To create and develop the skills critical judgments about the legal, ethical, social, and business aspects of biotechnology.
- To train students in biochemical concepts and techniques and how to apply this knowledge in practical ways.
- To create and apply appropriate techniques, resources and modern instruments for biochemical estimation, animal tissue culture and plant tissue culture experiments, environment insults measurements, genetics, bioinformatics, cellular, molecular and physiological activities of all living organisms with an understanding of the application and limitations.

- To introduce with the area of research as per the recent outbreaks or demand in the society.
- To train and enhance skills using biological principles and systems to create new products.
- To practice biotechnological research, its importance for society, health, safety, legal and environmental issues and the consequent responsibilities relevant to the biodiversity conservation practice.
- To foster innovation and entrepreneurship skills, enabling students to identify opportunities, drive positive change and contribute to the growth of biotechnology field.
- To prepare students to adapt to evolving technologies and methodologies, emphasizing the importance of continuous learning and professional development.

3. Eligibility

A student who has passed Bachelor's degree in a relevant field, such as biotechnology, biology, life sciences, biochemistry, botany, zoology, or microbiology with a minimum aggregate of 50 % in Bachelor's degree (5 % relaxation for SC/ST candidates) from a recognized university is eligible to take admission to the M.Sc. Biotechnology Programme.

4. Programme structure

Choice-based Credit System (CBCS) Structure

Basket	Type of Course	Minimum Credit Requirement	
		PG	
		Credit	Approx. Weightage
I	Core Courses	56	64 %
II	Specialization Courses	29	27 %
III	Skill Courses	08	9 %
TOTAL		93	100 %

5. Types of courses

5.1 Major (Core) courses

Major (Core) Courses are the foundational and specialized courses directly related to a student's chosen major discipline. These courses form the core of the academic programme and provide in-depth knowledge and skills in the chosen field of study.

Major (Core) Courses aim to build a strong theoretical and practical foundation in the chosen major discipline. They equip students with the specialized knowledge and expertise required to excel in their field of study and future careers.

Please refer to Annexure- I for courses offered in major (core) discipline.

5.2 Elective Courses

Elective Courses: These are courses from advanced biotechnology fields, providing students with a secondary area of expertise and will benefit students for research and development.

Please refer to Annexure- II for courses offered under this basket.

5.3 Domain Courses

Domain Courses: These are courses from a chosen minor discipline, providing students with a secondary area of expertise. There are several domains offered by the university for the academic year 2023-24.

Please refer to Annexure- III for courses offered under this basket.

5.4 Skill Courses / Summer Internship / Research Project / Dissertation / Production Action Learning

Skill Courses: These courses focus on developing practical skills and competencies that are valuable in various professional contexts. Please refer to Annexure-3 for courses offered under this basket.

Summer Internship or Community Engagement programmes involve students participating in real-world work experiences, either in industry or within the community, during the summer break. These experiences can be credit-bearing and provide practical exposure to their chosen field of study.

Summer Internship and Community Engagement experiences bridge the gap between theoretical knowledge and practical application. They offer students an opportunity to apply

what they have learned in a real-world context, gain hands-on experience and develop professional networks.

These are in-depth, research-oriented components of the academic programme. Students engage in original research, dissertation writing, or production action learning, depending on the programme's requirements. Research projects are typically carried out under the guidance of faculty members.

These components aim to develop students' research skills, critical thinking abilities and problem-solving capabilities. They encourage students to explore, analyze and contribute to the knowledge base of their major discipline, preparing them for careers in research, academia, or industry leadership roles.

Please refer to Annexure- IV for courses offered under this basket.

6. Assessment

6.1 Evaluation for Theory Components

i. End semester theory examinations (50% weightage):

- a. Duration – 3 hrs
- b. Full Mark – 100. During result processing, it will be proportionately added.
- c. Distribution of marks (should cover all COs)
 - i. 10 short questions x 2 marks = 20 marks
 - ii. 5 long questions x 12 marks = 60 marks
 - iii. 4 short notes x 5 marks = 20 marks

ii. Continuous assessments: Details are as indicated in the table below:

Sl. No.	Continuous Assessment	Score
1	Individual / Group Presentation <i>Rubric is as under:</i> <ul style="list-style-type: none"> • Content & creativity – 05 • Presentation & Discussion – 05 	10
2	Mid-semester (Written Examination) <i>Mark Distribution:</i> <ul style="list-style-type: none"> • 5 short questions x 1 marks = 5 marks • 2 long questions x 5 marks = 10 marks • 2 short notes x 2.5 marks = 5 marks 	20

3	Assignment (2 assignments x 5 marks each)	10
4	Learning Record (<i>Based on the parameters indicated in the learning record format, course faculty to evaluate and award score</i>)	10
Total		50

6.2 Evaluation of Practice/ Laboratory Components

The evaluation of the practice component will be carried out 50% by concerned faculty and 50% by the external examiner and will be conducted as per the present policy. Details are as under:

Internal

A	Concept	10
B	Planning & Execution/ Practical/ Simulation/ Programming	10
C	Result and Interpretation	10
D	Record/ Report	10
E	Viva	10
Total		50

External

A	Execution & Result	20
B	Record of Applied and Action Learning	10
C	Viva	20
Total		50

6.3 Evaluation of Project Component

The evaluation of the project component will be completed 50% by concerned faculty and 50% by the external examiner and will be conducted as per the present policy. Following guideline may be referred during evaluation of internal and external components:

Internal

A	Understanding the relevance, scope and dimension of the project	10
B	Methodology	10
C	Quality of Analysis and Results	10
D	Interpretations and Conclusions	10
E	Report	10
Total		50

External

A	Understanding the relevance, scope and dimension of the project	10
B	Report	20
C	Viva	20
Total		50

6.4 Evaluation of Internship

The evaluation of the internship will be completed 50% by concerned faculty and 50% by the industry guide. Following guideline may be referred during evaluation of internal and external components:

Internal

A	Daily Diary & Log Report	20
B	Periodical (Weekly/Monthly) Report	10
C	Presentation & Viva	20
Total		50

External

A	Completion of the task / project assigned	30
B	Feedback of the industry supervisor	20
Total		50

6.5 Evaluation of Workshop Component

The evaluation of the workshop component will be completed 100% by concerned faculty as per the present policy. Following guideline may be referred during evaluation:

A	Critical Thinking/ Simulation/ Field work & Report	50
B	Presentation & Viva	50
Total		50

7. Pass criteria

A. **Theory papers**: students must secure a minimum of **30% in individual components** (both continuous assessment & end-semester theory) **along with 40% in aggregate**

B. **Theory & practice papers**

- i. Theory component: minimum of 30% in individual components (both continuous assessment & end-semester theory) along with 40% in aggregate
- ii. Practice component: minimum of 50% marks both in internal & external

C. **Theory & project type papers**

- i. Theory component: minimum of 30% in individual components (both continuous assessment & end-semester theory) along with 40% in aggregate
- ii. Project component: minimum of 50% marks both in internal & external

D. **Theory, practice & project type papers**

- i. Theory component: minimum of 30% in individual components (both continuous assessment & end-semester theory) along with 40% in aggregate
- ii. Practice component: minimum of 50% marks both in internal & external
- iii. Project component: minimum of 50% marks both in internal & external

E. **Practice & project type papers**

- i. Practice component: minimum of 50% marks both in internal & external
- ii. Project component: minimum of 50% marks both in internal & external

F. **Workshop or Internship type papers**: 50% in aggregate

8. Grading

CUTM follows “Absolute” grading system / Grade point or marks scheme applicable for different programmes. Under absolute grading system, a Ten Point grading system on base of 10 shall be followed in CUTM. Categorization of these grades and their correlation shall be as under:

Qualification	Grade	Score on 100 Percentage Points	Point
Outstanding	O	90 and above up to 100	10
Excellent	E	80 and above but less than 90	9
Very Good	A	70 and above but less than 80	8
Good	B	60 and above but less than 70	7
Fair	C	50 and above but less than 60	6
Pass	D	40 and above but less than 50	5
Failed	F	Below 40	2
Malpractice	NOT APPLICABLE	NOT APPLICABLE	0
Absent	NOT APPLICABLE	NOT APPLICABLE	0

N.B. Grade C shall be considered as average, Grade D shall be the passing Grade for theory and Grade C shall be the Pass Grade for Practical/ Project/ Workshop mode paper.

9. Attendance

Attendance will be calculated from the date of commencement of classes or date of admission, whichever is later.

- a. A student attending at least 75% of the total number of classes held shall be allowed to sit for the concerned Semester Examinations subject to fulfilment of other conditions laid down in the regulation.
- b. A student attending at least 60% but less than 75% of the total number of classes held shall be allowed to sit for the concerned Semester Examinations subject to the payment of prescribed fees and fulfilment of other conditions laid down in the regulations.

- c. A student attending less than 60% of the total number of classes held shall not be allowed to sit for the concerned Semester Examinations and he /she has to take admission to the same Semester in the very next year for attending the classes and appearing at the said Semester Examination.

Details of the Courses for M.Sc. Biotechnology

Basket I

Sl. No.	Course Type	Course Code	Course Title	Credit	Type (T+P+Pj)
1	Core Courses	CUTM1433	Biochemistry and Enzyme Technology	4	3+1+0
2	Core Courses	CUTM1437	Cell and Molecular Biology	4	3+1+0
3	Core Courses	CUTM1451	Immunology and Cancer Biology	4	3+1+0
4	Core Courses	CUTM1438	Bioanalytical Techniques	4	3+1+0
5	Core Courses	MRM301T	Research Methodology & Biostatistics	4	4+0+0
6	Core Courses	CUTMXXXX	Advanced Microbiology	4	3+1+0
7	Core Courses	CUTM1454	Genetics and epigenetics	4	3+1+0
8	Core Courses	CUTM1563	Genetic Engineering	4	2+2+0
9	Core Courses	CUTM1569	IPR, Biosafety and Bioentrepreneurship	4	2+0+2
10	Core Courses	CUTM1452	Animal Biotechnology	4	3+1+0
11	Core Courses	CUTM1439	Plant Biotechnology	4	3+1+0
12	Core Courses	CUTM1568	Transcriptomics, Proteomics and Metabolomics	4	2+2+0
13	Core Courses	CUTM1567	Frontiers in Genomics	4	3+1+0
14	Core Courses	CUTM1428	Plant Physiology and Metabolism	4	3+1+0

Credits to be completed from Basket I \geq 56.

Basket II

Sl. No.	Course Type	Course Code	Course Title	Credit	Type (T+P+Pj)
1	Specialization	CUTMXXXX	Domain	29	

Credits to be completed from Basket II \geq 24.

Basket III

Sl. No.	Course Type	Course Code	Course Title	Credit	Type (T+P+Pj)
1	Skill Courses	CUTMXXXX	Skill Course I	4	0+2+2
1	Skill Courses	CUTMXXXX	Skill Course II	4	0+2+2

Credits to be completed from Basket III \geq 8.

Semester-wise course distribution

Semester I

Course Code	Course Title	Credit	Type (T+P+Pj)
CUTM1433	Biochemistry and Enzyme Technology	4	3+1+0
CUTM1437	Cell and Molecular Biology	4	3+1+0
CUTM1451	Immunology and Cancer Biology	4	3+1+0
CUTMXXXX	Advanced Microbiology	4	3+1+0
CUTM1438	Bioanalytical Techniques	4	3+1+0
CUTMXXXX	Skill Course I	4	0+2+2

Semester II

Course Code	Course Title	Credit	Type (T+P+Pj)
CUTM1595	Research Methodology Biostatistics	4	4+0+0
CUTM1439	Plant Biotechnology	4	3+1+0
CUTM1452	Animal Biotechnology	4	3+1+0
CUTM1454	Genetics and epigenetics	4	3+1+0
CUTM1563	Genetic Engineering	4	2+2+0
CUTM1569	IPR, Biosafety and Bioentrepreneurship	4	2+0+2

Semester III

Course Code	Course Title	Credit	Type (T+P+Pj)
CUTM1568	Transcriptomics, Proteomics and Metabolomics	4	2+2+0
CUTM1567	Frontiers in Genomics	4	3+1+0
CUTM1428	Plant Physiology and Metabolism	4	3+1+0
CUTMXXXX	Domain Subject I	3	1+2+0
CUTMXXXX	Domain Subject II	3	1+2+0
CUTMXXXX	Domain Subject III	3	1+2+0
CUTMXXXX	Skill II	4	0+2+2

Semester IV

Course Code	Course Title	Credit	Type (T+P+Pj)
CUTMXXXX	Domain Subject I	3	0+3+0
CUTMXXXX	Domain Subject V	3	0+3+0
CUTMXXXX	Domain Subject VI	3	0+3+0
CUTMXXXX	Domain Project	11	0+0+11

Core Courses

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	Mapping COs with POs and PSOs (High-3, Medium-2, Low-1)
CO1	Learn 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 (3), PO3 (1), PO4 (2), PO5(2), PSO3 (3)
CO2	Know details about the structure and function of proteins, their types, modification and functions.	PO1 (3), PO2 (3), PO3 (3), PO5 (3), PSO(2)
CO3	Construct the chemical structures of carbohydrate, nucleosides, nucleotides and lipids, circulating lipids and inflammatory lipid mediators etc	PO1 (3), PO2 (2), PO3 (2), PO4 (3), PO5 (3)
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	PO1 (3), PO2 (2), PO3 (2), PO5 (3), PO6 (1), PSO1 (2)
CO5	Evaluate and apply biochemical calculation for enzyme kinetics. Compare methods for production, purification, characterization and immobilization of enzymes. And their application in industry.	PO1 (3), PO2 (2), PO3 (2), PO4 (3), PO5 (3), PO8 (2), PSO1 (1)

Module I

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

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

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

Module IV

Classification, structure, properties and functions of fatty acid, essential fatty acids, fats, phospholipids, sphingolipids, cerebrosides, steroids, lipoproteins, membrane protein. Plant Biofuel; Structure and functions of vitamins, Source of phytochemicals, Natural Antioxidants

Module V

Overview of enzyme: Chemical Nature, Characteristics, Classification (IUB), Nomenclature, Enzyme conformation, Active Sites, Ribozyme, isozymes, multi enzyme complex, Michaelis-Menten equation, Treatment of Data (Briggs-Haldane, Lineweaver-Burk, Eadie-Hofstee, Cornish-Bowden, Van Slyke-Cullen behavior) Enzyme inhibition, Significance of Km, Kcat, Vm; Single substrate, bi substrate, multi substrate reaction, Significance and Evaluation of activation energy; 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, Acid-base catalysis, covalent catalysis, metal ion catalysis, proximity, orientation effect, site directed mutagenesis of enzyme.

Module VI

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 beverage industry, Leather Industry, Textile industry etc).

Module VII

Industrial Enzymes – production & applications, Biofuel: production of biomethane and bioethanol from agro-food wastes/Microalgae; Nutritional profiling of agricultural products; Biopolymer, Microbial polysaccharides; Dextran. 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

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

<ul style="list-style-type: none">• 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.
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Course outcome

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

COs	Course outcomes	Mapping COs with POs and PSOs (High-3, Medium-2, Low-1)
CO1	Recall the fundamental components of biological membranes and their roles in cellular function along with basic molecular process of cell.	PO1 (3), PO2 (2), PSO1 (3)
CO2	Understand the mechanisms behind DNA replication, transcription, and translation in both prokaryotic and eukaryotic systems	PO1 (3), PO2 (3), PO3 (1), PO4 (2), PO5 (3), PO6 (1), PO7 (3), PO8 (1), PSO1 (3), PSO3 (2)
CO3	Apply laboratory techniques such as PCR, gel electrophoresis, and enzyme assays to explore molecular and cellular processes.	PO1 (3), PO2 (2), PO3 (1), PO4 (2), PO5 (2), PSO2 (3), PSO3 (3)
CO4	Analyse the structure-function relationships of proteins and enzymes, understanding how these molecules catalyze biochemical reactions and are regulated within the cell.	PO1 (1), PO2 (2), PO3 (3), PO4 (3), PO5 (2), PSO1 (3), PSO3 (3)
CO5	Evaluate experimental data on cell signalling pathways and gene expression regulation, forming conclusions about cellular responses to various stimuli.	PO1 (3),PO2 (2),PO5 (1), PO6 (3), PO7 (1), PO8 (2), PSO1 (3), PSO3 (3)

Module I

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 (circulardichroism, 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. *In silico* membrane-receptor and ligand interaction studies

Text Books:

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

Reference Books:

1. *Molecular Biology of the Cell* Alberts, B., et al. 6th 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.

Immunology and Cancer Biology

Code	Course Title	Course Type	Credits	L-Pr-P (hrs)
CUTM1451	Immunology and Cancer biology	Theory + Practice	4	3-1-0

Objectives

- The primary objective of this course is to help students develop knowledge and skills related to health and disease and role of immune system.
- Students are taught immunology so as to develop understanding of the subject, such as functioning the immune system, the molecular and cellular components and pathways that protect an organism from infectious agents.
- The common cellular and molecular mechanisms that are deregulated in cancerous cells and their contribution to the development of cancer. Role of gene mutation and environmental factors in the development of cancer.

Course Outcome

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

COs	Course outcomes	Mapping COs with POs and PSOs (High-3, Medium-2, Low-1)
CO1	Understand the immunomodulatory strategies essential for generating or suppressing immune responses as required in hypersensitivity reactions, transplantation, autoimmune diseases and cancer.	PO1 (3), PO3 (3), PSO1 (3), PSO3 (3)
CO2	Know about biological aspects of cancer, carcinogenesis and cancer therapy.	PO1 (3), PO2 (3), PO3 (1), PO4 (2), PO5 (1), PO8 (2), PSO1 (3), PSO3 (2)
CO3	Apply the principle and application of various immune techniques and they can Will be able to make a strategy for immunological research and execute it.	PO1 (3), PO2 (2), PO3 (1), PO4 (2), PO5 (2), PSO1 (3), PSO3 (3)
CO4	Analyze the immunomodulatory strategies essential for generating or suppressing immune responses as required in hypersensitivity reactions, transplantation, autoimmune diseases and cancer.	PO1 (1), PO2 (2), PO3 (3), PO4 (3), PO5 (2), PSO2 (3)
CO5	Examine the various immune techniques and they can will be able to make a strategy for immunological research and execute it.	PO1 (3), PO2 (2), PO5 (1), PO6 (3), PO7 (1), PSO1 (3), PSO3 (3)

Module I

Hematopoiesis, Cells and Organs of the Immune System, Structure and function of antibodies, Inflammation

Module-II

Development and Signaling of Immune system- Innate Immunity, TLRs and their role in innate, Immune response Adaptive Immunity, Cytokines, Development of B-lymphocyte and T-lymphocyte

Module III

Structure and function of MHC complex -antigen processing cells, Antigen processing and presentation to T lymphocytes, MHC restriction. TCR structure and function

Module-IV

Effector mechanisms and regulation of immune responses: Complement system, hypersensitivity, autoimmunity and tolerance, Transplantation

Module V

Techniques related to immunology Monoclonal Antibodies, Vaccines, Radio, Immunoassay, ELISA, Diffusion.

Module-VI

Biology of cancer cells, Genetics of Cancer, Genetic Variation and Mutation, Two-Hit Hypothesis, Epigenetics of cancer

Module VII

Oncogene and tumour suppressor gene: progression of cancer, Metastasis, Apoptosis in cancer, DNA repair in cancer

Practice

- Demonstration of lymphoid organs
- To isolate the lymphocyte from whole blood by density gradient centrifugation method
- Screening antisera or hybridoma supernatants for specific antibodies
- To detect the presence of an antigen in a sample
- To learn coupling of antibody to enzyme Horse Radish Peroxidase (HRP)
- Study of basic Ouchterlony's double immuno-diffusion method.
- Tumor cell growth in different media

Recommended books:

1 Text Books:

Owen, J. A., Punt, J., &Stranford, S. A. (2013). Kuby immunology. seventh Edition, New York: WH Freeman.

2 Robert A. Weinberg, "The Biology of Cancer," Garland Science; 1 Cdr Edition, 2010

Reference Books

1. Owen, J. A., Punt, J., &Stranford, S. A. (2013). Kuby immunology. New York: WH Freeman
2. Abbas, K. Abul and Lechtman H. Andrew (2003.) Cellular and Molecular Immunology, V Edition, Saunders Publication.
3. Janeway's Immunobiology(2016) 9th Edition, by Kenneth Murphy, Casey Weaver, Garland Science
4. David Male, Jonathan Brostoff, David Roth and Ivan Roitt(2012) Immunology,8th Edition, Elsevier Publication
5. Lauren Pecorino, “Molecular Biology of cancer: Mechanisms, Targets, and Therapeutics,” Oxford University.

Bioanalytical 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	Mapping COs with POs and PSOs (High-3, Medium-2, Low-1)
CO1	Learn different staining procedures and visualization techniques, Laws of absorption of light, Beer-Lambert's Law, Isotopes and Nature of radioactivity.	PO1(2), PO3 (3), PO5 (2), PSO1(2), PSO3(2)
CO2	Demonstrate principles of various analytical techniques for quantification of biochemical compounds.	PO1(3), PO2(2), PO3 (1) PO4(2), PSO1(2)
CO3	Utilize different instruments for conducting the research work.	PO1(2), PO2(3), PO3(1), PO5(2), PO7(1), PSO2(2)
CO4	Analyze different phyto-constituents using different instruments.	PO1(3), PO2(2), PO4(1), PO5(2), PO8 (2), PSO1(2), PSO3(2)
CO5	Interpret the results of different techniques.	PO1(3), PO3 (3), PSO1(2), PSO3(2)

Module I

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

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

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

Module IV

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

Module V

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

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

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 phytochemicals by different chromatographic techniques.
6. To study the separation of Protein by SDS PAGE

Text Books:

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

Reference Books:

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

Research Methodology & Biostatistics

Subject Name	Code	Type of course	T-P-Pr (Credit)
Research Methodology & Biostatistics	MRM301T	Theory	4-0-0 (04)

Objectives

- Biostatistics and Research Methodology is a graduate-level course designed to provide students with the foundational knowledge and skills necessary to understand and apply statistical methods in biomedical and public health research.
- The course will cover basic statistical concepts, study design, data collection, analysis techniques, and interpretation of results.
- Emphasis will be placed on practical applications through hands-on exercises and real-world examples.

Course Outcome

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

COs	Course outcomes	Mapping COs with POs and PSOs (High-3, Medium-2, Low-1)
CO1	Understand fundamental statistical concepts and their relevance in biomedical research.	PO1 (3), PO3 (3), PSO1 (3), PSO3 (3)
CO2	Learn about different types of study designs and their strengths and limitations.	PO1 (3), PO2 (3), PO3 (1), PO4 (2), PO5 (1), PO8 (2), PO10 (1), PSO1 (3), PSO2 (2)
CO3	Acquire skills in data collection, management, and quality assurance.	PO1 (3), PO2 (2), PO3 (1), PO4 (2), PO5 (2), PSO1 (3), PSO3 (3)
CO4	Gain proficiency in using statistical software for data analysis.	PO1 (1), PO2 (2), PO3 (3), PO4 (3), PO5 (2), PSO10 (3), PSO3 (3)
CO5	Interpret statistical results and communicate findings effectively.	PO5 (1), PO6 (3), PO7 (1), PO8 (2), PSO1 (3), PSO2 (2)

Course Outline

MODULE I

General Research Methodology: Research, objective, requirements, practical difficulties, review of literature, study design, types of studies, strategies to eliminate errors/bias, controls, randomization, crossover design, placebo, blinding techniques.

MODULE II

Biostatistics: Definition, application, sample size, importance of sample size, factors influencing sample size, dropouts, statistical tests of significance, type of significance tests, parametric tests (students “t” test, ANOVA, Correlation coefficient, regression), non-

parametric tests (wilcoxon rank tests, analysis of variance, correlation, chi square test), null hypothesis, P values, degree of freedom, interpretation of P values.

MODULE III

Medical Research: History, values in medical ethics, autonomy, beneficence, non-maleficence, double effect, conflicts between autonomy and beneficence/non-maleficence, euthanasia, informed consent, confidentiality, criticisms of orthodox medical ethics, importance of communication, control resolution, guidelines, ethics committees, cultural concerns, truth telling, online business practices, conflicts of interest, referral, vendor relationships, treatment of family members, sexual relationships, fatality.

MODULE IV

CPCSEA guidelines for laboratory animal facility: Goals, veterinary care, quarantine, surveillance, diagnosis, treatment and control of disease, personal hygiene, location of animal facilities to laboratories, anesthesia, euthanasia, physical facilities, environment, animal husbandry, record keeping, SOPs, personnel and training, transport of lab animals.

MODULE V

Declaration of Helsinki: History, introduction, basic principles for all medical research, and additional principles for medical research combined with medical care.

Reference Books

Singh, Y.K., 2006. Fundamental of research methodology and statistics. New Age International.

Advanced Microbiology

Code	Course Title	Credit	T-P-PJ	Prerequisite
CUTMxxxx	Advanced Microbiology	4	3-1-0	Nil

Objectives

<ul style="list-style-type: none">• To introduce the concept polyphasic taxonomy which eventually lead to report a novel organism.• To enlighten on growth and development of microbial culture techniques.• To obtain overall holistic knowledge on Agricultural, Food, Medical Microbiology.
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Course outcomes

COs	Course outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	To gain foundational knowledge in microbiology along with hands-on experience through laboratory work.	PO1 (3), PO2 (3), PO3 (2), PO4 (1)
CO2	To learn concepts of polyphasic taxonomy and learn how to use them when identifying and reporting new microbial species.	PO1 (3), PO2 (2), PO3 (3), PO4 (1), PO5 (3), PO9 (1), PO10 (1), PO 11 (2), PO12 (1)
CO3	To develop an understanding of bacterial cell structures and control measures.	PO1 (3), PO3 (3), PO4 (1), PO5 (2), PO11 (1), PO12 (1)
CO4	To analyze and evaluate the significance of microbiology in soil health, agriculture, food safety, and medical applications.	PO1 (2), PO2 (3), PO3 (3), PO4 (3), PO5 (3), PO6 (2), PO7 (1), PO8 (2), PO11 (2), PO12 (1)
CO5	To achieve a comprehensive understanding of microbiology from the perspective of a biotechnologist.	PO1 (2), PO2 (2), PO4 (2), PO5 (2)

Course contents

Module I

Concepts of species and hierarchical taxa, Bacterial nomenclature, Classification of Fungi and Viruses, Microbial Culture Collection centers – India and International organizations. Microbial Identification through physiological and biochemical methods (Vitek), Polyphasic approach –16S rRNA gene sequencing, Phylogenetic grouping, Techniques used in taxonomy – Mol % G+C analysis, DNA-DNA hybridization, Fatty Acid Methyl Ester (FAME) analysis.

Module II

Extremophiles and its types, application of microbes from various ecological niches – Hydrothermal vent, unexplored forest soil and marine sediments Acellular microorganisms (Viruses, Viroids, Prions) and Cellular microorganisms (Bacteria) with emphasis on

distribution, economic importance. General characteristics of Algae and Fungi; ultra structure: thallus organization, Pigments reproduction, life cycles in micro algae with suitable examples; General characteristics, nutritional types, fungal cell ultra- structure: life cycles in fungi with suitable examples.

Module III

Cell size, shape and arrangement, capsule, flagella and motility, fimbriae and pili, Cytoplasm: Ribosomes, mesosomes, inclusion bodies, nucleoid, plasmids, Cell-wall: Composition and detailed structure of Gram-positive and Gram-negative bacteria, Archaea: Archaeobacterial cell wall, lipopolysaccharide (LPS), sphaeroplasts, protoplasts, and L-forms. Pure culture isolation: Streaking, serial dilution and plating methods (spread plate and pour plate), maintenance and preservation/stocking of pure cultures, cultivation of anaerobic bacteria, Bacterial staining: Gram and acid-fast staining, Negative-staining.

Module IV

Nutritional requirements in bacteria and nutritional types; Culture media: natural media, synthetic media, complex media, selective and differential media, enriched and enrichment media, phases of growth, logarithmic representation of bacterial populations, calculation of generation time and specific growth rate. Bacterial conjugation, Physical methods of microbial control: high and low temperature, filtration, desiccation, osmotic pressure, radiation Chemical methods of microbial control: disinfectants, types and mode of action.

Module V

Spoilage of food: Principles and types, Food preservation techniques, Food poisoning – Food borne pathogens, Quality control and Food laws. Microorganisms in soil processes: role of microorganisms in soil fertility: carbon cycle, nitrogen cycle, Biological nitrogen fixation, Biopesticides, PGPR. Bacterial Diseases: Streptococcus, Urinary Tract Infections; Viral Diseases: Epidemiology, pathogenesis, prevention and Treatment - Covid19, AIDS; Fungal Diseases: Infections caused by yeast: *Candida*, *Aspergillus* sp.

Module VI

Types of fermentation processes - stationary and submerged fermentations; batch and continuous fermentations; Designing of a typical bio-reactor and its components, Batch fermenter and constantly stirred tank fermenters; Fermentation parameters - pH, temperature, foaming and aeration. Down-stream processing - Cell disruption, filtration, centrifugation, solvent extraction, precipitation, lyophilization and spray drying.

Module VII

Microbial production: Citric acid, glutamic acid, ethanol, penicillin, Vaccine, Vitamin B12, Enzymes (amylase, protease), steroid; Enzyme immobilization: Definition, Methods of immobilization, advantages and applications of immobilization.

Books Recommended

1. Principles of Microbiology. 2nd edition. W.M.T.Brown Publishers. Atlas RM. (2008).
2. Microbiology: Principles and Explorations. 7th edition. Prentice Hall Black JG. (2008).
3. Understanding Bacteria. Kluwer Academic Srivastava S and Srivastava PS. (2022). Publishers, Dordrecht.
4. General Microbiology. 5th edition McMillan. Stanier RY, Ingraham JL, Wheelis ML and Painter PR. (2024).
5. Microbiology: An Introduction. 9th edition Pearson Education. Tortora GJ, Funke BR, and Case CL. (2023).
6. Prescott's Microbiology. 9th edition. McGraw Hill Higher Education. Willey JM, Sherwood LM, and Woolverton CJ. (2022).
7. Industrial Microbiology. 1st edition, Macmillan India Limited. Patel A.H. (1996).
8. Modern Industrial Microbiology and Biotechnology. 1st edition. Bios Scientific Publishers Limited. USA. Okafor N. (2007).
9. Industrial Microbiology: An Introduction. 1st edition. Wiley – Blackwell Waites M.J., Morgan N.L., Rockey J.S. and Higton G. (2001).

Practice

1. Bacterial staining technique.
2. Fungal staining technique.
3. Isolation of bacteria and fungi by spread and pour plate technique.
4. Preparation of pure cultures of bacteria and slant preparation technique.
5. Antibiotic sensitivity test.
6. PGPR Tests viz; P solubilization, Zinc solubilization.
7. Isolation of bacteria from root nodules.
8. Isolation of bacteria and fungus from spoiled foods and vegetable.
9. Microbial activity study on (qualitative) analysis of: Enzymes: Amylase.
10. Microbial activity study on (qualitative) analysis of: Substrate: Citrate test.
11. Study of different parts of fermenter by photograph/field visit to an industry.

Genetics and Epigenetics

Subject Name	Code	Type of course	T-P-P	Prerequisite
Genetics and Epigenetics	CUTM1454	Theory and Practice	3-1-0	

Course Objectives

<ul style="list-style-type: none"> To explain and provide examples of how continuous traits are “quantitative traits” and that phenotypic variation may be due to genetic variation within a population and/or environmental variation experienced by individuals within a population. To explain the polygenic theory of genetic variance and the nature of additive alleles, and the assumptions that accompany these ideas and also able to provide competing hypotheses that explain a distribution data set of phenotypes. To discuss epigenetics and its role in cancer, imprinting and X chromosome inactivation.

Course Outcomes

At the end of the course, students will be able to

COs	Course Outcomes	Mapping COs with POs and PSOs (High-3, Medium-2, Low-1)
CO1	Understand the role of genetic mechanism in evolution.	PO1 (3) , PO2 (2), PO3 (1), PO4 (1), PO5 (3), PO7 (1), PSO1 (2), PSO2 (2), PSO3 (3)
CO2	Predict the phenotypic classes and their ratios from a monohybrid cross involving dominant and recessive alleles.	PO1 (1) , PO2 (2), PO3 (2), PO4 (3), PO5 (3), PO8 (1), PSO1 (2), PSO2 (2), PSO3 (3)
CO3	Select from different gene delivery methods that are currently available based on the type of target tissue involved.	PO1 (2) , PO2 (2), PO3 (1), PO4 (3), PO5 (3), PSO1 (2), PSO2 (2)
CO4	Compare different methods used in assisted reproduction and identify the challenges in natural method of conception.	PO1 (3) , PO2 (3), PO3 (1), PO4 (2), PO5 (2), PO11 (1), PSO1 (2), PSO3 (3)
CO5	Analyze the modifications/mechanisms of DNA marks that result in epigenetic changes and also to discuss the role of epigenetics in environmental exposures.	PO1 (3) , PO2 (3), PO3 (2), PO6 (2), PO8 (3), PO12 (1), PSO1 (2), PSO2 (2), PSO3 (3)

MODULE I

Laws of heredity, Co-and incomplete dominance, Gene Linkage and crossing over, Varieties of Gene interactions - lethal genes, Multiple alleles, Pleiotropic genes, Gene epistasis, Structural and numerical alterations of chromosomes and meiotic consequence, Cytoplasmic Inheritance,

Sex-chromosome systems; Different mechanisms of sex determination in animals (Drosophila, Man, Bees and Bonellia)

Module II

Sex linkage: Sex linked genes in man, Sex chromosome disorders in man, Detection of linkage & Linkage maps: Test cross, Test for linkage on the basis of F₂ generation, LOD score, Gene mapping, Three point test cross in Drosophila, Construction of linkage maps, Identification of particular linkage groups with specific chromosome, Physical distance and map distance, Interference and coincidence

Module III

Mitotic Recombination, Recombination within gene, Spontaneous and induced mutations, Physical and chemical mutagens, Chromosomal aberrations, meiotic behaviour of deletion, Duplication, Inversion and translocation, Euploids and aneuploids-classification, Origin, Induction, Role of polyploidy in evolution.

Module IV

Human genetics - Chromosomal disorder, Some common human syndromes, Twin study, Superfoetation, Polyembryony, Free Martin, Multiple birth, Amniocentesis and Genetic Counselling, Nature and function of genetic material, Chemical compounds causing genetic damage, Gene mapping and genome analysis.

Module V

Epigenetics vs Genetics, Epigenetics from phenomena to field : overview and concepts, Basic organization of eukaryotic genome, Histone proteins.

Module VI

Histone modifications and the histone code, Chromatin remodelling complex and histone variants, DNA Methylation, Acetylation and Deacetylation, Phosphorylation, Ubiquitylation, Deubiquitylation and Phosphorylation.

Module VII

Dosage compensation in mammals, Genomic imprinting in mammals, Germline and pluripotent stem cells, Epigenetics and human disease.

Practice

- Preparation of Mitotic chromosomes from the given sample
- To study the karyotyping of chromosomes from the given animal samples.
- To study the chromatin modelling and Chromatin-immunoprecipitation (ChIP)
- Isolation of total histones, and resolution on SDS-PAGE.
- Isolation of DNA from animal cell (Isolation of nuclei (as a source for studies on structure of chromatin) from rat/mouse liver by discontinuous sucrose-density gradient centrifugation.

- Identification of inactivated X chromosomes as barr body from the given sample
- Preparation and study of metaphase chromosomes from mouse bone marrow

Reference & Textbooks

- 1 Gardner, E.J., Simmons, M.J., Snustad, D.P. (2008). Principles of Genetics. VIII Edition. Wiley India.
- 2 Snustad, D.P., Simmons, M.J. (2009). Principles of Genetics. V Edition. John Wiley and Sons Inc.
- 3 Klug, W.S., Cummings, M.R., Spencer, C.A. (2012). Concepts of Genetics X Edition. Benjamin Cummings.
- 4 Russell, P. (2009). Genetics- A Molecular Approach. III Edition. Benjamin Cummings.
- 5 Griffiths, A.J.F., Wessler, S.R., Lewontin, R.C. and Carroll, S.B.
- 6 Introduction to Genetic Analysis. IX Edition. W. H. Freeman and Co.
- 7 Ridley, M. (2004). Evolution. III Edition. Blackwell Publishing
- 8 Barton, N. H., Briggs, D. E. G., Eisen, J. A. Goldstein, D. B. and Patel, N. H. (2007). Cold Spring, Harbour Laboratory Press.
- 9 Hall, B. and Hallgrimsson, B. (2008). Evolution. IV Edition. Jones and Bartlett Publishers
- 10 Campbell, N. and Reece J. B. (2011). Biology. IX Edition, Pearson, Benjamin, Cummings.
- 11 Epigenetics, C. David Allis and Thomas Jenuwein, (2007) Cold Spring Harbor Laboratory Press, New York, USA .
- 12 Molecular Biology of Gene, Watson et al., (5th Ed. 2004), Pearson Education, Delhi, INDIA.
- 13 Genetics by P.K Gupta.

Genetic Engineering

Subject Name	Code	Type of course	T-P-Pr (Credit)
Genetic Engineering	CUTM1563	Theory+ practice	2-2-0 (04)

Objective

- To strengthen the knowledge on various cloning and expression vectors
- To impart the importance of vectors in genetic engineering experiments
- To strengthen the knowledge on various Strategies of gene cloning

Course outcome

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

COs	Course outcomes	Mapping COs with POs and PSOs (High-3, Medium-2, Low-1)
CO1	Understand the concepts of vectors, gene cloning, and gene manipulation.	PO1 (3), PO2 (3), PO3 (1), PO4 (2), PO5(2), PSO (2)
CO2	Demonstrate the concepts of PCR, primer designing, PCR-based genotyping and their applications in biotechnology.	PO1 (3), PO2 (3), PO3 (3), PO5 (3), PSO3(3)
CO3	Utilize on the different methods of DNA sequencing and their applications.	PO1 (3), PO2 (2), PO3 (2), PO4 (3), PO5 (3), PSO1(2), PSO2 (3)
CO4	Analyze and practice the concepts of gene expression, expression estimation, and recombinant proteins.	PO1 (3), PO2 (2), PO3 (2), PO5 (3), PO6 (1)
CO5	Examine on the applications of gene manipulations and gene cloning towards gene silencing and product generation.	PO1 (3), PO2 (2), PO3 (2), PO4 (3), PO5 (3), PO8 (2), PSO1(3), PSO3(2)

Module I:

Introduction to genetic engineering, general requirements for performing a genetic engineering experiment; restriction endonucleases and methylases; DNA ligase, Klenow enzyme, T4 DNA polymerase, polynucleotide kinase, alkaline phosphatase; cohesive and blunt end ligation; linkers; adaptors; homopolymeric tailing; labelling of DNA: nick translation, random priming, radioactive and non-radioactive probes, PCR.

Module II:

Gene cloning vectors: Plasmids; Bacteriophages; M13 mp vectors; PUC19 and Bluescript vectors, phagemids; Lambda vectors; Insertion and Replacement vectors; Cosmids; Artificial chromosome vectors (YACs; BACs); Expression vectors: plant based vectors, Ti and Ri as vectors, yeast vectors, shuttle vectors.

Module III:

Insertion of foreign DNA into host cells; Physical, chemical and biological methods of DNA delivery; isolation of mRNA and total RNA; reverse transcriptase and cDNA synthesis; cDNA and genomic libraries; study of protein-DNA interactions: electrophoretic mobility shift assay; DNase footprinting; methyl interference assay, chromatin immunoprecipitation; protein-protein interactions using yeast two-hybrid system; phage display.

Module IV

Gene Tagging- T-DNA tagging, t-DNA tagging strategies, isolation and cloning sequences flanking t-DNA; Types of transposons, transposon tagging; Gene knockout technologies and Gene therapy: Targeted gene transfer, homologous recombination; site-specific mutagenesis

Practice

- Restriction digestion of supplied DNA
- Demonstration of PCR
- Gel elution and purification
- Isolation and purification of plasmid DNA
- Vector cloning and ligation
- Competent cell preparation and transformation of recombinant DNA into *E. coli*.
- Alpha complementation assay in *E. coli*.
- Detection of positive transformants using colony PCR.
- DNA delivery using calcium phosphate method.
- Isolation of total RNA from plant sample.
- Purification and quantification of RNA.
- Reverse transcriptase PCR.
- Southern blotting.
- Western blotting.

BOOKS

1. Analysis of Genes and Genome. R J Reese. Wiley Publications.
2. Molecular Cloning: A laboratory manual by J. Sambrook and E.F. Fritsch. Cshl Press.
3. Molecular biology of the gene by J.D. Watson, T.'A. Baker, S.P. Bell, A. Gann, M. Levine and R. Losick. Pearson Publication.
4. Gene Cloning and DNA analysis. T A Brown. Wiley Blawell Publications.
5. Genes and Genome-A changing Perspective. M. Singer and P. Berg. Wiley Publications.
6. Essential Molecular Biology – TA Brown. Wiley Blawell Publications.

IPR, Biosafety and Bioentrepreneurship

Subject	Code	Type of course	T-P-Pr (Credit)
IPR, Biosafety and Bioentrepreneurship	CUTM1569	Theory+ practice	2-0-2 (04)

Course Objective

<ul style="list-style-type: none">• The risks of handling chemical and biological materials and hazardous, toxic, explosive, inflammable, infective effects of some chemical and biological substances.• To become familiar with ethical issues in biological research.• To teach students about concepts of entrepreneurship including identifying a winning business opportunity, gathering funding and launching a business, growing and nurturing the organization and harvesting the rewards.
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Course outcome

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

COs	Course outcomes	Mapping COs with POs and PSOs (High-3, Medium-2, Low-1)
CO1	Learn the ethical aspects related to biological, and biotechnology research.	PO1 (1) , PO2 (3), PO3 (3), PO4 (3), PO5 (3)
CO2	Understand ethical aspects related to biomedical and health care and biotechnology research.	PO1 (2) , PO2 (2), PO3 (2), PO4 (3), PO5 (3)
CO3	Make use of the entrepreneurial skill and the schemes promoted through knowledge centers and various agencies.	PO1 (3) , PO2 (2), PO3 (2), PO4 (3), PO5 (3)
CO4	Discover the scope for entrepreneurship in biosciences.	PO1 (3) , PO2 (3), PO3 (1), PO4 (2), PO5 (3)
CO5	Evaluate the various operations involved in venture creation.	PO1 (3) , PO2 (3), PO3 (2), PO4 (2), PO5 (1)

Module I

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 farmers rights; 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.

Module II

Introduction; historical background; introduction to biological safety cabinets; primary containment for biohazards; biosafety levels; GRAS organisms, biosafety levels of specific microorganisms; recommended biosafety levels for infectious agents and infected animals; definition of GMOs & LMOs; principles of safety assessment of transgenic plants; risk – environmental risk assessment and food and feed safety assessment; risk assessment of transgenic crops, RNAi, genome edited crops

Module III

International regulations – Cartagena protocol, OECD consensus documents and Codex Alimentarius; Indian regulations – EPA act and rules, guidance documents, regulatory framework – RCGM, GEAC, IBSC and other regulatory bodies; Draft bill of Biotechnology Regulatory authority of India.

Module IV

Introduction and scope in Bio-entrepreneurship, Types of bio-industries and competitive dynamics between the sub-industries of the bio-sector (*e.g.* pharmaceuticals *vs.* Industrial biotech), Strategy and operations of bio-sector firms: Factors shaping opportunities for innovation and entrepreneurship in bio-sectors, and the business implications of those opportunities,

Project: Preparation of proposals for entrepreneurship development programs of public and private agencies (MSME, DBT and BIRAC).

BOOKS

1. Adams, D. J., & Sparrow, J. C. (2008). *Enterprise for Life Scientists: Developing Innovation and Entrepreneurship in the Biosciences*. Bloxham: Scion.
2. Shimasaki, C. D. (2014). *Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies*. Amsterdam: Elsevier. Academic Press is an imprint of Elsevier.
3. Jordan, J. F. (2014). *Innovation, Commercialization, and Start-Ups in Life Sciences*. London: CRC Press.

Animal Biotechnology

Subject Name	Code	Type of course	T-P-P	Prerequisite
Animal Biotechnology	CUTM1452	Theory and Practice	3-1-0	-

Course Objectives

<ul style="list-style-type: none"> To make the student understand the tools and techniques required for the animal cell culture, assisted reproductive technology, development of transgenic animals, and development of animal models. The methods of culturing animal cells. To utilize animal production technologies for sustainable agriculture and food security

Course Outcomes

At the end of the course, students will be able to

COs	Course Outcomes	Mapping COs with POs and PSOs (High-3, Medium-2, Low-1)
CO1	Appraise the importance of animal cell culture techniques in the development of novel drug, cell and gene therapy product	PO1 (1) , PO2 (3), PO3 (3), PO4 (3), PO5 (3), PSO1 (2), PSO2 (2), PSO3 (3)
CO2	Make use of the various techniques in cell line authentication and characterization, and identify contaminations in cell culture.	PO1 (2) , PO2 (2), PO3 (2), PO4 (3), PO5 (3), PO6(3), PSO1 (2), PSO2 (2), PSO3 (3)
CO3	Select from different gene delivery methods that are currently available based on the type of target tissue involved.	PO1 (3) , PO2 (2), PO3 (2), PO4 (3), PO5 (3), PO7 (2), PSO1 (2), PSO2 (2), PSO3 (3)
CO4	Compare different methods used in assisted reproduction and identify the challenges in natural method of conception.	PO1 (3) , PO2 (3), PO3 (1), PO4 (2), PO5 (3), PO8 (1), PSO1 (2), PSO2 (2), PSO3 (3)
CO5	Apply the principle of gene targeting methods used in the generation of animal models for biomedical research and the concept about molecular techniques in animal conservation.	PO1 (3) , PO2 (3), PO3 (2), PO4 (2), PO5 (1), PO8 (1), PSO1 (2), PSO2 (2), PSO3 (3)

Course outline

Module-I

Overview of animal cell and tissue culture technology, Cell culture laboratory design and basic laboratory equipments, Media preparation, Role of important components of culture media, Common laboratory hazards and safety issues to consider in cell culture laboratory.

Module-II

Types of animal cell culture, Characterization and preservation of animal cells , Advances in cell culture technology, Opportunities and challenges in animal cell and tissue culture technology

Module-III

Overview of transgenic technology, Biopharming through animal transgenesis, Methods of producing transgenic farm animals, Identification and transfer of gene influencing better production and disease resistance.

Module-IV

Gene transfer methods in animals: Microinjection, Retrovirus mediated gene delivery, Embryonic stem cell mediated gene transfer, Knockout model systems & their utility, Animal as bioreactor.

Module-V

Reproduction biotechnologies and their use in livestock, Somatic cell nuclear transfer cloning, In Vitro Fertilization, Embryo production, Preservation and transfer, Sperm and embryo sexing, Intracytoplasmic sperm injection (ICSI), Cryopreservation and gamete banking.

Module-VI

Polyculture of fish for high yield, Edible oyster production, Pearl oyster production, Vermiculture and vermicomposting for alternative and sustainable agriculture, Fish culture in flow through system and recirculation technology.

Module-VII

Recombinant therapeutics and production of pharmaceuticals; Production of tissues and organs for humans and xenotransplantation, Process of gene therapy, *Pros* and *cons* in gene therapy, Retrovirus and adenovirus mediated gene therapy.

Practice

- Sterilization techniques used in animal cell culture
- Preparation of media for animal cell culture
- Study of primary cell culture technique using chick embryo
- Animal cell batch culture technique
- Vermicompost preparation from plant debris, cattle dung and paper waste
- : Preparation of competent cell (Calcium chloride treatment method)

Text Books

- 1 Freshney RI (1992) Animal cell culture: a practical approach, Oxford University Press
- 2 Singh B, Gautam SK (2013) Text Book of Animal Biotechnology, TERI

Reference Books

- 1 Singh B, Mal G, Gautam SK, Mukesh M (2019) Advances in Animal Biotechnology, Springer
- 2 Butler M (2003) Animal Cell Culture and Technology, Taylor & Francis

Plant Biotechnology

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

Course objectives

<ul style="list-style-type: none"> 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.
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Course outcome

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

COs	Course outcomes	Mapping COs with POs and PSOs (High-3, Medium-2, Low-1)
CO1	Learn to propagate plants, conduct research, develop disease-free germplasm and advance agricultural and horticultural practices	PO1 (1), PO2 (3), PO3 (3), PO4 (3), PO5 (3), PSO1 (3)
CO2	Understand different genetic manipulation techniques, to create genetically modified plants, enhance crop traits, and address agricultural challenges	PO1 (2), PO2 (2), PO3 (2), PO4 (3), PO5 (3), PSO1(2), PSO2(3)
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	PO1 (3), PO2 (2), PO3 (2), PO4 (3), PO5 (3), PSO1(2), PSO3(2)
CO4	Discovering the knowledge and skills in designing, developing, and evaluating genetically modified plants for enhanced disease resistance	PO1 (3), PO2 (3), PO3 (1), PO4 (2), PO5 (3), PO8 (2)
CO5	Evaluating the gene function, mechanisms and skills to manipulate gene expression using techniques like RNA interference (RNAi) in plants.	PO1 (3), PO2 (3), PO3 (2), PO4 (2), PO5 (1), PSO3(3)

Module I

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.

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

Transcriptomics, proteomics and metabolomics

Subject Name	Code	Type of course	T-P-Pr (Credit)
Transcriptomics, Proteomics and Metabolomics	CUTM1568	Theory+ practice	2-2-0 (04)

Course objective

- To comprehend the principles and techniques involved in transcriptomics, proteomics and metabolomics.
- To explore integrative omics approaches.
- To apply omics technologies to real-world challenges.

Course outcome

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

COs	Course outcomes	Mapping COs with POs and PSOs (High-3, Medium-2, Low-1)
CO1	Define the fundamental concepts, terminologies, and methodologies associated with transcriptomics, proteomics, and metabolomics.	PO1 (1), PO2 (3), PO3 (3), PO4 (3), PO5 (3), PSO1 (3)
CO2	Explain and illustrate the workflow and experimental approaches for analyzing transcripts, proteins, and metabolites in biological systems.	PO1 (2), PO2 (2), PO3 (2), PO4 (3), PO5 (3), PSO1 (2), PSO2(2)
CO3	Demonstrate the ability to utilize bioinformatics tools and analytical techniques for processing and interpreting omics data.	PO1 (3), PO2 (2), PO3 (2), PO4 (3), PO5 (3), PSO2 (3)
CO4	Evaluate omics datasets to identify patterns, correlations, and biological significance, linking molecular data to physiological functions.	PO1 (3), PO2 (3), PO3 (1), PO4 (2), PO5 (3), PSO1(2), PSO2(1), PSO3(2)
CO5	Design and propose integrative omics-based research strategies to address complex problems in areas such as disease diagnostics, drug discovery, and systems biology.	PO1 (3), PO2 (3), PO3 (2), PO4 (2), PO5 (1), PSO3(3)

Module I

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 II

Protein interactions; DNA – protein Interactions, yeast two-hybrid systems; affinity tagging, pathway building. Proteomes in different tissues/organs and in response to biotic and abiotic stresses; nuclear and organellar proteomics.

Module III

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 IV

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

Practice

- Demonstration of Northern blotting
- Analysis of transcriptome data using JMP Genomics
- Analysis of transcriptome data using open source GALAXY platform.
- Protein separation using SDS-PAGE.
- Protein structure visualization using RasMol.
- Generating Ramchandran plots for protein using web based tool.
- Demonstration of 2D-PAGE.
- Proteome data analysis using web-based tools.
- Demonstration of Mass spectroscopy using virtual lab
- Isolation of secondary metabolite using Clevenger's apparatus.
- Isolation of secondary metabolites using Soxhlet apparatus.
- Demonstration of chemical fingerprints of bioactive compounds using HPLC through virtual lab.

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.
- Liebler, D.C. Introduction to Proteomics: Tools for the New Biology. Human Press, Totowa NJ. 2002.

Reference Books

1. 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.

Frontiers in Genomics

Subject Name	Code	Type of course	T-P-Pr (Credit)
Frontiers in Genomics	CUTM1567	Theory+ practice	3-1-0 (04)

Objective

<ul style="list-style-type: none">• To provide students with an in-depth understanding of the latest advancements in genomics, including next-generation sequencing and high-throughput genomic analysis techniques.• To equip students with the skills to analyze and interpret genomic data using bioinformatics tools and software, with applications in personalized medicine, agriculture, and evolutionary studies.• To expose students to cutting-edge topics in genomics such as epigenomics, metagenomics, and functional genomics, highlighting their relevance in modern biological research and their potential for innovation.

Course outcome

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

COs	Course outcomes	Mapping COs with POs and PSOs (High-3, Medium-2, Low-1)
CO1	Recall key concepts and terminologies in genomics, including genome structure, sequencing technologies, and functional genomics.	PO1 (1), PO2 (3), PO3 (3), PO4 (3), PO5 (3), PSO1 (3)
CO2	Explain the principles and applications of next-generation sequencing, genome editing tools, and comparative genomics in understanding genetic diversity and evolution.	PO1 (2), PO2 (2), PO3 (2), PO4 (3), PO5 (3), PSO1(2), PSO2(3)
CO3	Use bioinformatics tools to analyze genomic data, interpret genome annotations, and identify genes associated with traits and diseases.	PO1 (3), PO2 (2), PO3 (2), PO4 (3), PO5 (3), PSO1(2), PSO3(2)
CO4	Analyze advancements in genomics, such as epigenomics, metagenomics, and transcriptomics, to explore their implications for personalized medicine and biotechnology.	PO1 (3), PO2 (3), PO3 (1), PO4 (2), PO5 (3), PO8 (2)
CO5	Design research strategies integrating genomic technologies to address specific biological questions or challenges in healthcare, agriculture, or environmental sustainability.	PO1 (3), PO2 (3), PO3 (2), PO4 (2), PO5 (1), PSO3(3)

Module I

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

Module II

Molecular Mapping of Genome: Genetic mapping- linkage analysis, Choice of mapping populations, markers for genetic mapping; methods and techniques used for genetic mapping; Physical mapping- tools for physical mapping of genes, cytogenetic maps, FISH, radiation hybrid maps, high resolution physical mapping.

Module III

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.

Module IV

Next generation sequencing technologies- 454, Illumina, ABI SOLiD, single molecule and nanopore sequencing.

Module V

Whole Genome Assembly and challenges, Gene prediction, Functional annotation, Web based servers for genome analysis: ENSEMBL, VISTA, UCSC Genome Browser, NCBI genome.

Module VI

Human Genome Sequencing Project, Genome sequencing projects for microbes (including yeast), Genome sequencing projects for plants (Rice, Arabidopsis).

Module VII

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

Practice

- Demonstration of genetic mapping.
- Demonstration of web tools for genome analysis.
- Demonstration of genome browsers- ENSEMBL, VISTA and UCSC Genome Browser.
- Demonstration of genome assembly & alignment using Splign.
- Phylogenetic analysis using genomic tools.
- Genome comparison using MOAV tool.

References

1. Azuaje F & Dopazo J. 2005. Data Analysis and Visualization in Genomics and Proteomics. John Wiley & Sons, US
2. Baxevanis. A. D. and Ouellette. B. F. F. (Eds). 2001. Bioinformatics: A Practical guide to the analysis of genes and proteins. Wiley Interscience. New York. 470p.
3. Genomics and Proteomics. Functional and computational aspects. Ed. Sandor Suhai, Heidelberg, Germany.

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

<ul style="list-style-type: none"> To understand the structure and function of light harvesting complexes and the mechanisms of electron transport system To understand the uptake, transport, and translocation of water, ions, solutes, and macromolecules. To analyse sensory photobiology, 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	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	Recollect the concept and mechanisms of photosynthesis and photophosphorylation	PO1 (3), PO2 (2)
CO2	Understand the mechanisms of water and mechanisms of loading and unloading of photo assimilates, Sensory photobiology and stress physiology	PO1 (3), PO2 (3), PO3 (1), PO4 (2), PO5 (3), PO8 (1), PO9 (2), PO10 (1)
CO3	Apply the knowledge on the mechanisms of cellular respiration, oxidative phosphorylation and lipid metabolism in plant.	PO1 (3), PO2 (2), PO3 (1), PO4 (2), PO5 (2), PO6 (1), PO7 (3)
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	PO1 (1), PO2 (2), PO3 (3), PO4 (3), PO5 (2)
CO5	Interpret the oxidative stress, reactive oxygen species (ROS) and the role of antioxidant enzymes in different stress condition in plant	PO1 (3), PO2 (2), PO5 (1), PO6 (3), PO7 (1), PO8 (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. 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. Glyoxalate cycle. Nitrogen fixation & Metabolism: Biological Nitrogen fixation, asymbiotic and symbiotic Nitrogen fixation, nodule formation, Nod and Nif genes their regulation and function, mechanism of nitrate uptake and reduction, ammonium transport and assimilation.

Practice

1. Isolation of chloroplast and measurement of electron transport activity
2. Comparative study of photosynthetic pigment in C₃ and C₄ plant, grown in light and shade condition

3. Extraction of pigments from leaves and preparation of absorption spectra for chlorophyll and carotenoids
4. To compare chlorophyll content in juvenile and matured leaves
5. Estimation of relative leaf water contents in stress and control plant condition
6. Accumulation of proline content comparison in stress and control plant condition

Text Books:

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

Reference Books:

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