



BHARATHIDASAN UNIVERSITY, TIRUCHIRAPPALLI - 620 024.

M.Sc. BIOTECHNOLOGY

CHOICE BASED CREDIT SYSTEM - LEARNING OUTCOMES BASED CURRICULUM FRAMEWORK (CBCS - LOCF)

(Applicable to the candidates admitted from the academic year 2026 - 2027 onwards)

Sem.	Course	Course Title	Ins. Hrs.	Credit	Exam Hrs.	Marks		Total
						Int.	Ext.	
I	Core Course - 1 (CC - 1)	Cell and Molecular Biology	6	4	3	30	70	100
	Core Course - 2 (CC - 2)	Advanced Biochemistry	6	4	3	30	70	100
	Core Practical - 1 (CP - 1)	Cell and Molecular Biology and Advanced Biochemistry Practical	6	4	3	40	60	100
	Discipline Centric Elective Course - 1 (DCEC - 1)	1. Cancer Biology (or) 2. Developmental Biology	5	4	3	30	70	100
	Generic Elective Course - 1 (GEC - 1)	1. Biotechnology for Human Welfare (or) 2. Organic Farming and Management (or) 3. Man and Microbes	5	3	3	30	70	100
	Skill Enhancement Course - 1 (SEC - 1)	Sustainable Waste Management	2	2	3	30	70	100
	Value Added Course - 1 (VAC - 1)*	Biofertilizers and Biopesticides	-	2*		30	70	100*
Total			30	21	-	-	-	600
II	Core Course - 3 (CC - 3)	Advanced Microbiology	6	4	3	30	70	100
	Core Course - 4 (CC - 4)	Genetic Engineering	6	4	3	30	70	100
	Core Practical - 2 (CP - 2)	Advanced Microbiology and Genetic Engineering Practical	6	4	3	40	60	100
	Discipline Centric Elective Course - 2 (DCEC - 2)	1. Pharmacology (or) 2. Stem Cell Technology	4	4	3	30	70	100
	Generic Elective Course - 2 (GEC - 2)	1. Mushroom Technology (or) 2. Health Care in Biotechnology (or) 3. Lifestyle Diseases	4	3	3	30	70	100
	Skill Enhancement Course - 2 (SEC - 2)	Clinical Trial and Data Management	2	2		30	70	100
	Non-Major Elective Course - 1 (NMEC - 1)	One Course from Outside Department	2	2	3	30	70	100
Total			30	23	-	-	-	700
Summer Internship / Industrial Activity during the Summer Vacation after 1st Year								

III	Core Course - 5 (CC - 5)	Immunology and Immunotechnology	6	4	3	30	70	100
	Core Course - 6 (CC - 6)	Plant and Animal Biotechnology	6	4	3	30	70	100
	Core Practical - 3 (CP - 3)	Immunology & Immunotechnology, Plant and Animal Biotechnology Practical	6	4	2	40	60	100
	Discipline Centric Elective Course - 3 (DCEC - 3)	1. Artificial Intelligence in Biotechnology (or) 2. Molecular Diagnostics	5	4	2	30	70	100
	Generic Elective Course - 3 (GEC - 3)	1. Food Biotechnology (or) 2. Natural Products and Herbal Medicine (or) 3. Biodiversity and Conservation	5	3	3	30	70	100
	Non-Major Elective Course - 2 (NMEC - 2)	One Course from Outside Department	2	2	3	30	70	100
	Internship / Industrial Activity @			2		20	80	100
Total			30	23	-	-	-	700
IV	Core Course - 7 (CC - 7)	Bioprocess and Environmental Biotechnology	6	4	3	30	70	100
	Core Course - 8 (CC - 8)	Bioinformatics, Bioethics, IPR and Biosafety	6	4	3	30	70	100
	Core Course - 9 (CC - 9)	Research Methodology	6	4	3	30	70	100
	Discipline Centric Elective Course - 4 (DCEC - 4)	1. Emerging technologies in Biotechnology (or) 2. CRISPR-Cas Technology	4	4	2	30	70	100
	Entrepreneurship / Industry Based Course @	Bioentrepreneurship	3	3	3	30	70	100
	Project Work @		5	5	-	20	80	100
	Value Added Course - 2 (VAC - 2) *	Plant Tissue Culture	-	2*		30	70	100*
Total			30	24	-	-	-	600
Grand Total				91				2600

LIST OF DISCIPLINE CENTRIC ELECTIVE COURSE

Discipline Centric Elective Course - 1 (DCEC - 1)	
1.	Cancer Biology
2.	Developmental Biology
Discipline Centric Elective Course - 2 (DCEC - 2)	
1.	Pharmacology
2.	Stem Cell Technology
Discipline Centric Elective Course - 3 (DCEC - 3)	
1.	Artificial Intelligence in Biotechnology
2.	Molecular Diagnostics
Discipline Centric Elective Course - 4 (DCEC - 4)	
1.	Emerging technologies in Biotechnology
2.	CRISPR-Cas Technology

LIST OF NON-MAJOR ELECTIVE COURSE (for other Department Students only)

NON-MAJOR ELECTIVE COURSE - 1 (NME-1)	
1	Biotechnology and its Application
2	Nanobiotechnology

LIST OF GENERIC ELECTIVE COURSE (GEC)

GENERIC ELECTIVE COURSE - 1 (GEC - 1)	
1.	Biotechnology for Human Welfare
2.	Organic Farming and Management
3.	Man and microbes
GENERIC ELECTIVE COURSE - 2 (GEC - 2)	
1.	Mushroom Technology
2.	Health Care in Biotechnology
3.	Lifestyle Diseases
GENERIC ELECTIVE COURSE - 3 (GEC - 3)	
1.	Food Biotechnology
2.	Natural Products and Herbal Medicine
3.	Biodiversity and Conservation

SUMMARY OF CURRICULUM STRUCTURE OF PG PROGRAMMES: SCIENCE

Sl. No.	Types of the Course	No. of Courses	Credits for each Course	Total Credits	Marks
1.	Core Course	9	4	36	900
2.	Core Practical	3	4	12	300
3.	Discipline Centric Elective Course	4	4	16	400
4.	Generic Elective Course	3	3	9	300
5.	Skill Enhancement Course	2	2	4	200
6.	Non-Major Elective Courses	2	2	4	200
7.	Internship / Industrial Activity @	1	2	2	100
8.	Entrepreneurship / Industry Based Course @	1	3	3	100
9.	Project @	1	5	5	100
Total		26	-	91	2600
Value Added Courses *		2*	2	4*	200*

*	The value added courses credit will not be included in the total CGPA. These courses are extra-credit courses. Instruction hours for these courses is 30 hours								
@	Summer Internship will be carried out during the summer vacation after the First year. Viva Voce will be conducted by the college and Marks shall be sent to the University and the same will be included in the 3rd semester Mark Statement. Summer Internship / Industrial Activity & Project Scheme of Evaluation: <table border="1" style="width: 100%;"> <tr> <th>Description</th><th>Marks</th></tr> <tr> <td>Report</td><td>80</td></tr> <tr> <td>Viva</td><td>20</td></tr> <tr> <td>Total</td><td>100</td></tr> </table>	Description	Marks	Report	80	Viva	20	Total	100
Description	Marks								
Report	80								
Viva	20								
Total	100								

PO 1	Disciplinary Knowledge: Broad and in-depth knowledge of advanced scientific concepts, principles, and methodologies within the chosen domain. Ability to critically explain, integrate, and apply scientific knowledge to theoretical and practical problems. Opportunities to earn additional credits through specialized and interdisciplinary courses further enhance expertise and broaden disciplinary understanding.
PO 2	Critical Thinking: Field visits, academic interactions, and experiential learning activities will help students develop critical observation, interpretation, and analytical skills. Ability to evaluate and interpret scientific data, formulate hypotheses, and draw logical conclusions. Encourages independent thinking and the ability to assess scientific problems from multiple perspectives.
PO 3	Analytical Reasoning: Through classroom discussions, scientific literature reviews, and interactive learning environments, students will strengthen their analytical reasoning abilities. Ability to critically evaluate scientific texts, identify gaps in existing knowledge, formulate research questions, and synthesize new ideas and concepts. Promotes evidence-based reasoning and logical interpretation of scientific information.
PO 4	Scientific Reasoning: Strong foundation in scientific methods, experimental design, and data interpretation through laboratory-based courses. Enhances practical knowledge of scientific instrumentation, calibration procedures, laboratory safety, and appropriate research techniques. Ability to conduct scientifically sound experiments and interpret results accurately.
PO 5	Self-Directed Learning: Encourages independent and self-directed learning through assignments, field reports, project work, and literature-based studies. Ability to organize, analyze, and present scientific findings in professional formats relevant to academic and industrial settings. Fosters responsibility, time management, and continuous self-improvement in learning.
PO 6	Reflective Thinking: Laboratory-intensive core courses will expose students to a broad range of research methodologies and experimental techniques. Ability to reflect on learning experiences, evaluate the effectiveness of scientific approaches, and understand the broader applications of scientific techniques within the discipline.
PO 7	Problem-Solving Skills: Ability to develop and apply scientific principles, quantitative reasoning, and mathematical concepts to solve discipline-specific problems. Ability to analyze experimental data, interpret scientific observations, and derive meaningful conclusions. Prepares students to address real-world scientific and societal challenges effectively.
PO 8	Research-Related Skills: Internships, dissertation work, and research-oriented projects provide opportunities to design, develop, and execute independent research studies. Students gain hands-on experience in research methodology, experimental techniques, data analysis, scientific writing, and ethical research practices. These experiences strengthen laboratory competence and prepare students for advanced research and professional careers.
PO 9	Lifelong Learning: Cultivates a mindset of continuous learning and professional adaptability. Ability to identify gaps in knowledge and skills,

	adapt to emerging technologies and scientific advancements, and pursue self-directed learning throughout their careers. Encourages lifelong learning that supports academic growth, employability, and professional excellence.
PO 10	Leadership Readiness: Ability to take initiative, work collaboratively, and manage academic and research responsibilities effectively. Through seminars, group projects, internships, and research activities, students develop decision-making, problem-solving, organizational, and interpersonal skills. Ability to lead scientific teams, communicate effectively in professional environments, and contribute responsibly to academic, industrial, and societal development.

COURSE OBJECTIVES

The main objectives of this course are to:

- Critically analyze the molecular architecture and functional dynamics of cellular membranes and organelles.
- Evaluate the molecular mechanisms of DNA replication, repair, and recombination.
- Analyze the regulation of gene expression at the transcriptional, translational, and epigenetic levels.
- Critically evaluate the molecular basis of cancer and current therapeutic strategies.
- Develop a research-oriented understanding of contemporary advances in cell and molecular biology.

UNIT – I: PLASMA MEMBRANE

Chemical composition of membranes: membrane lipids, lipid asymmetry, and membrane carbohydrates. Structure and function of membrane proteins - integral, peripheral, and lipid-anchored. Membrane fluidity, lipid rafts, and membrane microdomains. Movement of substances across membranes: diffusion, facilitated diffusion, and active transport. Membrane trafficking: endocytosis, exocytosis, and vesicular transport; an introduction to receptor-mediated membrane signalling.

UNIT – II: CELL ORGANELLES

Mitochondria: structure, origin, evolution, respiratory chain organization, and the mitochondrial genome; mitochondrial dynamics — fission, fusion, and mitophagy. Structure and function of peroxisomes, microbodies, the Golgi apparatus, lysosomes, and the endoplasmic reticulum; the endomembrane system and vesicular trafficking. The cytoskeleton: microtubules, microfilaments, intermediate filaments, cellular motility, and molecular motors. Nucleus: nuclear envelope, lamina, nucleolus, and chromatin organization.

UNIT – III: DNA REPLICATION AND REPAIR

Models of DNA replication: semiconservative, semidiscontinuous, unidirectional, and bidirectional. Mechanism of DNA replication in prokaryotes and eukaryotes; structure and function of DNA polymerases; replication licensing and cell cycle checkpoints; role of telomerase. DNA repair: nucleotide excision repair, base excision repair, mismatch repair, and double-strand break repair. Recombination: the double-strand break model, homologous recombination, and non-homologous end joining.

UNIT – IV: GENE EXPRESSION

Overview of the flow of genetic information in the cell. Transcription in bacteria; transcription and RNA processing in eukaryotes, including synthesis of rRNA, tRNA, and mRNA. Small noncoding RNAs and RNA interference; post-

transcriptional and translational control; RNA-binding proteins. Translation: initiation, elongation, and termination. Introduction to epigenetic regulation of gene expression — DNA methylation and histone modification.

UNIT – V: CANCER BIOLOGY

Basic properties, causes, and genetics of cancer. Tumour suppressor genes and oncogenes; tumour viruses, transformed cells, and detection and structure of integrated viral DNA. Protein kinases and transformation by retroviruses; the cellular counterpart of src. Carcinogens and mechanisms of oncogene activation; oncogenic proteins - protein kinases, growth factors, and the Ras protein. Cancer genomics and next-generation sequencing approaches. Emerging strategies for combating cancer: immunotherapy and checkpoint inhibitors; inhibiting the activity of cancer-promoting proteins.

UNIT – VI: CURRENT CONTOURS (CIA ONLY)

Critical review and discussion of recent research publications and advancements in the course topics, introduced through expert lectures, online seminars, or webinars.

REFERENCES

1. Alberts B, Johnson A, Lewis J, Morgan D, Raff M, Roberts K, Walter P. (2014). *Molecular Biology of the Cell*. 6th Edition. Garland Science.
2. Weinberg RA. (2013). *The Biology of Cancer*. 2nd Edition. Garland Science.
3. Freifelder D. (2004). *Molecular Biology*. Narosa Publishing House.
4. Lewin B. (2018). *Genes XII*. Oxford University Press.
5. Paul A. (2014). *Textbook of Cell and Molecular Biology*. Books and Allied Ltd.
6. Karp G, Iwasa J, Marshall W. (2018). *Karp's Cell Biology*. John Wiley & Sons.
7. Alberts B, Bray D, Hopkin K, Johnson AD, Lewis J, Raff M, Walter P. (2019). *Essential Cell Biology*. 5th Edition. Garland Science.
8. Lodish H, Berk A, Kaiser CA, Krieger M, Scott MP, Matsudaira P. (2008). *Molecular Cell Biology*. Macmillan.
9. Pollard TD, Earnshaw WC, Johnson GT. (2016). *Cell Biology*. 3rd Edition. Elsevier Health Sciences.
10. Watson JD, Gilman M, Witkowski J, Zoller M. (2010). *Recombinant DNA*. 4th Edition. Scientific American Books.
11. Blackburn GM, Gait MJ. (2022). *Nucleic Acids in Chemistry and Biology*. 4th Edition. Oxford University Press.
12. Lodish H, Baltimore D, Berk A, Zipursky SL, Matsudaira P, Darnell J. (2007). *Molecular Cell Biology*. 4th Edition. Scientific American Books.
13. Cooper GM. (2007). *The Cell: A Molecular Approach*. 2nd Edition. ASM Press.
14. Kleinsmith L J, Kish VM. (1995). *Principles of Cell and Molecular Biology*. 2nd Edition. Benjamin-Cummings Publishing.
15. De Robertis EDP, De Robertis EMF. (1987). *Cell and Molecular Biology*. 8th Edition. Saunders College Publishing.
16. Brown TA. (2011). *Introduction to Genetics: A Molecular Approach*. Garland Science.

17. Watson JD, Baker TA, Bell SP, Levine M, Losick R. (2013). Molecular Biology of the Gene. 7th Edition. Benjamin/Cummings.
18. Lewin B. (2010). Genes XI. 11th Edition. Jones & Bartlett Learning.
19. Meyers RA (Ed.). (1996). Molecular Biology and Biotechnology: A Comprehensive Desk Reference. Wiley-Blackwell.

COURSE OUTCOMES

CO No.	Course Outcome (Upon completion of the course, students will be able to)	Knowledge Level
CO1	Critically analyze the structure-function relationship of the plasma membrane and the mechanisms of membrane transport and trafficking.	K4
CO2	Evaluate the structural and functional organization of cell organelles and the cytoskeleton, including their roles in cellular dynamics.	K4
CO3	Critically analyze the mechanisms of DNA replication, repair, and recombination, and their relevance to genome stability.	K4
CO4	Evaluate the molecular mechanisms regulating gene expression, from transcription and RNA processing through translational and epigenetic control.	K4
CO5	Critically evaluate the molecular and genetic basis of cancer, including oncogene activation and current therapeutic strategies.	K5
CO6	Critically review and present recent research advances in cell and molecular biology.	K5, K6

MAPPING WITH PROGRAMME OUTCOMES

PO Mapping Strategy: This course primarily aligns with **Disciplinary Knowledge (PO1), Problem Solving (PO3), and Research Aptitude (PO4)**, with strong engagement of critical thinking and analytical skills appropriate to postgraduate scholarship. It provides the cellular and molecular foundation for advanced research in genetics, cancer biology, and biotechnology.

Mean Calculation: To be computed by the department from the PG PO–CO correlation matrix once faculty assign course-specific correlation scores (0–3) across all Programme Outcomes.

COURSE OBJECTIVES

The main objectives of this course are to:

- Study the structure, properties and metabolism of different biomolecules.
- Know the interrelationships between different metabolisms and their disorders.
- Acquire knowledge of biomolecules and their consequences for interpreting & solving clinical problems.

UNIT – I: BIOENERGETICS:

Free energy and entropy. Phosphoryl group transfers and ATP. Enzymes involved in redox reactions. The electron transport chain—organization and role in electron capture. Electron transfer reactions in mitochondria. Oxidative phosphorylation-F1/F0 ATPase-structure and mechanism of action. The chemiosmotic theory. Inhibitors of respiratory chain and Oxidative phosphorylation – uncouplers, ionophores. Regulation of oxidative phosphorylation.

UNIT – II: CARBOHYDRATE METABOLISM:

Classification, Structure and Isomerism. Monosaccharides, Oligosaccharides, Polysaccharides– Structure and Properties. Metabolism of Carbohydrates- Glycolysis, Mechanism of pyruvate Dehydrogenase, Citric acid cycle, HMP shunt, Glucuronic acid Gluconeogenesis, Glycogenesis, Glycogenolysis, Glyoxylate cycle. Metabolic disorders associated with carbohydrate metabolism. CSDB (Carbohydrate Structure Database, Glycome DB, Calvin cycle).

Unit – III: LIPID METABOLISM:

Biosynthesis of fatty acid and its regulation, biosynthesis of triacylglycerol, phospholipids and cholesterol. Metabolism of triacylglycerol during stress. α , β , γ , Oxidation of fatty acids– Role of carnitine cycle in the regulation of β -oxidation. Ketogenesis and its control. Lipoprotein types and its functions. Metabolic disorders associated with lipid metabolism, LMSD (Lipid Maps Structure Database), Lipid Bank.

UNIT – IV: METABOLISM OF AMINO ACIDS, PROTEINS:

Overview of biosynthesis of nonessential amino acids. Catabolism of amino acid-transamination, deamination, ammonia formation, urea cycle and its significance. Catabolism of carbon skeletons of amino acids. Protein – classification, types, characteristics and structures, PDB (Protein Data Bank), Ramachandran plot, PROCHECK Solid state synthesis of peptides, Sequence determination.

UNIT – V: METABOLISM OF PURINES AND PYRIMIDINES:

Digestion and absorption of nucleoproteins, Fractionation, sequencing and chemical synthesis of oligonucleotides. Metabolism of purines- de novo and

salvage pathways for purine biosynthesis, regulation of biosynthesis of nucleotides. Purine catabolic pathway. Metabolism of pyrimidines - biosynthesis and catabolism. Disorders of purine and pyrimidine metabolism, intermediary metabolism and KEGG pathway.

UNIT – VI: CURRENT CONTOURS (For continuous internal assessment only):

The recent advancements in the course topics will be explained to the students then and there through expert lectures, online seminars or webinars.

References:

1. L. Lehninger. 2021. Principles of Biochemistry, 8th Edition. W.H Freeman and Company.
2. Stryer. 2002. Biochemistry. 5th Edition. W.H. Freeman and Company.
3. G.L. Zubay., V.R. Rastogi., K.R. A. Geoffrey., V.B. Rastogi., K.R. Aneja 2017. Zubay's Principles of Biochemistry. Medtech Publisher
4. M.N. ChattergeaRanaShinde. 2011. Text book of Medical Biochemistry. 8th Edition. J.P. Medical Ltd.
5. J. L. Jain, Sunjay Jain, Nitin Jain. 2005. Fundamentals of Biochemistry. S. Chand and Company, New Delhi.
6. Allan Fershi. 1984. Enzyme structure and mechanism. 2nd Edition. W.H.Freeman& Co. Ltd., USA.
7. Trevor Palmer, 1985. Understanding Enzymes. 2nd Edition. Ellis, Horwood Limited.
8. Victor W. Rodwell, David A Bender, Kathleen M. Botham, Peter J. Kennelly and Anthony P. Weli. 2015. Harper's Illustrated Biochemistry 30th Edition. McGraw Hill Lange Medical Books.
9. Donald Voet and Judith G.Voet, 2004. Biochemistry. 3rd Edition. John Wiley, New York.
10. https://nptel.ac.in/courses/102/105/102105034/https://nptel.ac.in/content/storage2/courses/126104004/LectureNotes/Week-1_06-Carbohydrate.pdf
11. <https://csdb.glycoscience.ru/database/>
12. <http://www.glycome-db.org/>
13. <https://www.lipidmaps.org/data/structure/index.php>
14. <https://www.rcsb.org/>
15. <https://www.ebi.ac.uk/thornton-srv/software/PROCHECK/>

COURSE OUTCOMES:

- Acquire knowledge about bioenergetics and its principles.
- Describe the metabolic pathways of carbohydrates and their regulatory mechanisms.
- Illustrate the structure, biological functions and metabolism of lipids.
- Intellectual about the structures of amino acids, their chemical properties and their metabolism.
- Assess the synthesis of purines and pyrimidines along with their regulation and explain.

PO Mapping Strategy: This course primarily aligns with **Disciplinary Knowledge (PO1), Problem-Solving Skills (PO7), and Research-Related Skills (PO8)**, with strong engagement in **Critical Thinking (PO2), Analytical Reasoning (PO3), and Scientific Reasoning (PO4)**.

Mean Calculation: Each CO mean is derived by calculating the average correlation score across all 10 POs. The **Overall Mean Score of 2.60** indicates a moderate-to-high level of alignment between the course and the programme outcomes.

COURSE OBJECTIVES:

The main objectives of this course are to:

- Study the physiology of the cells and their enumeration.
- Identify the specialized chromosomes.
- Perform the isolation, purification and quantification of nucleic acids.

EXPERIMENTS:**CELL AND MOLECULAR BIOLOGY**

1. Cell division - Mitotic stages - Preparation of Onion (Allium Sepa) Root Tip
2. Cell division - Meiotic stages - Preparation of Tradescantia Flower bud
3. Barr body Identification in cells of Buccal smear.
4. Isolation and purification of Genomic DNA from prokaryotes.
5. Separation of DNA by AGE.
6. Separation of Protein by SDS – PAGE.
7. Conjugation, Transformation and Transduction (Demo)

ADVANCED BIOCHEMISTRY

1. Extraction and Estimation of sugar from natural sources – glucose.
2. Estimation of protein by Lowry's method.
3. Estimation of amino acid by Ninhydrin method – Paper Chromatography
4. Thin Layer Chromatography
5. Quantitative analysis of blood urea/ creatinine
6. Estimation of DNA by diphenylamine and RNA by orcinol method

REFERENCES:

1. David A. Thompson. 2011. Cell and Molecular Biology Lab Manual. Create Space Independent Publishing Platform'
2. Julio E Celis, David Shotton, Nigel Carter, Tony Hunter, Victor small J, Kai Simons. 2005. Cell Biology. Four Volume Set: Cell Biology. Vol. 1, 3rd Edition: A laboratory Handbook. Elsevier. Academic Press.

COURSE OUTCOMES:

On the successful completion of the course, the students will be able to:

- Describe the basic instruments in cell biology
- Demonstrate the morphology of various types of cells and their enumeration
- Illustrate the different types of cell division
- Apply the various methods for the quantification of nucleic acids
- Acquire knowledge on protein quantification and separation.

PO Mapping Strategy: The mapping reflects the strong alignment of **Cell and Molecular Biology and Advanced Biochemistry Practical** with **Disciplinary Knowledge (PO1), Critical Thinking (PO2), Analytical Reasoning (PO3), Scientific Reasoning (PO4), Problem-Solving Skills (PO7), and Research-Related Skills (PO8).**

Mean Calculation: Each CO mean is derived by calculating the **average correlation score across all 10 POs.** The **Overall Mean Score of 2.56** indicates a **high level of alignment** between the practical course and the Programme Outcomes.

COURSE OBJECTIVES:

The main objectives of this course are to:

- Provide the basic facts about cancer.
- Acquire the knowledge of molecular genetics of cancer.
- Provide the basic knowledge of cancer diseases and their treatment

UNIT – I: CANCER:

Definition, Description of cancer, Basic facts about cancer, cancer is clonal in origin, Hallmarks of Cancer, general classification of human cancers, microscopic and macroscopic features of neoplasm's, Grade and stage of neoplasm – Histologic grade of malignancy and tumor staging.

UNIT – II: CAUSES OF CANCER:

Theory of HITS, Chemical carcinogenesis – metabolic activation of chemical carcinogens (donors of simple alkyl group, cytochrome P-450 mediated activation), Mechanism of tumor initiation, promotion and progression. Irradiation carcinogenesis and viral carcinogenesis (Epstein Barr virus and Hepatitis virus).

UNIT – III: MOLECULAR GENETICS OF CANCER:

Oncogenes, Oncogene families, cell transforming ability of onc gene, functional classes of oncogenes, Characteristics of individual oncogene (ras and erbA). Tumor suppressor genes – suppressor genes (rb and p53). Cancer diagnosis – categories of tumor markers (nucleic acid based markers and gene expression microarray).

UNIT – IV: APOPTOSIS:

Bcl2 family proteins, Caspases, Apoptotic signaling pathway (Intrinsic and extrinsic pathway- Telomeres and immortality-Molecular mechanism of tumor metastasis. - WHO classification- Tumor staging and grading- VEGF signaling, Angiogenesis.

UNIT – V: DIAGNOSIS AND TREATMENT:

Methods in cancer cytogenetics (Karyotyping, FISH). Tumor markers, genetic markers of cancer predisposition (Tumor suppressor genes as diagnostic tool), Strategies of anticancer drug therapy: Chemotherapy (Cdk inhibitors as target of chemotherapeutic agents and ubiquitination in cancer, classification of cytotoxic drugs: Alkylating agents, Platinum drugs, Topoisomerase inhibitors), gene therapy, Immunotherapy and Radiotherapy - Stem Cells and Cancer - Personalized medicine in cancer.

UNIT – VI: CURRENT CONTOURS (For continuous internal assessment only):

The recent advancements in the course topics will be explained to the students then and there through expert lectures, online seminars or webinars.

REFERENCES:

1. Raymond W. Ruddon, 2007. Cancer Biology. Oxford University Press, USA.
2. MomnaHejmadi, 2010. Introduction to cancer biology. MomnaHejmadi & Ventus Publishing ApS.
3. Bruce Alberts, Molecular Biology of the Cell (2015), Garland Science Publications, Newyork, USA.
4. S Pelengaries and M Khan, 2006. The molecular biology of Cancer. Ed. Blackwell Publishing.
5. Hanahan, Douglas et al., 2011. Hallmarks of Cancer: The Next Generation. Cell, Volume 144,646–674.
6. R. A. Weinberg, 2006. The Biology of Cancer: Garland Science.
7. R. G. McKinnell, R. E. Parchment, A. O. Perantoni, G. BarryPierce, I. Damjanov, 2006.
8. The Biological Basis of Cancer. 2nd Edition (2006), Cambridge University Press.
9. <https://nptel.ac.in/courses/104/105/104105102/>
10. <https://nptel.ac.in/content/storage2/courses/102103047/PDF/mod1.pdf>

COURSE OUTCOMES:

On the successful completion of the course, the students will be able to:

- Gain a deep understanding of the fundamental processes related to cancer, growth, causes, and differentiation.
- Understand the multistep genetic alterations which enable the transformation of a normal cell into cancer.
- Describe the Molecular genetics of Oncogenes and Tumour Suppressor genes
- Acquire the knowledge of Apoptosis and its signalling
- Gain knowledge of cancer-related diseases and their treatment.

PO Mapping Strategy: This course primarily aligns with **Disciplinary Knowledge (PO1), Critical Thinking (PO2), Analytical Reasoning (PO3), Scientific Reasoning (PO4), Problem-Solving Skills (PO7), and Research-Related Skills (PO8).**

Mean Calculation: To be computed by the department from the PG PO–CO correlation matrix once faculty assign course-specific correlation scores (0–3) across all Programme Outcomes.

COURSE OBJECTIVES:

The main objectives of this course are to:

- Study the cellular basis of development.
- Study the early development process of humans.
- Provide knowledge on the medical implications of developmental biology.

UNIT – I: BASIC CONCEPTS OF DEVELOPMENT:

The general concept of organisms development: Potency, commitment, specification, induction, competence, determination & differentiation; morphogenetic gradients; cell fate & cell lineages; genomic equivalence and cytoplasmic determinants; imprinting. Mutant and transgenic in analysis of development. General principles of cell-cell communication in development: cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix, integrins, paracrine factors.

UNIT – II: GAMETOGENESIS AND FERTILIZATION:

Gametogenesis and fertilization in animals, ultra structure of sperm and ovum, egg types, egg membrane. Fertilization, cleavage, Morula, Implantation, blastulation, gastrulation, formation of germ layers, axis formation - anterior and posterior. Sex determination - chromosomes and environment. Molecular events during fertilization, genetic regulations in embryonic development. Establishment of symmetry in plants, Seed formation and germination.

UNIT – III: MORPHOGENESIS AND ORGANOGENESIS IN ANIMALS:

Cell aggregation and differentiation in Dictyostelium; axes and pattern formation in Drosophila, amphibia and chick; organogenesis – vulva formation in Caenorhabditis elegans; eye lens induction, limb development and regeneration in vertebrates; differentiation of neurons, post embryonic development-larval formation, metamorphosis; environmental regulation of normal development; sex determination. Chromosomal sex determination in mammals and Drosophila.

UNIT – IV: MORPHOGENESIS AND ORGANOGENESIS IN PLANTS:

Organization of shoot and root apical meristem; shoot and root development; leaf development and phyllotaxy; transition to flowering, floral meristems and floral development in Arabidopsis and Antirrhinum.

UNIT – V: IMPLICATIONS OF DEVELOPMENTAL BIOLOGY:

Medical implications of developmental biology - genetic disorders in human development, environmental assaults on human development, Future therapies, Environmental regulation of animal development - Environment as a part of normal development, Polyphenisms, plasticity and Learning. Development and Evolution.

UNIT – VI: CURRENT CONTOURS (For continuous internal assessment only):

The recent advancements in the course topics will be explained to the students then and there through expert lectures, online seminars or webinars.

REFERENCES:

1. Gilbert S.F. (2010) Developmental Biology, (Ed: 9) - Sinauer Associates Inc. Massachusetts, USA,
2. Berrill N.J, (1974).Developmental Biology, TMH Edition,
3. Diwan A.P., Dhakad N.K., (1996). Animal Regeneration-. Anmol Publications Ltd, India.
4. Browder L.W., Erickson C.A., and Jeffery W.R, Saunder. (1991). Developmental Biology-College Publishing House, Philadelphia, USA.
5. Strickberger, (2002). Genetics, 3rd edition- Prentice Hall of India.
6. Benjamin Lewin. (2000). Genes VII- Oxford University Press.
7. Sarin C. (1990). Genetics-, Tata McGraw–Hill Publishing Co., Ltd., New Delhi,
8. Gupta PK. (1996). Genetics- Rastogi Publications, Meerut, India.
9. Alberts B. (2002). Molecular Biology of the Cell, (Ed: 3) -, Garland Science, USA.
10. Brian K. Hall, Kluwer. (1999). Evolutionary Developmental Biology (2nd edition) - Academic Publishers.
11. T.Subramaniam. (2013) Molecular Developmental Biology.
12. Leon W. Browder (2013). The Cellular Basis of Morphogenesis (Developmental Biology, 2) Springer Softcover reprint of the original 1st ed. 1986 Edition.
13. Blanche Capel. (2019). Sex Determination in Vertebrates (Volume 134) (Current Topics in Developmental Biology, Volume 134) Academic Press;1st Edition
14. Michael J.F. Barresi (Author), Scott F. Gilbert. (2019). Developmental Biology 12th Edition
15. <http://www.sinauer.com/>
16. <https://www.amazon.com/dp/1493957341?tag=uuid10-20>
17. <https://www.textbooks.com/Developmental-Biology-10th-Edition/9780878939787/Gilbert.php?CSID=2MBWM2TBS3DS3CAAAMK2C2SMB>

COURSE OUTCOMES:

On the successful completion of the course, the students will be able to:

- Give the basic knowledge on organism development and determination
- Know about gametogenesis and fertilization in animals
- Understand the differentiation and regulation of normal.
- Learn about organogenesis in plant development
- Exhibit contemporary knowledge in Development and Evolution

MAPPING WITH PROGRAMME OUTCOMES

PO Mapping Strategy: This course primarily aligns with **Disciplinary Knowledge (PO1)**, **Critical Thinking (PO2)**, **Analytical Reasoning (PO3)**, and **Research-Related Skills (PO8)**, with strong engagement of scientific reasoning, problem-solving, self-directed learning, and lifelong learning.

Mean Calculation: Each CO mean is derived by calculating the average correlation score across all 10 POs. The **Overall Mean Score of 2.47** indicates a **moderate-to- high level of alignment** between Developmental Biology and the Programme Outcomes.

Year: I

GENERIC ELECTIVE COURSE 1

Semester: I

Code:

**1. BIOTECHNOLOGY FOR HUMAN
WELFARE
(Theory)**

Credits: 3

COURSE OBJECTIVES:

This course is designed to:

1. **Understand** the applications of biotechnology in healthcare, including molecular diagnostics, recombinant therapeutics, vaccines, and monoclonal antibodies.
2. **Explain** the role of biotechnology in agriculture through GM crops, biofertilizers, biopesticides, tissue culture, and biofortification.
3. **Examine** industrial applications of biotechnology in enzyme production, fermentation, biopolymers, bioplastics, and food and beverage industries.
4. **Analyse** the applications of biotechnology in environmental protection, including biofuels, wastewater treatment, phytoremediation, bioleaching, and waste management.
5. **Evaluate** ethical issues and emerging trends in biotechnology, including stem cell research, GM crops, IVF, bioterrorism, sustainability, climate change, food security, and global health.

UNIT - I: HEALTHCARE

- Overview of molecular diagnostic approaches for infectious and genetic diseases- **Therapeutics:** Recombinant human insulin, and growth hormones.
- **Vaccines & Diagnostics:** Recombinant live vaccines, monoclonal antibodies, and molecular diagnostic tools for infectious diseases. -PCR, RT-PCR, RAPD, RFLP; Karyotyping.

UNIT - II: AGRICULTURE

- Overview on GM crops- Pest resistance- stress tolerant Importance of Biofertilizers - Role of tissue culture-based micropropagation in agriculture; Biofortification
- Biofertilizers and Biopesticides.

UNIT - III: INDUSTRIAL APPLICATIONS

Bioplastics - Biopolymer- Role of industrial enzymes - food, textile and paper industries; Role of biotechnology in the fermentation and beverage industries;

UNIT - IV: BIOTECHNOLOGY IN ENVIRONMENT

Biofuels – Bioethanol, Biodiesel and Biogas; Waste water treatment; Phytoremediation- bioleaching; Waste and Oil Spillage Management;

UNIT - V: ETHICS IN BIOTECHNOLOGY

Informed Consent and Exploitation - Ethical issues Associated: Stem Cell Research - Equity and Access; Controversy over GM crops, bioterrorism, IVF technologies.

UNIT – VI: CURRENT TRENDS

Emerging biotechnological solutions to global health challenges; Recent developments in sustainable and green biotechnology; Role of biotechnology in addressing climate change and food security; Periodic literature-based updates on notable discoveries relevant to this course.

Text Book

1. D.Balasubramanian, CF.A.Bryce, K. Dharmalingham, J. Green and K.Jayaraman.1996. concepts in biotechnology. Universities press.
2. Ashok k.Chauhan.2009.A Textbook of molecular Biotechnology. I.K. International Publishing house Pvt. Ltd.
3. Chandrakantkokate, S S Jalalpute, pramod H.J.2011. Textbook of pharmaceutical biotechnology. A division of reed Elsevier india Pvt. Ltd.

Course Outcome:

CO1	Define the fundamental concepts and importance of Human Welfare in individual and societal development.	K3
CO2	Describe the factors influencing human welfare including health, education, environment, and social well-being.	K2
CO3	Apply principles and practices that promote human welfare, quality of life, and community development.	K1
CO4	Analyze social issues and evaluate strategies for improving human welfare and sustainable development.	K6
CO5	Demonstrate awareness and responsibility towards social values, public health, and community welfare activities.	K5

MAPPING WITH PROGRAMME OUTCOMES (POs)

- **PO Mapping Strategy:** This course aligns strongly with Disciplinary Knowledge (PO1), Problem Solving (PO3), and Entrepreneurial Skills (PO9).
- **Mean Calculation:** Each CO mean is derived by calculating the average correlation score across all 10 POs. The **Overall Mean Score of 2.54** indicates a **high level of alignment** between Biotechnology for Human Welfare and the Programme Outcomes.

Year: I

GENERIC ELECTIVE COURSE 1

Semester: I

Code:

**2. ORGANIC FARMING AND
MANAGEMENT
(Theory)**

Credits: 3

COURSE OBJECTIVES:

The student will value the concepts of ecology and environment.

- To know the techniques of Vermicomposting and enjoying the cultivation of common Medicinal Herbs
- To gain the knowledge about Principles and Policies in Organic farming and Certification agencies.
- To realize the Concept of Health and importance of wellbeing.
- To appreciate the Role of exercise and nutrition in Health related fitness.

UNIT – I: Introduction

Organic Farming - Physical & Chemical properties of soil - Management of Organic Wastes & Green Manures - Farm Manures, Composts, and Mulches.

UNIT – II: Composting

Organic Versus Inorganic Agriculture Composting – Organic Nutrient Resources and Fortification – Biofertilizers - Microbial Compost – Vermicomposting – Setup for vermicomposting unit.

UNIT – III: Policies for organic farming and market

Status of national and state policies and schemes - Economic and Socioeconomic Status- Commercialisation of rural products, FSSAI, marketing, packaging and handling of organic products.

UNIT – IV: Applications of organic products

Application of bio-pesticides – Plant -based pesticides (Neem oil, neem seed kernel, lantana etc.); Biological weed control agents- multiplication and method of use.

UNIT – V: Health Management

Soil Health – Water Health – Plant Health – Ecology Health - Human Health: Farmers, Consumers and Children;

UNIT – VI: CURRENT CONTOURS (For continuous internal assessment only):

The recent advancements in the course topics will be explained to the students then and there through expert lectures, online seminars or webinars.

Reference:

1. G.K. Veeresh, 2006. Organic farming, First edition, New Delhi, India Foundation Books in association with Centre for Environment Education.
2. Mangalarai, 2012. Hand Book of Agriculture, Sixth Edition, ICAR New Delhi. B.B. Sharma, 2007. A Guide to Home Gardening, Second Edition, MIB India, New Delhi.
3. Adrienne E. Hardman, 2009. Physical Activity and Health – The evidence explained Second edition, Taylor and Francis Group.

4. Organic Farming: Components and Management Edition: 1 Author/s: Gehlot, Publisher: M/s AGROBIOS (INDIA) ISBN: 978817754400

S. No.	ORGANIC FARMING AND MANAGEMENT	Knowledge Level
Upon completion of the course, the students will be able to		
CO1	Define the fundamental concepts and principles of Organic Farming and Health Management.	K3
CO2	Describe organic farming practices, nutrient management, and the relationship between food, health, and environment.	K2
CO3	Apply organic farming techniques and health management practices for sustainable agricultural development and well-being.	K1
CO4	Analyze the impact of organic farming on environmental sustainability, food quality, and human health.	K6
CO5	Demonstrate awareness and practical understanding of eco-friendly farming methods and healthy lifestyle management practices.	K5

MAPPING WITH PROGRAMME OUTCOMES (POs)

- **PO Mapping Strategy:** This course aligns strongly with Disciplinary Knowledge (PO1), Problem solving (PO3), Environment and Sustainability (PO7), Health awareness (PO8) and Entrepreneurial skills (PO9).
- **Mean Calculation:** The Overall Mean Score of **2.8** indicates a high level of alignment with the programme outcomes.

COURSE OBJECTIVES:

- Understand the diversity and significance of microorganisms associated with humans.
- Explain host–microbe interactions in health and disease.
- Study the role of the human microbiome in immunity, metabolism, and physiology.
- Develop skills in molecular, microbiological, and bioinformatics techniques.

UNIT - I: Introduction to Human–Microbe Interactions

History and scope of microbiology - Human-associated microorganisms- Symbiosis, commensalism, mutualism, and parasitism- Human Microbiome Project (HMP)

UNIT - II: Human Microbiome

Skin, oral, gut, respiratory, and urogenital microbiota- Microbiome development and functions

Gut–brain axis - Microbiome and immunity

UNIT - III: Microbes and Human Diseases

Virulence factors and microbial pathogenesis - Biofilm formation and quorum sensing Antibiotic resistance - Dysbiosis and human diseases

UNIT - IV: Host–Microbe Interactions

Microbial colonization of the human body - Host immune responses to microorganisms

Microbe – microbe interactions - Communication between microorganisms (quorum sensing)

Biofilm formation and its significance - Gut–brain axis - Influence of environmental factors, diet, and lifestyle on microbial communities

UNIT - V: Microorganisms in Human Health and Disease

Beneficial microorganisms and normal microbiota - Opportunistic and pathogenic microorganisms - Microbial infections and transmission - Antibiotic resistance and antimicrobial stewardship - Probiotics, prebiotics, synbiotics, and postbiotics - Emerging trends in microbiome-based therapeutics

UNIT - VI: CURRENT CONTOURS (Self-directed learning activities for Continuous Internal Assessments Only):

Review recent advances in the Human Microbiome Project (HMP), Analyze case studies related to antibiotic resistance, microbial pathogenesis, biofilm formation, and emerging infectious diseases.

Recommended Books (latest editions), References, and e-Books

Text Books

1. Douglas, A. E. (2018). Fundamentals of Microbiome Science: How Microbes Shape Animal Biology. Princeton University Press.
2. Wilson, M. (2018). The Human Microbiota in Health and Disease: An Ecological and Community-Based Approach. CRC Press.
3. Holban, A. M., and Grumezescu, A. M. (2018). Diet, Microbiome and Health. Academic Press.
4. Moya, A., Ferrer, M., and co-authors (2021). The Microbiomes of Humans, Animals, Plants, and the Environment. Frontiers Media.

Reference Books

1. Marchesi, J. (2014). The Human Microbiota and Microbiome. CAB International.
2. Schwiertz, A. (2016). Microbiota of the Human Body: Implications in Health and Disease. Springer.
3. Gazouli, M., and Theodoropoulos, G. (2021). Gut Microbiome-Related Diseases and Therapies. Springer.
4. Panesar, P. S., and Anal, A. K. (2022). Probiotics, Prebiotics and Synbiotics. Wiley.
5. Berg, G., and Raaijmakers, J. M. (2023). The Microbiome: Concepts and Applications. Springer.

Course Outcomes (COs)

CO1: Explain the diversity and functions of microorganisms associated with the human body.

CO2: Describe the interactions between microbial communities and host physiological processes.

CO3: Analyze the role of microorganisms in the development and progression of diseases.

CO4: Apply molecular and bioinformatics tools to investigate microbial communities.

CO5: Evaluate the applications of microbiome-based therapies in healthcare and biotechnology.

COURSE OUTCOMES: (with Mapping)

PO Mapping Strategy:

This course primarily aligns with **PO1 (Disciplinary Knowledge)**, **PO2 (Critical Thinking)**, **PO3 (Analytical Reasoning)**, **PO4 (Scientific Reasoning)**, **PO7 (Problem-Solving Skills)**, **PO8 (Research-Related Skills)** and **PO9 (Lifelong Learning)**.

Mean Calculation

Considering the **significant CO–PO relationships** in the above mapping:

Overall Mean Score

The **Overall Mean Score of 1.94** indicates a **moderate level of alignment** of the Human Microbiology course with the Programme Outcomes, with particularly strong contributions toward **Disciplinary Knowledge, Critical Thinking, Analytical Reasoning, Scientific Reasoning, Problem-Solving, and Research-Related Skills**.

Year: I

SKILL ENHANCEMENT COURSE 1

Semester: I

Code:

**SUSTAINABLE WASTE MANAGEMENT
(Theory)**

Credits: 2

COURSE OBJECTIVES:

Understand the principles of sustainable waste management.

- Apply biotechnology for waste treatment, resource recovery, and environmental protection.
- Explore modern technologies for waste valorization and renewable energy production.
- Evaluate environmental policies, waste regulations, and sustainability assessment.
- Develop innovative solutions for sustainable waste management in industrial and municipal sectors.

UNIT – I: Fundamentals of Sustainable Waste Management

Introduction - Types and sources of waste: Municipal, agricultural, industrial, biomedical, electronic, plastic, e-waste and hazardous wastes. Principles of sustainable waste management (5 Rs) with example and advantages; Waste hierarchy;

UNIT – II: Waste Management

Recycling - Composting – Incineration- Landfilling - Anaerobic Digestion
Sustainable Development Goals (SDGs) related to waste management;
Significance and challenges of waste management.

UNIT – III: Waste Valorization and recovery

Conversion of biomass into value-added products - Biofertilizers and biostimulants from organic waste - Biochar production and application - Recovery of nutrients (Nitrogen and Phosphorus); Industrial symbiosis and zero-waste industries

UNIT – IV: Emerging Technologies in Sustainable Waste Management

AI and IoT in smart waste management - Remote sensing and GIS for waste monitoring - Biosensors for environmental pollution detection - Nanobiotechnology in waste treatment - Microbial fuel cells.

UNIT – V: Environmental Policies, Regulations and Future Aspects

Environmental Impact Assessment (EIA) - Life Cycle Assessment (LCA) - Carbon footprint and waste auditing - National and international waste management regulations - Extended Producer Responsibility (EPR) - Green technologies and climate-resilient waste management

UNIT – VI: CURRENT CONTOURS (For continuous internal assessment only):

The recent advancements in the course topics will be explained to the students then and there through expert lectures, online seminars or webinars.

Textbooks

1. Thompson, D. A. (2011). Cell and Molecular Biology Lab Manual. CreateSpace Independent Publishing Platform.
2. Gunasekaran, P. (2007). Laboratory Manual in Microbiology. New Age International Publishers.
3. Ledbetter, M. L. (1993). Cell Biology Laboratory Manual (2nd ed.). Ron Jon Publishing.
4. Cappuccino, J. G., and Sherman, N. (2013). Microbiology: A Laboratory Manual (10th ed.). Benjamin Cummings.
5. Miller, H. B., Witherow, D. S., and Carson, S. (2011). Molecular Biology Techniques: A Classroom Laboratory Manual (3rd ed.). Academic Press.

Reference Books

1. Alberts, B., Johnson, A., Lewis, J., Morgan, D., Raff, M., Roberts, K., and Walter, P. (2022). Molecular Biology of the Cell (7th ed.). W. W. Norton & Company.
2. Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A., and Martin, K. C. (2021). Molecular Cell Biology (9th ed.). W. H. Freeman and Company.
3. Cooper, G. M., and Hausman, R. E. (2019). The Cell: A Molecular Approach (8th ed.). Oxford University Press.
4. Brown, T. A. (2020). Gene Cloning and DNA Analysis: An Introduction (8th ed.). Wiley-Blackwell.
5. Krebs, J. E., Goldstein, E. S., and Kilpatrick, S. T. (2018). Lewin's Genes XII. Jones & Bartlett Learning.

Course Outcomes (COs)

CO1: Explain the principles of sustainable waste management and circular bioeconomy.

CO2: Apply microbial and biotechnological approaches for treatment of different waste streams.

CO3: Develop strategies for converting waste into renewable energy and value-added bioproducts.

CO4: Evaluate emerging technologies including AI, IoT, biosensors, nanobiotechnology and synthetic biology for sustainable waste management.

CO5: Assess environmental policies, sustainability metrics, and regulatory frameworks to design integrated waste management systems.

PO Mapping Strategy: This course primarily aligns with **Disciplinary Knowledge (PO1), Critical Thinking (PO2), Analytical Reasoning (PO3), Scientific Reasoning (PO4), Problem-Solving Skills (PO7), and Research-Related Skills (PO8).**

Each CO mean is derived by calculating the average correlation score across all 10POs. The Overall Mean Score of **2.88** indicates a very high level of alignment between Sustainable Waste Management and the Programme Outcomes.

COURSE OBJECTIVES:

Understand the role of beneficial microorganisms in sustainable agriculture.

- Study the diversity, production, and application of biofertilizers and biopesticides.
- Explain the mechanisms involved in plant growth promotion and biological pest control.
- Understand recent advances in microbial formulations and commercialization

UNIT – I: Introduction to Biofertilizers and Biopesticides

Principles and scope of biofertilizers and biopesticides - Beneficial microorganisms in agriculture - Plant growth-promoting microorganisms (PGPM) - Rhizosphere and plant-microbe interactions - Sustainable agriculture and integrated nutrient management

UNIT – II: Biofertilizers

Biological nitrogen fixation - Nitrogen-fixing microorganisms (*Rhizobium*, *Azotobacter*, *Azospirillum*) - Cyanobacterial biofertilizers - Phosphate-solubilizing and potassium-solubilizing microorganisms - Arbuscular mycorrhizal fungi (AMF) - Mechanisms of plant growth promotion.

UNIT – III: Production Technology and Quality Control

Isolation and screening of beneficial microorganisms - Mass production of microbial inoculants - Carrier materials and formulation methods - Liquid and solid biofertilizers - Storage, shelf life, and quality assurance - Field applications

UNIT – IV: Biopesticides

Classification of biopesticides - Bacterial biopesticides (*Bacillus thuringiensis*, *Pseudomonas fluorescens*) - Fungal biopesticides (*Trichoderma* species, *Beauveria bassiana*) - Viral biopesticides and bioherbicides - Botanical pesticides and biocontrol agents - Mechanisms of biological control

UNIT – V: Commercialization and Recent Advances

Regulatory aspects of biofertilizers and biopesticides - Commercial production and formulation technologies - Nanobiofertilizers and nanobiopesticides - Microbial consortia and biofilms - Genetically engineered microorganisms - Future prospects in sustainable agriculture

UNIT – VI: CURRENT CONTOURS (Self-directed learning activities for Continuous Internal Assessments Only):

Study of commercially available biofertilizers and biopesticides - Review of recent research articles on sustainable agriculture - Case studies on integrated pest management (IPM).

Text Books

1. Kaushik, B. D., Kumar, D., and Shamim, M. (2020). *Biofertilizers and Biopesticides in Sustainable Agriculture*. Apple Academic Press.
2. Giri, B., Prasad, R., Wu, Q. S., and Varma, A. (2019). *Biofertilizers for Sustainable Agriculture and Environment*. Springer.
3. Hakeem, K. R., Dar, G. H., Mehmood, M. A., and Bhat, R. A. (2021). *Microbiota and Biofertilizers: A Sustainable Continuum for Plant and Soil Health*. Springer.
4. Appanna, V. (2020). *Biofertilizers in Horticulture Crops*. New India Publishing Agency.

Reference Books

1. Panda, H. (2011). *Manufacture of Biofertilizer and Organic Farming*. Asia Pacific Business Press.
2. Abbey, L., Abbey, J., Leke-Aladekoba, A., Iheshiulo, E. M., and Ijenyo, M. (2019). *Biopesticides and Biofertilizers: Types, Production, Benefits, and Utilization*. Wiley.
3. Trust for Advancement of Agricultural Sciences (2020). *Biofertilizers and Biopesticides for Enhancing Crop Production – A Success Story*.
4. Bashan, Y., and de-Bashan, L. E. (2015). *Advances in Plant Growth-Promoting Bacterial Inoculants*. Elsevier.
5. Vessey, J. K., and co-authors (2020). *Biofertilizers in Agriculture: Concepts, Strategies and Effects on Soil Microorganisms*. Elsevier.

COURSE OUTCOMES: (with Mapping)

CO1: Explain the principles and significance of biofertilizers and biopesticides in sustainable agriculture.

CO2: Describe the role of beneficial microorganisms in nutrient cycling and plant growth promotion.

CO3: Apply production and quality-control methods used in the preparation of microbial formulations.

CO4: Evaluate the role of microbial biocontrol agents in pest and disease management.

CO5: Assess recent developments and commercialization strategies associated with biofertilizers and biopesticides.

PO Mapping Strategy: This course primarily aligns with **Disciplinary Knowledge (PO1), Critical Thinking (PO2), Analytical Reasoning (PO3), Scientific Reasoning (PO4), Problem-Solving Skills (PO7), Research-Related Skills (PO8), and Lifelong Learning (PO9). microbial consortia, and sustainable agricultural practices.**

Mean Calculation: Each CO mean is derived by calculating the average correlation score across all 10 POs. The Overall Mean Score of **2.84** indicates a very high level of alignment between Biofertilizers and Biopesticides and the Programme Outcomes.

COURSE OBJECTIVES:

- To understand the diversity, classification, physiology, metabolism, and genetics of microorganisms.
- To acquire knowledge of microbial growth, nutrition, and molecular systematics.
- To understand the influence of environmental factors on microbial metabolism.
- To develop an understanding of microbiological methods and microbial genetics.
- To explore recent advances in microbial biotechnology and metagenomics.

UNIT – I: Introduction to Microbiology

History and development of microbiology- Contributions of Pasteur, Koch, Fleming, and Winogradsky- Discovery of antibiotics and anaerobic microorganisms - Classification, identification, morphology, and ultrastructure of bacteria, fungi, algae, protozoa, and viruses Ecological and symbiotic associations among microorganisms

UNIT – II: Microbial Diversity, Growth, and Molecular Systematics

Origin and evolution of microorganisms - Concepts of microbial taxonomy and nomenclature - Bergey's system of classification - Measurement of microbial diversity - Nutritional requirements of microorganisms - Culture media and cultivation techniques - Growth measurement and preservation of microbial cultures

UNIT – III: Microbial Physiology and Metabolism

Microbial growth and growth kinetics - Environmental factors affecting microbial growth - Nutritional factors and microbial metabolism - Energy production and metabolic pathways - Growth inhibition and cell death - Preservation and maintenance of microbial cultures

UNIT – IV: Methods in Microbiology

Isolation and purification of microorganisms - Serial dilution and pure-culture techniques Staining methods and microscopic examination - Sterilization and disinfection methods Physical and chemical methods of microbial control - Evaluation of disinfectants and antimicrobial agents.

UNIT – V: Microbial Genetics and Metagenomics

Transformation, transduction, conjugation, recombination, plasmids, and transposons - Molecular systematics (16S rRNA and 18S rRNA sequencing) - Molecular typing methods (RFLP, RAPD, PFGE, ERIC-PCR, MLST, and ribotyping) - Microbial community analysis (DGGE, TGGE, T-RFLP, and FISH) - Metagenomics, transcriptomics, and culture-independent microbial analysis

UNIT – VI: CURRENT CONTOURS (Self-directed Learning Activities for Continuous Internal Assessments Only)

Review recent developments in microbial genomics, metagenomics, antimicrobial resistance, microbial ecology, and synthetic biology through seminars, case studies, journal reviews, scientific reports, and online workshops.

TEXT BOOKS (2010 onwards)

1. Willey, J. M., Sherwood, L. M., and Woolverton, C. J. (2020). Prescott's Microbiology. 11th Edition. McGraw-Hill.
2. Tortora, G. J., Funke, B. R., and Case, C. L. (2021). Microbiology: An Introduction. 13th Edition. Pearson.
3. Pommerville, J. C. (2020). Alcamo's Fundamentals of Microbiology. 11th Edition. Jones and Bartlett Learning.
4. Black, J. G., and Black, L. J. (2018). Microbiology: Principles and Explorations. 10th Edition. Wiley.

REFERENCE BOOKS (2010 onwards)

1. Madigan, M. T., Bender, K. S., Buckley, D. H., Sattley, W. M., and Stahl, D. A. (2021). Brock Biology of Microorganisms. 16th Edition. Pearson.
2. Glick, B. R. (2018). Molecular Biotechnology: Principles and Applications of Recombinant DNA. 5th Edition. ASM Press.
3. Atlas, R. M., and Bartha, R. (2018). Microbial Ecology: Fundamentals and Applications. Benjamin Cummings.
4. Parija, S. C. (2023). Textbook of Microbiology and Immunology. Elsevier.
5. Singh, R. L., and Mondal, S. (2019). Biotechnology for Sustainable Agriculture. Woodhead Publishing.

COURSE OUTCOMES (COs)

Course Outcomes	Mapping
CO1: Explain the diversity, classification, and characteristics of microorganisms.	K1
CO2: Describe microbial growth, nutrition, metabolism, and systematics.	K2
CO3: Apply microbiological methods for the isolation, cultivation, and characterization of microorganisms.	K3
CO4: Analyze microbial genetics, metabolism, and environmental interactions.	K4
CO5: Evaluate recent advances in microbial biotechnology, metagenomics, and molecular microbiology.	K5

K1 – Remembering; K2 – Understanding; K3 – Applying; K4 – Analyzing; K5 – Evaluating

PO Mapping Strategy: This course primarily aligns with **Disciplinary Knowledge (PO1)**, **Critical Thinking (PO2)**, **Analytical Reasoning (PO3)**, **Scientific Reasoning (PO4)**, **Problem-Solving Skills (PO7)**, **Research-Related Skills (PO8)**, and **Lifelong Learning (PO9)**.

Mean Calculation: The Overall Mean Score of **2.74** indicates a high level of alignment with the Programme Outcomes, particularly in disciplinary knowledge, analytical reasoning, scientific reasoning, and research-related skills.

COURSE OBJECTIVES:

The main objectives of this course are to:

- Study about principles of genetic engineering.
- Provide methodologies of rDNA technology
- Understand the applications of rDNA technology

UNIT – I: BASICS CONCEPTS:

DNA structure and properties. Restriction enzymes, DNA ligase, klenow enzyme, T4 DNA polymerase, polynucleotide kinase, alkaline phosphatase, cohesive and blunt end ligation, linkers, adaptors and homopolymeric tailing. Labeling of DNA - nick translation, random priming, radioactive and non-radioactive probes, hybridization techniques - northern, southern and colony hybridization, fluorescence in-situ hybridization, chromatin immunoprecipitation, DNA - protein interactions, electrophoresis shift assay, DNA footprinting and methyl interference assay.

UNIT – II: CLONING VECTORS:

Plasmids, bacteriophages, M13 mp vectors, PUC19 and blue script vectors. Phagemids, lambda phage vectors, insertion and replacement vectors, EMBL, cosmids, artificial chromosome vectors (YAC, BAC), animal virus derived vectors - SV40, vaccinia/baculo & retroviral vectors. Expression vectors – pMal, GST and pET based vectors. Protein purification. his-tag, GST-tag, MBPtag etc., intein-based vectors, inclusion bodies, methodologies to reduce formation of inclusion bodies, baculovirus and pichia vectors system, plant based vectors, Ti and Ri as vectors, yeast vectors and shuttle vectors.

UNIT – III: CLONING METHODOLOGIES:

Insertion of foreign DNA into host cells, transformation, construction of libraries, isolation of mRNA and total RNA. cDNA and genomic libraries, cDNA and genomic cloning, expression cloning and protein-protein interactive cloning. Yeast two hybrid system, phage display and principles in maximizing gene expression.

UNIT – IV: PRINCIPLES OF POLYMERASE CHAIN REACTION:

Primer design, fidelity of thermophilic enzymes, DNA polymerases, types of PCR - multiplex, nested, reverse transcriptase, real time, touchdown, hot start, and colony. Cloning of PCR products, T-vectors, proof reading enzymes, PCR in gene recombination, deletion, addition, overlap extension, and site specific mutagenesis. PCR in molecular diagnostics, viral and bacterial detection, PCR based mutagenesis, mutation detection - SSCP, DGGE, RFLP, oligo ligation assay (OLA), Mismatch Chemical Cleavage (MCC), Allele-Specific Amplification (ASA) and Protein Truncation Test (PTT).

UNIT – V: SEQUENCING METHODS:

DNA sequencing - Enzymatic, chemical & automated DNA sequencing and RNA sequencing. Chemical synthesis of oligonucleotides, introduction of DNA into mammalian cells, and transfection techniques. Gene silencing techniques, introduction to siRNA,

siRNA technology, micro RNA, construction of siRNA vectors, principle and application of gene silencing. Gene knockouts and gene therapy, creation of knockout mice, disease model, somatic and germ line therapy – in-vivo and ex-vivo, suicide gene therapy, gene replacement and gene targeting. Transgenics, cDNA and intragenic arrays, differential gene expression and protein array.

UNIT – VI: CURRENT CONTOURS (For continuous internal assessment only):

The recent advancements in the course topics will be explained to the students then and there through expert lectures, online seminars or webinars.

REFERENCES:

1. S.B. Primrose, R.M. Twyman and R.W.Old. (2001). Principles of Gene Manipulation. 6th Edition. S.B.University Press.
2. J.D. Watson, N.H. Hopkins, J.W Roberts, J. A. Seitz & A.M. Weiner. (2007). Molecular Biology of the Gene. 6th Edition. Benjamin Cummings Publishing Company Inc.
3. Watson JD, Gilman M, Witkowski J, Zoller M. (1992). Recombinant DNA. Scientific American Books.
4. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, and Peter Walter. (2002). Molecular Biology of the Cell, 4th Edition. Garland Sciences.
5. Stanley Maloy (1994). Microbial genetics. 2nd Edition. Jones and Bartlett publisher.
6. Uldis N. Streips and Ronald E. Yasbin. (2002). Modern Microbial Genetics. 2nd Edition. Wiley-Blackwell.
7. Sandy B. Primrose, Richard M. Twyman, Robert W. Old. (2008). Principles of Gene Manipulation. 6th Edition. Blackwell Science.
8. Brown TA. (2008). Genomes. 3rd Edition. New York: Garland Publishing Co. New York: Garland Science.
9. <https://www.ncbi.nlm.nih.gov/>
10. https://www.amazon.com/Principles-Manipulation-Genomics-Sandy-Primrose-ebook/dp/B00D88OH7S?dchild=1&keywords=Principles+of+Gene+Manipulation+and+Genomics&qid=1618059356&s=digital-text&sr=1-1&linkCode=li3&tag=microbiologyn-20&linkId=ffbeea5b07e689ff62f2dd6bab07683c&language=en_US&ref_=as_li_ss_il
11. https://www.amazon.com/Gene-Cloning-DNA-Analysis-Introduction-ebook/dp/B08KR7W53N?dchild=1&keywords=Gene+Cloning+and+DNA+Analysis.&qid=1618059059&sr=8-2&linkCode=li3&tag=microbiologyn-20&linkId=c5db8e4b4711b286fb20e8b408efcc38&language=en_US&ref_=as_li_ss_il

COURSE OUTCOMES:

On the successful completion of the course, the students will be able to:

- Explain the basic concepts of labelling and DNA-protein interactions
- Describe how the vectors can be used for the insertion of genetic material
- Know about methodologies involved in cloning
- Gain the ability to improve the knowledge of PCR amplification
- Understand various types of nucleic acid sequencing

PO Mapping Strategy: This course primarily aligns with **Disciplinary Knowledge (PO1)**, **Critical Thinking (PO2)**, **Analytical Reasoning (PO3)**, **Scientific Reasoning (PO4)**, **Problem-Solving Skills (PO7)**, and **Research-Related Skills (PO8)**, with strong support for **Self-Directed Learning (PO5)**, **Lifelong Learning (PO9)**, and **Leadership Readiness (PO10)**.

Mean Calculation: The Overall Mean Score of **2.78** indicates a high level of alignment, reflecting the strong research orientation and experimental/molecular nature of Genetic Engineering.

COURSE OBJECTIVES:

The main objectives of this course are to:

- Update the hands-on training skills of students on the experiments of rDNA technology, immunology and industrial biotechnology.
- Get training in basic genetic engineering techniques which are essential for them to enrich their technical skills.
- Illustrate Antigen – antibody interaction.

EXPERIMENTS:**MICROBIOLOGY:**

1. Isolation of microorganisms from air, soil & water - spread plate, pour plate, streak plate techniques
2. Staining methods – simple, differential, acid - fast & negative
3. Identification - Macroscopic, microscopic, biochemical, serological & generic level
4. Antibiotic sensitivity test – Kirby - Bauer method.

rDNA TECHNOLOGY:

1. Isolation of genomic DNA from plant and animal cells.
2. Isolation of plasmid DNA
3. Transformation and Transduction
4. RFLP & RAPD
5. PCR

REFERENCES:

1. A Practical Text book genetic engineering in bacteria (2021) - P V G K Sharma
2. Harley Presscot. 2002. Laboratory Exercises in Microbiology. 5th Edition. The McGraw Hill.
3. P.Gunasekaran. 2007. Laboratory Mannual in Microbiology. New Age International.
4. Alfred Brown, Heidi Smith. 2014. Benson's Microbiologica; Applications. Laboratory Manual in General Microbiology. John wiley & Sons.
5. Competency Based practical manual for microbiology (2021)- Upasana Bhumbla, Jaypee.
6. Text and Practical microbiology for MLT(2021) - Dr.C.P.Baveja & Dr. V. Baveja

7. Richard A. Goldsby, Thomas J. Kindt. Barbara, A. Osborne, Janis Kuby. 2003. Immunology. 5th Edition, W. H. Freeman & Company.
8. Topley and Wilson. G. Wilson, A.Miles, M.T.Paker. Arnold, Heineman, 1984. Principles of Bacteriology, Virology and immunology. Willy – Blackwell.
9. Brenda D. Spangler. 2002. Methods in Molecular Biology and protein chemistry. John Wiley & sons, Ltd.
10. Bruce Rirren/Eric. D. Green. 1997. Genome Analysis – A laboratory manual – vol I Analyzing DNA. Cold spring Harbor Laboratory press.
11. Frederick M. Ausbel, Roger Breut. 2002. Short protocols in Molecular Biology. Vol I & II, 5th Edition. John Wiley & Sons Inc

COURSE OUTCOMES:

On the successful completion of the course, the students will be able to:

- Understand the basics of crucial experiments in rDNA technology, immunology and bioprocess/industrial biotechnology.
- Gain knowledge about the steps and operations involved in these experiments.
- Acquire knowledge on qualitative and quantitative methods on antigen – antibody interaction
- Perform primary and secondary metabolites production.
- Demonstrate DNA amplification methods

PO Mapping Strategy: The mapping reflects the strong alignment of **Advanced Microbiology and Genetic Engineering Practical with Disciplinary Knowledge (PO1), Critical Thinking (PO2), Analytical Reasoning (PO3), Scientific Reasoning (PO4), Problem-Solving Skills (PO7), and Research-Related Skills (PO8).**

Mean Calculation: Each CO mean is derived by calculating the average correlation score across all 10 Programme Outcomes. The Overall Mean Score of **2.68** indicates a high level of alignment between the practical course and the Programme Outcomes.

Course Objectives:

The objectives of this course are to:

- Explain the mechanism of drug action
- Apply the basic pharmacological knowledge for prevention and treatment
- Understand the drugs development process and regulations

UNIT – I: GENERAL PHARMACOLOGY:

Introduction to Pharmacology- Definition, historical landmarks and scope of pharmacology, nature and source of drugs, essential drugs concept and routes of drug administration, Agonists, antagonists, addiction, tolerance. Pharmacokinetics-Membrane transport, absorption, distribution, metabolism and excretion of drugs. Enzyme induction, enzyme inhibition, kinetics of elimination.

UNIT – II: PRINCIPLES OF TOXICOLOGY:

Definition and basic knowledge of acute, subacute and chronic toxicity. Definition and basic knowledge of genotoxicity, carcinogenicity, teratogenicity [1] and mutagenicity. Chronopharmacology - Definition of rhythm and cycles, Biological clock and their significance leading to chronotherapy.

UNIT- III: PHARMACODYNAMICS:

Principles and mechanisms of drug action. Receptor theories and classification of receptors, regulation of receptors. drug receptors interactions signal transduction mechanisms, G-protein-coupled receptors, ion channel receptor, dose response relationship, therapeutic index, combined effects of drugs and factors modifying drug action.

UNIT – IV: DRUG DEVELOPMENT PROCESS:

Methods involved in the development of new drugs. Preclinical toxicological studies. Calculation of LD₅₀ & ED 50. Acute, subacute and chronic toxicity studies. Pre-clinical pharmacokinetic and dynamic studies. High throughput screening (in vitro and in vivo) for pre-clinical pharmacokinetic and pharmacodynamic studies.

UNIT – V: DRUG REGULATIONS:

Drug and Cosmetics Act, Drug Price Control order, Application for Investigational New Drug (IND), Application for New drug Discovery (NDD) according to Indian Control Authority & USFDA guidelines. Conducting bio-equivalence studies. Ethical considerations in utilizing human subjects for drug discovery process. Helsinki's declaration. ICH-GCP Guidelines. Ethical guidelines in utilizing animals for experimental purposes.

UNIT – VI: CURRENT CONTOURS (For continuous internal assessment only):

The recent advancements in the course topics will be explained to the students then and there through expert lectures, online seminars or webinars.

REFERENCES:

1. Rang H. P., Dale M. M., Ritter J. M., Flower R. J., Rang and Dale's Pharmacology, Churchill Livingstone Elsevier (2020)
2. Katzung B. G., Masters S. B., Trevor A. J., Basic and clinical pharmacology, Tata McGraw-Hill 11th edition (2010)
3. W.C.Evans, Trease and Evans Pharmacognosy, 16th edition, W.B. Saunders & Co., London, 2009.
4. Mohammad Ali. Pharmacognosy and Phytochemistry, CBS Publishers & Distribution, New Delhi.
5. Text book of Pharmacognosy by C.K. Kokate, Purohit, Gokhale (2007), 37th Edition, NiraliPrakashan, New Delhi.
6. Herbal drug industry by R.D. Choudhary (1996), 1stEdn, Eastern Publisher, New Delhi.
7. K.D.Tripathi. Essentials of Medical Pharmacology (2016), JAYPEE Brothers Medical Publishers (P) Ltd, New Delhi
8. Sharma H. L., Sharma K. K., Principles of Pharmacology (2017), Paras medical publisher
9. Modern Pharmacology with clinical Applications, by Charles R. Craig & Robert.
10. Ghosh MN. Fundamentals of Experimental Pharmacology. Hilton & Company, Kolkata.
11. Kulkarni SK. Handbook of experimental pharmacology. Vallabh Prakashan.
12. R Endress, Plant cell Biotechnology, Springer-Verlag, Berlin, 1994.
13. Tara V Shanbhag. 2020. Pharmacology for Medical Graduates. 1st Edition, Elsevier India.
14. Dr. HazaifShaikh. 2021. Pharmacology. 1st Edition, Clever Pen Publishing LLP.

COURSE OUTCOMES:

On the Successful Completion of the course, the students will be able to:

- Understand the pharmacological actions of different categories of drugs
- Know the concept of pharmaco-toxicology
- Apply the basic knowledge in pharmacodynamics
- Know drug development procedures
- Know the drug regulation act and ethics

PO Mapping Strategy: This course primarily aligns with **Disciplinary Knowledge (PO1), Critical Thinking (PO2), Analytical Reasoning (PO3), Scientific Reasoning (PO4), Problem-Solving Skills (PO7), and Research-Related Skills (PO8)**, with significant support for **Self-Directed Learning (PO5), Reflective Thinking (PO6), and Lifelong Learning (PO9)**.

Mean Calculation: The Overall Mean Score of **2.82** indicates a high level of alignment, especially because the course integrates scientific reasoning, drug development, regulatory requirements, ethical research and pharmacological evaluation.

COURSE OBJECTIVES:

- The objective of this paper is to familiarize the students with stem cell technology and its applications for betterment of the society.
- The course is designed to give a broad view of mammalian stem cells, reviewing where they are found in the body, the different types and how they are cultured.
- The topics will cover the basic biology of these stem cells as well as bioengineering and application of these stem cells to potential treatments of human diseases.

UNIT – I: INTRODUCTION TO STEM CELLS

Definition, origin of thoughts on the potential of nucleus and identification on the significance of cytoplasm, history of the origin of stem cells, properties, proliferation, culture of stem cells, medical applications of stem cells, ethical and legal issues in use of stem cells.

UNIT – II: STEM CELLS AND ITS TYPES

Isolation of stem cells, types of stem cells its advantages and disadvantages. Classification of stem cells. Normal stem cells: hematopoietic stem cells, mesenchymal stem cells, cardiac stem cells. Embryonic stem cells (ESC): difference between mouse and human ESCs, derivation of ESCs, scientific and ethical hindrance to ESC therapy. Adult stem cell. Stem Cell culture and the potential benefits of stem cell technology.

UNIT – III: THERAPEUTIC APPLICATIONS OF STEM CELLS

Gene Therapy: Introduction, History and evolution of Gene therapy, optimal disease targets, Failures and successes with gene therapy and future prospects, Genetic Perspectives for Gene Therapy, Gene Delivery methods: Viral vectors and Non-viral Vectors

UNIT – IV: CANCER STEM CELLS

Historical perspective, isolation and characterization of cancer stem cells. Solid cancer stem cells (Breast, Lung, prostate, liver, stomach, Glioma). Targeting cancer stem cells. Hematological malignancies and stem cells. Side population cells in flow cytometry, Induced pluripotent stem cells, its derivation and applications.

UNIT – V: ETHICS OF STEM CELLS

Ethical Issues associated with stem cell-based regenerative medicine field Regulatory and Ethical Considerations of stem cell and Gene Therapy, Assessing Human Stem Cell Safety, Use of Genetically Modified Stem Cells in Experimental Gene Therapies.

UNIT – VI: CURRENT CONTOURS (Self-directed learning activities for Continuous Internal Assessments Only)

Students are to develop conceptual understanding and analytical skills (PO1, PO2) by preparing a concept map on types and classification of stem cells. Submit a diagrammatic report. To develop research aptitude and scientific thinking (PO4, PO5) by reviewing recent articles on stem cell applications in regenerative medicine. Submit a short review report. To develop practical knowledge and observation skills (PO4, PO6) by visiting nearby research labs / hospitals / biotech centers (or virtual labs). Observe stem cell culture techniques and applications. Submit a field/virtual observation report.

Recommended Books, References, and e-Books

1. Robert Lanza, “Essentials of Stem cell Biology”, Elsevier, 2006 Daniel R. Marshak, Richard L. Gardner and David Gottlieb, “Stem cell Biology”, Cold spring Harbour Laboratory Press, 2001
2. TEXT BOOK: Robert Lanza, “Essentials of Stem cell Biology”, Elsevier, 2006
3. REFERENCE Book: Daniel R. Marshak, Richard L. Gardner and David Gottlieb, “Stem cell Biology”, Cold spring Harbour Laboratory Press, 2001
4. Stem Cell Biology, Daniel Marshak, Richard L. Gardener and David Gottlieb, Cold Spring Harbour
5. Laboratory Press Stem cell biology and gene therapy, Booth C., Cell Biology International, Academic Press
6. Stem Cell and Gene-Based Therapy: Frontiers in Regenerative Medicine, Alexander Battler

Upon completion of the course, the students will be able to		
CO1	Explain the basic concepts, history, properties, and medical applications of stem cells, including ethical and legal issues	K2
CO2	Classify and compare different types of stem cells (embryonic, adult, hematopoietic, mesenchymal, cardiac) and evaluate their advantages and limitations.	K4
CO3	Describe the principles and techniques of stem cell isolation, culture, and proliferation, and assess their potential in biotechnology.	K3
CO4	Analyze the concepts of gene therapy, including gene delivery methods (viral and non-viral vectors), and evaluate its applications and challenges.	K5
CO5	Examine the role of cancer stem cells, their identification, characterization, and targeting strategies, including applications of induced pluripotent stem cells (iPSCs).	K4

MAPPING WITH PROGRAMME OUTCOMES

- **PO Mapping Strategy:** The mapping reflects the strong alignment of Knowledge of basic and applied stem cells (PO1), students involving practical skills, laboratory techniques, and applications are mapped with PO3 (Problem-solving) and PO4 (Research skills).
- **Mean Calculation:** Each CO mean is derived by calculating the average correlation score across all 10 POs. The Overall Mean Score of 1.90 indicates a moderate-to-high level of alignment between the course and the programme outcomes.

COURSE OBJECTIVES:

- To know the nutrient value of mushroom.
- To study the morphology and types of Mushrooms.
- To differentiate edible and non-edible Mushrooms.
- To learn the prospects and scope of mushroom cultivation in small scale industry

UNIT – I: INTRODUCTION:

History of mushroom - Morphology of Mushroom -Nutritional and medicinal properties - Types of edible and Properties of mushroom – Current scenario - Economic importance.

UNIT – II: REQUIREMENTS FOR MUSHROOM CULTIVATION:

Agro-climate requirements – Selection of Location – Composting platform, Equipment & facilities, pasteurization room & growing rooms. Facilities required for spawn preparation, Preparation of spawn substrate, preparation of pure culture, media used for pure culture, culture maintenance, storage of spawn. Casting materials & Case running: Importance of casing mixture, Quality parameters of casing soil, different types of casing mixtures, commonly used materials.

UNIT III: CULTIVATION OF ECONOMICALLY IMPORTANT MUSHROOM:

Cultivation of Button, Oyster and Straw Mushrooms: Collection of raw materials, compost & composting, spawn & spawning, casing & case run, cropping & crop management, picking & packing.

UNIT – IV: POST HARVEST MANAGEMENT:

Post-harvest packaging and Management, Disease and Pest: Pest and pathogens of mushroom; control measures; Integrated Pest Management (IPM).

UNIT – V: MARKETING:

Marketing of mushroom: market demand; market channels; direct marketing and wholesale marketing.

UNIT – VI: CURRENT CONTOURS (For continuous internal assessment only):

The recent advancements in the course topics will be explained to the students then and there through expert lectures, online seminars or webinars

REFERENCES:

1. Tripathi, D.P. Mushroom Cultivation. 2005. Oxford & IBH Publishing Co. Pvt.Ltd., New Delhi.
2. Acharya, K., Roy, A. and Sarkar, J.2020.Mushroom cultivation technology. Techno world.
3. Pathak Y. G. 2010. Mushroom production and processing technology (2010), Agrobios (India).

COURSE OUTCOMES:

- Cultivation of different edible mushrooms.
- Acquaintance with climatic requirements of mushroom cultivation.
- Acquire building knowledge for mushroom cultivation and pest management.
- Learn Harvesting and post harvesting processes of mushroom.
- Entrepreneur for mushroom and its value added products.

PO Mapping Strategy: This course primarily aligns with **Disciplinary Knowledge (PO1)**, **Critical Thinking (PO2)**, **Scientific Reasoning (PO4)**, **Problem-Solving Skills (PO7)**, **Self-Directed Learning (PO5)**, and **Lifelong Learning (PO9)**, with supporting contributions to **Analytical Reasoning (PO3)**, **Research-Related Skills (PO8)**, and **Leadership Readiness (PO10)**.

Mean Calculation: The Overall Mean Score of **2.60** indicates a high level of alignment, with particular relevance to applied disciplinary knowledge, problem-solving, self-directed learning, entrepreneurship and lifelong learning.

Course Objectives

- To introduce the fundamental concepts and scope of healthcare biotechnology in disease prevention, diagnosis, and treatment.
- To impart knowledge on molecular diagnostics, biomarkers, and modern clinical laboratory techniques.
- To understand the principles and applications of biopharmaceuticals, vaccines, gene therapy, and regenerative medicine.
- To explore the role of biotechnology in managing infectious and non-communicable diseases.
- To familiarize students with biosafety, bioethics, regulatory frameworks, and recent advances in healthcare biotechnology.

UNIT – I: Introduction to Health Care Biotechnology

Definition, history, and scope of healthcare biotechnology. Biotechnology in healthcare delivery. Human health and disease concepts. Molecular basis of diseases. Biomolecules in health and disease. Personalized and precision medicine. Ethical, legal, and social issues (ELSI) in healthcare biotechnology.

UNIT – II: Molecular Diagnostics and Clinical Biotechnology

Principles and applications of molecular diagnostics. Polymerase Chain Reaction (PCR), Real-Time PCR (qPCR), Reverse Transcriptase PCR (RT-PCR), DNA sequencing, Next Generation Sequencing (NGS), DNA microarrays, biomarkers, biosensors, point-of-care diagnostics, laboratory quality assurance, Good Laboratory Practices (GLP), and biosafety in clinical laboratories.

UNIT – III: Therapeutic Biotechnology

Recombinant therapeutic proteins and hormones. Monoclonal antibodies and antibody engineering. Vaccine technology (conventional, recombinant, DNA, and mRNA vaccines). Gene therapy, stem cell therapy, regenerative medicine, tissue engineering, RNA therapeutics, pharmacogenomics, and nanobiotechnology-based drug delivery systems.

UNIT – IV: Biotechnology in Disease Management

Applications of biotechnology in infectious diseases, cancer, cardiovascular disorders, diabetes, neurodegenerative diseases, autoimmune disorders, and rare genetic diseases. Antimicrobial resistance. Immunotherapy. Role of artificial intelligence and digital healthcare in disease diagnosis and management.

UNIT – V: Regulatory Affairs and Emerging Trends in Healthcare Biotechnology

Clinical trials and translational medicine. Good Manufacturing Practices (GMP) and Good Clinical Practices (GCP). Regulatory guidelines of ICMR, CDSCO, WHO, and US FDA. Biosafety and bioethics. Intellectual Property Rights (IPR). CRISPR-

Cas genome editing, organoids, organ-on-chip technology, precision medicine, and future prospects of healthcare biotechnology.

UNIT – VI: Current Contours (Self-Directed Learning for Continuous Internal Assessment Only)

Students shall undertake a mini-project involving the review of a recent healthcare biotechnology innovation, prepare a case study on the molecular diagnosis or treatment of a selected disease, analyze a biotechnology-based healthcare product approved for clinical use, and present a seminar on emerging trends such as precision medicine, CRISPR technology, or artificial intelligence in healthcare.

Recommended Books & References

1. Glick, B.R., Pasternak, J.J., & Patten, C.L. Molecular Biotechnology: Principles and Applications of Recombinant DNA. ASM Press.
2. Primrose, S.B., & Twyman, R.M. Principles of Gene Manipulation and Genomics. Wiley-Blackwell.
3. Brown, T.A. Gene Cloning and DNA Analysis: An Introduction. Wiley.
4. Nelson, D.L., & Cox, M.M. Lehninger Principles of Biochemistry. W.H. Freeman.
5. Murphy, K., & Weaver, C. Janeway's Immunobiology. Garland Science.
6. World Health Organization (WHO). Laboratory Biosafety Manual, latest edition.
7. Indian Council of Medical Research (ICMR). National Ethical Guidelines for Biomedical and Health Research Involving Human Participants, latest edition.

HEALTH CARE IN BIOTECHNOLOGY		
S. No.	Course Outcomes	Knowledge Level
CO1	Explain the fundamental concepts and applications of healthcare biotechnology in modern medicine.	K2
CO2	Apply molecular diagnostic techniques for disease detection and clinical investigation.	K3
CO3	Explain the principles and therapeutic applications of biopharmaceuticals, vaccines, gene therapy, and regenerative medicine.	K2
CO4	Analyze the role of biotechnology in the prevention, diagnosis, and management of infectious and non-communicable diseases.	K4
CO5	Evaluate regulatory guidelines, biosafety, ethical issues, and emerging technologies in healthcare biotechnology.	K5

PO Mapping Strategy: This course primarily aligns with **Disciplinary Knowledge (PO1)**, **Critical Thinking (PO2)**, **Analytical Reasoning (PO3)**, **Scientific Reasoning (PO4)**, **Problem-Solving Skills (PO7)**, and **Research-Related Skills (PO8)**, with strong support for **Self-Directed Learning (PO5)**, **Reflective Thinking (PO6)**, **Lifelong Learning (PO9)**, and **Leadership Readiness (PO10)**.

Mean Calculation: The **Overall Mean Score of 2.86** indicates a **very high level of alignment**, reflecting the course's strong integration of disciplinary knowledge, molecular diagnostics, research, clinical applications, regulatory affairs and emerging biotechnology.

COURSE OBJECTIVES:

- To understand the profound impact of modern living on human health.
- To identify the physiological and biochemical basis of common metabolic disorders.
- To evaluate the critical role of nutrition and physical activity in disease prevention.
- To analyze the psychological factors contributing to lifestyle-related stress.
- To develop evident based strategies for promoting healthy lifestyle modifications in society.

UNIT - I: Introduction

Lifestyle Diseases – Definition; Risk factors – Eating, Smoking, drinking, stress, Physical activity, illicit drug use; Obesity, Diabetes, Cardiovascular diseases, Respiratory diseases, Cancer; Prevention – Diet and exercise.

UNIT - II: Food habits and health

Junk food- Facts and ill effects, Carbonated drinks, Ready to eat foods, Acidity, Obesity, Eating disorders- Anorexia, Bulimia nervosa, Amoebiasis.

UNIT - III: Modern lifestyle for Health and Disease

Sedentary lifestyle - Obesity and hypertension, Diabetics, cancer Alzheimer's disease, Causes, Complications and Management -Stress related disorders, Sleeping disorders. Smoking, Alcoholism, Drugs- Risk factors, Electronic gadgets- Radiation and Health. Heart disease – Atherosclerosis.

UNIT - IV: Diabetes and Obesity

Types of Diabetes Mellitus, Blood glucose regulation. Obesity: Complications, Adolescent obesity, Weight control and BMI.

UNIT - V: Cardiovascular Diseases

Coronary atherosclerosis, coronary artery disease, hypertension, heart attacks, stroke, diagnosis: ECG and EEG- Role of Diet and Exercise in Heart Health, Lifestyle Management

UNIT - VI: CURRENT CONTOURS (Self-directed learning activities for Continuous Internal Assessments Only)

Students are to track their daily sleep and nutritional intake for one week, conduct a survey on stress levels among peers, and prepare a presentation on a chosen lifestyle disorder's prevention plan.

Recommended Books, References, and e-Books

1. Lifestyle Medicine, James M. Rippe, CRC Press, 2024.
2. Textbook of Preventive and Social Medicine, K. Park, Banarsidas Bhanot, 2023.
3. The Metabolic Syndrome, Ronald A. Kloner, Springer, 2022.

4. Nutrition and Lifestyle Medicine (Selected Open Educational Resources), Michelle E. Hauser et al., American College of Lifestyle Medicine, 2020.

LIFESTYLE DISEASES		
S. No.	Course Outcome	Knowledge Level
Upon completion of the course, the students will be able to		
CO1	Define and classify various lifestyle disorders to understand their prevalence in modern society.	K1
CO2	Explain the physiological and metabolic basis of chronic conditions like obesity and diabetes.	K2
CO3	Apply knowledge of nutritional habits and sedentary behaviors to analyze their impact on digestive and metabolic health..	K3
CO4	Analyze the connection between chronic stress, mental well-being, and lifestyle-associated disorders.	K4
CO5	Formulate evidence-based strategies and public health interventions for disease prevention and healthy living	K6

MAPPING WITH PROGRAMME OUTCOMES

PO Mapping Strategy: The mapping reflects the strong alignment of Lifestyle Disorders with Disciplinary Knowledge (PO1), Problem Solving (PO3), and Lifelong Learning (PO10).

Mean Calculation: Each CO mean is derived by calculating the average correlation score across all 10 POs. The **Overall Mean Score** of **2.22** indicates a moderate-to-high level of alignment between the course and the programme outcomes.

COURSE OBJECTIVES

- To provide fundamental knowledge of clinical research and clinical trial methodologies.
- To familiarize students with the design, conduct, monitoring, and management of clinical trials.
- To develop an understanding of clinical data management, documentation, and regulatory requirements.
- To understand ethical principles and international guidelines governing clinical research.
- To provide practical knowledge of pharmacovigilance, quality assurance, and regulatory affairs.

UNIT – I: Introduction to Clinical Trials

Definition, history, and scope of clinical research - Terminologies used in clinical trials - Clinical trial phases (Phase I, II, III, and IV) - Types of clinical trials - Randomization, blinding, placebo control, and study design - Clinical trial protocols and their components.

UNIT – II: Clinical Trial Management

Project management in clinical research - Protocol development and implementation - Investigator's brochure and case report forms - Selection of investigators and clinical trial sites - Contract research organizations (CROs) - Site management organizations (SMOs) - Clinical trial stakeholders and responsibilities.

UNIT – III: Clinical Monitoring and Pharmacovigilance

Clinical trial monitoring - Monitoring visits and investigator meetings - Trial documentation and record management - Regulatory compliance and auditing - Pharmacovigilance and adverse event reporting - Fraud detection and research misconduct

UNIT – IV: Clinical Data Management

Introduction to clinical data management - Design and validation of case report forms Clinical data collection and entry - Data verification and discrepancy management Database management systems - Quality assurance and regulatory requirements

UNIT – V: Ethics and Regulatory Affairs

Ethical principles in clinical research - Nuremberg Code - Declaration of Helsinki - Belmont Report - International Council for Harmonisation (ICH) guidelines - Informed consent process - Vulnerable populations and ethical review procedures

UNIT – VI: CURRENT CONTOURS (Self-directed Learning Activities for Continuous Internal Assessments Only)

Review recent advances in clinical research, artificial intelligence in clinical data management, decentralized clinical trials, electronic data capture systems, pharmacovigilance, and international regulatory guidelines through seminars, case studies, journal reviews, and scientific reports.

TEXT BOOKS

1. Gallin, J. I., Ognibene, F. P., and Johnson, L. L. (2018). Principles and Practice of Clinical Research. 4th Edition. Academic Press.
2. Rondels, R. W., Varley, S. A., and Webb, C. F. (2021). Clinical Data Management. 3rd Edition. Wiley-Blackwell.
3. Gupta, S. K. (2011). Textbook of Clinical Trials. Jaypee Brothers Medical Publishers.
4. Bhatt, A. (2020). Principles of Clinical Research and Drug Development. Jaypee Brothers Medical Publishers.

REFERENCE BOOKS

1. Friedman, L. M., Furberg, C. D., DeMets, D. L., Reboussin, D. M., and Granger, C. B. (2015). Fundamentals of Clinical Trials. 5th Edition. Springer.
2. Piantadosi, S. (2017). Clinical Trials: A Methodologic Perspective. 3rd Edition. Wiley.
3. Chin, R., and Lee, B. Y. (2018). Principles and Practice of Clinical Trial Medicine. Academic Press.
4. Agrawal, D., and Biswas, N. R. (2021). Ethics in Clinical Research. Springer.
5. Wang, X., and Bakhai, A. (2020). Clinical Trials: A Practical Guide to Design, Analysis and Reporting. CRC Press.

COURSE OUTCOMES (COs)

	Course Outcomes	Mapping
CO1	Explain the principles, phases, and design of clinical trials.	K1
CO2	Describe the procedures involved in clinical trial management and monitoring.	K2
CO3	Apply data management principles in clinical research studies.	K3
CO4	Analyze ethical, legal, and regulatory issues related to clinical research.	K4
CO5	Evaluate recent developments in clinical trial management and pharmacovigilance.	K5

K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, and K5 – Evaluating

PO Mapping Strategy: The mapping reflects the strong alignment of **Clinical Trial and Data Management with Disciplinary Knowledge (PO1), Critical Thinking (PO2), Analytical Reasoning (PO3), Scientific Reasoning (PO4), Problem-Solving Skills (PO7), and Research-Related Skills (PO8).**

Mean Calculation: Each CO mean is derived by calculating the **average correlation score across all 10 POs**. The **Overall Mean Score of 2.62** indicates a high level of alignment between the course and the Programme Outcomes, particularly in disciplinary knowledge, analytical reasoning, scientific reasoning, research-related skills, and ethical/regulatory decision-making.

COURSE OBJECTIVES:

- To make the students to understand the technological aspect applied to fermentation technology,
- To make the students understand gene cloning, transgenic plants and animals.
- To make the students understand Applications of biotechnology for environmental issues.

UNIT – I: MICROBIAL BIOTECHNOLOGY

Biotechnology – scope and importance, Basic principles of microbial growth, Bioreactor- batch and continuous bioreactor, fermentation culture medium, downstream processing. Fermentation production of penicillin and vitamin B12.

UNIT – II: FOOD AND INDUSTRIAL BIOTECHNOLOGY

Fermentation production of yoghurt and cheese. Production of single cell protein; spirulina - cultivation and uses. Biofertilizers – blue green algae- cultivation and uses. Production of amylase and protease.

UNIT – III: MOLECULAR BIOTECHNOLOGY

Basic principles of cloning, Introduction of foreign DNA into host by particle bombardment gun, electroporation and microinjection. Basic Polymerase Chain Reaction (PCR), applications.

UNIT – IV: ANIMAL AND PLANT BIOTECHNOLOGY

Elementary details of Animal cell and tissue culture, medium, targeted gene transfer. Transgenic animals (Knockout Mice, transgenic sheep with human alpha1-antitrypsin gene, transgenic pigs for organs for humans, transgenic mosquitoes for disease control, transgenic chicken for high protein). Plant cell and tissue culture, medium, totipotent, pluripotent cells. Transgenic plants (enhancing photosynthetic efficiency, golden rice, BT cotton, herbicide tolerant plants, stress tolerant plants).

UNIT – V: ENVIRONMENTAL BIOTECHNOLOGY

Biological fuel generation- ethanol and methane from biomass. Sewage treatment. Bioremediation: oil spill cleanup, bioleaching. Intellectual property management and handling of GMO's. Biosafety and hazards of environmental engineering.

UNIT – VI: CURRENT CONTOURS (FOR CONTINUOUS INTERNAL ASSESSMENT ONLY)

Stem cell from bioreactors, Stem Cell Research, Human Genome Project. Students are to track their develops practical knowledge & sustainability awareness (PO4, PO6) Visit nearby farms or agricultural centers. Observe use of: Biofertilizers (e.g., nitrogen fixers) and Biopesticides (e.g., neem-based products). Submit field observation report.

Recommended Books, References, and e-Books

1. B.R.Glick & J.J. Pasterak , Molecular Biotechnology: Principles and Applications of Recombinant DNA, ASM Press, Washington, D.C., 2010
2. A.H.Patel , Industrial Microbiology, Macmillan , India Ltd, 2012
3. Michael Butler, Animal Cell Culture and Technology, Garland Science/BIOS Scientific Publishers, Second Edition, London and New York. 2004.
4. Ramawat, K.G..Plant Biotechnology, S.Chand and Company Ltd, Ram Nagar, New Delhi, 2008.
5. Wang, L.K. Environmental Biotechnology, First Edition, A Product of Human Press, 2010.
6. R.C.Dubey , A text book of Biotechnology-, S.Chand Publications, 2014
7. P.K.Gupta , Elements of Biotechnology-, Rastogi Publications, 2nd edition 3rd reprint, 2015 2016.
8. Brown, T.A. Gene Cloning and DNA Analysis: An Introduction, 7th edition Wiley Blackwell 2012.
9. Renneberg, R. & Berkling, V. Biotechnology for beginners, Academic Press, 2017. John M Walker and Ralph Raply, Molecular Biology and Biotechnology 5th Edition, RCS publishing, 2009.

BIOTECHNOLOGY AND ITS APPLICATION		
S. No.	Course Outcome	Knowledge Level
Upon completion of the course, the students will be able to		
CO1	Illustrate the various aspects of Biotechnological applications in Fermentation Industries.	K1
CO2	Describe the principles underlying design of Fermenters, Fermentation Process and downstream processing and its applications.	K2
CO3	Explain the concept of gene cloning	K4
CO4	Explain the applications of transgenic plants and animals.	K3
CO5	Explain the IPR and handling of GMO's	K2

MAPPING WITH PROGRAMME OUTCOMES

PO Mapping Strategy: The Mapping reflects the strong alignment of knowledge of basic and applied sciences knowledge (PO1), effectively contribute knowledge of practical application (PO3), and use of modern tools in for (PO5). Environment & Sustainability (PO6) and Ethics & Safety (PO7).

Mean Calculation: Each CO mean is derived by calculating the average correlation score across all 10 POs. The Overall Mean Score of **1.26** indicates a moderate-to-high level of alignment between the course and the programme outcomes.

COURSE OBJECTIVES:

The course is designed to enable students to:

- Understand the basic principles, organization, cells, organs, and mechanisms of the immune system.
- Explain the development, activation, differentiation, and regulation of B and T lymphocytes and their role in immune responses.
- Describe antigen-antibody interactions, complement activation, inflammation, and mechanisms of immune regulation.
- Understand the principles of immunization, different types of vaccines, adjuvants, monoclonal antibodies, and antibody engineering.
- Develop knowledge of clinical immunology, including immunity to infections, hypersensitivity, autoimmunity, transplantation, immunodeficiency, and tumor immunity.

UNIT – I: INTRODUCTION TO IMMUNE SYSTEM:

Organs and cells are involved in the immune system and response - Primary lymphoid organs, secondary lymphoid organs, lymphocytes, cytokines and lymphokines. Immune response (humoral and cell mediate). Types of immunity (innate and acquired). Terminology – Antigen, immunogen, hapten, allergen, tolerogen, super antigens, antibody, immunoglobulin, antigenicity, immunogenicity. Lymphatic system, lymphocyte circulation and lymphocyte homing. Mucosal and Gut-associated lymphoid tissue (MALT&GALT) and mucosal immunity. Principles of cell signalling.

UNIT – II: REGULATION OF IMMUNE RESPONSE:

B-cell - development, maturation, activation and differentiation. B-cell receptor and determinants. B-cell subsets. Immunoglobulins - basic structure, classes & subclasses of immunoglobulins, and antigenic determinants. T-cell development, maturation, activation and differentiation. T-cell receptor and determinants. T-cell subsets. Antigen processing and presentation - endogenous antigens, exogenous antigens, non-peptide bacterial antigens. Activation of B and T-lymphocytes, cytokines, their role in immune regulation, and immunological tolerance. Transplantation immunology - MHC, types of grafts, graft rejection and its mechanisms, GVH reactions, and prevention of graft rejection.

UNIT – III: ANTIGEN-ANTIBODY REACTION:

Antigen-Antibody reaction by precipitation, agglutination and complement fixation. Non-specific immune mechanism - Surface defences, tissue defences, opsonization, inflammatory reaction, and hormone balance. Complement system - complement components, types, complement activation, regulation of complement system, biological consequences and pathways of complement activation, and complement deficiencies.

UNIT – IV: VACCINOLOGY:

Immunization - Objectives of immunization, active, passive and combined immunization. Live, killed, attenuated, plasma derived, sub unit, recombinant DNA, protein based, plant-based, peptide, anti-idiotypic and conjugate vaccines. Role and properties of adjuvants & ISCOMS. Antibody genes and antibody engineering - chimeric and hybrid monoclonal antibodies, catalytic antibodies and generation of immunoglobulin gene libraries.

UNIT – V: CLINICAL IMMUNOLOGY:

Immunity to infection, bacteria, viral, fungal and parasitic infections (with examples from each group). Hypersensitivity – Type I, II, III and IV. Autoimmunity and types of autoimmune diseases. Mechanism and role of CD4+ T cells, MHC and TCR in autoimmunity. Treatment of autoimmune diseases. Transplantation – immunological basis of graft rejection, clinical transplantation and immunosuppressive therapy. Tumor immunology, tumor antigens, immune response to tumors and tumor evasion of the immune system. Cancer immunology and immunotherapy. Immunodeficiency - primary immunodeficiencies, acquired or secondary immuno-deficiencies.

UNIT – VI: CURRENT CONTOURS (For continuous internal assessment only):

The recent advancements in the course topics will be explained to the students then and there through expert lectures, online seminars or webinars.

REFERENCES:

1. Kuby Immunology (8th Edition) 2019- Jenni Punt, Sharon Stranford, Patricia Jones.
2. Essentials of Immunology (2017) - Dr. S.K. Gupta.
3. Immunology and Immunotechnology(2010) - Dr. B. Annadurai.
4. Allergy and Immunology- Scott Jasmin RV.
5. Roitt's Essential Immunology (13th Edition) - Seamus J. Martin and Dennis R Burton-Iran M Roitt.
6. Peter J. Delves, Seamus J. Martin, Dennis R. Burton and Ivan M. Roitt. 2011. Essential Immunology 12th Edition. Wiley - Blackwell.
7. Charles A Janeway, Jr. Paul Travers, Mark Walport, and Mark J Shlomchik. 1999. Immunobiology. 4th Edition. Journal of Current Biology publications.
8. D. M. Weir and John Stewart. 1997. Immunology. 8th Edition. Churchill Livingstone.
9. P.J.Delves, I S.J.Artin, I D.R.BurtonandI.M.Roitt. 2006. Essential Immunology. 11th Edition. Wiley - Blackwell.
10. Brostoff J, Seaddin JK, Male D and Roitt IM., 2002. Clinical Immunology.6th Edition.Gower Medical Publishing.
11. Ross, G.D. Ed Immuno biology of the Complement System.
12. Immunology - Understanding of Immune System by Claus D. Elgert. 1996. Wiley -Liss, New York.
13. Immunobiology: The Immune System in Health and Disease. 3rd Edition by Travers.
14. <https://archive.nptel.ac.in/courses/102/105/102105058/>

COURSE OUTCOMES:

On the successful completion of the course, the students will be able to:

CO1: Describe the organization of the immune system, immune cells, lymphoid organs, types of immunity, and fundamental immunological terminology.

CO2: Explain B-cell and T-cell development, antigen processing and presentation, lymphocyte activation, cytokine-mediated regulation, immune tolerance, and transplantation immunology.

CO3: Analyse antigen–antibody reactions, complement pathways, inflammation, opsonization, and other non-specific immune mechanisms.

CO4: Explain different immunization strategies, vaccine types, adjuvants, monoclonal antibodies, and principles of antibody engineering.

CO5: Discuss the immunological basis of infectious diseases, hypersensitivity, autoimmunity, transplantation, immunodeficiency, cancer, and immunotherapy.

PO Mapping Strategy: This course primarily aligns with **Disciplinary Knowledge (PO1), Analytical Reasoning (PO3), and Problem-Solving Skills (PO7)**, with significant contributions to **Critical Thinking (PO2), Research-Related Skills (PO8), and Lifelong Learning (PO9)**.

Mean Calculation:

Each **PO mean** is calculated by taking the average correlation score across all **6 Course Outcomes (COs)**. The **Overall Mean Score of 2.47** indicates a **moderate-to-high level of alignment** between the Immunology and immunotechnology course and the M.Sc. Biotechnology Programme Outcomes.

COURSE OBJECTIVES

The objectives of this course are to:

- Understand the basic principles and techniques of **plant and animal tissue/cell culture**.
- Develop knowledge of **plant and animal genetic manipulation, transgenesis and molecular biotechnology**.
- Understand applications of biotechnology in **crop improvement, animal production, disease diagnosis and therapeutic development**.
- Familiarize students with **molecular markers, cloning, gene transfer, gene therapy and biotechnology-based products**.
- Introduce students to the **ethical, regulatory and commercial aspects** of plant and animal biotechnology.

UNIT – I: PLANT TISSUE CULTURE AND MICROPROPAGATION

Principles and techniques of plant tissue culture; in vitro pollination and fertilization; embryo culture; embryogenesis and organogenesis; micropropagation; haploid production and applications; somaclonal variation; endosperm culture and triploid production; protoplast isolation, culture and regeneration; protoplast fusion and somatic hybridization.

UNIT – II: ANIMAL CELL AND ORGAN CULTURE

Principles and techniques of animal cell culture; culture environment, substrates and media; establishment and maintenance of cell lines; insect cell culture; organ and embryo culture; cryopreservation; valuable products from animal cell culture; artificial insemination, ICSI, embryo transfer and in vitro fertilization; nuclear transplantation and cloning.

UNIT – III: GENETIC ENGINEERING AND TRANSGENESIS

Agrobacterium-mediated gene transfer; Ti and Ri plasmid vectors; viral vectors; direct gene transfer methods including electroporation, microinjection and particle bombardment; transformation of animal cells; cloning and expression vectors; characterization of transgenic organisms; selectable and screenable markers; marker-free strategies and gene targeting; gene silencing.

UNIT – IV: TRANSGENIC PLANTS AND ANIMALS

Applications of transgenic plants in crop improvement; resistance to drought, salinity, herbicides, insects and viruses; biofortified crops; plants as bioreactors; genetically modified foods and their applications, risks and ecological implications. Development and applications of transgenic animals including mice, cattle, goat, sheep and fish; transgenic animal products; molecular farming; therapeutic protein production; embryonic stem cells and their applications.

UNIT – V: MOLECULAR MARKERS, APPLICATIONS AND REGULATORY ASPECTS

PCR and RT-PCR; Southern, Northern and Western blotting; DNA sequencing; DNA fingerprinting; RFLP and RAPD; molecular markers and marker-assisted selection; DNA barcoding; molecular diagnosis and disease biomarkers; genetic correction of disorders and human gene therapy; biotechnology applications in silkworm and pest management; biotechnology-based animal production; animal welfare and ethical considerations; intellectual property rights and patenting of biotechnology inventions; regulatory aspects of genetically modified organisms and biotechnology products.

UNIT – VI: CURRENT CONTOURS (For Continuous Internal Assessment Only)

Recent developments in plant and animal biotechnology, including genome editing, advanced tissue culture, transgenic technologies, molecular farming, stem-cell applications and emerging biotechnological products, through expert lectures, seminars and webinars.

REFERENCES:

1. Slater A., Scott N.W. and Fowler, M.R. (2008). Plant Biotechnology - the genetic manipulation of plants. (2nd) Edition. Oxford University press, USA.
2. Chawla H.S., (2002). Introduction to Plant Biotechnology. Oxford and IBH P Publishing Co. Pvt. Ltd. New Delhi.
3. Phundan Singh. (2013). Principles of Plant Biotechnology. Kalyani Publishers, India.
4. V. Kumaresan. (2015). Applied Plant Biotechnology. Saras Publication, India.
5. Singh. (2014). Plant Biotechnology, (2nd) Revised Edition, Kalyani Publishers, India.
6. B Singh, SK Gautam and MS Chauhan. (2015). Textbook of Animal biotechnology. Teri Publication.
7. M.K. Sateesh. (2010). Biotechnology: V: (Including Animal Cell Biotechnology, Immunology and Plant Biotechnology). 2nd Edition. New Age International Pvt. Ltd. Publishers.
8. Harrison, M.S. and Bal, I.R. (1997). General techniques of all culture Cambridge University press.
9. Prasash M. and Arora. C.K. (1998). Plant tissue culture, Ammol publication Pvt. Ltd.
10. Darling D.C. and Morgan S.J. (1994). Animal cells, culture Media. Wiley, New York.
11. In-vitro cultivation of animal cells. (1994). I. ed., Butter worth – Heinemann Ltd.
12. R. Ian Freshney. (2010). Culture of Animal cells & Manual of basic technique. 6th Edition. Wiley – Blakwell publication.
13. Bernard B. Glick, Jack J. Pastunak. (2009). Molecular Biotechnology principles and application of Recombinant – DNA
14. R. Sasidhara. (2006). Animal Biotechnology. MJP publishers
15. Duhcy R.C. (2007). Text book of biotechnology. S.Chand& Company Ltd.
16. Bobert C. Tait. (1997). An Introduction to Molecular Biology. 1st Edition. Horizon Scientific Press.
17. Bobert Matheson. (1994). Entomology- an introductory course. 2nd Edition. Comstock Publishing Company.

18. <https://nptel.ac.in/courses/102/103/102103016/>
19. <https://www.mooc-list.com/tags/biotechnology>
20. <https://www.coursera.org/courses?query=biotechnology>
21. <http://www.intechopen.com/books/genetic-transformation>
22. <https://link.springer.com/book/10.1007%2F978-3-662-07424-4>
23. <https://link.springer.com/book/10.1007%2F978-81-322-1026>
24. <http://www.ebook777.com/plant-tissue-culture-development-biotechnology/>
25. https://books.google.co.in/books?id=DYRrngEACAAJ&printsec=frontcover&sour ce=gbs_ge_summary_r&cad=0
26. https://books.google.co.in/books?id=DKM_k7M8dAUC&source=gbs_book_other_versions
27. <https://books.google.co.in/books?id=1qacDwAAQBAJ&printsec=frontcover>

COURSE OUTCOMES

On successful completion of the course, students will be able to:

CO1: Explain the principles and applications of plant and animal tissue/cell culture techniques.

CO2: Describe and apply basic approaches used in genetic manipulation, gene transfer and transgenesis.

CO3: Explain the applications of transgenic plants and animals in agriculture, animal production, medicine and industry.

CO4: Apply knowledge of molecular markers, PCR, blotting, sequencing and DNA-based techniques in biotechnology.

CO5: Discuss biotechnology applications along with associated **ethical, regulatory, biosafety and patenting aspects**.

CO6: Evaluate emerging developments and applications in modern plant and animal biotechnology.
plants. Marker assisted selection (MAS) for crop improvement.

PO Mapping Strategy:

This course primarily aligns with Disciplinary Knowledge (PO1), Analytical Reasoning (PO3), and Problem-Solving Skills (PO7), with strong contributions to Critical Thinking (PO2), Research-Related Skills (PO8), and Lifelong Learning (PO9). It provides a strong foundation in plant and animal tissue culture, genetic engineering, transgenesis, molecular markers, biotechnology applications, and emerging technologies, supporting advanced research and professional applications in biotechnology.

Mean Calculation:

Each PO mean is derived by calculating the average correlation score across all 6 Course Outcomes (COs). The Overall Mean Score of **2.53** indicates a moderate-to-high level of alignment between the Plant and Animal Biotechnology course and the M.Sc. Biotechnology Programme Outcomes.

COURSE OBJECTIVES:

The main objectives of this course are to:

- Provide hands on training on plant and animal tissue culture technology.
- Acquire knowledge on DNA isolation from animal cell
- Understand about the establishment and maintenance of cultures.
- Illustrate Antigen – antibody interaction

EXPERIMENTS:**IMMUNOLOGY & IMMUNOTECHNOLOGY**

1. Preparation of plasma and serum from the collected blood samples.
2. Precipitation techniques– Agar gel diffusion, counter immuno-electrophoresis, single radial immuno-diffusion, rocket immuno-electrophoresis (Hands on).
3. Agglutination techniques -Blood grouping and Rh factor; Latex agglutination – RF, HBsAg and CRP.
4. WIDAL test
5. Labelled Assays - Enzyme Linked Immunosorbent Assay (ELISA), Immunofluorescence (IF), and Immunohistochemistry (IH).

PLANT BIOTECHNOLOGY

1. Introduction to the laboratory and general Safety Practices for plant cell, Plant growth and development. Laboratory Report Guidelines (Demo).
2. Aseptic culture techniques for establishment and maintenance of cultures.
3. Tissue culture media preparation – Seedling and Callus culture
4. Protoplast isolation – 1. Mechanical and 2. Enzymatic method.
5. Protoplast culture
6. Isolation of plant genomic DNA
7. Size analysis of DNA by Agarose Electrophoresis
8. Transformation of leaf discs with Agrobacterium
9. Regeneration abilities of the Shoot Apical Meristem (SAM).
10. Preparation of chloroplast from pea

ANIMAL BIOTECHNOLOGY

1. Preparation of animal tissue culture media
2. Isolation of DNA from Animal liver
3. Cytotoxicity Assay
4. Stem Cell Isolation
5. Human PBMC isolation
6. Isolation of primary cell culture

REFERENCES:

1. Richard A. Goldsby, Thomas J. Kindt. Barbara, A. Osborne, Janis Kuby. 2003. Immunology. 5th Edition, W. H. Freeman & Company.
2. Topley and Wilson. G. Wilson, A.Miles, M.T.Paker. Arnold, Heineman, 1984. Principles of Bacteriology, Virology and immunology. Willy – Blackwell.
3. M. S. Clark. 1997. Plant Molecular Biology: A Laboratory Manual. Springer-
4. Slater A., Scott N.W. and Fowler, M.R. 2008. Plant Biotechnology - the
5. genetic manipulation of plants. 2nd Edition. Oxford University press, USA.
6. Harrison, M.S. and Bal, I.R. 1997. General techniques of all culture Cambridge University press.
7. Prasash M. and Arora. C.K. 1998. Plant tissue culture, Ammol publication Pvt. Ltd.
8. Darling D.C. and Morgan S.J. 1994. Animal cells, culture Media. Wiley, New York.
9. Razdan, M. K. (1993). An Introduction to Plant Tissue Culture. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi, Calcutta. India.
10. Reinert, J and Y. P. S. Bajaj (1995). Plant Tissue and Organ Culture: Applied and fundamental aspects. Narosa publishing House, New Delhi, India.
11. Vasil, I. K. and Thorpe. T. A. (1994). Plant Cell and Tissue Culture. Kluwer Academic Publishers. The Netherlands.
12. <https://archive.nptel.ac.in/courses/102/107/102107075/>

IMMUNOLOGY & IMMUNOTECHNOLOGY, PLANT AND ANIMAL BIOTECHNOLOGY PRACTICAL		
S. No.	Course Outcome	Knowledge Level
Upon completion of the course, the students will be able to		
C01	Prepare culture medium and transfer cultures without contamination.	K3
C02	Sterilize instruments, lab wares, culture media and explants.	K3
C03	Design and prepare various culture media, stock solutions of inorganic salts, growth regulators.	K4
C04	Identify appropriate explant and learn inoculation techniques into suitable culture media under sterile condition.	K3
C05	Use the techniques for isolation of DNA from animal and its size analysis by agarose gel electrophoresis.	K3
C06	culture Perform transformation of Agrobacterium	K3
C07	Have the capability to perform the techniques for protoplast isolation	K3
C08	Acquire knowledge on qualitative and quantitative methods on antigen – antibody interaction	K2

MAPPING WITH PROGRAMME OUTCOMES

- **PO Mapping Strategy:** This practical course strongly supports PO1 (Disciplinary Knowledge), PO2 (Critical Thinking and Problem Solving), PO3 (Practical and Technical Skills), PO4 (Scientific Reasoning), PO5 (Modern Tool Usage), PO6 (Research Aptitude), PO7 (Teamwork), PO8 (Ethics and Biosafety), PO9 (Communication Skills), and PO10 (Lifelong Learning) through hands-on training in immunological techniques, plant tissue culture, molecular biology, animal cell culture, and biotechnology laboratory practices.
- **Mean Calculation:** Each CO mean is derived by calculating the average correlation score across all 10 POs. The Overall Mean Score of 2.65 indicates a moderate-to-high level of alignment between the course and the programme outcomes.

COURSE OBJECTIVES:

- To introduce the principles and applications of Artificial Intelligence (AI) in biotechnology and life sciences.
- To provide knowledge on machine learning, deep learning, and data analytics for biological data.
- To understand AI-assisted approaches in genomics, proteomics, drug discovery, and precision medicine.
- To familiarize students with AI applications in healthcare, agriculture, environmental biotechnology, and industrial biotechnology.
- To explore ethical, legal, regulatory, and future perspectives of Artificial Intelligence in biotechnology.

UNIT – I: Introduction to Artificial Intelligence in Biotechnology

Definition, history, and scope of Artificial Intelligence. Fundamentals of AI, Machine Learning (ML), Deep Learning (DL), Neural Networks, and Data Science. Types of AI. Biological databases. Big Data in biotechnology. AI workflow in life science research. Applications of AI in biotechnology.

UNIT – II: Machine Learning for Biological Data Analysis

Types of Machine Learning: Supervised, Unsupervised, and Reinforcement Learning. Data preprocessing and feature selection. Classification and clustering algorithms. Pattern recognition. AI tools for genomics, transcriptomics, proteomics, metabolomics, and biological image analysis. Introduction to Python and AI software used in biotechnology.

UNIT – III: Artificial Intelligence in Drug Discovery and Healthcare

AI-assisted drug discovery and drug repurposing. Virtual screening. Molecular docking integrated with AI. Protein structure prediction. Biomarker identification. Precision medicine. AI in molecular diagnostics. Medical imaging. Clinical decision support systems. AI applications in vaccine development and personalized medicine.

UNIT – IV: AI Applications in Industrial, Agricultural and Environmental Biotechnology

AI in bioprocess optimization. Fermentation monitoring. Process control using intelligent systems. AI applications in precision agriculture, crop improvement, disease diagnosis, smart biosensors, environmental monitoring, waste management, synthetic biology, and bioinformatics.

UNIT – V: Ethics, Regulations and Emerging Trends

Ethical issues in AI. Responsible AI in healthcare and biotechnology. Data privacy and security. Regulatory guidelines. Explainable AI (XAI). Internet of Medical Things (IoMT). Digital twins. AI-assisted CRISPR genome editing. Generative AI in biological research. Future prospects of AI in biotechnology.

UNIT – VI: Current Contours (Self-Directed Learning for Continuous Internal Assessment Only)

Students shall review a recent research article on AI applications in biotechnology, prepare a case study on AI-assisted drug discovery or disease diagnosis, perform a hands-on demonstration using an open-source AI tool (Google Colab/Python/Orange Data Mining), and present a seminar on recent innovations in Artificial Intelligence for biological research.

Recommended Books & References

1. Kevin P. Murphy. Machine Learning: A Probabilistic Perspective. MIT Press.
2. Trevor Hastie, Robert Tibshirani & Jerome Friedman. The Elements of Statistical Learning.
3. Aurélien Géron. Hands-On Machine Learning with Scikit-Learn, Keras & TensorFlow.
4. Pierre Baldi & Søren Brunak. Bioinformatics: The Machine Learning Approach.
5. Mohammed J. Zaki & Wagner Meira Jr. Data Mining and Machine Learning: Fundamental Concepts and Algorithms.
6. Andrew Ng. Machine Learning Yearning.
7. National Institutes of Health (NIH) Guidelines on Artificial Intelligence in Biomedical Research.
8. OECD Principles on Artificial Intelligence.
9. WHO. Ethics and Governance of Artificial Intelligence for Health.

Course Outcomes

S. No.	Upon completion of the course, the students will be able to
CO1	Explain the fundamental concepts and applications of Artificial Intelligence in biotechnology.
CO2	Apply machine learning techniques for analyzing biological datasets.
CO3	Explain AI-assisted approaches in genomics, proteomics, drug discovery, and healthcare.
CO4	Analyze the role of Artificial Intelligence in industrial, agricultural, environmental, and healthcare biotechnology.
CO5	Evaluate ethical, legal, regulatory, and emerging AI technologies in biotechnology.

PO Mapping Strategy:

This course primarily aligns with **Disciplinary Knowledge (PO1), Critical Thinking (PO2), Analytical Reasoning (PO3), Problem-Solving Skills (PO7), and Lifelong Learning (PO9)**. It develops computational and analytical capabilities through machine learning, biological data analysis, AI-assisted drug discovery, healthcare applications, bioprocess optimization, and emerging AI technologies, while also promoting research-oriented and responsible application of AI in biotechnology.

Mean Calculation:

Each **PO mean** is derived by calculating the average correlation score across all **5 Course Outcomes (COs)**. The **Overall Mean Score of 2.46** indicates a **moderate-to-high level of alignment** between the *Artificial Intelligence in Biotechnology* course and the M.Sc. Biotechnology Programme Outcomes.

COURSE OBJECTIVES:

- To understand the principles, significance, and historical development of molecular diagnostics in clinical laboratories.
- To learn various molecular techniques used for nucleic acid extraction, amplification, mutation detection, and genomic analysis.
- To develop knowledge of sample collection, preparation, storage, and analytical procedures used in molecular diagnostic testing.
- To understand quality assurance, standardisation, and validation procedures in molecular diagnostic laboratories.
- To evaluate the clinical applications, ethical considerations, and legal aspects of molecular genetic testing.

UNIT – I: Introduction to Molecular Diagnostics and Nucleic Acid Amplification

Introduction and historical perspective of the clinical diagnostic laboratory. Principles and significance of molecular diagnostics. Methods for the extraction of nucleic acids (DNA and RNA). Methods for nucleic acid amplification: Polymerase Chain Reaction (PCR) and its modifications, including Multiplex-PCR, Sequence-Specific Primer PCR (SSP-PCR), Nested PCR, Reverse Transcriptase PCR (RT-PCR), and Real-Time PCR. Applications of amplification techniques in clinical diagnosis.

UNIT – II: Mutation Detection and Advanced Diagnostic Technologies

Methods for mutation detection: PCR-Restriction Fragment Length Polymorphism (PCR-RFLP), DNA Sequencing, Reverse Hybridization Assay, Multiplex Ligation-Dependent Probe Amplification (MLPA), and Allele-Specific PCR. Next Generation Sequencing (NGS): Applications, global review of NGS platforms, and clinical NGS in practice. Other clinical diagnostic technologies: Flow Cytometry, Fluorescence In Situ Hybridization (FISH), Immunohistochemistry (IHC), and Laser Capture Microdissection using Formalin-Fixed Paraffin-Embedded (FFPE) tissues.

UNIT – III: Quality Assurance in Molecular Diagnostics

Framework for quality assurance in molecular diagnostic laboratories. Verification and validation of molecular assays. Standards and standardization in molecular diagnostics. Laboratory-developed tests (LDTs) in molecular diagnostics. Quality control measures, accreditation requirements, documentation, and regulatory compliance in diagnostic laboratories.

UNIT – IV: Clinical Applications of Molecular Diagnostics

Applications of molecular diagnostics in genetic diseases. Molecular diagnostics of coagulation disorders and cystic fibrosis. Prenatal genotyping. Applications of molecular diagnostics in human cancers. Molecular diagnostics for infectious diseases. Identity-based testing, including HLA typing using molecular methods. Molecular analysis for forensic casework and parentage testing. Molecular

assessment of bone marrow transplant engraftment. Personalised medicine and precision healthcare.

UNIT – V: Genetic Counselling and Ethical Issues in Molecular Diagnostics

Genetic counselling considerations in molecular diagnosis. Ethical, social, and legal issues related to molecular genetic testing. Patient confidentiality, informed consent, genetic discrimination, and privacy concerns. Regulatory guidelines governing molecular diagnostic testing. Emerging challenges and future perspectives in molecular diagnostics.

UNIT VI: CURRENT CONTOURS (CIA ONLY)

Critical review and discussion of recent research publications and advancements in the course topics, introduced through expert lectures, online seminars, or webinars.

Recommended Books and References

1. Coleman, W. B., & Tsongalis, G. J. (Eds.). Molecular Diagnostics: For the Clinical Laboratorian. Springer-Verlag New York, LLC.
2. Buckingham, L., & Flaws, M. L. Molecular Diagnostics: Fundamentals, Methods and Clinical Applications. F.A. Davis Company, First Edition, 2007.
3. Leonard, D. G. B. Molecular Pathology in Clinical Practice. Springer.
4. Persing, D. H., Tenover, F. C., Hayden, R. T., et al. Molecular Microbiology: Diagnostic Principles and Practice. ASM Press.
5. Current guidelines and publications from WHO, CDC, CAP, and other regulatory agencies related to molecular diagnostics.

Course Outcomes:

S. No.	Course Outcome	Knowledge Level
Upon completion of the course, the students will be able to		
C01	Understand the molecular diagnostic aspects, their significance, and goals in clinical laboratory practice.	K2
C02	Explain the principles and applications of various molecular techniques used for diagnosis of pathogenic and genetic conditions.	K3
C03	Develop awareness of sample types, preparation methods, handling, and storage requirements for molecular diagnostic testing	K4
C04	Understand quality assurance, assay validation, and standardization procedures followed in molecular diagnostic laboratories	K5
C05	Evaluate ethical, social, and legal issues associated with molecular genetic testing and genetic counseling.	K6

MAPPING WITH PROGRAMME OUTCOMES

PO Mapping Strategy: The course demonstrates strong alignment with Disciplinary Knowledge (**PO1**), Laboratory Proficiency (**PO2**), Problem Solving (**PO3**), Research Aptitude (**PO4**), Modern Tool Usage (**PO5**), Ethics and Professionalism (**PO6**), and Lifelong Learning (**PO10**).

Mean Calculation: Each PO mean is derived by calculating the average correlation score across all Course Outcomes (COs). The Overall Mean Score of **1.88** indicates a moderate-to-high level of alignment between the course outcomes and the M.Sc. Biotechnology Programme Outcomes, highlighting the course's contribution to advanced molecular diagnostics, clinical biotechnology, research aptitude, and professional practice.

COURSE OBJECTIVES

The objectives of this course are to:

- Understand the fundamental principles of **food biotechnology, food microbiology and food fermentation**.
- Develop knowledge of microorganisms involved in the production and preservation of fermented foods.
- Explain the application of **enzymes, probiotics, prebiotics and microbial cultures** in food processing and functional foods.
- Understand modern biotechnological approaches for **food quality, safety, preservation and authentication**.
- Familiarize students with **genetic engineering, molecular diagnostics and emerging technologies** used in food biotechnology.
- Develop awareness of food regulations, biosafety, food-borne pathogens and current trends in biotechnology-based food production.

UNIT – I: FUNDAMENTALS OF FOOD BIOTECHNOLOGY

Introduction and scope of food biotechnology; Food science; Food microbiology - Microorganisms associated with foods - Beneficial and harmful microorganisms - Factors affecting microbial growth in foods; Food spoilage; Food preservation; starter cultures and selection; food fermentation.

UNIT – II: FOOD FERMENTATION AND MICROBIAL PRODUCTS

Microbial fermentation of food and beverages; production - yoghurt, cheese, fermented vegetables, bread and traditional fermented foods; alcoholic and non-alcoholic beverages; microbial production of organic acids, amino acids, vitamins and food additives; microbial enzymes; single-cell protein; microbial biomass; value-added food products.

UNIT – III: FUNCTIONAL FOODS

Probiotics; Prebiotics and Synbiotics; Postbiotics - mechanisms and health benefits; Psychobiotic bacteria; Nutraceuticals - Bioactive peptides; Dietary fibres-omega-3 fatty acids; antioxidants; fermented functional foods;

UNIT – IV: FOOD SAFETY AND MOLECULAR BIOTECHNOLOGY

Food-borne pathogens and toxins; microbial contamination; rapid detection of food-borne microorganisms; PCR and real-time PCR in food analysis; DNA-based identification and authentication of food materials; Food quality - biosensors and immunological methods; genetically modified foods; allergen detection; traceability and molecular authentication of food products.

UNIT – V: EMERGING TRENDS IN FOOD BIOTECHNOLOGY

Advanced fermentation technologies - microbial cell factories for production of food ingredients, enzymes, vitamins and bioactive compounds; precision fermentation and novel food production; plant-based and microbial protein production; cultured meat and cellular agriculture; food waste valorization and

circular bioeconomy; development of sustainable, nutritious and safe foods using biotechnology.

UNIT – VI: CURRENT CONTOURS (For Continuous Internal Assessment Only)

Recent developments in food biotechnology, including precision fermentation, alternative proteins, novel probiotics, genome editing, AI-assisted food development and sustainable food processing, will be discussed through expert lectures, seminars, webinars and research articles.

Textbooks

1. Ray, R. C. (2020). Microbial Biotechnology in Food and Health. Elsevier.
2. Nevárez-Moorillón, G. V., et al. (2020). Food Microbiology and Biotechnology: Safe and Sustainable Food Production. Apple Academic Press.
3. Brandelli, A. (2021). Probiotics: Advanced Food and Health Applications. Elsevier.
4. Cruz, A. G., et al. (2021). Probiotics and Prebiotics in Foods: Challenges, Innovations, and Advances. Academic Press.
5. Adams, M. R., McClure, P. J., and Moss, M. O. (2024). Food Microbiology (5th ed.). Royal Society of Chemistry.

Reference Books

1. Rai, A. K., et al. (2021). Current Developments in Biotechnology and Bioengineering: Technologies for Production of Nutraceuticals and Functional Food Products. Elsevier.
2. Kumar, A., Patruni, K., and Singh, V. (2022). Recent Advances in Food Biotechnology. Springer.
3. Paramithiotis, S., et al. (2022). Lactic Acid Bacteria in Food Biotechnology: Innovations and Functional Aspects. Elsevier.
4. Handu, S., et al. (2024). Functional Foods and Nutraceuticals: Chemistry, Health Benefits and the Way Forward. Springer.
5. Doyle, M. P., Diez-Gonzalez, F., and Hill, C. (2020). Food Microbiology: Fundamentals and Frontiers (5th ed.). ASM Press.
6. Gálvez, A., Abriouel, H., López, R. L., and Ben Omar, N. (2018). Food Protection by Lactic Acid Bacteria: Antimicrobials and Functional Foods. Springer.
7. Hutkins, R. W. (2018). Microbiology and Technology of Fermented Foods (2nd ed.). Wiley-Blackwell.
8. Sun-Waterhouse, D. (2021). The Role of Functional Foods in Health and Disease. Academic Press.
9. A. Ashokkumar. (2020). Enzymes in Food Biotechnology: Production, Applications, and Future Prospects. Academic Press.
10. Fellows, P. J. (2017). Food Processing Technology: Principles and Practice (4th ed.). Woodhead Publishing.

COURSE OUTCOMES

On successful completion of the course, students will be able to:

CO1: Explain the fundamental principles of **food biotechnology, food microbiology, food spoilage and fermentation.**

CO2: Describe and evaluate the role of microorganisms and enzymes in **food fermentation and production of value-added food products.**

CO3: Explain the applications of **probiotics, prebiotics, postbiotics, functional foods and nutraceuticals** in human health.

CO4: Apply molecular and biotechnological approaches for **food safety, pathogen detection, food authentication and quality assessment**.

CO5: Analyze advanced applications of biotechnology in **genetically modified foods, precision fermentation, alternative proteins, genome editing and sustainable food production**.

CO6: Evaluate emerging developments in food biotechnology and their **industrial, nutritional, environmental, ethical and regulatory implications**.

PO Mapping Strategy:

This course primarily aligns with **Disciplinary Knowledge (PO1), Problem-Solving Skills (PO7), Research-Related Skills (PO8), and Lifelong Learning (PO9)**, with strong engagement in **Critical Thinking (PO2), Analytical Reasoning (PO3), and Scientific Reasoning (PO4)**. biotechnology, research literature, emerging technologies, food safety and industrial applications. These PO descriptions follow the supplied M.Sc. programme outcomes.

Mean Calculation:

Each CO mean is derived by calculating the **average correlation score across all 10 POs**. Based on the CO–PO mapping, the **Overall Mean Score is 2.30**, indicating a **moderate-to-high level of alignment** between the Food Biotechnology course and the programme outcomes.

COURSE OBJECTIVES:

- To introduce the historical and contemporary importance of natural products in modern drug discovery.
- To impart comprehensive knowledge regarding various classes of plant secondary metabolites.
- To understand the downstream processing, extraction, and standardization of herbal drugs.
- To identify the therapeutic applications and ethnobotanical value of indigenous medicinal plants.
- To explore the regulatory compliance, frameworks, and safety evaluation of herbal medicines.

UNIT – I: Introduction to Natural Products

Definition, history, and significance of natural products. Classification, biosynthesis, and structural characteristics of major secondary metabolites: Alkaloids, glycosides, flavonoids, and terpenoids. Role of natural products in traditional systems of medicine and modern pharmacology.

UNIT – II: Pharmacognosy and Plant Materials

Morphology, microscopy, and physical evaluation of medicinal plants. Standard protocols for the collection, harvesting, drying, and storage of crude drugs. Core principles of plant extraction: maceration, percolation, and Soxhlet extraction.

UNIT – III: Phytochemical Analysis

General qualitative screening tests for various phytoconstituents. Basic principles and applications of chromatography (TLC, HPTLC) and spectroscopy (UV-Visible) in the identification and isolation of herbal active principles.

UNIT – IV: Herbal Formulations and Standardization

Overview and preparation of traditional herbal formulations: Churna, Vati, Asava, Arishta, and medicated oils. Importance of quality control and standardization parameters according to WHO guidelines: ash values, extractive values, and microbial limit tests.

UNIT – V: Pharmacology of Herbal Medicine

Detailed pharmacognostic study of selected medicinal plants: Aloe vera, Curcuma longa, Ocimum sanctum, Withania somnifera, and Centella asiatica. Evaluation of their primary pharmacological activities: Antioxidant, anti-inflammatory, and hepatoprotective properties.

UNIT – VI: Current Contours (Self-Directed Learning for Continuous Internal Assessment Only)

Students are required to document the ethnobotanical and traditional uses of medicinal plants in their local region, perform a laboratory-scale mini-project on

the preparation of a simple herbal extract, and present a structured report on the safety and toxicological profile of a chosen Ayurvedic formulation.

Recommended Books, References, and e-Books

1. Textbook of Pharmacognosy, C.K. Kokate, A.P. Purohit, and S.B. Gokhale, Nirali Prakashan, 2022.
2. Trease and Evans Pharmacognosy, William Charles Evans, Saunders Ltd, 2009.
3. Pharmacognosy and Phytochemistry, Vinod D. Rangari, Career Publications, 2017.
4. Quality Control Methods for Medicinal Plant Materials, World Health Organization (WHO), 2011.

NATURAL PRODUCTS AND HERBAL MEDICINE		
S. No.	Course Outcome	Knowledge Level
Upon completion of the course, the students will be able to		
C01	Classify different types of plant secondary metabolites and their significance.	K2
C02	Execute basic extraction and characterization methods for plant materials.	K3
C03	Explain the standardization parameters for herbal drugs based on WHO guidelines.	K2
C04	Analyze the therapeutic potential and clinical mechanisms of selected indigenous medicinal plants.	K4
C05	Evaluate the safety profiles, regulatory standards, and broad pharmacological activities of herbal medicines.	K5

MAPPING WITH PROGRAMME OUTCOMES (POs)

PO Mapping Strategy: The mapping reflects the strong alignment of Natural Products and Herbal Medicine with Disciplinary Knowledge (PO1), Laboratory Proficiency (PO2), and Research Aptitude (PO4).

Mean Calculation: The Overall Mean Score of **2.34** indicates a high level of alignment between the course and the programme outcomes.

COURSE OBJECTIVES:

- To understand the different levels and measurements of biodiversity.
- To evaluate the ecological, economic, ethical, and cultural values of biodiversity.
- To analyse the major drivers responsible for biodiversity loss.
- To identify biodiversity hotspots and prioritise conservation efforts.
- To examine conservation strategies and legal frameworks for biodiversity protection.

UNIT – I: Levels and Measurements of Biodiversity

Hierarchical levels of biodiversity: Genetic diversity, species diversity, and ecosystem diversity. Quantification of biodiversity using species richness and species evenness. Diversity indices: Shannon-Wiener Index, Simpson's Index, Alpha, Beta, and Gamma diversity.

UNIT – II: Ecological Importance and Values of Biodiversity Ecosystem services, economic values, ethical and aesthetic values, traditional ecological knowledge, community biodiversity registers, biopiracy, and indigenous rights.

UNIT – III: Drivers of Biodiversity Loss

The H.I.P.P.O framework: Habitat loss, invasive species, pollution, population pressures, and overexploitation. Climate change and biodiversity loss.

UNIT – IV: Identification and Prioritisation of Biodiversity, biodiversity hotspots, mega-diversity regions, Western Ghats, Indo-Burma, indicator species, flagship species, and keystone species.

UNIT – V: Conservation Strategies and Legal Frameworks: In-situ and ex-situ conservation. Convention on Biological Diversity (CBD), Kunming-Montreal Global Biodiversity Framework, Biological Diversity Act, and National Biodiversity Authority.

UNIT – VI: CURRENT CONTOURS (For Continuous Internal Assessment Only)

Recent developments in biodiversity conservation, including environmental DNA (eDNA), DNA barcoding, remote sensing and GIS, AI-based biodiversity monitoring, restoration ecology, nature-based solutions, citizen science, and digital biodiversity databases, will be discussed through expert lectures, seminars, webinars and recent research articles.

Textbooks

1. Primack, R. B. (2023). Essentials of Conservation Biology (7th ed.). Sinauer Associates/Oxford University Press.
2. Hunter, M. L., Jr., and Gibbs, J. P. (2014). Fundamentals of Conservation Biology (4th ed.). Wiley-Blackwell.
3. Gaston, K. J., and Spicer, J. I. (2004). Biodiversity: An Introduction (2nd ed.). Blackwell Publishing.

4. Krishnamurthy, K. V. (2020). An Advanced Textbook on Biodiversity: Principles and Practice. Oxford & IBH Publishing.
5. Singh, J. S., Singh, S. P., and Gupta, S. R. (2017). Ecology, Environmental Science and Conservation. S. Chand Publishing.

Reference Books

1. Sodhi, N. S., and Ehrlich, P. R. (2010). Conservation Biology for All. Oxford University Press.
2. Primack, R. B. (2014). A Primer of Conservation Biology (5th ed.). Sinauer Associates.
3. Wilson, E. O. (2016). Half-Earth: Our Planet's Fight for Life. Liveright Publishing.
4. Secretariat of the Convention on Biological Diversity. (2022). Kunming-Montreal Global Biodiversity Framework. Convention on Biological Diversity.
5. National Biodiversity Authority. (2023). Biological Diversity Act, 2002 and Biological Diversity Rules. Government of India.
6. Ministry of Environment, Forest and Climate Change. (2023). National Biodiversity Action Plan and Biodiversity Conservation Framework. Government of India.
7. IUCN. (2024). The IUCN Red List of Threatened Species

Course Outcomes:

S. No.	Course Outcome	Knowledge Level
Upon completion of the course, the students will be able to		
CO1	Differentiate and evaluate biodiversity at genetic, species, and ecosystem levels.	K2
CO2	Calculate and interpret biodiversity indices such as Shannon-Wiener and Simpson's Index.	K3
CO3	Analyse the major drivers of biodiversity loss using the H.I.P.P.O framework.	K3
CO4	Assess biodiversity hotspots and prioritise conservation actions.	K4
CO5	Critically evaluate conservation strategies within legal frameworks	K5

MAPPING WITH PROGRAMME OUTCOMES

PO Mapping Strategy: The course demonstrates strong alignment with **Disciplinary Knowledge (PO1), Problem Solving (PO3), Research Aptitude (PO4), Ethics and Professionalism (PO6), Environmental Sustainability (PO7), and Lifelong Learning (PO10).**

Mean Calculation: The **Overall Mean Score of 1.96** indicates a moderate-to-high level of alignment between the course outcomes and the programme outcomes, reflecting the course's contribution to biodiversity conservation, ecological awareness, and sustainable development.

COURSE OBJECTIVES

The objectives of this course are to:

- Introduce the fundamental concepts of Artificial Intelligence, Machine Learning, Deep Learning, and Data Science and their applications in biotechnology.
- Develop an understanding of machine learning approaches for biological data analysis, including genomics, transcriptomics, proteomics and metabolomics.
- Familiarize students with AI-assisted drug discovery, protein structure prediction, molecular docking, precision medicine and healthcare applications.
- Explain the applications of AI in industrial, agricultural and environmental biotechnology, including bioprocess optimization and intelligent monitoring.
- Develop awareness of ethical, legal, regulatory and responsible AI practices and emerging technologies such as generative AI, digital twins and AI-assisted genome editing.

UNIT – I:

Introduction to Nanobiotechnology: Definition and concepts, biological, microbial and nano world. Nanomaterials: nanoparticles, nanowires, nanoclusters, nanotubes, nanocomposites, nanovesicles, nanospheres and nanocapsules. Biomolecules as nanomaterials: lipids as nanobridges, proteins as nanomolecules, polysaccharides and nucleic acids in nanotechnology.

UNIT – II:

Biological synthesis of nanomaterials: Synthesis of nanomaterials using plants, extracellular synthesis of nanoparticles by bacteria, extracellular and intracellular synthesis of nanoparticles by fungi. Production of bacterial magnetosomes, hybrid nano-conjugates, DNA-oligomers and aptamers. Optimization of parameters for biological synthesis of nanoparticles. Advantages and limitations of biological synthesis of nanomaterials.

UNIT – III:

Characterization of nanomaterials: Confirmation of synthesis and characterization by UV-Vis spectroscopy, X-ray diffraction (XRD), Transmission electron microscopy (TEM), Scanning electron microscopy (SEM), Selected-area electron diffraction (SAED), Energy dispersive x-ray analysis (EDAX) AFM, Infrared (IR) and Thermo gravimetric analysis (TGA) analysis.

UNIT – IV:

Applications of nanomaterials in medicine, agriculture and environment: Medical applications-Nanomedicines, drug delivery, nanoparticles for pathogen detection, nanodevices, diagnosis and imaging. Nano-based antimicrobial agents and cosmetics. Agricultural applications- Nanofertilizers, Nanopesticides, Nanopigments, Food processing and Smart packing. Nanoparticles for compound

and gene delivery. Environmental applications: Antimicrobial nanoparticles in textile industry, Nanopaints and Nanofilters. Nanocatalysts for degradation of pollutants.

UNIT – V:

Impact, ethical issues, challenges, patent issues in nanotechnology. Health and environment risk assessments. Nanoeconomy and commercialization. Impact of nanotechnology on society.

UNIT – VI: CURRENT CONTOURS (For Continuous Internal Assessment Only)

Recent developments in nanobiotechnology, including green synthesis of nanomaterials, nano-enabled drug delivery, nanodiagnostics, nanoformulations in agriculture, nanobiosensors, environmental nanotechnology, and emerging nano-based therapeutic applications, through expert lectures, seminars and webinars.

Text Books:

1. D. E. Reisner, Joseph D. Bronzino. Bionanotechnology: Global Prospects. CRC Press (2008).
2. E. Papazoglou and A. Parthasarathy. Bionanotechnology. Morgan & Claypool publishers (2007).
3. E. Gazit. Plenty of room for Biology at the Bottom: An Introduction to Bionanotechnology. Imperial College Press (2006).

References:

1. C. M. Niemeyer, C. A. Mirkin, -Nanobiotechnology: Concepts, Application and Perspectives, Wiley – VCH, (2004).
2. T. Predeep, - Nano: The Essentials, McGraw – Hill education, (2007).
3. D. S. Goodsell, - Bionanotechnology, John Wiley & Sons, (2004).

Course Outcomes:

Students will acquire knowledge on the basic concepts of biological nanomaterials and their utility in health, agriculture and environment.

S. No.	NANOBIOTECHNOLOGY	Knowledge Level
Upon completion of the course, the students will be able to		
CO1	Apply the principles of nanobiotechnology and explain the synthesis, properties, and characterization of nanomaterials used in biological systems.	K3
CO2	Understand the applications of nanobiotechnology in medicine, agriculture, food and environmental sciences.	K2
CO3	Recall the basic concepts, terminology, and types of nanomaterials and nanoparticles.	K1
CO4	Design innovative nanobiotechnology- based approaches for Diagnosis, drug delivery, biosensors, and environmental remediation.	K6
CO5	Evaluate the advantages, Limitations, safety, ethical issues, and future prospects of nanobiotechnology.	K5

PO Mapping Strategy:

This course primarily aligns with Disciplinary Knowledge (**PO1**), Critical Thinking (**PO2**), Analytical Reasoning (**PO3**), and Problem-Solving Skills (**PO7**), with significant contributions to Research-Related Skills (**PO8**) and Lifelong Learning (**PO9**). The course develops computational and analytical capabilities through AI, machine learning, biological data analysis, drug discovery, precision medicine and biotechnology applications, preparing students for emerging research and professional opportunities in computational biotechnology.

Mean Calculation:

Each PO mean is derived by calculating the average correlation score across all 5 Course Outcomes (COs). The Overall Mean Score of **2.46** indicates a moderate-to-high level of alignment between the Artificial Intelligence in Biotechnology course outcomes and the M.Sc. Biotechnology Programme Outcomes.

Course Objectives

- To understand the principles of upstream bioprocessing, including the isolation, screening, selection of industrial microorganisms, media formulation, sterilization techniques, and process monitoring for large-scale fermentation.
- To acquire knowledge of downstream processing techniques involved in the recovery, purification, quality assurance, economic evaluation, and commercialization of biotechnological products.
- To gain comprehensive knowledge of the design, construction, operation, and scale-up of various fermenters and bioreactors used in microbial, plant, and animal cell culture processes.
- To understand the role of microorganisms in environmental biotechnology, including biodegradation, bioremediation, wastewater treatment, solid waste management, pollution control, and environmental sustainability.
- To familiarize students with renewable bioenergy technologies, environmental management strategies, biosafety regulations, circular bioeconomy, and emerging technologies, including Artificial Intelligence applications in environmental biotechnology.

UNIT – I: Upstream Processing in Bioprocess Technology

Introduction to bioprocess technology – upstream and downstream events-generalized process flow sheets; upstream processing- scope and importance in industrial biotechnology. Isolation and selection of industrially important microorganisms from natural sources. Primary, secondary screening methods and high-throughput screening. Media formulation and optimization, including carbon and nitrogen sources, minerals, vitamins, growth factors, precursors, inducers, inhibitors, antifoaming agents. Sterilization of media, fermenters, air and ancillary equipment. Process monitoring and control of pH, temperature, dissolved oxygen, agitation, aeration, foam formation and contamination during fermentation.

UNIT – II: Downstream Processing in Bioprocess Technology

Recovery and purification of fermentation products: Objectives and criteria – Foam separation – precipitation methods – Filtration devices and filter aids – Industrial scale centrifugation and cell disruption methods – Liquid –liquid extraction – solvent recovery – chromatography – two phase aqueous methods – super critical fluid extraction – crystallization and whole broth processing. Product polishing, crystallization, drying (spray drying and freeze drying), formulation, packaging, storage, quality control, quality assurance, and Good Manufacturing Practices (GMP). Fermentation economics: objectives - market potential –economic measures in plant and equipment, media and cooling processes –process economics –capital costs, operating cost and product cost estimation

UNIT – III: Types of Fermenters bioreactors

Introduction to fermenters and bioreactors, design principles, construction materials, and essential components including vessel, agitator, baffles, sparger, sensors, cooling system, sampling ports, and foam control devices. Types of fermenters including stirred tank fermenter, bubble column fermenter, airlift fermenter, tower fermenter, packed-bed bioreactor, fluidized-bed bioreactor, membrane bioreactor, photobioreactor, hollow-fiber bioreactor, and rotating drum bioreactor. Specialized bioreactors for plant, animal and microbial cell cultures. Modes of fermentation including batch, fed-batch, continuous, repeated-batch, submerged and solid-state fermentation. Scale-up and scale-down of fermentation processes from laboratory to pilot and industrial production, including criteria and challenges associated with large-scale bioprocess operations.

UNIT – IV: Environmental Biotechnology

Microbial ecology and microbial diversity in terrestrial and aquatic ecosystems. Microbial interactions in natural environments. Environmental pollution: sources, types, and impact on ecosystems. Biodegradation of organic pollutants, xenobiotics, pesticides, hydrocarbons, plastics, and industrial effluents. Bioremediation strategies including in situ and ex situ bioremediation, phytoremediation. Microbial treatment of municipal and industrial wastewater. Solid waste management, composting, vermicomposting and anaerobic digestion. Biomonitoring, bioindicators, biosensors, environmental impact assessment and applications of environmental biotechnology in pollution control and sustainable development.

UNIT – V: Environmental Management and Emerging Technologies

Renewable bioenergy resources: biogas, bioethanol, biodiesel, biohydrogen, and algal biofuels. Carbon sequestration and microbial roles in climate change mitigation. Biogeochemical cycling of carbon, nitrogen, sulfur and phosphorus. Biofertilizers, biopesticides and sustainable agricultural biotechnology. Biosafety and environmental risk assessment of genetically modified microorganisms. Environmental legislation, biodiversity conservation, waste valorization, circular bioeconomy and green biotechnology. Artificial intelligence applications in environmental biotechnology.

UNIT – VI: Current Contours (Self-Directed Learning for Continuous Internal Assessment Only)

Students shall review recent advances in bioprocess and environmental biotechnology, including precision fermentation, single-use bioreactors, process automation, artificial intelligence in bioprocessing, microbial bioremediation, bioenergy production, circular bioeconomy and sustainable biomanufacturing. They shall prepare a case study or seminar based on recent research articles or industrial applications.

Recommended Books & References

1. Stanbury, P.F., Whitaker, A. and Hall, S.J. **Principles of Fermentation Technology**. 3rd Edition, Elsevier, 2017.
2. Shuler, M.L. and Kargi, F. **Bioprocess Engineering: Basic Concepts**. 3rd Edition, Pearson Education, 2017.

3. Doran, P.M. **Bioprocess Engineering Principles**. 2nd Edition, Academic Press, 2013.
4. Crueger, W. and Crueger, A. **Biotechnology: A Textbook of Industrial Microbiology**. Panima Publishing.
5. Ratledge, C. and Kristiansen, B. **Basic Biotechnology**. Cambridge University Press.
6. Glazer, A.N. and Nikaido, H. **Microbial Biotechnology: Fundamentals of Applied Microbiology**. Cambridge University Press.
7. Rittmann, B.E. and McCarty, P.L. **Environmental Biotechnology: Principles and Applications**. McGraw-Hill.
8. Evans, G.M. and Furlong, J.C. **Environmental Biotechnology: Theory and Application**. Wiley.
9. Pepper, I.L., Gerba, C.P. and Gentry, T.J. **Environmental Microbiology**. Academic Press.
10. APHA. **Standard Methods for the Examination of Water and Wastewater**. Latest Edition.
11. Ministry of Environment, Forest and Climate Change (MoEFCC), Government of India – Environmental Protection Rules and Guidelines.
12. CPCB (Central Pollution Control Board) Guidelines on Wastewater Treatment and Environmental Management.
13. OECD Guidelines on Biosafety and Environmental Risk Assessment.
14. Recent research articles from **Bioresource Technology, Journal of Industrial Microbiology and Biotechnology, Applied Microbiology and Biotechnology, Biotechnology Advances, Environmental Science & Technology**, and **Nature Biotechnology**.

Course Outcomes

S. No.	Upon completion of the course, the students will be able to	Knowledge Level
C01	Explain the principles of upstream and downstream processing involved in industrial bioprocess technology.	K2
C02	Apply the concepts of fermenter design, bioreactor operation, fermentation strategies, and process scale-up for industrial production.	K3
C03	Explain the applications of microorganisms in environmental biotechnology, pollution control, and waste management.	K2
C04	Analyze renewable bioenergy production, environmental management practices, and biosafety aspects for sustainable biotechnological applications.	K4
C05	Evaluate emerging technologies including artificial intelligence, green biotechnology, circular bioeconomy and recent advances in industrial and environmental biotechnology.	K5

MAPPING WITH PROGRAMME OUTCOMES

PO Mapping Strategy: The course demonstrates strong alignment with **Disciplinary Knowledge (PO1)**, **Laboratory Proficiency (PO2)**, **Problem Solving (PO3)**, **Research Aptitude (PO4)**, **Modern Tool Usage (PO5)**, **Ethics and Professionalism (PO6)**, and **Lifelong Learning (PO10)**.

Mean Calculation:

Each PO mean is derived by calculating the average correlation score across all **6 Course Outcomes (COs)**. The **Overall Mean Score of 2.74** indicates a **high level of alignment** between the **Bioprocess and Environmental Biotechnology course** and the **M.Sc. Biotechnology Programme Outcomes**.

COURSE OBJECTIVES:

- To provide fundamental knowledge of bioinformatics databases, computational tools, and sequence analysis.
- To develop understanding of genome, protein, and phylogenetic analyses using bioinformatics software.
- To familiarize students with intellectual property rights, patent systems, and biotechnology commercialization.
- To impart knowledge on biosafety principles, regulatory frameworks, and risk assessment of genetically modified organisms.
- To understand ethical principles governing biotechnology research, environmental sustainability, and responsible scientific conduct.

UNIT – I: Fundamentals of Bioinformatics and Biological Databases

Introduction to bioinformatics and its applications. Computers in biology, UNIX/Linux basics, biological databases (primary, secondary, structural), NCBI, EMBL-EBI resources, biological XML, database mining, pattern matching, sequence retrieval, and identification of protein sequences from DNA.

UNIT – II: Sequence Analysis and Protein Structure Prediction

DNA sequence databases and GenBank submission. Pairwise and multiple sequence alignment using BLAST, FASTA, CLUSTALW and CLUSTALX. Motif discovery, gene prediction, genome assembly, phylogenetic analysis, molecular evolution, protein structure prediction, homology modelling, secondary structure prediction, and energy minimization.

UNIT – III: Intellectual Property Rights in Biotechnology

Introduction to IPR, GATT, WTO and WIPO. Types of intellectual property, patentability, prior art, Indian Patent Act, WIPO treaties, Budapest Treaty, Patent Cooperation Treaty (PCT), patent filing, licensing, TRIPS, plant variety protection, farmers' rights, biopiracy, and traditional knowledge with relevant case studies.

UNIT – IV: Biosafety and Biotechnology Regulations

Principles of biosafety, biosafety levels, biological safety cabinets, GRAS organisms, GLP, recombinant DNA guidelines, transgenic research, risk assessment of GMOs, LMOs and gene-edited organisms, Cartagena Biosafety Protocol, OECD, Codex Alimentarius, IBSC, RCGM, GEAC, BRAI, SOPs, and FSSAI regulations.

UNIT – V: Bioethics and Responsible Conduct in Biotechnology

Introduction to bioethics, responsible conduct of research, animal ethics, stem cell research, cloning, gene editing, environmental ethics, biodiversity conservation, biosafety, biosecurity, gene flow in GM crops, public perception, and national and international ethical guidelines.

UNIT – VI: CURRENT CONTOURS (Self-directed Learning Activities for Continuous Internal Assessments Only)

Students are to explore recent developments in bioinformatics, bioethics, intellectual property rights, and biosafety to enhance computational skills, ethical awareness, and regulatory understanding (PO2, PO4, PO5 & PO6).

1. Review recent advances in bioinformatics tools and their applications in genomics, proteomics, metagenomics, structural biology, or artificial intelligence.
2. Prepare a report on recent case studies involving patents, biopiracy, traditional knowledge, or biotechnology commercialization.
3. Present a seminar or case study on recent developments in biosafety, biosecurity, gene editing, synthetic biology, GMOs, or biotechnology regulations.

Recommended Books, References and e-Books

1. Rastogi, S.C., Mendiratta, N. & Rastogi, P. (2023). Bioinformatics: Methods and Applications. PHI Learning.
2. Mount, D.W. (2021). Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor Laboratory Press.
3. Lesk, A.M. (2019). Introduction to Bioinformatics. Oxford University Press.
4. Primrose, S.B. & Twyman, R.M. (2019). Principles of Gene Manipulation and Genomics. Wiley-Blackwell.
5. Sateesh, M.K. (2020). Bioethics and Biosafety. I.K. International Publishing House.
6. Ganguli, P. (2018). Intellectual Property Rights: Unleashing the Knowledge Economy. Tata McGraw-Hill.
7. Indian Patent Office. The Patents Act, 1970 (as amended).
8. National Biodiversity Authority (NBA), Department of Biotechnology (DBT), Government of India – Biosafety and Biotechnology Regulatory Guidelines.

Course Outcomes

BIOINFORMATICS, BIOETHICS, IPR & BIOSAFETY		
S. No.	Course Outcome	Knowledge Level
Upon completion of the course, the students will be able to		
C01	Understand the principles of bioinformatics databases, computational biology, and biological sequence analysis.	K2 & K3
C02	Apply bioinformatics tools for DNA, protein, genome, and phylogenetic analyses.	K3 & K4
C03	Demonstrate knowledge of intellectual property rights, patent systems, biotechnology commercialization, and technology protection.	K2 & K4
C04	Evaluate biosafety principles, risk assessment procedures, and national and international regulatory frameworks governing biotechnology research.	K4 & K5
C05	Analyze ethical issues related to biotechnology, genetic engineering, biodiversity conservation, and responsible scientific research.	K4 & K5

MAPPING WITH PROGRAMME OUTCOMES (POs)

PO Mapping Strategy: The course strongly aligns with Disciplinary Knowledge (PO1), Research Aptitude (PO4), Digital and Computational Competence (PO5), and Professional Ethics (PO8) by integrating computational biology, intellectual property protection, biosafety regulations, and ethical decision-making. Moderate emphasis is placed on Critical Thinking (PO3), Innovation & Entrepreneurship (PO6), and Lifelong Learning (PO10) through applications in biotechnology research, technology commercialization, and regulatory compliance.

Mean Calculation: The Overall Mean Score of 2.56 indicates a high level of alignment between the course outcomes and programme outcomes, reflecting the interdisciplinary nature of the course and its relevance to contemporary biotechnology education.

COURSE OBJECTIVES

The course is designed to enable students to:

- Understand the basic concepts and steps involved in scientific research.
- Develop skills in literature search, research planning and scientific writing.
- Understand basic bioinformatics, computational and instrumental methods.
- Learn methods of data collection, analysis, presentation and interpretation.
- Apply basic statistical methods to biological research data.

UNIT – I: BASICS OF SCIENTIFIC RESEARCH

Introduction to research – basic and applied research – selection of research problem – research objectives and planning – literature search and review – scientific journals and databases – citation and impact factor – thesis and research paper writing – abstract preparation – research ethics – plagiarism – good research practices.

UNIT – II: COMPUTATIONAL METHODS

Introduction to bioinformatics – biological databases – DNA and protein sequence databases – sequence analysis – sequence alignment – motif analysis – primer design – basic next-generation sequencing analysis – molecular docking – applications of computational tools in biotechnology.

UNIT – III: INSTRUMENTAL METHODS

Principles and applications of spectrophotometer, fluorescence, NMR, ESR, XRD, FTIR, SEM-EDX and FPLC – surface plasmon resonance – microfluidics – basic imaging techniques – applications of artificial intelligence in biotechnology research.

UNIT – IV: DATA COLLECTION AND SCIENTIFIC COMMUNICATION

Data collection and organization – tables, percentages and graphs – basic data interpretation – use of Excel and GraphPad – research paper format – citation and referencing – abstract, results and discussion – oral and poster presentation – scientific databases and reference management.

UNIT – V: BASIC STATISTICS

Introduction to biostatistics – data presentation – mean, median and standard deviation – correlation and regression – t-test – chi-square test – ANOVA – one-way and two-way ANOVA – DMRT – introduction to SPSS and statistical data analysis.

UNIT – VI: CURRENT CONTOURS (Self-Directed Learning for Continuous Internal Assessment Only)

Recent developments in AI-based research, bioinformatics, advanced data analysis, digital research tools and reproducible research through expert lectures, seminars, webinars and recent research articles.

Text Books

1. **Goh, K. M. (2023). Research Methodology in Bioscience and Biotechnology: Research Mindset, Best Practices, Integrity, Publications and Societal Impact. Springer Nature.**
— Particularly suitable for Unit I, including research planning, literature review, thesis/research writing, publication ethics and research integrity.
2. **Thomas, C. G. (2021). Research Methodology and Scientific Writing. Springer.**
— Covers research problems, literature review, research design, data collection and analysis, proposal writing and thesis preparation.
3. **Dandekar, T., & Kunz, M. (2021). Bioinformatik: Ein einführendes Lehrbuch. Springer.**
— Useful for biological databases, sequence analysis, DNA/RNA/protein analysis and computational approaches.
4. **Dandekar, T., & Kunz, M. (2022). Bioinformatics: An Introductory Textbook. Springer.**
— Suitable for undergraduate/postgraduate students and covers sequence analysis, genomes, RNA, proteins, metabolic pathways and current computational topics including AI.
5. **Kappelmann-Fenzl, M. (2021). Next Generation Sequencing and Data Analysis. Springer.**
— Recommended for the NGS component of Unit II, including sequencing data analysis, visualization and statistical concepts.

Reference Books

1. **Singh, V., & Kumar, A. (Eds.). (2021). Advances in Bioinformatics. Springer.**
— Useful for genomics, transcriptomics, proteomics, AI, drug design and computational biotechnology.
2. **Lin, S., Scholtens, D., & Datta, S. (2023). Bioinformatics Methods: From Omics to Next Generation Sequencing. Chapman & Hall/CRC.**
— Useful for advanced bioinformatics, omics data, NGS and biostatistical analysis.
3. **Suravajhala, P. N. (Ed.). (2021). Your Passport to a Career in Bioinformatics, 2nd Edition. Springer.**
— Useful supplementary reference for bioinformatics applications and professional development.

COURSE OUTCOMES

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

CO1: Explain the basic concepts and steps of scientific research.

CO2: Use basic bioinformatics and computational tools for biological research.

CO3: Describe the principles and applications of major research instruments.

CO4: Collect, present and interpret scientific data effectively.

CO5: Apply basic statistical methods to biological research data.

CO6: Follow ethical research practices and use emerging research tools in biotechnology.

MAPPING WITH PROGRAMME OUTCOMES

PO Mapping Strategy: The course demonstrates strong alignment with **Disciplinary Knowledge (PO1), Laboratory Proficiency (PO2), Problem Solving (PO3), Research Aptitude (PO4), Modern Tool Usage (PO5), Ethics and Professionalism (PO6), and Lifelong Learning (PO10)**. The syllabus develops skills in research planning, literature review, bioinformatics, scientific instrumentation, data analysis, biostatistics, scientific communication, research ethics, and emerging research technologies.

Mean Calculation:

Each PO mean is derived by calculating the average correlation score across all **6 Course Outcomes (COs)**. The **Overall Mean Score of 2.74** indicates a **high level of alignment** between the **Research Methodology course** and the **M.Sc. Biotechnology Programme Outcomes**. The course strongly supports research aptitude, problem-solving, modern tool usage, scientific knowledge, ethical research practices, and lifelong learning.

COURSE OBJECTIVES:

- To obtain knowledge on advancement and function of different microscopic technique and its various applications.
- To gain knowledge about mass spectroscopy methods and its applications.
- To understand the basic concepts of high throughput analysis using systems biology approach.
- To acquire knowledge on advanced methods.
- To educate the application of CRISPR-CAS.

UNIT – I: Basic and Advanced Microscopy

Principles of light microscopy, lenses, microscope optics, and resolution based on Rayleigh's criterion. Darkfield, phase contrast, differential interference contrast (DIC), and fluorescence microscopy, including fluorescence principles, fluorophores, microscope configuration, light sources, filter sets (excitation filter, dichroic mirror, barrier filter), image capture systems, CCD cameras, back illumination, binning, color recording, and signal enhancement. Confocal microscopy, including confocal principles, point spread function, resolution, laser light sources, beam splitters, beam scanning, pinhole optics, detectors, pixels, voxels, image contrast, spatial and temporal sampling, signal-to-noise ratio, and multichannel imaging. Advanced fluorescence techniques such as Fluorescence Lifetime Imaging Microscopy (FLIM), Fluorescence Resonance Energy Transfer (FRET), and Fluorescence Correlation Spectroscopy (FCS). Evanescent wave microscopy, Total Internal Reflection Fluorescence Microscopy (TIRFM), and Near-Field Microscopy.

UNIT – II: Mass Spectrometry and Proteomics

Principles of mass spectrometry, ionization techniques, and mass analyzers. Fourier Transform Ion Cyclotron Resonance (FT-ICR) and Orbitrap mass spectrometry. Peptide fragmentation and protein identification. Proteomics applications, including nano LC-MS, phosphoproteomics, and interaction proteomics. Applications of mass spectrometry in structural biology and imaging mass spectrometry for spatial analysis of biomolecules.

UNIT – III: High-Throughput Screening and Omics Data Analysis

High-throughput screening approaches in cellular systems for target discovery. Target identification and validation strategies. Experimental design and validation methods for generating reliable omics datasets. Bioinformatics tools and analyses for interpretation of omics data. Mathematical modeling of biological systems and development of testable hypotheses and predictive models.

UNIT – IV: Structural Biology and Advanced Imaging Techniques

Principles and applications of X-ray diffraction methods, solution-state and solid-state Nuclear Magnetic Resonance (NMR) spectroscopy, and cryo-electron microscopy (Cryo-EM) for structural analysis of biomolecules. Small-angle X-ray

scattering (SAXS) and Atomic Force Microscopy (AFM) for investigating molecular structure, dynamics, and nanoscale surface properties.

UNIT – V: CRISPR-Cas Genome Editing and Therapeutic Applications

History and discovery of the CRISPR-Cas system, elucidation of its molecular mechanism, and the roles of key molecular components involved in genome editing. Development and application of CRISPR-based technologies for in vivo genome engineering and functional genetic studies. Potential of CRISPR technology as a next-generation therapeutic platform for the treatment of genetic and acquired diseases.

UNIT – VI: CURRENT CONTOURS (Self-directed learning activities for Continuous Internal Assessments Only)

Students are to monitor recent developments in emerging biotechnologies and enhance their scientific inquiry, analytical ability, and technological awareness (PO2, PO4, PO5, PO6).

1. Review recent research articles (published within the last 3–5 years) on advanced microscopy, proteomics, structural biology, CRISPR-Cas technologies, or omics-based approaches, and prepare a critical summary.
2. Prepare a case study on the application of CRISPR, advanced imaging, mass spectrometry, or structural biology in disease diagnosis, drug discovery, precision medicine, or industrial biotechnology.

Recommended Books, References, and e-Books

1. Old, R. W., Primrose, S. B., & Twyman, R. M. (2001). Principles of Gene Manipulation: an Introduction to Genetic Engineering. Oxford: Blackwell Scientific Publications.
2. Green, M. R., & Sambrook, J. (2012). Molecular Cloning: a Laboratory Manual. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
3. Brown, T. A. (2006). Genomes (3rd ed.). New York: Garland Science Pub.

Course Outcomes

EMERGING TECHNOLOGIES IN BIOTECHNOLOGY		
S. No.	Course Outcome	Knowledge Level
Upon completion of the course, the students will be able to		
C01	Gain knowledge on microscopic techniques and their applications in various research field.	K2, K4 & K5
C02	Understanding concepts and application of spectroscopy	K2 & K5
C03	Understanding the concepts and application systems biology	K2 & K4
C04	Learn the concepts and application of structural application	K3 & K4
C05	Learn to understand the application of CRISPR-CAS	K2 & K3

MAPPING WITH PROGRAMME OUTCOMES (POs)

PO Mapping Strategy: The mapping indicates a strong alignment of the course with Research Aptitude (**PO4**), Scientific Knowledge and Technical Competence (**PO6–PO10**), all of which exhibit the highest weighted average score of 3.0. This reflects the course's emphasis on advanced analytical techniques, microscopy, structural biology, omics technologies, and genome engineering.

Mean Calculation: The Overall Mean Score of **2.78** indicates a very high level of alignment between the course outcomes and programme outcomes, demonstrating the course's effectiveness in strengthening advanced research capabilities, technical expertise, and interdisciplinary applications in contemporary life sciences.

COURSE OBJECTIVES:

- To understand the principles and evolution of genome editing technologies with emphasis on CRISPR-Cas systems.
- To learn the molecular mechanisms underlying CRISPR-mediated genome editing and guide RNA design.
- To explore delivery systems and experimental approaches used in CRISPR applications.
- To examine the applications of CRISPR technology in medicine, biotechnology, agriculture, and diagnostics.
- To evaluate the ethical, legal, and social implications associated with genome editing technologies.

UNIT – I: Introduction to Genome Editing and the CRISPR-Cas System

History of genome editing technologies: Zinc Finger Nucleases (ZFNs), Transcription Activator-Like Effector Nucleases (TALENs), and CRISPR. Discovery and evolution of CRISPR-Cas systems. Structure and function of CRISPR-Cas9, Cas12, and Cas13. Types of CRISPR systems and their biological roles in prokaryotes. Comparison of CRISPR with other genome editing tools.

UNIT – II: CRISPR-Cas Mechanism and Design Strategies

Molecular mechanism of CRISPR-Cas9-mediated DNA cleavage. Guide RNA (gRNA) design and synthesis. PAM sequences and target site selection. CRISPR efficiency and off-target prediction. CRISPR toolkits: plasmid-based systems, ribonucleoprotein (RNP) complexes, and viral delivery methods.

UNIT – III: Delivery Systems and Experimental Implementation

In vitro and in vivo delivery methods: lipofection, electroporation, and viral vectors. Cell types and model organisms used in CRISPR experiments. Genome editing workflows: knockout, knock-in, base editing, and prime editing. Validation techniques include PCR, sequencing, and functional assays. Troubleshoot and optimisation strategies for successful genome editing.

UNIT – IV: Applications in Medicine and Biotechnology

Therapeutic applications of CRISPR in monogenic disorders, cancer, and infectious diseases. CRISPR-based diagnostics including SHERLOCK and DETECTR platforms. Agricultural and environmental applications of genome editing. Drug discovery and functional genomics using CRISPR screening approaches. Case studies of clinical trials and preclinical research involving CRISPR technologies.

UNIT – V: Ethical, Legal, and Social Implications (ELSI)

Germline versus somatic genome editing and associated ethical considerations. Regulatory landscape and global perspectives, including FDA, WHO, and other international guidelines. Biosecurity concerns and potential misuse of genome

editing technologies. Intellectual property rights and patent issues related to CRISPR. Public perception, communication, and engagement in gene editing research.

UNIT – VI: CURRENT CONTOURS (For Continuous Internal Assessment Only)

Recent developments in next-generation CRISPR systems, base and prime editing, CRISPR-based therapeutics, AI-assisted guide RNA design, advanced delivery systems, and emerging clinical applications, through expert lectures, seminars and webinars.

Recommended Books and References

1. Santisteban, M. S. (2023). Introduction to CRISPR-Cas9 Techniques. Springer.
2. Gasiunas, G., Barrangou, R., Horvath, P., & Siksnys, V. (Eds.). (2021). Introduction to CRISPR-Cas9 Techniques. Springer.
3. Gaur, R. K., & Rossi, J. J. (Eds.). (2009). Regulation of Gene Expression by Small RNAs. CRC Press. ISBN: 978-1138111738.
4. Appasani, K. (Ed.). (2018). Genome Editing and Engineering: From TALENs, ZFNs and CRISPRs to Molecular Surgery. Cambridge University Press. ISBN: 978-1107170377.
5. Doudna, J. (Ed.). (2016). CRISPR-Cas: A Laboratory Manual. Cold Spring Harbour Laboratory Press. ISBN: 978-1621821311.
6. Synthego Corporation. (n.d.). CRISPR 101: Your Guide to Understanding CRISPR.
7. Recent publications and guidelines from WHO, FDA, and NIH related to genome editing technologies.

Course Outcomes

S. No.	Course Outcome	Knowledge Level
Upon completion of the course, the students will be able to		
C01	Describe genome editing technologies with a focus on CRISPR-Cas systems.	K2
C02	Design and assess guide RNAs and CRISPR components for gene editing applications.	K3
C03	Apply CRISPR delivery methods and genome editing techniques in experimental setups.	K4
C04	Analyze genome editing outcomes using molecular, genetic, and functional assays.	K5
C05	Evaluate CRISPR applications in medicine, diagnostics, agriculture, and biotechnology while considering ethical and regulatory aspects.	K6

MAPPING WITH PROGRAMME OUTCOMES

PO Mapping Strategy: The course demonstrates very strong alignment with **Disciplinary Knowledge (PO1), Laboratory Proficiency (PO2), Problem Solving (PO3), Research Aptitude (PO4), Modern Tool Usage (PO5), Ethics and Professionalism (PO6), and Lifelong Learning (PO10)**. The course integrates advanced genome editing technologies, experimental methodologies, bioinformatics tools, clinical applications, and ethical considerations, thereby strengthening both research and professional competencies in biotechnology.

Mean Calculation: Each Course Outcome (CO) mean is derived by calculating the average correlation score across all ten Programme Outcomes (POs) using a three-point correlation scale (3 = High, 2 = Moderate, 1 = Low). **The Overall Mean Score of 2.22** indicates a strong alignment between the course outcomes and the programme outcomes, reflecting the course's significant contribution to advanced biotechnology education, research innovation, and responsible application of genome editing technologies.

COURSE OBJECTIVES:

- To understand the interdisciplinary relationship between life sciences, innovation, and business management in the context of entrepreneurship.
- To develop knowledge of entrepreneurial concepts, opportunity identification, and business model development in the life science sector.
- To gain insights into funding mechanisms, intellectual property management, and commercialization strategies for scientific innovations.
- To understand the principles involved in establishing, managing, and scaling biotechnology and life science ventures.
- To explore leadership, strategic decision-making, and sustainable growth practices for successful bio-based enterprises and projects.

UNIT – I: Introduction to Bioentrepreneurship & Bioindustry Landscape

Definition, scope, and significance of bio-entrepreneurship. Overview of the bio-industry and its major sectors, including pharmaceuticals, agricultural biotechnology, industrial biotechnology, healthcare biotechnology, and environmental biotechnology. Competitive dynamics and market characteristics among different bio-sector industries. Strategy and operational management of bio-sector firms. Factors influencing innovation, technology commercialization, and entrepreneurial opportunities in the life sciences sector. Business implications of scientific and technological advancements, emerging trends, challenges, and future prospects in bio-based enterprises.

UNIT – II: Entrepreneurship Development and Strategic Management in Biotechnology

Strategic alternatives and challenges faced by emerging bio-firms. Decision-making tools for opportunity assessment, risk management, and business growth. Entrepreneurship development programs and support schemes of agencies such as MSME, DBT, BIRAC, Startup India, and Make in India. Fundamentals of intellectual property rights, patenting, technology transfer, licensing, and commercialization strategies in biotechnology.

UNIT – III: Commercialization, Marketing, and Business Agreements in Biotechnology

Strategies and processes for translating biotechnology innovations from the laboratory to the market, including interactions with financiers, government bodies, and regulatory authorities. Principles of pricing and marketing in the bio-business sector, market analysis, customer needs assessment, and distribution channel development. Fundamentals of business contracts, types of agreements commonly used in biotechnology ventures, key contractual terms in joint venture and development agreements, and methods of dispute resolution.

UNIT – IV: Business Planning and Financial Management in Biotechnology

Business plan development, including statutory, legal, and regulatory requirements. Business feasibility analysis, financial planning, capital procurement, and cost management. Principles of collaborations, partnerships, and strategic alliances in biotechnology enterprises. Role of information technology in business operations, management, and decision-making.

UNIT – V: Technology Management and Regulatory Compliance in Biotechnology

Technology assessment, development, upgradation, and management of technology transfer. Quality control systems and transfer of foreign technologies. Role of knowledge centers, incubators, and technology transfer agencies in promoting innovation and commercialization. Regulatory compliance and approval procedures governing biotechnology products, including CDSCO, NBA, GCP, GLP, and GMP guidelines.

UNIT – VI: CURRENT CONTOURS (Self-directed learning activities for Continuous Internal Assessments Only)

Students are to explore recent developments in biotechnology entrepreneurship, innovation, and commercialization to strengthen their entrepreneurial skills, business acumen, and understanding of the biotechnology ecosystem (PO2, PO4, PO5, PO6).

1. Review recent case studies of successful biotechnology startups, biotech incubators, or technology-based enterprises in India or abroad, and prepare a critical analysis of their innovation and commercialization strategies.
2. Explore entrepreneurship support initiatives and funding opportunities offered by agencies such as **BIRAC, DBT, MSME, Startup India**, and **Make in India**, and prepare a report on their role in promoting biotechnology ventures.
3. Prepare a business model canvas or a preliminary business plan for a biotechnology-based product, process, or service, including market analysis, value proposition, regulatory considerations, and commercialization strategy.

Recommended Books, References, and e-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
3. Onetti, A., & Zucchella, A. Business Modeling for Life Science and Biotech Companies: Creating Value and Competitive Advantage with the Milestone Bridge. Routledge.
4. Jordan, J. F. (2014). Innovation, Commercialization, and Start-Ups in Life Sciences. London: CRC Press.
5. Desai, V. (2009). The Dynamics of Entrepreneurial Development and Management. New Delhi: Himalaya Pub. House.

Course Outcomes

BIOENTREPRENEURSHIP		
S. No.	Course Outcome	Knowledge Level
Upon completion of the course, the students will be able to		
CO1	Get introduced to the concept, fundamentals and types of bioindustries in bio-sector.	K2 & K4
CO2	Obtain a comprehensive knowledge about Entrepreneurship development programs and patenting & commercialization strategies.	K4
CO3	Student would be able to select the best strategies to market products.	K3 & K4
CO4	Analyze and understand the business feasibility and financial management	K3
CO5	Learn to assess the technologies and regulatory process in upgrading the business.	K2 & K3

MAPPING WITH PROGRAMME OUTCOMES (POs)

PO Mapping Strategy: The mapping demonstrates a strong alignment of the Bio-Entrepreneurship course with Disciplinary Knowledge (**PO1**), Research Aptitude (**PO4**), and Innovation & Entrepreneurship Skills (**PO6**), reflecting the course's emphasis on biotechnology-based enterprise development, technology commercialization, and strategic decision-making. Moderate contributions are observed towards Problem Solving (**PO3**), Communication and Teamwork (**PO9**), and Professional Competence (**PO2**) through business planning, marketing, regulatory compliance, and technology management components.

Mean Calculation: The Overall Mean Score of **2.52** indicates a high level of alignment between the course outcomes and programme outcomes, highlighting the course's effectiveness in integrating scientific knowledge with entrepreneurial and managerial competencies.

COURSE OBJECTIVES

- To understand the principles and techniques of plant tissue culture.
- To learn the preparation of media, sterilisation methods, and aseptic techniques.
- To understand plant regeneration pathways and micropropagation methods.
- To gain knowledge about applications of plant tissue culture in agriculture and biotechnology.
- To understand advanced techniques such as haploid culture, somatic hybridisation, and genetic transformation.

UNIT – I: Introduction to Plant Tissue Culture

History, principles, and concept of totipotency in plant tissue culture. Explant selection, sterilisation, culture media preparation, and plant growth regulators. Laboratory organisation, aseptic techniques, and maintenance of cultures.

UNIT – II: In Vitro Culture Techniques

Callus culture, suspension culture, organogenesis, and somatic embryogenesis. Micropropagation, plant regeneration, rooting, and acclimatisation methods. Factors influencing the growth and development of cultured plant tissues.

UNIT – III: Specialised Tissue Culture Techniques

Anther culture, pollen culture, haploid production, and embryo rescue techniques. Protoplast isolation, culture, somatic hybridisation, and cybridization. Synthetic seeds and their applications in plant biotechnology.

UNIT – IV: Applications of Plant Tissue Culture

Production of disease-free plants and rapid multiplication through micropropagation. Secondary metabolite production, germplasm conservation, and cryopreservation. Applications in crop improvement and conservation of endangered plants.

UNIT – V: Advanced Plant Biotechnology

Agrobacterium-mediated transformation and plant genetic engineering. Transgenic plants, molecular markers, and genome editing approaches. Biosafety, ethical issues, and commercial applications of plant biotechnology.

UNIT – VI: Current Contours (Self-Directed Learning Activities – Continuous Internal Assessment Only)

Students shall prepare reports on emerging developments in plant tissue culture, including automation, synthetic seeds, CRISPR-based plant improvement, AI-assisted plant biotechnology, and advanced applications in sustainable agriculture and conservation biotechnology.

TEXT BOOKS

1. Plant Tissue Culture: Theory and Practice – S.S. Bhojwani & M.K. Razdan, Elsevier, 1996.
2. Plant Cell and Tissue Culture: A Tool in Biotechnology – B. Bhojwani, Oxford & IBH Publishing, 1990.
3. Plant Biotechnology: Principles and Applications – S. Chawla, Oxford & IBH Publishing, 2009.

REFERENCE BOOKS

1. Plant Tissue Culture: Techniques and Experiments – Roberta H. Smith, Academic Press, 2013.
2. Introduction to Plant Tissue Culture – M.K. Razdan, Oxford & IBH Publishing, 2003.
3. Plant Biotechnology and Genetics: Principles, Techniques and Applications – C. Neal Stewart Jr., Wiley, 2008.
4. Plant Cell Culture: A Practical Approach – R.A. Dixon & Gonzales, Oxford University Press, 1994.

Course Outcomes

S. No.	Course Outcome	Knowledge Level
Upon completion of the course, the students will be able to		
C01	Explain the principles, history, totipotency concept, and basic requirements of plant tissue culture techniques.	K2
C02	Apply aseptic techniques, media preparation methods, and in vitro culture procedures for plant regeneration.	K3
C03	Analyse specialized tissue culture techniques such as haploid culture, embryo rescue, protoplast culture, and somatic hybridisation.	K3
C04	Evaluate applications of plant tissue culture in crop improvement, secondary metabolite production, conservation, and commercial propagation.	K4
C05	Assess advanced plant biotechnology approaches including genetic transformation, genome editing, biosafety, and ethical aspects.	K5
C06	Assess emerging trends in PTC and biotechnology, including CRISPR-based plant improvement, synthetic biology, AI-assisted plant research, automation in tissue culture, and advanced conservation strategies through critical review of current developments. (Current Contours – Continuous Assessment Only)	K5

PO Mapping Strategy:

The course demonstrates strong alignment with **Disciplinary Knowledge (PO1), Problem Analysis (PO2), Problem Solving (PO3), Research Aptitude (PO4), Modern Tools and Techniques (PO5), Ethics and Professionalism (PO6), Environmental Sustainability (PO7), Communication Skills (PO8), and Lifelong Learning (PO10).**

Mean Calculation:

The Overall **Mean Score of 2.30** indicates a **moderate-to-high level of alignment** between the Course Outcomes and Programme Outcomes, demonstrating the course's contribution to developing competency in plant tissue culture techniques, in vitro regeneration, micropropagation, crop improvement strategies, conservation approaches, and application of advanced biotechnological tools.
