

**DHANALAKSHMI SRINIVASAN
INSTITUTE OF RESEARCH AND TECHNOLOGY**

(Deemed to be University under section 3 of UGC Act, 1956.)
PERAMBALUR – 621 212, TAMIL NADU, INDIA.

SCHOOL OF ARTS AND SCIENCE

CURRICULUM AND SYLLABUS

M.Sc. Biotechnology

REGULATION 2026

PROGRAMME:

Vision:

To attain excellence in multidisciplinary biotechnology education, research, and entrepreneurship by fostering innovation, ethical values, and societal well-being, thereby contributing to sustainable nation-building and global progress.

Mission:

- To deliver high-quality education through a scientifically structured, contemporary curriculum that equips students with the knowledge and skills required for global competitiveness.
- To foster confidence, critical thinking, and analytical abilities among students, enabling them to develop innovative solutions to present and future issues of global significance.
- To provide advanced academic and laboratory infrastructure, hands-on training, and interdisciplinary learning experiences that encourage research aptitude, innovation, and entrepreneurial mindset.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO	PROGRAM EDUCATIONAL OBJECTIVES
PEO1	To provide students with a strong foundation in Biotechnology and develop technical skills for careers in research, industry, and higher education.
PEO2	To nurture innovation, ethical values, and problem-solving abilities to address societal and environmental challenges through biotechnology

PROGRAM SPECIFIC OUTCOMES(PSOs)

PSO	PROGRAM SPECIFIC OUTCOMES
PSO1	Apply advanced knowledge and specialized laboratory skills in molecular biology, genetic engineering, bioinformatics, cell culture, and bioprocess technology to solve scientific and industrial problems.
PSO2	Design and undertake independent research using modern biotechnological tools to develop innovative and sustainable solutions for healthcare, agriculture, industry, and environmental applications.

PROGRAM OUTCOMES (Pos)

PO	PROGRAM OUTCOMES
PO1	Acquire in-depth knowledge and understanding of advanced concepts in molecular biology, genetics, microbiology, biochemistry, immunology, bioinformatics, and other emerging areas of biotechnology.
PO2	Design, conduct, and interpret experiments using scientific methods and apply advanced laboratory techniques to address biological problems.
PO3	Analyze complex biological data, evaluate scientific evidence, and develop innovative solutions to challenges in biotechnology and allied disciplines.
PO4	Demonstrate proficiency in modern biotechnological tools, instrumentation, computational techniques, and data analysis methods.
PO5	Integrate knowledge from life sciences, chemistry, physics, mathematics, computer science, and engineering to address multidisciplinary problems.
PO6	Apply scientific knowledge to develop innovative products, processes, and entrepreneurial ventures relevant to biotechnology industries and society.
PO7	Communicate scientific findings effectively through technical reports, research publications, presentations, and interactions with diverse audiences.
PO8	Adhere to ethical principles, biosafety guidelines, intellectual property rights, and regulatory standards in research and professional practice.
PO9	Exhibit leadership qualities, collaborative skills, and professional responsibility while working independently and in multidisciplinary teams.
PO10	Apply biotechnology for environmental sustainability, healthcare, agriculture, and societal welfare, contributing to sustainable development goals.
PO11	Engage in lifelong learning, adapt to emerging technologies, and pursue careers in academia, research, industry, entrepreneurship, and global scientific communities.

SEMESTER-I

SEMESTER I										
Semester	Course Category	Title of the Course	Course Code	L	T	P	Credits	Marks		
								CAT	ESE	Total
I	Core	Microbiology	PBT26101	3	0	0	3	40	60	100
	Core	Lab in Microbiology	PBT26102	0	0	4	2	40	60	100
	SEC	Biochemistry and Metabolic Regulation	PBT26S01	2	1	0	3	40	60	100
		Lab in Biochemistry	PBT26S02	0	0	4	2	40	60	100
	MDC	MDC-1	-	3	0	0	3	40	60	100
	DEC	Ecology & Evolutionary Biology	PBT26001	4	0	0	4	40	60	100
		Human Anatomy & Physiology	PBT26002							
		Cell Signaling	PBT26003							
	DEC	Metabolomics	PBT26004	4	0	0	4	40	60	100
		Methods in Biology	PBT26005							
		Protein Engineering	PBT26006							
							21			700

SEMESTER-II

Semester	Course Category	Title of the Course	Course Code	L	T	P	Credits	Marks		
								CAT	ESE	Total
II	Core	Molecular Biology & rDNA Technology	PBT26203	2	1	0	3	40	60	100
	Core	Lab in Molecular Biology & rDNA Technology	PBT26204	0	0	4	2	40	60	100
	Core	Developmental Biology	PBT26205	4	0	0	4	40	60	100
	SEC	Immunotechnology	PBT26S03	3	0	0	3	40	60	100
		Lab in Immunotechnology	PBT26S04	0	0	4	2	40	60	100
	MDC	MDC-2	-	3	0	0	3	40	60	100
	DEC	Cancer Biology	PBT26007	4	0	0	4	40	60	100
		Synthetic Biology	PBT26008							
		Pharmaceutical Biotechnology	PBT26009							
	DEC	IPR, Bioethics & Biosafety	PBT26010	4	0	0	4	40	60	100

		Biomedical Data science	PBT26011							
		Genome Editing Technology	PBT26012							
							25			700

SEMESTER-III

Semester	Course Category	Title of the Course	Course Code	L	T	P	Credits	Marks		
								CAT	ESE	Total
III	Core	Plant & Animal Biotechnology	PBT26306	2	1	0	3	40	60	100
	Core	Lab in Plant & Animal Biotechnology	PBT26307	0	0	4	2	40	60	100
	Core	Enzyme Technology	PBT26308	2	1	0	3	40	60	100
	Core	Lab in Enzyme Technology	PBT26309	0	0	4	2	40	60	100
	Core	Nanobiotechnology	PBT26310	4	0	0	4	40	60	100
	DEC	Clinical Research in Biotechnology	PBT26013	4	0	0	4	40	60	100
		Stem cell Biology	PBT26014							
		Industrial Biotechnology	PBT26015							
	EE	Experiential Elective (Internship)	PBTEE01	0	0	4	2	*	*	100
	SEC	Communication and Soft Skill	-	1	0	0	1	40	60	100
							21			800

SEMESTER-IV

Semester	Course Category	Title of the Course	Course Code	L	T	P	Credits	Marks		
								CAT	ESE	Total
IV	Core	Bioinformatics	PBT26411	4	0	0	4	40	60	100
	Core	Research Methodology & IPR	PBT26412	3	1	0	4	40	60	100
	Core	Project	PBT26413	0	0	24	12	40	60	100
							20			400

Semester-wise Categorization of Courses

COURSE CATEGORY	Semester				No of Courses	Total Credits
	I	II	III	IV		
Core Courses (Theory & Practical)	2	3	5	3	12	48
SEC–Skill Enhancement Course	2	2	1	-	4	11
MDC–Multi Disciplinary Course	1	1	-	-	2	6
DEC–Disciplinary Elective Course	2	2	1	-	5	20
EE–Experiential Elective	-	-	1	-	1	2
Total Courses Per Semester	7	7	8	3	25 (Courses)	
Total Credits	21	25	21	20	87 (Credits)	

MDC offered to other Department

PBT26901- Drug discovery and Development

PBT26902 - Entrepreneurship and Innovation in Life sciences

DEC offered by the Department

PBT26001- Ecology & Evolutionary Biology

PBT26002 - Human Anatomy & Physiology

PBT26003 - Cell Signaling

PBT26004 - Metabolomics

PBT26005 - Methods in Biology

PBT26006 - Protein Engineering

PBT26007 - Cancer Biology

PBT26008 - Synthetic Biology

PBT26009 - Pharmaceutical Biotechnology

PBT26010 - IPR, Bioethics & Biosafety

PBT26011 - Biomedical Data science

PBT26012 - Genome Editing Technology

PBT26013 - Clinical Research in Biotechnology

PBT26014 – Stem cell Biology

PBT26015 - Industrial Biotechnology

Sem	Course Code	Title of the Course	Course Category	L	T	P	Credits
I	PBT26101	Microbiology	Core	3	0	0	3
Pre-Requisite: Knowledge of basic Microbiology, Cell Biology, Biochemistry, Genetics, and Molecular Biology.							
Co-Requisite: Microbiology Laboratory and Molecular Biology course.							
Progressive manner: Medical Microbiology, Industrial Microbiology, Environmental Microbiology, Food Microbiology, Microbial Genomics, Recombinant DNA Technology, Bioprocess Engineering, and Functional Genomics.							
Course Objectives:							
1. Acquire knowledge of microbial diversity, taxonomy, and ultrastructure.							
2. Understand microbial physiology, metabolism, and growth.							
3. Apply microorganisms in industrial, agricultural, medical, and environmental biotechnology.							
4. Analyze microbial diseases, host–pathogen interactions, and antimicrobial resistance.							
5. Evaluate the role of microorganisms in environmental sustainability and current biotechnological applications.							
Course Outcomes:							
CO1: Recall the diversity, taxonomy, classification, and ultrastructure of microorganisms (K1)							
CO2: Explain microbial physiology, metabolism, nutrition, and growth (K2)							
CO3: Apply microbiological principles in industrial and biotechnological processes (K3)							
CO4: Analyze microbial diseases, host–pathogen interactions, and antimicrobial resistance (K4)							
CO5: Evaluate the role of microorganisms in environmental management, biofertilizers, biocontrol, and pollution monitoring (K5)							
Unit-I	Microbial Diversity and Systematics						9 Hrs.
History and scope of microbiology. Microbial diversity and evolution. Prokaryotic and eukaryotic microorganisms. Modern microbial taxonomy and nomenclature. Bergey's Manual of Systematic Bacteriology. Advanced microscopy techniques: Fluorescence microscopy, Confocal microscopy, Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM). Ultrastructure of bacteria, fungi, algae, protozoa, and viruses.							

Unit-II	Microbial Physiology and Metabolism	9 Hrs.
Microbial nutrition and transport mechanisms. Growth kinetics and mathematical models of microbial growth. Continuous culture, chemostat and turbidostat. Synchronous culture. Stress physiology and microbial adaptation. Microbial energetics. Aerobic and anaerobic respiration. Fermentation pathways. Photosynthesis in microorganisms. Nitrogen metabolism, sulfur metabolism, carbon metabolism and methylophony. Secondary metabolites. Regulation of microbial metabolism.		
Unit-III	Applied and Industrial Microbiology	9 Hrs.
Industrial production of microbial products: antibiotics, enzymes, amino acids, organic acids, vitamins, biofertilizers, biopesticides, probiotics and vaccines. Fermentation technology and bioreactor design. Downstream processing. Wastewater treatment-Bioremediation- Bioleaching. Microbial fuel cells. Microbial applications in agriculture, healthcare, pharmaceuticals, and environmental biotechnology.		
Unit-IV	Medical Microbiology and Immunological Aspects	9 Hrs.
Host-microbe interactions. Normal microbiota and opportunistic pathogens. Virulence factors and mechanisms of pathogenesis. Epidemiology of infectious diseases. Emerging and re-emerging infectious diseases. Antimicrobial agents and mechanisms of action. Antimicrobial resistance (AMR), multidrug resistance (MDR), and resistance mechanisms. Biofilms and quorum sensing.		
Unit-V	Environmental Microbiology	9 Hrs.
Brief account of microbial interactions (symbiosis, neutralism, commensalism, competition, ammensalism, synergism, parasitism, and predation); biological nitrogen fixation - symbiotic and asymbiotic; biofertilizers, biological pest control. Plant disease (brown spot of rice, black stem rust of wheat) dissemination and control. Different types of microorganisms in the air, aerosols, sampling techniques. Coliform test - detection of fecal and non-fecal coliform.		

Text Book(s):

1. Pelczar, M.J., Chan, E.C.S., & Krieg, N.R. (2018). *Microbiology*. 5th Edition. McGraw-Hill Education.
2. Madigan, M.T., Bender, K.S., Buckley, D.H., Sattley, W.M., & Stahl, D.A. (2022). *Brock Biology of Microorganisms*. 16th Edition. Pearson.
3. Willey, J.M., Sherwood, L.M., & Woolverton, C.J. (2021). *Prescott's Microbiology*. 11th Edition. McGraw-Hill Education.
4. Atlas, R.M. (2019). *Principles of Microbiology*. 3rd Edition. McGraw-Hill Education.
5. Tortora, G.J., Funke, B.R., & Case, C.L. (2022). *Microbiology: An Introduction*. 14th Edition. Pearson.

Reference Book(s):

1. Moat, A.G., Foster, J.W., & Spector, M.P. (2002). *Microbial Physiology*. 4th Edition. Wiley-Liss.
2. Stanier, R.Y., Ingraham, J.L., Wheelis, M.L., & Painter, P.R. *General Microbiology*. 5th Edition. Macmillan.
3. Schaechter, M. (2019). *Schaechter's Mechanisms of Microbial Disease*. 6th Edition. Wolters Kluwer.
4. Slonczewski, J.L., & Foster, J.W. (2020). *Microbiology: An Evolving Science*. 5th Edition. W.W. Norton.
5. Snyder, L., Peters, J.E., Henkin, T.M., & Champness, W. (2020). *Molecular Genetics of Bacteria*. 5th Edition. ASM Press

e Resources:

1. National Center for Biotechnology Information (NCBI) – <https://www.ncbi.nlm.nih.gov>
2. American Society for Microbiology (ASM) – <https://asm.org>
3. Microbiology Society (UK) – <https://microbiologysociety.org>
4. PubMed Database – <https://pubmed.ncbi.nlm.nih.gov>
5. NPTEL – Biotechnology and Microbiology Courses – <https://nptel.ac.in>

Relationship Matrix for COs, POs and PSOs

Semester	Course code			Title of the course								Hours		Credit
I	PBT26101			Microbiology								3		3
Course Outcomes (COs)	Programme Outcomes (POs)											Programme Specific Outcomes (PSOs)		Mean Score of COs
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	
CO1	3		2	1	1	-	-	-	-	-	1	2	-	1.67
CO2	3	2	2	2	2	1	-	-	-	-	1	2	1	1.78
CO3	2	3	3	3	2	3		1	1	2	2	3	3	2.15
CO4	2	3	3	2	2	2	1	2	1	3	2	2	3	2.15
CO5	2	2	3	2	3	3	1	2	2	3	2	3	3	2.38
Mean	2.4	2.5	2.6	2	2	2.25	1	1.6	1.3	2.6	1.9	2.4	2.5	2.1

Sem	Course Code	Title of the Course	Course Category	L	T	P	Credits
I	PBT26102	Lab in Microbiology	Core	0	0	4	2
Pre-Requisite: Knowledge of basic microbiology, aseptic techniques, microscopy, culture media preparation, and laboratory safety							
Co-Requisite: Microbiology (Theory) and Molecular Biology							
Progressive course: Advanced Microbiology Laboratory, Industrial Microbiology, Medical Microbiology, Molecular Diagnostics, Fermentation Technology							
Course Objectives:							
1. Understand laboratory safety practices, aseptic techniques, and the operation of basic microbiological instruments.							
2. Develop skills in isolation, cultivation, identification, and preservation of microorganisms using standard microbiological methods.							
3. Perform quantitative and qualitative microbiological analyses for environmental, food, and clinical samples.							
4. Apply biochemical, physiological, and molecular techniques for microbial characterization.							
5. Interpret experimental results and develop competency in microbiological research and industrial applications.							
Course Outcomes:							
CO1: Demonstrate aseptic techniques, sterilization methods, and laboratory safety practices in microbiology (K3)							
CO2: Perform isolation, cultivation, staining, and preservation of microorganisms using standard microbiological techniques (K3)							
CO3: Identify microorganisms using microscopic observation and biochemical tests (K4)							
CO4: Evaluate microbial growth under different environmental conditions and assess antimicrobial susceptibility (K5)							
CO5: Perform microbiological experiments and interpret the results for research and industrial applications (K3)							

List of Experiments

1. Laboratory safety practices and aseptic techniques.
2. Preparation and sterilization of microbiological culture media.
3. Isolation of microorganisms by streak plate, spread plate, and pour plate techniques.
4. Enumeration of microorganisms by serial dilution and standard plate count method.
5. Microscopic examination of microorganisms using wet mount and hanging drop techniques.
6. Gram staining and observation of bacterial morphology.
7. Staining techniques: Endospore staining, Capsule staining, and Acid-fast staining.
8. Identification of bacteria using biochemical tests (IMViC, Catalase, Oxidase, Urease, TSI, Citrate, and Nitrate reduction tests).
9. Study of the bacterial growth curve using spectrophotometric analysis.
10. Effect of environmental factors (temperature, pH, and salinity) on microbial growth.
11. Antibiotic susceptibility testing by Kirby–Bauer disc diffusion method.
12. Isolation and characterization of soil microorganisms (bacteria, fungi, and actinomycetes).
13. Microbiological analysis of water by Most Probable Number (MPN) and total viable count methods.
14. Microbial fermentation for the production of ethanol or organic acids.
15. Preservation and maintenance of microbial cultures using agar slants and glycerol stock methods.

Text Books

1. Pelczar, M.J., Chan, E.C.S. & Krieg, N.R. *Microbiology: Concepts and Applications*. McGraw-Hill Education.
2. Cappuccino, J.G. & Welsh, C.T. *Microbiology: A Laboratory Manual*. Pearson Education.
3. Atlas, R.M. *Handbook of Microbiological Media*. CRC Press.
4. Benson, H.J. *Microbiological Applications: Laboratory Manual in General Microbiology*. McGraw-Hill.
5. Prescott, L.M., Harley, J.P. & Klein, D.A. *Microbiology*. McGraw-Hill Education.

Reference Books

1. Madigan, M.T., Bender, K.S., Buckley, D.H., Sattley, W.M. & Stahl, D.A. *Brock Biology of Microorganisms*. Pearson.
2. Atlas, R.M. *Principles of Microbiology*. McGraw-Hill.
3. Tortora, G.J., Funke, B.R. & Case, C.L. *Microbiology: An Introduction*. Pearson.
4. Gerhardt, P. et al. *Manual of Methods for General Bacteriology*. American Society for Microbiology (ASM Press).
5. Aneja, K.R. *Experiments in Microbiology, Plant Pathology and Biotechnology*. New Age International Publishers.

E-Resources

1. National Center for Biotechnology Information (NCBI) – <https://www.ncbi.nlm.nih.gov>
2. American Society for Microbiology (ASM) – <https://asm.org>
3. Centers for Disease Control and Prevention (CDC) – <https://www.cdc.gov>
4. Microbiology Society – <https://microbiologysociety.org>
5. OpenStax – Microbiology (Free Textbook) – <https://openstax.org/details/books/microbiology>

Relationship Matrix for COs, POs and PSOs

Semester	Course code			Title of the course								Hours		Credit
I	PBT26102			Lab in Microbiology								4		2
Course Outcomes (COs)	Programme Outcomes (POs)											Programme Specific Outcomes (PSOs)	Mean Score of COs	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11			PSO1
CO1	2	3	1	2	1	—	1	3	2	1	1	2	1	1.67
CO2	2	3	2	3	1	1	1	2	2	1	1	3	2	1.92
CO3	3	3	3	3	2	1	1	1	1	1	1	3	2	1.92
CO4	2	3	3	2	2	2	1	2	1	3	2	2	3	2.15
CO5	2	3	3	3	2	3	2	2	2	2	3	3	3	2.54
Mean	2.2	3	2.5	2.6	1.8	1.7	1.3	2.0	1.6	1.6	1.6	2.6	2.4	2.1

Sem	Course Code	Title of the Course	Course Category	L	T	P	Credits
I	PBT26S01	Biochemistry and Metabolic Regulation	SEC	2	1	0	3
Pre-Requisite: Basic knowledge of Cell Biology and Molecular Biology							
Co- Requisite: Basic laboratory skills in Biotechnology.							
Progressive Course: Molecular Biology, Metabolic Engineering, Clinical Biochemistry							
Course Objectives:							
1. Understand the structure, chemistry and biological significance of biomolecules.							
2. Explain enzyme kinetics, regulation and biochemical energetics involved in cellular metabolism.							
3. Describe the integration and regulation of carbohydrate, lipid, amino acid and nucleotide metabolism.							
4. Analyze molecular mechanisms of metabolic regulation in health, disease and biotechnology.							
5. Apply biochemical principles to biotechnology, drug discovery, diagnostics and industrial bioprocesses.							
Course Outcomes:							
CO1: Explain the structural organization and biological functions of proteins, carbohydrates, lipids and nucleic acids (K1)							
CO2: Evaluate enzyme mechanisms, kinetics, inhibition and regulation using biochemical principles (K2)							
CO3: Analyze metabolic pathways and their regulation under normal and pathological conditions (K2)							
CO4: Interpret biochemical pathways involved in cellular signaling, bioenergetics and molecular metabolism (K3)							
CO5: Apply biochemical knowledge in biotechnology research, pharmaceutical industries, clinical diagnostics and metabolic engineering (K3)							
Unit-I	Biomolecules and Structural Biochemistry						9 Hrs.
Water as biological solvent - Acid-base balance and biological buffers - Amino acids: Classification, properties and reactions - Protein structure (Primary, Secondary, Tertiary and Quaternary) - Protein folding and molecular chaperones -Carbohydrates: Classification and biological importance -Lipids: Classification, membrane lipids and biological functions -Nucleic acids: Structure of DNA and RNA Biomolecular interactions.							

Unit-II	Enzymology and Bioenergetics	9 Hrs.
Classification and nomenclature of enzymes - Active site and catalytic mechanisms - Michaelis-Menten kinetics -Lineweaver-Burk plot - Enzyme inhibition-Allosteric regulation - Isoenzymes -Ribozymes - Coenzymes and cofactors - Bioenergetics -ATP synthesis -Oxidative phosphorylation -Electron transport chain - Chemiosmotic theory		
Unit-III	Intermediary Metabolism	9 Hrs.
Carbohydrate Metabolism: Glycolysis - Gluconeogenesis -Glycogen metabolism -Pentose phosphate pathway -TCA cycle. Lipid Metabolism: β -oxidation -Fatty acid biosynthesis -Ketone body metabolism - Cholesterol biosynthesis. Amino Acid Metabolism: Transamination -Oxidative deamination -Urea cycle - Biosynthesis of non-essential amino acids. Nucleotide Metabolism: Purine metabolism -Pyrimidine metabolism -Salvage pathways -Metabolic disorders		
Unit-IV	Regulation of Metabolism and Molecular Biochemistry	9 Hrs.
Hormonal regulation of metabolism -Signal transduction pathways -Second messengers -Protein phosphorylation -Cellular communication -Oxidative stress -Reactive oxygen species (ROS) - Antioxidant defense mechanisms -Apoptosis -Metabolic disorders - Diabetes mellitus -Obesity -Inborn errors of metabolism		
Unit-V	Applied Biochemistry in Biotechnology	9 Hrs.
Clinical biochemistry and biomarkers -Biochemical basis of inherited diseases -Recombinant protein production -Enzyme engineering -Industrial enzymes -Protein purification strategies -Metabolomics - Nutritional biochemistry -Biochemical basis of drug action -Applications in pharmaceutical biotechnology -Synthetic biology and metabolic engineering		

Text Book(s):

1. Nelson, D. L., & Cox, M. M. (2021). *Lehninger principles of biochemistry* (8th ed.). W. H. Freeman.
2. Berg, J. M., Tymoczko, J. L., Gatto, G. J., Jr., & Stryer, L. (2023). *Biochemistry* (10th ed.). W. H. Freeman.
3. Rodwell, V. W., Bender, D. A., Botham, K. M., Kennelly, P. J., & Weil, P. A. (2023). *Harper's illustrated biochemistry* (32nd ed.). McGraw-Hill Education.
4. Satyanarayana, U., & Chakrapani, U. (2022). *Biochemistry* (7th ed.). Elsevier India.
5. Jain, J. L., Jain, S., & Jain, N. (2016). *Fundamentals of biochemistry* (8th ed.). S. Chand Publishing.

Reference Book(s):

1. Voet, D., Voet, J. G., & Pratt, C. W. (2019). *Fundamentals of biochemistry: Life at the molecular level* (5th ed.). John Wiley & Sons.
2. Devlin, T. M. (2010). *Textbook of biochemistry with clinical correlations* (7th ed.). John Wiley & Sons.
3. Garrett, R. H., & Grisham, C. M. (2016). *Biochemistry* (6th ed.). Cengage Learning.
4. Murray, R. K., Bender, D. A., Botham, K. M., Kennelly, P. J., Rodwell, V. W., & Weil, P. A. (2018). *Harper's illustrated biochemistry* (31st ed.). McGraw-Hill Education.
5. Ferrier, D. R. (2022). *Lippincott illustrated reviews: Biochemistry* (8th ed.). Wolters Kluwer.

e Resources:

- 1 [NCBI Bookshelf](https://www.ncbi.nlm.nih.gov/books/) - <https://www.ncbi.nlm.nih.gov/books/>
- 2 NCBI - <https://www.ncbi.nlm.nih.gov/>
3. UniProt Knowledgebase (UniProtKB) - <https://www.uniprot.org>
4. EMBL- [KEGG \(Kyoto Encyclopedia of Genes and Genomes\)](https://www.kegg.jp/) –
5. <https://www.kegg.jp/><https://www.ebi.ac.uk/training/>

Relationship Matrix for COs, POs and PSOs

Semester	Course code		Title of the course										Hours		Credit
I	PBT26S01		Biochemistry and Metabolic Regulation										3		3
Course Outcomes (COs)	Programme Outcomes (POs)											Programme Specific Outcomes (PSOs)		Mean Score of COs	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2		
CO1	3	2	2	2	1	2	2	1	2	1	2	3	2	2.0	
CO2	3	3	3	2	2	2	-	-	-	-	2	3	3	2.5	
CO3	3	3	3	3	2	2	2	-	-	-	2	3	3	2.7	
CO4	3	2	2	3	3	2	2	2	-	-	2	3	3	2.3	
CO5	3	3	1	3	3	3	2	3	2	2	3	3	3	2.6	
Mean	3.0	2.8	2.6	2.6	2.2	2.2	2.0	2.0	2.0	1.5	2.2	3.0	2.8	2.4	

Sem	Course Code	Title of the Course	Course Category	L	T	P	Credits
I	PBT26S02	Lab in Biochemistry	SEC	0	0	4	2
Pre-Requisite: Knowledge of basic Biochemistry, Cell Biology, and fundamental laboratory techniques.							
Co-Requisite: Biochemistry (Theory).							
Progressive Course: Molecular Biology, Enzymology, Clinical Biochemistry, Proteomics, Metabolomics, and Research Project.							
Course Objectives:							
1. Understand the principles and applications of qualitative and quantitative biochemical techniques.							
2. Develop practical skills in the analysis and estimation of biomolecules using standard biochemical methods.							
3. Perform enzyme assays and interpret enzyme activity under laboratory conditions.							
4. Apply chromatographic and spectrophotometric techniques for the separation and analysis of biomolecules.							
5. Develop analytical, experimental, and data interpretation skills required for research and industrial biotechnology							
Course Outcomes:							
CO1: Prepare standard solutions and perform qualitative analysis of carbohydrates, proteins, amino acids, and lipids (K3)							
CO2: Estimate biomolecules such as sugars, proteins, amino acids, DNA, RNA, cholesterol, and vitamin C using standard (K3)							
CO3: Perform enzyme assays and analyze enzyme activity using biochemical techniques (K4)							
CO4: Apply chromatographic techniques to separate and identify biomolecules (K3)							
CO5: Interpret experimental results and apply biochemical techniques in research and biotechnology applications (K4)							

List of Experiments

1. Preparation of standard solutions and determination of pH using a pH meter.
2. Qualitative analysis of carbohydrates.
3. Qualitative analysis of amino acids.
4. Qualitative analysis of proteins.
5. Qualitative analysis of lipids.
6. Estimation of reducing sugars by the DNS method.
7. Estimation of total protein by the Lowry method.
8. Estimation of amino acids by the Ninhydrin method.
9. Estimation of DNA by the Diphenylamine (DPA) method.
10. Estimation of RNA by the Orcinol method.
11. Estimation of cholesterol by the CHOD-PAP method.
12. Estimation of ascorbic acid (Vitamin C).
13. Assay of Amylase enzyme activity.
14. Assay of Catalase enzyme activity.
15. Separation of amino acids by Paper Chromatography.
16. Separation of plant pigments by Thin Layer Chromatography (TLC).

Text Books

1. Plummer, D.T. *An Introduction to Practical Biochemistry*. Tata McGraw-Hill Education.
2. Wilson, K. & Walker, J. *Principles and Techniques of Practical Biochemistry*. Cambridge University Press.
3. Jayaraman, J. *Laboratory Manual in Biochemistry*. New Age International Publishers.
4. Sadasivam, S. & Manickam, A. *Biochemical Methods*. New Age International Publishers.
5. Sawhney, S.K. & Singh, R. *Introductory Practical Biochemistry*. Narosa Publishing House.

Reference Books

1. Nelson, D.L. & Cox, M.M. *Lehninger Principles of Biochemistry*. W.H. Freeman.
2. Berg, J.M., Tymoczko, J.L., Gatto, G.J. & Stryer, L. *Biochemistry*. W.H. Freeman.
3. Voet, D. & Voet, J.G. *Biochemistry*. John Wiley & Sons.
4. Rodwell, V.W., Bender, D.A., Botham, K.M., Kennelly, P.J. & Weil, P.A. *Harper's Illustrated Biochemistry*. McGraw-Hill Education.
5. Devlin, T.M. *Textbook of Biochemistry with Clinical Correlations*. Wiley-Liss.

E-Resources

1. National Center for Biotechnology Information (NCBI) – <https://www.ncbi.nlm.nih.gov>
2. ExPASy Bioinformatics Resource Portal – <https://www.expasy.org>
3. KEGG (Kyoto Encyclopedia of Genes and Genomes) – <https://www.kegg.jp>
4. PubMed – <https://pubmed.ncbi.nlm.nih.gov>
5. MIT OpenCourseWare – Biochemistry – <https://ocw.mit.edu>

Relationship Matrix for COs, POs and PSOs

Semester	Course code			Title of the course								Hours		Credit
I	PBT26S02			Lab in Biochemistry								4		2
Course Outcome s (COs)	Programme Outcomes (POs)											Programme Specific Outcomes (PSOs)		Mean Score of COs
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO 2	
CO1	2	3	2	2	1	1	1	2	1	–	1	3	1	1.77
CO2	2	3	3	3	2	2	1	2	1	1	1	3	2	2.08
CO3	2	3	3	3	2	2	1	1	1	1	2	3	2	2.00
CO4	2	3	3	3	2	2	1	1	1	1	2	3	3	2.08
CO5	2	3	3	3	2	3	2	2	2	2	3	3	3	2.54
Mean	2	3	2.8	2.8	1.8	2.0	1.2	1.6	1.2	1.3	1.8	3	2.8	2.1

Sem	Course Code	Title of the Course	Course Category	L	T	P	Credits
I	PBT26001	Ecology & Evolutionary Biology	DEC	4	0	0	4
Pre-Requisite: Knowledge of Biology, Cell Biology, Genetics, Environmental Science, and Basic Ecology.							
Co- Requisite: Ecology and Evolutionary Biology Practical.							
Progressive Course: Conservation Biology, Environmental Biotechnology, Systems Biology, Evolutionary Genomics, Climate Change Biology, Restoration Ecology, and Biodiversity Management.							
Course Objectives:							
1. Understand the fundamental concepts of ecology, ecosystems, and environmental interactions.							
2. Explain the mechanisms governing population dynamics, communities, and biodiversity.							
3. Analyze ecosystem structure, energy flow, nutrient cycling, and ecological succession.							
4. Understand the principles and mechanisms of evolution, speciation, and adaptation.							
5. Apply ecological and evolutionary concepts in biodiversity conservation and environmental management.							
Course Outcomes:							
CO1: Explain the fundamental concepts of ecology, ecological organization, population dynamics, and species interactions (K2)							
CO2: Analyze the structure and functioning of communities and ecosystems, including energy flow, productivity, ecological succession, and biogeochemical cycles (K4)							
CO3: Evaluate the significance of biodiversity, conservation strategies, ecosystem restoration, and the impact of climate change on biological diversity (K5)							
CO4: Apply the principles of evolutionary biology, population genetics, Hardy–Weinberg equilibrium, and mechanisms of evolution to explain biological diversity and adaptation (K3)							
CO5: Assess phylogenetic relationships and the applications of evolutionary biology in biotechnology, agriculture, medicine, and conservation for solving biological problems (K5)							
Unit-I	Fundamentals of Ecology						12Hrs.
Introduction to ecology and its scope. Levels of ecological organization. Abiotic and biotic factors. Habitat and ecological niche. Population ecology: population characteristics, growth models, carrying capacity, life tables, survivorship curves. Species interactions: competition, predation, mutualism, commensalism, parasitism and amensalism.							

Unit-II	Community Ecology and Ecosystem	12 Hrs.
Community structure and organization. Ecological succession (primary and secondary). Ecosystem concept, structure and functions. Energy flow in ecosystems. Food chains, food webs and ecological pyramids. Ecological efficiency. Productivity of ecosystems (primary and secondary productivity). Biogeochemical cycles (Carbon, Nitrogen, Phosphorus and Water).		
Unit-III	Biodiversity and Conservation Biology	12Hrs.
Concept and levels of biodiversity. Patterns of biodiversity. Biodiversity hotspots. Threats to biodiversity. Endangered species. In situ and ex situ conservation. Protected areas, biosphere reserves, national parks and wildlife sanctuaries. Restoration ecology. Sustainable development and ecosystem services. Climate change and biodiversity conservation.		
Unit-IV	Principles of Evolutionary Biology	12 Hrs.
History of evolutionary thought. Darwinism and Neo-Darwinism. Origin of life. Molecular evolution. Population genetics. Hardy–Weinberg equilibrium. Mutation, recombination, gene flow, genetic drift and natural selection. Adaptation and fitness. Speciation (allopatric, sympatric and parapatric). Co-evolution.		
Unit-V	Evolution, Phylogeny and Applied Evolutionary Biology	12Hrs
Evolutionary genetics. Phylogenetic classification. Molecular phylogeny. Molecular clocks. Human evolution. Evolution of microorganisms. Adaptive radiation. Evolutionary developmental biology (Evo-Devo). Applications of evolutionary biology in biotechnology, agriculture, medicine and conservation biology.		

Text Book(s):

1. Odum, E.P. & Barrett, G.W. *Fundamentals of Ecology*. Cengage Learning.
2. Molles, M.C. *Ecology: Concepts and Applications*. McGraw-Hill Education.
3. Freeman, S. & Herron, J.C. *Evolutionary Analysis*. Pearson Education.
4. Futuyma, D.J. & Kirkpatrick, M. *Evolution*. Sinauer Associates.
5. Begon, M., Townsend, C.R. & Harper, J.L. *Ecology: From Individuals to Ecosystems*. Wiley-Blackwell.

Reference Book(s):

1. Ricklefs, R.E. & Relyea, R.A. *Ecology: The Economy of Nature*. W.H. Freeman.
2. Smith, T.M. & Smith, R.L. *Elements of Ecology*. Pearson.
3. Primack, R.B. *Essentials of Conservation Biology*. Sinauer Associates.
4. Stearns, S.C. & Hoekstra, R.F. *Evolution: An Introduction*. Oxford University Press.
5. Campbell, N.A. et al. *Campbell Biology*. Pearson.

e- Resources:

1. National Center for Biotechnology Information (NCBI) – <https://www.ncbi.nlm.nih.gov>
2. Encyclopedia of Life (EOL) – <https://eol.org>
3. International Union for Conservation of Nature (IUCN) – <https://www.iucn.org>
4. Convention on Biological Diversity (CBD) – <https://www.cbd.int>
5. Nature Education (Scitable Archives) – <https://www.nature.com/scitable>

Relationship Matrix for COs, POs and PSOs

Semester	Course code			Title of the course								Hours		Credit
I	PBT26001			Ecology & Evolutionary Biology								4		4
Course Outcomes (COs)	Programme Outcomes (POs)											Programme Specific Outcomes (PSOs)		Mean Score of COs
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	
CO1	3	1	2	1	2	1	–	1	–	2	1	1	1	1.7
CO2	3	2	3	2	3	2	1	1	1	3	2	2	2	2.08
CO3	2	2	3	2	3	2	1	2	2	3	2	2	3	2.23
CO4	3	2	3	2	3	2	1	1	1	2	2	2	2	2.00
CO5	2	3	3	3	3	3	2	2	2	3	3	3	3	2.69
Mean	2.6	2.1	2.8	2	2.8	2	1.3	1.4	1.5	2.6	2	2	2.4	2.2

Sem	Course Code	Title of the Course	Course Category	L	T	P	Credits
I	PBT26002	Human Anatomy and Physiology	DEC	4	0	0	4

Pre-Requisite: Basic knowledge of Human biology and Cell biology.

Co-Requisite: Study of Biochemistry and Medical Biotechnology

Progressive Course: Provides a foundation for clinical Biotechnology, Pharmacology, and Biomedical research.

Course Objectives:

1. Understand the structural organization of the human body and the functions of major organ systems.
2. Explain physiological mechanisms involved in maintaining homeostasis.
3. Analyze the functioning and regulation of cardiovascular, respiratory, digestive, and excretory systems.
4. Comprehend the role of endocrine, nervous, and reproductive systems in health and disease.
5. Apply anatomical and physiological principles to biomedical and biotechnological research.

Course Outcomes:

CO1: Describe the anatomical organization and physiological functions of major human organ systems (K2)

CO2: Explain the mechanisms involved in maintaining cellular and systemic homeostasis (K2)

CO3: Analyze the functions and regulation of cardiovascular, respiratory, digestive, and renal systems (K4)

CO4: Evaluate the physiological roles of endocrine, nervous, and reproductive systems (K5)

CO5: Apply physiological concepts to understand human health, disease, and biomedical applications (K3)

Unit-I	Organization of Human Body and Integumentary System	12 Hrs.
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Levels of structural organization. Homeostasis and feedback mechanisms. Cells and tissues. Epithelial, connective, muscular, and nervous tissues. Skin and accessory structures. Skeletal system and joints. Organization and functions of muscles. Structure and physiology of skeletal muscle contraction.

Unit-II	Cardiovascular and Respiratory Systems	12 Hrs.
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Composition and functions of blood. Hemostasis and blood groups. Structure and physiology of the heart. Cardiac cycle and electrocardiogram. Blood vessels and circulation. Blood pressure regulation. Structure and functions of respiratory organs. Mechanism of respiration. Gas exchange and transport of respiratory gases. Regulation of respiration.

Unit-III	Digestive and Excretory Systems	12 Hrs.
Structure and functions of the digestive system. Digestion and absorption of carbohydrates, proteins, and lipids. Liver and pancreas. Metabolism and energy balance. Structure and functions of kidneys. Formation of urine. Water and electrolyte balance. Acid-base balance and renal regulation		
Unit-IV	Nervous and Endocrine Systems	12 Hrs.
Organization of nervous system. Neuron structure and nerve impulse transmission. Synaptic transmission and neurotransmitters. Central and peripheral nervous systems. Sense organs. Endocrine glands and hormones. Mechanism of hormone action. Regulation of endocrine functions and hormonal disorders.		
Unit-V	Reproductive System and Human Health	12 Hrs.
Male and female reproductive systems. Gametogenesis. Menstrual cycle. Fertilization, implantation, pregnancy, and lactation. Reproductive hormones. Immune system overview. Aging and physiological changes. Lifestyle disorders and metabolic diseases. Biomedical and biotechnological applications in human health		

Text Book(s):

1. Tortora, G.J. & Derrickson, B.H. *Principles of Anatomy and Physiology*. John Wiley & Sons.
2. Marieb, E.N. & Hoehn, K. *Human Anatomy & Physiology*. Pearson Education.
3. Ross, M.H. & Wilson, K. *Anatomy and Physiology in Health and Illness*. Elsevier.
4. Seeley, R.R., Stephens, T.D. & Tate, P. *Anatomy & Physiology*. McGraw-Hill Education.
5. Guyton, A.C. & Hall, J.E. *Textbook of Medical Physiology*. Elsevier

Reference Book(s):

1. Widmaier, E.P., Raff, H. & Strang, K.T. *Vander's Human Physiology: The Mechanisms of Body Function*. McGraw-Hill Education.
2. Ganong, W.F. *Review of Medical Physiology*. McGraw-Hill Education.
3. Junqueira, L.C. & Carneiro, J. *Basic Histology: Text and Atlas*. McGraw-Hill Education.
4. Barrett, K.E., Barman, S.M., Brooks, H.L. & Yuan, J.X.J. *Ganong's Review of Medical Physiology*. McGraw-Hill Education.
5. Sherwood, L. *Human Physiology: From Cells to Systems*. Cengage Learning

e- Resources:

1. National Center for Biotechnology Information (NCBI Bookshelf) – <https://www.ncbi.nlm.nih.gov/books/>
2. OpenStax – Anatomy and Physiology – <https://openstax.org/details/books/anatomy-and-physiology>
3. Visible Body (3D Human Anatomy Learning Resource) – <https://www.visiblebody.com>
4. TeachMeAnatomy – <https://teachmeanatomy.info>
5. MedlinePlus (Human Anatomy, Physiology & Health Information) – <https://medlineplus.gov>

Relationship Matrix for COs, POs and PSOs

Semester	Course code			Title of the course								Hours		Credit
I	PBT26002			Human Anatomy and Physiology								4		4
Course Outcomes (COs)	Programme Outcomes (POs)											Programme Specific Outcomes (PSOs)		Mean Score of COs
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	
CO1	3	1	2	1	2	1	—	—	—	2	1	1	1	1.56
CO2	3	2	2	2	2	1	1	1	—	2	2	2	1	1.82
CO3	3	2	3	2	2	2	1	1	1	2	2	2	2	2.00
CO4	3	2	3	2	2	2	1	1	1	2	2	2	2	2.00
CO5	2	3	3	3	3	3	2	2	2	3	3	3	3	2.69
Mean	2.8	2	2.6	2	2.2	1.8	1.3	1.3	1.5	2.2	2	2	1.9	2.1

Sem	Course Code	Title of the Course	Course Category	L	T	P	Credits
I	PBT26003	Cell Signaling	DEC	4	-	-	4
Pre-Requisite: Basic knowledge of Cell Biology, Fundamentals of Biochemistry and Introductory Molecular Biology							
Co- Requisite: Advanced Molecular Biology and biochemical techniques / Laboratory Course							
Progressive Course: Advanced Cell Biology, Molecular Medicine, Cancer Biology, Immunology, Systems Biology and Drug Discovery and Development.							
Course Objectives:							
1. To provide in-depth knowledge of cellular communication mechanisms							
2. To understand molecular basis of signal transduction pathways							
3. To analyze integration and regulation of signaling networks							
4. To relate signaling pathways with physiological and pathological conditions							
5. To introduce experimental and computational approaches in cell signaling							
Course Outcomes:							
CO1: Explain the principles and types of cell signaling mechanisms (K1)							
CO2: Describe structure and function of different receptors (K2)							
CO3: Analyze major intracellular signaling pathways and their regulation (K2)							
CO4: Interpret signaling network interactions and cross-talk (K3)							
CO5: Evaluate the role of signaling pathways in diseases and therapeutics (K3)							
Unit-I	Introduction to Cell Signaling						12Hrs.
Definition and importance of cell signaling - Types of signaling: Autocrine, Paracrine, Endocrine, Synaptic - Signaling molecules: hormones, neurotransmitters, cytokines - Receptors: intracellular vs cell surface receptors - General principles of signal transduction.							
Unit-II	Receptors and Signal Transduction Mechanisms						12 Hrs.
G-protein coupled receptors (GPCRs) - Receptor tyrosine kinases (RTKs) - Ion channel-linked receptors - Cytokine receptors (JAK-STAT pathway) - Second messengers: cAMP, Ca ²⁺ , IP ₃ , DAG - Amplification and specificity of signals.							

Unit-III	Intracellular Signaling Pathways	12 Hrs.
MAPK/ERK pathway - PI3K–Akt pathway - NF-κB signaling - Wnt/β-catenin pathway - Cross-talk - between pathways - Feedback regulation and signal integration.		
Unit-IV	Cell Signaling in Cellular Processes	12 Hrs.
Role of signaling in: Cell cycle regulation - Apoptosis and survival - Cell differentiation and development - Immune signaling and cytokine networks - Signal transduction in stem cells and tissue engineering - Role in morphogenesis and development.		
Unit-V	Cell Signaling in Disease and Applications	12 Hrs.
Dysregulation of signaling in diseases: Cancer, Diabetes and Neurological disorders - Oncogenes and tumor suppressor signaling - Drug targets in signaling pathways - Applications in biotechnology: Drug discovery, Biosensors, Gene therapy. Experimental techniques: Western blot, ELISA, reporter assays.		

Text Book(s):

1. Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A. & Martin, K.C. *Molecular Cell Biology*. W.H. Freeman & Company.
2. Cooper, G.M. & Hausman, R.E. *The Cell: A Molecular Approach*. Sinauer Associates/Oxford University Press.
3. Alberts, B., Johnson, A., Lewis, J., Morgan, D., Raff, M., Roberts, K. & Walter, P. *Molecular Biology of the Cell*. Garland Science.
4. Pollard, T.D., Earnshaw, W.C., Lippincott-Schwartz, J. & Johnson, G.T. *Cell Biology*. Elsevier.
5. Karp, G. *Cell and Molecular Biology: Concepts and Experiments*. Wiley.

Reference Book(s):

1. Lim, W.A., Mayer, B.J. & Pawson, T. *Cell Signaling: Principles and Mechanisms*. Garland Science.
2. Krauss, G. *Biochemistry of Signal Transduction and Regulation*. Wiley-VCH.
3. Hancock, J.T. *Cell Signalling*. Oxford University Press.
4. Pawson, T. & Scott, J.D. *Signal Transduction in Cell Biology and Human Disease*. Academic Press.
5. Weinberg, R.A. *The Biology of Cancer*. Garland Science.

e - Resources:

1. NCBI Bookshelf (<https://www.ncbi.nlm.nih.gov/books/>)
2. KEGG Pathway Database (<https://www.genome.jp/kegg/>)
3. Reactome Pathway Database (<https://reactome.org/>)
4. PubMed (<https://pubmed.ncbi.nlm.nih.gov/>)
5. HHMI BioInteractive (<https://www.biointeractive.org/>)

Relationship Matrix for COs, POs and PSOs

Semester	Course code			Title of the course								Hours		Credit
I	PBT26003			Cell Signaling								4		4
Course Outcomes (COs)	Programme Outcomes (POs)											Programme Specific Outcomes (PSOs)		Mean Score of COs
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	
CO1	3	1	2	2	2	1	—	—	—	1	2	2	1	1.80
CO2	3	2	2	2	2	1	—	—	—	1	1	2	1	1.70
CO3	3	2	3	3	3	2	1	1	—	2	2	3	2	2.25
CO4	3	2	3	3	3	2	1	1	1	2	2	3	2	2.17
CO5	2	3	3	3	3	3	2	2	2	3	3	3	3	2.69
Mean	2.8	2.1	2.6	2.6	2.6	1.8	1.3	1.5	1.5	1.8	1.8	2.6	1.8	2.3

Sem	Course Code	Title of the Course	Course Category	L	T	P	Credits
I	PBT26004	Metabolomics	DEC	4	0	0	4
Pre-Requisite: Basic knowledge of Biochemistry, Molecular Biology, Cell Biology and Analytical Chemistry							
Co- Requisite: Bioinformatics							
Progressive Course: Systems Biology, Functional Genomics, Proteomics, Precision Medicine and Industrial Biotechnology							
Course Objectives:							
1. Understand the concepts and significance of metabolomics in modern biological research.							
2. Learn metabolite extraction, separation, identification and analytical techniques.							
3. Interpret metabolomics data using statistical and bioinformatics tools.							
4. Understand applications of metabolomics in medicine, agriculture, food science and environmental biotechnology.							
5. Develop the ability to critically analyze metabolomics research and emerging technologies.							
Course Outcomes:							
CO1: Explain the principles, scope and workflow of metabolomics (K2)							
CO2: Describe analytical platforms and instrumentation used in metabolomics (K2)							
CO3: Analyze metabolomics datasets using statistical and bioinformatics approaches (K4)							
CO4: Evaluate metabolomics applications in healthcare, agriculture, industry and environmental sciences (K5)							
CO5: Design metabolomics-based experimental approaches for biological research (K6)							
Unit-I	Introduction to Metabolomics						12 Hrs.
Introduction to omics technologies. Metabolomics: Definition, scope and significance, Types of metabolites - Metabolome and metabolic pathways - Targeted and untargeted metabolomics - Metabolomics workflow - Experimental design - Sample collection and storage - Sample preparation and metabolite extraction.							
Unit-II	Analytical Techniques in Metabolomics						12 Hrs.

Principles of chromatography: Gas Chromatography (GC), Liquid Chromatography (LC), Capillary Electrophoresis (CE), Mass Spectrometry (MS), Nuclear Magnetic Resonance (NMR), GC-MS, LC-MS/MS, CE-MS, MALDI-TOF, Instrument calibration and quality control.

Unit-III	Data Analysis and Bioinformatics	12 Hrs.
Data acquisition - Peak detection and alignment - Data preprocessing – Normalization - Metabolite identification - Spectral databases - Statistical analysis - t-test, ANOVA, PCA, PLS-DA, Pathway analysis - Metabolic network analysis - Machine learning applications in metabolomics.		
Unit-IV	Applications of Metabolomics	12 Hrs.
Clinical metabolomics - Biomarker discovery - Cancer metabolomics - Diabetes and cardiovascular diseases - Neurodegenerative disorders – Pharmaco metabolomics – Nutrimetabolomics – Plant metabolomics - Microbial metabolomics - Environmental metabolomics - Food metabolomics.		
Unit -V	Recent Advances and Emerging Trends	12 Hrs.
Single-cell metabolomics - Imaging metabolomics - Spatial metabolomics – Fluxomics – Lipidomics - Multi-omics integration - Artificial Intelligence in metabolomics - Personalized medicine - Precision agriculture - Ethical issues and future perspectives.		

Text Book(s):

1. Metabolomics: Fundamentals and Applications – Jens Nielsen and Michael C. Jewett (Eds.) – 2019 – 1st Edition.
2. Metabolomics in Practice: Successful Strategies to Generate and Analyze Metabolic Data – Michael Lämmerhofer and Wolfram Weckwerth (Eds.) – 2013 – 1st Edition.
3. Metabolomics: Methods and Protocols – Wolfram Weckwerth (Ed.) – 2007 – 2nd Edition.
4. Systems Biology: A Textbook – Edda Klipp, Wolfram Liebermeister, Christoph Wierling, Axel Kowald, Hans Lehrach, and Ralf Herwig – 2016 – 2nd Edition.
5. Bioinformatics and Functional Genomics – Jonathan Pevsner – 2015 – 3rd Edition.

Reference Book(s):

1. Metabolomics for Biomedical Research – Jerzy Adamski (Ed.) – 2020 – 1st Edition.
2. Mass Spectrometry for Metabolomics: Methods and Protocols – Ralf J. Weber and Wolfram Weckwerth (Eds.) – 2019 – 1st Edition.
3. Systems Biology in Practice: Concepts, Implementation and Application – Edda Klipp, Ralf Herwig, Axel Kowald, Christoph Wierling, and Hans Lehrach – 2005 – 1st Edition.
4. Introduction to Proteomics: Principles and Applications – Nawin C. Mishra – 2010 – 2nd Edition.
5. Introduction to Metabolomics – William J. Griffiths and Jens Nielsen – 2018 – 1st Edition

e- Resources:

1. KEGG (Kyoto Encyclopedia of Genes and Genomes) – <https://www.kegg.jp/>
2. Human Metabolome Database (HMDB) – <https://hmdb.ca/>
3. MetaboLights (EMBL-EBI Metabolomics Repository) – <https://www.ebi.ac.uk/metabolights/>
4. Metabolomics Workbench – <https://www.metabolomicsworkbench.org/>
5. PubChem (NCBI Chemical Database) – <https://pubchem.ncbi.nlm.nih.gov/>

Relationship Matrix for COs, POs and PSOs

Semester	Course code			Title of the course								Hours		Credit
I	PBT26004			Metabolomics								4		4
Course Outcomes (COs)	Programme Outcomes (POs)											Programme Specific Outcomes (PSOs)	Mean Score of COs	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	
CO1	3	2	1	-	-	-	-	2	-	-	-	3	2	1.90
CO2	2	3	2	2	-	-	-	-	-	2	-	3	3	2.41
CO3	2	3	3	3	2	-	-	-	-	2	-	3	3	2.14
CO4	2	2	3	3	3	2	-	-	-	2	-	3	3	2.00
CO5	3	3	3	3	3	2	2		-	-	-	3	3	2.31
Mean	2.4	2.6	2.4	2.2	2.6	0.8	2	2	0	2	0	3.0	2.8	2.4

Sem	Course Code	Title of the Course	Course Category	L	T	P	Credits
I	PBT26005	Methods in Biology	DEC	4	-	-	4
Pre-Requisite: Basic knowledge of Cell Biology, Biochemistry, Microbiology, Genetics and Molecular Biology.							
Co- Requisite: Practical course in Biological Techniques/Bioanalytical Techniques (if offered simultaneously).							
Progressive Course: Molecular Biology and Genetic Engineering, Genomics and Proteomics, Immunotechnology, Research Methodology and Biostatistics, Advanced Cell Biology, Pharmaceutical Biotechnology, Molecular Diagnostics and Dissertation/Research Project							
Course Objectives:							
1. Understand the principles, instrumentation and applications of modern biological research techniques.							
2. Develop competency in selecting appropriate analytical and molecular methods for biological investigations.							
3. Interpret experimental data generated through microscopic, biochemical, molecular and immunological techniques.							
4. Understand quality assurance, biosafety and ethical practices followed in biological laboratories.							
5. Build a strong methodological foundation for advanced research in biotechnology and allied disciplines							
Course Outcomes:							
CO1: Explain the principles and applications of microscopy, centrifugation, spectroscopy and chromatographic techniques (K2)							
CO2: Demonstrate understanding of molecular biology techniques including PCR, electrophoresis, blotting, sequencing and gene expression analysis (K2)							
CO3: Analyze biological samples using immunological, cell culture and imaging techniques for research applications (K4)							
CO4: Evaluate experimental data using statistical tools while maintaining quality assurance, biosafety and ethical standards (K5)							
CO5: Design suitable experimental approaches by integrating multiple biological methods for solving research problems in biotechnology (K6)							
Unit-I	Basic Biological Laboratory Methods and Instrumentation						12 Hrs.
Good Laboratory Practices (GLP), Good Manufacturing Practices (GMP) and laboratory safety - Biosafety levels and biological waste management - Preparation of solutions, buffers and culture media - Principles and applications of light microscopy, fluorescence microscopy and confocal microscopy - Electron microscopy (SEM and TEM) -Centrifugation: differential, density gradient and ultracentrifugation - Spectroscopic techniques: UV-Visible spectrophotometry, fluorescence spectroscopy and colorimetry							

Unit-II	Separation and Bioanalytical Techniques	12Hrs.
Chromatographic techniques: Paper chromatography, Thin Layer Chromatography (TLC), Column chromatography, Ion exchange chromatography, Gel filtration chromatography, Affinity chromatography High Performance Liquid Chromatography (HPLC) - Electrophoretic techniques: Agarose gel electrophoresis, Polyacrylamide Gel Electrophoresis (Native PAGE and SDS-PAGE) - Western, Southern and Northern blotting - Principles and applications of Mass Spectrometry		
Unit-III	Molecular Biology and Immunological Techniques	12 Hrs.
Isolation and purification of DNA, RNA and proteins - Polymerase Chain Reaction (PCR), RT-PCR and Quantitative PCR (qPCR) -DNA sequencing: Sanger sequencing and Next Generation Sequencing (NGS) -Recombinant DNA techniques and cloning strategies -CRISPR-Cas genome editing (overview) -ELISA, ELISPOT and Immunofluorescence assay -Flow cytometry and Fluorescence-Activated Cell Sorting (FACS)		
Unit-IV	Cell Culture, Imaging and Quantitative Biology	12 Hrs.
Animal cell culture and plant tissue culture techniques - Primary and continuous cell lines - Cell viability and cytotoxicity assays (MTT, Trypan Blue Exclusion) - Stem cell culture (overview) - Live-cell imaging and fluorescence imaging - Immunocytochemistry and immunohistochemistry- Digital image analysis - Introduction to biostatistics for biological experiments - Experimental design, data interpretation and statistical significance		
Unit-V	Advanced Biological Methods and Research Applications	12 Hrs.
Proteomics and metabolomics techniques - Protein purification and characterization - Protein-protein interaction studies (Yeast Two-Hybrid, Co-immunoprecipitation) -Bioinformatics tools for sequence analysis and structural biology -Gene expression analysis and transcriptomics -Quality assurance and quality control in biological laboratories -Research ethics, biosafety and bioethics -Scientific documentation, laboratory records, experimental troubleshooting and interpretation of biological data		

Text Book(s):

1. Wilson, K., & Walker, J. M. (2022). *Principles and Techniques of Biochemistry and Molecular Biology* (9th ed.). Cambridge University Press.
2. Green, M. R., & Sambrook, J. (2019). *Molecular Cloning: A Laboratory Manual* (4th ed.). Cold Spring Harbor Laboratory Press.
3. Ghatak, K. L. (2010). *Techniques and Methods in Biology*. PHI Learning Pvt. Ltd.

4. Seidman, L. A., & Moore, C. J. (2022). *Basic Laboratory Methods for Biotechnology: Textbook and Laboratory Reference* (3rd ed.). Pearson Education.
5. Skoog, D. A., Holler, F. J., & Crouch, S. R. (2018). *Principles of Instrumental Analysis* (7th ed.). Cengage Learning.

Reference Book(s):

1. Brown, T. A. (2023). *Gene Cloning and DNA Analysis: An Introduction* (9th ed.). Wiley-Blackwell.
2. Glick, B. R., Pasternak, J. J., & Patten, C. L. (2021). *Molecular Biotechnology: Principles and Applications of Recombinant DNA* (6th ed.). ASM Press.
3. Freshney, R. I. (2021). *Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications* (8th ed.). Wiley.
4. Nelson, D. L., & Cox, M. M. (2021). *Lehninger Principles of Biochemistry* (8th ed.). W. H. Freeman.
5. Alberts, B., Johnson, A., Lewis, J., Morgan, D., Raff, M., Roberts, K., & Walter, P. (2022). *Molecular Biology of the Cell* (7th ed.). Garland Science.

e Resources:

1. National Center for Biotechnology Information (NCBI) - <https://www.ncbi.nlm.nih.gov/>
2. PubMed - <https://pubmed.ncbi.nlm.nih.gov/>
3. European Molecular Biology Laboratory – European Bioinformatics Institute (EMBL-EBI)- <https://www.ebi.ac.uk/>
4. JoVE (Journal of Visualized Experiments) - <https://www.jove.com/>
5. HHMI BioInteractive - <https://www.biointeractive.org/>

Relationship Matrix for COs, POs and PSOs

Semes ter	Course code			Title of the course								Hours		Credit
I	PBT26005			Methods in Biology								4		4
Cours e Outco mes (COs)	Programme Outcomes (POs)											Programm e Specific Outcomes (PSOs)		Mean Score of COs
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO1 0	PO11	PSO1	PS O2	
CO1	3	3	2	2	2	1	1	-	-	-	-	3	2	1.46
CO2	3	3	3	2	2	2	1	1	1	-	-	3	3	1.85
CO3	3	3	3	3	2	2	2	1	2	-	-	3	3	2.15
CO4	2	2	2	3	3	3	3	2	2	2	2	2	2	2.31
CO5	3	3	3	3	3	3	2	2	2	2	2	3	3	2.62
Mean	2.8	2.8	2.6	2.6	2.4	2.2	1.8	1.2	1.4	1.0	0.8	2.80	2.6 0	2.08

Sem	Course Code	Title of the Course	Course Category	L	T	P	Credits
I	PBT26006	Protein Engineering	DEC	4	-	-	4
Pre-Requisite: Basic knowledge of Cell Biology, Biochemistry, Molecular Biology, Genetics, and Recombinant DNA Technology.							
Co- Requisite: - Basic knowledge of Molecular Biology, Biochemistry, and Bioinformatics.							
Progressive Course: Structural Biology, Computational Biology, Pharmaceutical Biotechnology, Synthetic Biology, Biopharmaceutical Manufacturing, Drug Discovery.							
Course Objectives:							
1. To introduce the principles, concepts, and scope of protein engineering.							
2. To explain protein structure, folding, stability, and physicochemical properties.							
3. To familiarize students with experimental and computational methods used in protein engineering.							
4. To understand various strategies for designing and modifying proteins with improved properties.							
5. To explore industrial, medical, and biotechnological applications of engineered proteins.							
Course Outcomes:							
CO1: Explain the principles, concepts, and significance of protein engineering (K2)							
CO2: Describe protein structure, stability, and factors influencing protein function (K2)							
CO3: Apply experimental methods used for protein engineering and protein optimization (K3)							
CO4: Analyze computational tools and bioinformatics approaches employed in protein engineering (K4)							
CO5: Evaluate the applications of engineered proteins in medicine, industry, agriculture, and biotechnology (K5)							
Unit-I	Introduction to Protein Engineering						12 Hrs.
Introduction to proteins and their structural organization; definition, principles, scope, and significance of protein engineering; characteristics of proteins that can be engineered, including affinity, specificity, catalytic activity, stability, solubility, spectroscopic properties, and aggregation propensity; applications of protein engineering in medicine, agriculture, industry, and environmental biotechnology; introduction to protein engineering using unnatural amino acids and their emerging applications.							
Unit-II	Protein Structure and Stability						12 Hrs.
Levels of protein structure and protein folding; forces stabilizing protein structure, including hydrogen bonding, hydrophobic interactions, electrostatic interactions, van der Waals forces, and weak polar interactions; factors affecting protein stability such as pH, temperature, solvents, and amino acid substitutions; methods for determining protein stability; thermodynamic concepts of protein stability, including entropy–enthalpy compensation; comparative stability of proteins from psychrophilic, mesophilic, and thermophilic organisms.							

Unit-III	Experimental Methods in Protein Engineering	12 Hrs.
Principles and strategies of experimental protein engineering; rational protein design and directed evolution; gene mutagenesis techniques including site-directed mutagenesis and site-saturation mutagenesis; DNA shuffling, module shuffling, and guided protein recombination; optimization strategies; high-throughput screening methods including microplate-based assays; selection and characterization of engineered proteins for enhanced function and stability.		
Unit-IV	Computational Approaches in Protein Engineering	12 Hrs.
Introduction to computational protein engineering; protein sequence and three-dimensional structure analysis; protein databases and data mining; structural visualization and analysis; Ramachandran plot and its significance in protein structure validation; molecular modelling and protein design; computational prediction of protein stability and function; integration of computational tools with experimental approaches for protein engineering.		
Unit-V	Applications of Protein Engineering	12 Hrs.
Applications of protein engineering in enzyme improvement, industrial biocatalysis, therapeutic protein development, antibody engineering using yeast surface display, vaccine development, peptidomimetics for drug discovery, biosensor development using bacteriorhodopsin, agricultural and environmental biotechnology, and future perspectives including artificial intelligence-assisted protein design, synthetic biology, and personalized medicine.		

Text Book(s):

1. Lutz, S. & Bornscheuer, U. T. (2012). *Protein Engineering Handbook* (2nd Edition). Wiley-VCH.
2. Branden, C. & Tooze, J. (2012). *Introduction to Protein Structure* (2nd Edition). Garland Science.
3. Voet, D., Voet, J. G. & Pratt, C. W. (2019). *Fundamentals of Biochemistry: Life at the Molecular Level* (6th Edition). Wiley.

Reference Book(s):

1. Urry, D. W. Protein Engineering: Principles and Practice. Academic Press.
2. Voet, D. & Voet, J. G. Biochemistry. 5th Edition, Wiley.
3. Alberts, B. et al. Molecular Biology of the Cell. Garland Science.
4. Lesk, A. M. Introduction to Protein Science: Architecture, Function and Genomics. Oxford University Press.
5. Creighton, T. E. Proteins: Structures and Molecular Properties. W.H. Freeman.

e Resources:

1. RCSB Protein Data Bank (PDB) – <https://www.rcsb.org>
2. UniProt Protein Knowledgebase – <https://www.uniprot.org>
3. NCBI Protein Database – <https://www.ncbi.nlm.nih.gov/protein>
4. ExPASy Bioinformatics Resource Portal – <https://www.expasy.org>
5. SWISS-MODEL – <https://swissmodel.expasy.org>

Relationship Matrix for COs, POs and PSOs

Semester	Course code			Title of the course								Hours		Credit
I	PBT26006			Protein Engineering								4		4
Course Outcomes (COs)	Programme Outcomes (POs)											Programme Specific Outcomes (PSOs)		Mean Score of COs
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO 1	PSO 2	
CO1	3	2	1	—	1	—	2	—	—	—	1	3	2	1.5
CO2	3	3	2	1	2	—	2	—	—	—	1	3	2	1.8
CO3	3	3	3	2	2	—	2	1	—	—	2	3	3	2.2
CO4	2	3	3	2	3	—	2	2	1	—	2	3	3	2.3
CO5	2	3	3	3	2	2	3	2	2	1	2	3	3	2.4
Mean	2.6	2.8	2.4	1.6	2.0	0.4	2.2	1.0	0.6	0.2	1.6	3.0	2.6	2.0

Sem	Course Code	Title of the Course	Course Category	L	T	P	Credits
I	PBT26901	Drug discovery and Development	MDC	3	0	0	3
Pre-Requisite: Basic knowledge of Biochemistry, Molecular Biology, Human Physiology, Microbiology, and Cell Biology.							
Co- Requisite: Drug Discovery and Development Practical / Bioinformatics / Pharmacology Laboratory.							
Progressive Course: Pharmacogenomics, Precision Medicine, Clinical Research, Regulatory Affairs, Pharmaceutical Biotechnology, Biopharmaceutical Manufacturing.							
Course Objectives:							
1. To understand the principles and workflow of modern drug discovery and development.							
2. To explain target identification, validation, lead discovery, and optimization strategies.							
3. To familiarize students with preclinical and clinical drug development processes.							
4. To understand pharmacokinetics, pharmacodynamics, drug safety, and regulatory requirements.							
5. To introduce recent advances in biotechnology-based drug discovery and personalized medicine.							
Course Outcomes:							
CO1: Explain the principles, workflow, and stages involved in modern drug discovery and development (K2)							
CO2: Apply target identification, lead discovery, computer-aided drug design, and optimization strategies in drug development (K3)							
CO3: Analyze preclinical evaluation methods, pharmacokinetic and pharmacodynamic properties, and toxicity assessment of drug candidates (K4)							
CO4: Evaluate clinical trial designs, regulatory guidelines, ethical considerations, and drug approval processes (K5)							
CO5: Assess the applications of biotechnology, biologics, AI, precision medicine, and emerging technologies in next-generation drug discovery (K5)							
Unit-I	Introduction to Drug Discovery						9 Hrs.
Introduction to drug discovery and pharmaceutical development. History of drug discovery. Sources of drugs (natural products, microorganisms, synthetic compounds, biologics). Drug discovery pipeline. Disease identification and target selection. Drug targets: enzymes, receptors, ion channels, transporters, nucleic acids. Target identification and validation techniques. Biomarkers in drug discovery. Role of genomics, proteomics, metabolomics and bioinformatics.							

Unit-II	Lead Discovery and Drug Design	9 Hrs.
Lead identification and lead optimization. High-throughput screening (HTS). Virtual screening. Structure-based drug design. Ligand-based drug design. Computer-aided drug design (CADD). Quantitative Structure–Activity Relationship (QSAR). Molecular docking. Pharmacophore modeling. Combinatorial chemistry. Medicinal chemistry principles. Drug repurposing.		
Unit-III	Preclinical Drug Development	9 Hrs.
Preclinical development process. In vitro and in vivo screening methods. Cell culture models. Animal models in drug development. Pharmacokinetics (ADME): Absorption, Distribution, Metabolism and Excretion. Pharmacodynamics. Toxicology studies: acute, sub-chronic and chronic toxicity. Genotoxicity, carcinogenicity and reproductive toxicity. Good Laboratory Practices (GLP). Bioavailability and bioequivalence studies.		
Unit-IV	Clinical Development and Regulatory Affairs	9 Hrs.
Clinical trial design and phases (Phase I–IV). Good Clinical Practice (GCP). Clinical trial protocols. Randomization and blinding. Ethics in clinical research. Institutional Ethics Committee (IEC). Informed consent. Regulatory agencies: CDSCO, DCGI, US FDA, EMA, ICH Guidelines. Drug approval process. Intellectual Property Rights (IPR), patents and data exclusivity. Pharmacovigilance and post-marketing surveillance.		
Unit -V	Biopharmaceuticals and Emerging Trends	9 Hrs.
Biopharmaceuticals and biologics. Monoclonal antibodies. Recombinant therapeutic proteins. Vaccines and vaccine development. Gene therapy. Cell therapy and stem cell-based therapeutics. RNA therapeutics and CRISPR-based medicines. Nanomedicine and targeted drug delivery. Artificial Intelligence (AI) and Machine Learning in drug discovery. Precision medicine and pharmacogenomics. Future perspectives in drug discovery.		

Text Book(s):

1. Patrick, G. L. An Introduction to Medicinal Chemistry. Oxford University Press.
2. Rang, H. P., Ritter, J. M., Flower, R. J., & Henderson, G. Rang & Dale's Pharmacology. Elsevier.
3. Nogrady, T., & Weaver, D. F. Medicinal Chemistry: A Molecular and Biochemical Approach. Oxford University Press.
4. Lemke, T. L., & Williams, D. A. Foye's Principles of Medicinal Chemistry. Wolters Kluwer.
5. Krogsgaard-Larsen, P., Liljefors, T., & Madsen, U. Textbook of Drug Design and Discovery. CRC Press.

Reference Book(s):

1. Smith, C. G., & O'Donnell, J. T. The Process of New Drug Discovery and Development. CRC Press.
2. Hughes, J. P., et al. Principles of Early Drug Discovery. British Journal of Pharmacology.
3. Katzung, B. G. Basic and Clinical Pharmacology. McGraw-Hill.
4. Goodman & Gilman's The Pharmacological Basis of Therapeutics. McGraw-Hill.
5. FDA Guidance Documents on Drug Development.

e- Resources:

1. PubMed – <https://pubmed.ncbi.nlm.nih.gov>
2. ClinicalTrials.gov – <https://clinicaltrials.gov>
3. U.S. FDA – <https://www.fda.gov>
4. European Medicines Agency (EMA) – <https://www.ema.europa.eu>
5. Drug Bank – <https://go.drugbank.com>

Relationship Matrix for COs, POs and PSOs

Semester	Course code			Title of the course								Hours		Credit
I	PBT26901			Drug discovery and Development								3		3
Course Outcomes (COs)	Programme Outcomes (POs)											Programme Specific Outcomes (PSOs)		Mean Score of COs
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	
CO1	3	1	2	2	2	1	–	1	–	1	1	2	1	1.60
CO2	3	3	3	3	3	3	1	1	1	2	2	3	3	2.38
CO3	3	2	3	3	2	2	1	2	1	2	2	3	2	2.15
CO4	2	2	3	2	2	2	2	3	2	2	2	2	2	2.15
CO5	3	3	3	3	3	3	2	2	2	3	3	3	3	2.77
Mean	2.8	2.2	2.8	2.6	2.4	2.2	1.6	1.8	1.5	2	2	2.6	2.2	2.3

Unit-I	Advanced Molecular Biology	9 Hrs.
Genome organization and genome complexity. DNA replication and repair pathways. Chromatin organization and epigenetic regulation. DNA methylation, histone modifications and chromatin remodeling. Non-coding RNAs and RNA interference.		
Unit-II	Gene Expression and Functional Genomics	9 Hrs.
Transcriptional and post-transcriptional regulation. Translational and post-translational regulation. Gene regulatory networks. Functional genomics. Transcriptomics. Gene expression analysis by microarray and RNA-Seq. Introduction to proteomics.		
Unit-III	Recombinant DNA Technology	9 Hrs.
Restriction enzymes and DNA-modifying enzymes. Advanced cloning vectors (BACs, YACs, cosmids, shuttle and expression vectors). Construction and screening of genomic and cDNA libraries. Gene cloning strategies. Expression of recombinant proteins in bacterial, yeast, insect and mammalian systems.		
Unit-IV	Advanced Molecular Techniques	9 Hrs.
PCR and quantitative PCR (qPCR). Digital PCR. DNA sequencing (Sanger and Next Generation Sequencing). Southern, Northern and Western blotting. Fluorescence in situ hybridization (FISH). Site-directed mutagenesis. CRISPR-Cas systems, TALENs and Zinc Finger Nucleases.		
Unit-V	Applications of Recombinant DNA Technology	9 Hrs.
Gene therapy and molecular medicine. Recombinant vaccines and monoclonal antibodies. Transgenic plants and animals. Molecular diagnostics and biosensors. Synthetic biology and metabolic engineering. Biosafety, bioethics, intellectual property rights and regulatory guidelines in recombinant DNA technology.		

Text Book(s):

1. Brown, T.A. (2021). *Gene Cloning and DNA Analysis: An Introduction*, 8th Edition, Wiley-Blackwell.
2. Glick, B.R., Pasternak, J.J. and Patten, C.L. (2022). *Molecular Biotechnology: Principles and Applications of Recombinant DNA*, 6th Edition, ASM Press.
3. Primrose, S.B. and Twyman, R.M. (2021). *Principles of Gene Manipulation and Genomics*, 8th Edition, Wiley-Blackwell.
4. Clark, D.P., Pazdernik, N.J. and McGehee, M.R. (2019). *Molecular Biology*, 3rd Edition, Elsevier.
5. Krebs, J.E., Goldstein, E.S. and Kilpatrick, S.T. (2021). *Lewin's Genes XIII*, Jones & Bartlett Learning.

Reference Book(s):

1. Alberts, B., Johnson, A., Lewis, J., Morgan, D., Raff, M., Roberts, K. and Walter, P. (2022). *Molecular Biology of the Cell*, 7th Edition, Garland Science.
2. Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R. (2014). *Molecular Biology of the Gene*, 7th Edition, Pearson.
3. Lodish, H., Berk, A., Kaiser, C.A. et al. (2021). *Molecular Cell Biology*, 9th Edition, W.H. Freeman.
4. Brown, T.A. (2017). *Genomes 4*, 4th Edition, Garland Science.
5. Green, M.R. and Sambrook, J. (2019). *Molecular Cloning: A Laboratory Manual*, 4th Edition, Cold Spring Harbor Laboratory Press.

e Resources:

1. NCBI Bookshelf – Molecular Biology Resources-<https://www.ncbi.nlm.nih.gov/books/>
2. National Center for Biotechnology Information (NCBI)-<https://www.ncbi.nlm.nih.gov>
3. EMBL-EBI Training Portal-<https://www.ebi.ac.uk/training/>
4. Nature Reviews Molecular Cell Biology-<https://www.nature.com/nrm/>
5. NPTEL – Biotechnology and Molecular Biology Courses-<https://nptel.ac.in>

Relationship Matrix for COs, POs and PSOs

Semester	Course code			Title of the course								Hours		Credit
II	PBT26203			Molecular Biology & r DNA Technology								3		3
Course Outcomes (COs)	Programme Outcomes (POs)											Programme Specific Outcomes (PSOs)		Mean Score of COs
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	
CO1	3	3	2	2	1	-	-	-	-	-	2	3	2	2.3
CO2	3	3	3	3	2	1	-	-	-	-	2	3	3	2.6
CO3	3	3	3	3	3	2	-	-	-	-	2	3	3	2.8
CO4	2	3	3	3	3	2	2	2	-	-	2	3	3	2.5
CO5	2	2	3	3	3	3	3	3	2	2	3	3	3	2.8
Mean	2.6	3.0	2.8	2.8	2.4	2.0	2.5	2.5	2.0	2.0	2.2	3.0	2.8	2.6

LIST OF EXPERIMENTS:

1. Preparation of molecular biology-grade solutions and sterilization techniques (DEPC water, loading dye, competent media, antibiotic stock solutions).
2. Isolation of high-quality total RNA from plant or bacterial samples and assessment of RNA integrity.
3. Synthesis of complementary DNA (cDNA) from total RNA using reverse transcriptase.
4. Primer design for PCR using bioinformatics tools and validation of primer characteristics.
5. Optimization of PCR conditions (annealing temperature, MgCl₂ concentration, and template concentration).
6. Reverse Transcription-PCR (RT-PCR) for gene expression analysis.
7. Restriction mapping of plasmid DNA using single and double restriction enzyme digestion.
8. Ligation of DNA fragments into plasmid vectors using T4 DNA ligase.
9. Confirmation of recombinant clones by colony PCR and restriction digestion analysis.
10. SDS–PAGE for separation and analysis of proteins.
11. Sequence analysis using BLAST, ORF Finder, and multiple sequence alignment.
12. In silico cloning and plasmid map construction using molecular biology software (SnapGene/Benchling/Serial Cloner).
13. Design of CRISPR-Cas9 guide RNA and identification of potential off-target sites using online bioinformatics tools (demonstration/computer exercise).

Reference Book(s):

1. Sambrook, J., & Russell, D. W. (2001). *Molecular Cloning: A Laboratory Manual* (3rd ed.). Cold Spring Harbor Laboratory Press.
2. Brown, T. A. (2021). *Gene Cloning and DNA Analysis: An Introduction* (8th ed.). Wiley-Blackwell.
3. Green, M. R., & Sambrook, J. (2019). *Molecular Cloning: A Laboratory Manual* (4th ed.). Cold Spring Harbor Laboratory Press.
4. Glick, B. R., Pasternak, J. J., & Patten, C. L. (2017). *Molecular Biotechnology: Principles and Applications of Recombinant DNA* (5th ed.). ASM Press.
5. Primrose, S. B., & Twyman, R. M. (2021). *Principles of Gene Manipulation and Genomics* (9th ed.). Wiley-Blackwell.

Relationship Matrix for COs, POs and PSOs

Semester	Course code			Title of the course								Hours		Credit
II	PBT26204			Lab in Molecular biology & rDNA Technology								4		2
Course Outcomes (COs)	Programme Outcomes (POs)											Programme Specific Outcomes (PSOs)		Mean Score of COs
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	
CO1	3	2	2	1	-	-	-	-	2	1	-	3	2	1.69
CO2	3	3	3	2	1	-	-	-	2	1	-	3	3	2.08
CO3	3	3	3	2	2	-	-	-	2	1	-	3	3	
CO4	2	3	2	3	2	1	-	-	2	1	-	2	3	2.15
CO5	2	3	3	3	3	2	1	-	2	2	1	3	3	1.92
Mean	2.6	2.8	2.6	2.2	1.6	0.6	0.2	-	2.0	1.2	0.2	2.8	2.8	2.15

Unit-II	Early Embryonic Development	12 Hrs.
Gastrulation and germ layer formation – Neurulation - Embryonic induction and axis formation - Cell migration and differentiation - Pattern formation during development.		
Unit-III	Molecular and Genetic Control of Development	12 Hrs.
Differential gene expression - Homeotic and Hox genes - Developmental signaling pathways - Epigenetic regulation and genomic imprinting - Developmental mutants and transgenic models - Gene regulation during morphogenesis		
Unit-IV	Organogenesis, Stem Cells and Regeneration	12 Hrs.
Organogenesis in animals - Development of nervous system and limbs - Regeneration and tissue repair - Stem cell biology: embryonic, adult and induced pluripotent stem cells - Cloning and nuclear transfer - Applications in regenerative medicine		
Unit-V	Plant Development, Developmental Disorders and Applications	12 Hrs.
Plant embryogenesis - Root and shoot development - Floral development and seed formation - Programmed cell death and aging - Developmental abnormalities and congenital disorders - Applications of developmental biology in biotechnology, agriculture and medicine		

Text Book(s):

1. Gilbert, S.F. and Barresi, M.J.F. (2020). *Developmental Biology* (12th Edition). Sinauer Associates, Oxford University Press.
2. Wolpert, L., Tickle, C. and Arias, A.M. (2019). *Principles of Development* (6th Edition). Oxford University Press.
3. Slack, J.M.W. (2018). *Essential Developmental Biology* (4th Edition). Wiley-Blackwell.
4. Balinsky, B.I. and Fabian, B.C. (2012). *An Introduction to Embryology* (5th Edition). CBS Publishers & Distributors.
5. Lewis Wolpert and Cheryll Tickle (2015). *Principles of Development* (5th Edition). Oxford University Press.

Reference Book(s):

1. Scott F. Gilbert (2014). *Developmental Biology* (10th Edition). Sinauer Associates.
2. Kalthoff, K. (2001). *Analysis of Biological Development* (2nd Edition). McGraw-Hill.
3. Berrill, N.J. (1971). *Developmental Biology*. Tata McGraw-Hill Publishing Company.
4. B.M. Carlson (2014). *Human Embryology and Developmental Biology* (5th Edition). Elsevier.
5. Martinez-Arias, A. and Stewart, A. (2015). *Molecular Principles of Animal Development* (2nd Edition). Oxford University Press.

e Resources:

1. NCBI -<https://www.ncbi.nlm.nih.gov>
2. PubMed -<https://pubmed.ncbi.nlm.nih.gov>
3. National Centre for Biotechnology Education-<https://www.ncbe.reading.ac.uk>
4. Khan Academy -<https://www.khanacademy.org>
5. MIT OpenCourseWare -<https://ocw.mit.edu>

Relationship Matrix for COs, POs and PSOs

Sem	Course code		Title of the course										Hours	Credit
II	PBT26205		Developmental Biology										4	4
Course Outcomes (COs)	Programme Outcomes (POs)											Programme Specific Outcomes (PSOs)		Mean Score of COs
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	
CO1	3	2	2	1	2	—	—	—	—	2	2	2	—	2.00
CO2	3	2	3	2	2	—	—	—	—	2	2	2	1	2.11
CO3	3	2	3	3	2	1	—	—	—	2	2	3	2	2.30
CO4	2	3	3	3	2	2	1	2	1	3	2	3	3	2.31
CO5	2	2	3	2	3	3	1	2	1	3	2	2	3	2.23

Sem	Course Code	Title of the Course	Course Category	L	T	P	Credits
II	PBT26S03	Immunotechnology	SEC	3	0	0	3
Pre-Requisite: Basic knowledge of Cell Biology, Microbiology, Biochemistry, Molecular Biology, Genetics, and Human Physiology.							
Co- Requisite. Practical course in Immunology/Immunological Techniques							
Progressive Course: Advanced Immunology, Immunogenetics, Cancer Biology, Immunotherapy, Vaccine Technology, Molecular Diagnostics, Clinical Biotechnology, Medical Biotechnology, Infectious Disease Biology, Regenerative Medicine, and Translational Research.							
Course Objectives:							
1. Explain the organization and functions of the innate and adaptive immune systems.							
2. Describe the structure and functions of immune cells, lymphoid organs, antibodies, antigens, cytokines, and the Major Histocompatibility Complex (MHC).							
3. Explain antigen recognition, antigen processing and presentation, immune regulation, antigen–antibody interactions, and basic immunological techniques.							
4. Analyze the principles of vaccinology, immunodiagnostics, clinical immunology, immunogenetics, and immunotherapy in disease prevention and treatment.							
5. Apply immunological concepts and laboratory techniques in biomedical research, diagnostics, vaccine development, and biotechnology applications.							
Course Outcomes:							
CO1: Explain the organization, components, and functions of the innate and adaptive immune systems (K2)							
CO2: Describe the mechanisms of immune responses, antigen processing and presentation, immune regulation, and antigen–antibody interactions (K2)							
CO3: Apply immunological principles and laboratory techniques for research, clinical diagnostics, and biotechnology applications (K3)							
CO4: Analyze the immunological basis of infectious diseases, hypersensitivity, autoimmunity, transplantation, immunodeficiency, and vaccine development (K4)							
CO5: Evaluate the applications of immunogenetics and emerging immunotherapies in disease diagnosis, prevention, treatment, and biotechnology (K5)							
Unit-I	Immunology: fundamental concepts and overview of the immune system						9 Hrs.
Components of innate and acquired immunity; phagocytosis; complement and inflammatory responses; pathogen recognition receptors (PRR) and pathogen associated molecular pattern (PAMP); innate immune response; mucosal immunity; antigens: immunogens, haptens; Major Histocompatibility Complex: MHC genes, MHC and immune responsiveness and disease susceptibility, Organs of immune system, primary and secondary lymphoid organs.							

Unit-II	Immune responses generated by B and T lymphocytes	9 Hrs.
Immunoglobulins - basic structure, classes & subclasses of immunoglobulins, antigenic determinants; multigene organization of immunoglobulin genes; B-cell receptor; Immunoglobulin superfamily; principles of cell signaling; basis of self & non-self-discrimination; kinetics of immune response, memory; B cell maturation, activation and differentiation; generation of antibody diversity; T-cell maturation, activation and differentiation and T-cell receptors; functional T Cell subsets; cell-mediated immune responses, ADCC; cytokines: properties, receptors and therapeutic uses; antigen processing and presentation- endogenous antigens, exogenous antigens, non-peptide bacterial antigens and super-antigens; cell-cell co-operation, Hapten-carrier system.		
Unit-III	Antigen-antibody interactions	9 Hrs.
Precipitation, agglutination and complement mediated immune reactions; advanced immunological techniques: RIA, ELISA, Western blotting, ELISPOT assay, immunofluorescence microscopy, flow cytometry and immunoelectron microscopy; surface plasmon resonance, biosensor assays for assessing ligand –receptor interaction; CMI techniques: lymphoproliferation assay, mixed lymphocyte reaction, cell cytotoxicity assays, apoptosis, microarrays, transgenic mice, gene knock outs.		
Unit-IV	Vaccinology	9 Hrs.
Active and passive immunization; live, killed, attenuated, subunit vaccines; vaccine technology: role and properties of adjuvants, recombinant DNA and protein based vaccines, plant-based vaccines, reverse vaccinology; peptide vaccines, conjugate vaccines; antibody genes and antibody engineering: chimeric, generation of monoclonal antibodies, hybrid monoclonal antibodies; catalytic antibodies and generation of immunoglobulin gene libraries, idiotypic vaccines and marker vaccines, viral-like particles (VLPs), dendritic cell based vaccines, vaccine against cancer, T cell based vaccine, edible vaccine and therapeutic vaccine.		
Unit-V	Clinical immunology	9 Hrs.
Immunity to infection : bacteria, viral, fungal and parasitic infections (with examples from each group); hypersensitivity: Type I-IV; autoimmunity; 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 immunotherapy; immunodeficiency: primary immunodeficiencies, acquired or secondary immunodeficiencies, autoimmune disorder, anaphylactic shock, immunosenescence, immune exhaustion in chronic viral infection, immune tolerance, NK cells in chronic viral infection and malignancy.		

Text Book(s):

1. Kindt, T. J., Goldsby, R. A., Osborne, B. A., & Kuby, J. (2006). Kuby Immunology. New York: W.H. Freeman.
2. Brostoff, J., Seaddin, J. K., Male, D., & Roitt, I. M. (2002). Clinical Immunology. London: Gower Medical Pub.
3. Murphy, K., Travers, P., Walport, M., & Janeway, C. (2012). Janeway's Immunobiology. New York: Garland Science.
4. Paul, W. E. (2012). Fundamental Immunology. New York: Raven Press.
5. Goding, J. W. (1996). Monoclonal Antibodies: Principles and Practice: Production and Application of Monoclonal Antibodies in Cell Biology, Biochemistry, and Immunology. London: Academic Press.
6. Parham, P. (2005). The Immune System. New York: Garland Science

Reference Book(s):

1. Fundamental Immunology. William E. Paul (Ed.). Lippincott Williams & Wilkins, 2013.
2. Clinical Immunology: Principles and Practice. Robert R. Rich, Thomas A. Fleisher, William T. Shearer, et al. Elsevier, 2022.
3. Monoclonal Antibodies: Principles and Practice. James W. Goding. Academic Press.
4. Cancer Immunotherapy: Principles and Practice. Lisa H. Butterfield, Howard L. Kaufman, & Cornelis J. M. Melief. Demos Medical Publishing.
5. Immunology: A Short Course. Richard Coico & Geoffrey Sunshine. Wiley-Blackwell.

e Resources:

1. The Journal of Immunology- [The Journal of Immunology](#)
2. Frontiers in Immunology- [Frontiers in Immunology](#)
3. American Association of Immunologists (AAI)- [American Association of Immunologists \(AAI\)](#)
4. British Society for Immunology (BSI)- [British Society for Immunology \(BSI\)](#)
5. World Health Organization (WHO) – Immunization, Vaccines and Biologicals
[WHO – Immunization, Vaccines and Biologicals](#)

Relationship Matrix for COs, POs and PSOs

Sem	Course code		Title of the course									Hours		Credit
II	PBT26S03		Immunotechnology									3		3
Course Outcomes (COs)	Programme Outcomes (POs)											Programme Specific Outcomes (PSOs)		Mean Score of COs
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	
CO1	3	2	1	-	-	-	-	-	-	-	-	3	2	2.20
CO2	3	3	2	2	-	-	-	-	-	-	-	3	3	2.67
CO3	2	2	3	3	2	2	-	-	-	-	-	3	3	2.50
CO4	2	3	3	3	2	2	2	-	-	1	-	3	3	2.30
CO5	2	3	3	3	3	2	2	2	1	2	2	3	3	2.38
Mean	2.40	2.60	2.40	2.40	2.33	2	2.00	2.00	1.00	1.50		3.00	2.80	2.41

Sem	Course Code	Title of the Course	Course Category	L	T	P	Credits
II	PBT26S04	Lab in Immunotechnology	SEC	-	-	4	2

Pre-Requisite:

Knowledge of the principles of immunology, antigen–antibody interactions, immune cells, biomolecules, and basic laboratory practices in biotechnology.

Co- Requisite: Immunology (Theory)

Progressive Course: Advanced Immunology Laboratory, Clinical Immunology, Immunodiagnostics, Immunotherapy, Vaccine Technology, Molecular Diagnostics, Cancer Immunology, and Translational Research.

Course Objectives:

1. Develop practical skills in antigen preparation, immunization procedures, antibody production, and handling of biological samples.
2. Train students in classical and advanced immunological techniques for the detection, quantification, and characterization of antigens and antibodies.
3. Enable students to perform isolation, purification, characterization, and preservation of immune cells and immunoglobulins using standard laboratory methods.
4. Provide hands-on experience with modern immunological tools and instrumentation

Course Outcomes:

CO1: Perform laboratory procedures for antigen preparation, animal immunization, blood collection, serum separation, and antibody titer determination using ELISA (K3)

CO2: Demonstrate antigen–antibody interaction techniques including double immunodiffusion, radial immunodiffusion, immunoelectrophoresis, complement fixation, SDS-PAGE, Western blotting, and dot blot assays (K3)

CO3. Apply methods for the isolation, purification, characterization, and cryopreservation of immunoglobulins and immune cells, including leukocytes and peripheral blood mononuclear cells (K3)

CO4: Analyze immune cell morphology and functions using Giemsa staining, phagocytosis assays, ELISPOT, and Flow Cytometry (FACS), and interpret the experimental results (K4)

CO5: Evaluate the applications of advanced immunological techniques in biomedical research, clinical diagnostics, vaccine development, and immunotherapy (K5)

LIST OF EXPERIMENTS:

1. Selection of animals, preparation of antigens, immunization and methods of blood collection, serum separation and storage.
2. Antibody titre by ELISA method.
3. Double diffusion, Immuno-electrophoresis and Radial Immuno diffusion
4. Complement fixation test.
5. Isolation and purification of IgG from serum or IgY from chicken egg.
6. SDS-PAGE, Immunoblotting, Dot blot assays.
7. Blood smear identification of leucocytes by Giemsa stain.
8. Separation of leucocytes by dextran method.
9. Demonstration of Phagocytosis of latex beads and their cryopreservation.
10. Separation of mononuclear cells by Ficoll-Hypaque and their cryopreservation.
11. Demonstration of ELISPOT.
12. Demonstration of FACS.

Reference Book(s):

1. Kuby Immunology. Jenni Punt, Sharon A. Stranford, Patricia P. Jones, & Judith A. Owen. W.H. Freeman/Macmillan Learning, 2019.
2. Janeway's Immunobiology. Kenneth Murphy & Casey Weaver. Garland Science, 2022.
3. Cellular and Molecular Immunology. Abul K. Abbas, Andrew H. Lichtman, & Shiv Pillai. Elsevier, 2021.
4. Roitt's Essential Immunology. Peter J. Delves, Seamus J. Martin, Dennis R. Burton, & Ivan M. Roitt. Wiley-Blackwell, 2021.
5. Practical Immunology. Frank C. Hay & Olwyn M. R. Westwood. Wiley-Blackwell.

Relationship Matrix for COs, POs and PSOs

Sem	Course code			Title of the course								Hours		Credit
II	PBT26S04			Lab in Immunotechnology								4		2
Course Outcom es (COs)	Programme Outcomes (POs)											Programme Specific Outcomes (PSOs)		Mean Score of COs
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	
CO1	3	2	3	2	-	-	-	-	-	-	-	3	3	2.57
CO2	3	3	3	2	2	-	-	-	-	-	-	3	3	2.71
CO3	2	3	3	3	2	2	-	-	-	-	-	3	3	2.63
CO4	2	3	3	3	2	2	2	2	-	1	-	3	3	2.42
CO5	2	3	3	3	3	2	2	2	2	2	1	3	3	2.32
Mean	2.4	2.8	3.00	2.6	2.2	2.00	2	2.00	2.00	1.50	1.00	3.00	3.0	2.54

Sem	Course Code	Title of the Course	Course Category	L	T	P	Credits
II	PBT26007	Cancer Biology	DEC	4	0	0	4
Pre-Requisite: Knowledge of cell biology, genetics, and molecular biology.							
Co- Requisite: Understanding of immunology and molecular diagnostics							
Progressive Course: Supports advanced studies in oncology, cancer therapeutics, and precision medicine.							
Course Objectives:							
1. Understand the fundamental concepts of cancer biology, including cell structure, cell cycle regulation, apoptosis, and the hallmarks of cancer.							
2. Explain the molecular and cellular mechanisms involved in carcinogenesis, tumor initiation, progression, invasion, angiogenesis, and metastasis.							
3. Describe the role of carcinogens, oncogenes, tumor suppressor genes, and signaling pathways in cancer development.							
4. Acquire knowledge of modern diagnostic techniques, biomarkers, and laboratory methods used for cancer detection and prognosis.							
5. Evaluate conventional and advanced therapeutic approaches, including chemotherapy, immunotherapy, targeted therapy, gene therapy, nanomedicine, and precision oncology.							
Course Outcomes:							
CO1: Explain the basic concepts of cancer biology, including cell cycle regulation, apoptosis, and the molecular characteristics of normal and cancer cells (K2)							
CO2: Describe the mechanisms of tumor invasion, angiogenesis, metastasis, tumor microenvironment, and cancer stem cells involved in cancer progression (K2)							
CO3: Analyze the role of physical, chemical, and biological carcinogens, including viral oncogenesis, in the initiation and development of cancer (K3)							
CO4: Interpret the functions of oncogenes, proto-oncogenes, tumor suppressor genes, and other molecular regulators involved in carcinogenesis (K4)							
CO5: Evaluate current diagnostic methods and emerging therapeutic strategies in oncology (K5)							
Unit-I	Animal cell						12 Hrs.
Structure of cell – Cell division – Mitosis and meiosis, cell cycle: Different phases of cell cycle. Significance of cell cycle arrest. Comparison of normal cell and cancer cell. Hall marks of cancer - Epidemiology and global burden of cancer – Apoptosis and cancer.							

Unit-II	Principle of cancer metastasis	12 Hrs.
Invasion and metastasis - Clinical significance of invasion, heterogeneity of metastatic phenotype, metastatic cascade and basement membrane disruption, three step theories of invasion, proteinases and tumor cell invasion- Angiogenesis- Tumor markers- Histopathology – Cytology- Tumor microenvironment- Types of cancer- Cancer stem cells.		
Unit-III	Carcinogens	12 Hrs.
Physical, chemical and biological carcinogens. Chemical carcinogenesis, metabolism of carcinogens, targets of chemical carcinogenesis. Multistep theory of carcinogenesis -Principles of physical carcinogenesis, X-ray radiation. Biological carcinogenesis- oncovirus – retrovirus- oncolytic virus and their mode of action.		
Unit-IV	Types of Cancer	12 Hrs.
Types of genes regulating the cancer- Progression and suppression- proto-oncogenes, oncogene- Anti tumor suppressor genes. Involvement of oncogenes in cancer progression- suppressor genes in cell P53, B Cell, 2, Bax, Oncogenes- COX, LOX3- Significance of cancer.		
Unit-V	Diagnosis and treatment of cancer	12 Hrs.
Biopsy: Liquid biopsy -Flow Cytometry-Immunohistochemistry -PCR-based diagnosis -FISH -DNA sequencing -Next-Generation Sequencing (NGS) - Endoscopy- Diagnostic imaging- Blood tests- Screening and testing- Prediction of aggressiveness of Cancer. Treatment: Radiation therapy, chemotherapy, immunotherapy, targeted therapy and gene therapy. Molecular imaging -Personalized medicine: Nanotechnology in cancer medicine – Cancer Vaccines- AI in oncology.		

Text Book(s):

1. Weinberg, R. A. (2023). The Biology of Cancer (3rd Edition). Garland Science, Taylor & Francis.
2. Pecorino, L. (2021). Molecular Biology of Cancer: Mechanisms, Targets, and Therapeutics (5th Edition). Oxford University Press.
3. Ruddon, R. W. (2007). Cancer Biology (4th Edition). Oxford University Press.
4. Kleinsmith, L. J. (2019). Principles of Cancer Biology (2nd Edition). Pearson.

Reference Book(s):

1. King, R. J. B., & Robins, M. W. (2006). Cancer Biology (3rd Edition). Pearson Education.
2. DeVita, V. T., Lawrence, T. S., & Rosenberg, S. A. (2023). DeVita, Hellman, and Rosenberg's Cancer: Principles and Practice of Oncology (12th Edition). Wolters Kluwer.
3. Croce, C. M., & Brenner, M. K. (Editors). (2016). Molecular Basis of Cancer (5th Edition). Elsevier.

4. Kumar, V., Abbas, A. K., & Aster, J. C. (2024). Robbins & Cotran Pathologic Basis of Disease (11th Edition). Elsevier.
5. Alberts, B., Johnson, A., Lewis, J., et al. (2022). Molecular Biology of the Cell (7th Edition). Garland Science.
6. Lodish, H., Berk, A., Kaiser, C. A., et al. (2021). Molecular Cell Biology (9th Edition). W.H. Freeman.

e Resources:

1. National Center for Biotechnology Information (NCBI)- <https://www.ncbi.nlm.nih.gov>
2. National Cancer Institute (NCI)- <https://www.cancer.gov>
3. American Association for Cancer Research (AACR)- <https://www.aacr.org>
4. World Health Organization (WHO) – Cancer- <https://www.who.int/health-topics/cancer>
5. International Agency for Research on Cancer (IARC)- <https://www.iarc.who.int>

Relationship Matrix for COs, POs and PSOs

Sem	Course code		Title of the course									Hours		Credit
II	PBT26007		Cancer Biology									4		4
Course Outcomes (COs)	Programme Outcomes (POs)											Programme Specific Outcomes (PSOs)		Mean Score of COs
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	
CO1	3	3	2	1	2	—	—	—	—	3	2	2	—	2.25
CO2	3	2	3	2	1	—	—	—	—	2	2	2	1	2.00
CO3	2	2	3	2	2	2	—	2	—	2	2	2	2	2.09
CO4	3	2	3	2	2	2	—	—	—	3	2	3	2	2.40
CO5	2	2	3	3	2	2	2	2	2	3	2	2	3	2.31
Mean	2.6	2.2	2.8	2.2	1.9	2	2	2	2	2.6	2	2.2	2	

editing; Multiplex genome engineering; Genome minimization; Synthetic genomes; Directed evolution.

Unit-III	Genetic Circuits and Computational Design	12 Hrs.
Genetic logic gates; Toggle switches; Oscillators; Biosensors; Synthetic promoters and regulatory elements; RNA switches; Quorum sensing circuits; Cell-cell communication; Mathematical modeling of gene networks; Computational tools for circuit design; Computer-aided biological design (CAD); Introduction to Systems Biology.		
Unit-IV	Applications of Synthetic Biology	12 Hrs.
Synthetic metabolic pathways; Metabolic engineering for production of pharmaceuticals, biofuels, fine chemicals and nutraceuticals; Synthetic biology in agriculture; Engineered probiotics; Microbiome engineering; Cell-free synthetic biology; Synthetic vaccines; CAR-T cell engineering; Tissue engineering; Environmental biotechnology; Biosensors for environmental monitoring; Carbon capture and sustainable biotechnology.		
Unit-V	Biosafety, Biosecurity and Future Perspectives	12 Hrs.
Ethical issues in synthetic biology; Biosafety levels; Containment strategies; Gene drives; Dual-use research concerns; Intellectual property rights; International regulations; Risk assessment; Responsible research and innovation; Artificial intelligence in synthetic biology; Automation and biofoundries; Future trends in engineering biology.		

Text Book(s):

1. Synthetic Biology: A Primer – Paul S. Freemont & Richard I. Kitney, 2nd Edition, 2019.
2. Synthetic Biology: Tools and Applications – Huimin Zhao, Academic Press, 2013.
3. Systems Biology and Synthetic Biology – Pengcheng Fu & Sven Panke, Springer, 2018.
4. Molecular Biology of the Cell – Bruce Alberts et al., 7th Edition, Garland Science, 2022.
5. Principles of Gene Manipulation and Genomics – Sandy B. Primrose & Richard Twyman, 8th Edition, Wiley-Blackwell, 2020.

Reference Book(s):

1. An Introduction to Systems Biology – Uri Alon, 2nd Edition, 2020.
2. Genome Editing and Engineering – Krishnarao Appasani, Cambridge University Press, 2018.
3. CRISPR-Cas: A Laboratory Manual – Jennifer Doudna & Prashant Mali, Cold Spring Harbor Laboratory Press, 2021.

4. Biotechnology: Applying the Genetic Revolution – David P. Clark & Nanette Pazdernik, 3rd Edition, 2021.
5. Metabolic Engineering: Principles and Methodologies – Gregory Stephanopoulos et al., Academic Press.

e Resources:

1. National Center for Biotechnology Information (NCBI) - <https://www.ncbi.nlm.nih.gov/>
2. Addgene - <https://www.addgene.org/>
3. iGEM Foundation - <https://igem.org/>
4. Benchling - <https://www.benchling.com/>
5. BioBricks Foundation - <https://biobricks.org/>

Relationship Matrix for COs, POs and PSOs

Sem	Course code		Title of the course									Hours		Credit
II	PBT26008		Synthetic Biology									4		4
Course Outcomes (COs)	Programme Outcomes (POs)											Programme Specific Outcomes (PSOs)		Mean Score of COs
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	
CO1	1	2	2	2	2	-	1	-	-	2	2	3	2	2.10
CO2	1	3	3	2	2	1	2	-	-	2	2	3	2	2.31
CO3	1	3	3	3	3	2	2	1	1	3	2	3	3	2.50
CO4	2	3	3	3	3	2	3	2	1	3	2	3	3	2.54
CO5	2	2	3	2	3	3	3	2	2	3	2	3	3	2.54
Mean	2.6	2.6	2.8	2.4	2.6	2.0	2.2	1.7	1.3	2.6	2.0	3.0	2.6	2.40

Sem	Course Code	Title of the Course	Course Category	L	T	P	Credits
II	PBT26009	Pharmaceutical Biotechnology	DEC	4	0	0	4

Pre-Requisite: Knowledge of biotechnology, biochemistry, and molecular biology.

Co- Requisite: Understanding of drug development and regulatory affairs.

Progressive Course: Supports careers in biopharmaceutical industries, innovation management, and intellectual property protection.

Course Objectives:

1. Understand the fundamental principles of pharmaceutical biotechnology.
2. Understand recombinant DNA technology and therapeutic protein production.
3. Analyze modern vaccine technologies and immunotherapeutics.
4. Understand industrial bioprocesses, regulatory affairs, and quality assurance in pharmaceutical industries.
5. Evaluate emerging technologies such as artificial intelligence, nanotechnology, and synthetic biology in pharmaceutical biotechnology.

Course Outcomes:

CO1: Explain the principles and scope of pharmaceutical biotechnology (K2)

CO2: Describe the production and applications of recombinant pharmaceuticals (K2)

CO3: Evaluate vaccines, monoclonal antibodies, and advanced therapeutics (K4)

CO4: Analyze industrial production, quality control, and regulatory aspects of biopharmaceuticals (K4)

CO5: Apply recent advances in pharmaceutical biotechnology for research and industrial applications (K4)

Unit-I	Introduction to Pharmaceutical Biotechnology and Biopharmaceuticals	12 Hrs.
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Introduction: Definition of Pharmaceutical Biotechnology, History and evolution, Scope and importance, Role of biotechnology in modern medicine. Classification of biopharmaceutical drugs- Pharmaceutical products: vaccines, hormones, enzymes, monoclonal antibodies. Overview of drug discovery- Introduction to molecular biology in drug development; DNA, RNA, Proteins, Central dogma, gene expression.

Unit-II	Recombinant Pharmaceuticals	12 Hrs.
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Recombinant DNA Technology; Restriction enzymes, DNA ligase, Cloning vectors, Expression vectors, Transformation, Screening methods. Expression Systems; Prokaryotic systems-Escherichia coli -Eukaryotic systems; Yeast, Insect cells, Mammalian cells, CHO cells. Transgenic animals-Recombinant insulin, Human growth hormone, Erythropoietin, Interferons, Blood clotting factors, Recombinant enzymes; protein

engineering: Therapeutic Protein Characterization.

Unit-III	Gene Therapy, Cell Therapy and Precision Medicine	12 Hrs.
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Gene therapy; Somatic gene therapy, Germline gene therapy, Viral vectors, non-viral vectors. CRISPR-Cas's genome editing -Base editing -Prime editing -Stem cell therapeutics -Induced pluripotent stem cells (iPSCs) - Tissue engineering -Regenerative medicine -Organoids -Xenotransplantation -Pharmacogenomics - Pharmacogenetics -Precision medicine -Companion diagnostics -Personalized therapeutics

Unit-IV	Industrial Pharmaceutical Biotechnology and Bioprocess Engineering	12 Hrs.
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Upstream processing-Cell culture technology -Bioreactor design -Scale-up strategies -Process optimization - Media optimization -Downstream processing -Cell harvesting -Protein purification -Chromatographic techniques -Membrane filtration -Lyophilization -Biosimilars -Comparability studies -Stability studies - Formulation development

Unit-V	Regulatory Affairs, AI in Drug Discovery and Emerging Trends	12 Hrs.
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Pharmaceutical regulations- Regulatory agencies -Clinical trials -IND and NDA applications -Biosafety - Bioethics -Intellectual Property Rights (IPR) -Patent filing -Technology transfer -Commercialization of biopharmaceuticals -Artificial Intelligence in drug discovery -Machine learning in pharmaceutical research - Digital therapeutics -Nanobiotechnology -Nanomedicine -Exosome therapeutics -RNA therapeutics -Synthetic biology -Future trends in pharmaceutical biotechnology

Text Book(s):

1. Walsh, G. (2018). Biopharmaceuticals: Biochemistry and Biotechnology (3rd ed.). John Wiley & Sons.
2. Crommelin, D. J. A., Sindelar, R. D., & Meibohm, B. (Eds.). (2019). Pharmaceutical Biotechnology: Fundamentals and Applications (5th ed.). Springer.
3. Glick, B. R., Pasternak, J. J., & Patten, C. L. (2022). Molecular Biotechnology: Principles and Applications of Recombinant DNA (6th ed.). ASM Press.
4. Primrose, S. B., & Twyman, R. M. (2020). Principles of Gene Manipulation and Genomics (8th ed.). Wiley-Blackwell.
5. Brown, T. A. (2021). Gene Cloning and DNA Analysis: An Introduction (8th ed.). Wiley-Blackwell

Reference Book(s):

1. Nelson, D. L., & Cox, M. M. (2021). Lehninger Principles of Biochemistry (8th ed.). W. H. Freeman.
2. Alberts, B., Johnson, A., Lewis, J., Morgan, D., Raff, M., Roberts, K., & Walter, P. (2022). Molecular Biology of the Cell (7th ed.). Garland Science.
3. Abbas, A. K., Lichtman, A. H., & Pillai, S. (2024). Cellular and Molecular Immunology (11th ed.). Elsevier.
4. Katzung, B. G., Vanderah, T. W., & Trevor, A. J. (2024). Basic and Clinical Pharmacology (16th ed.). McGraw-Hill Education.
5. Aulton, M. E., & Taylor, K. (Eds.). (2021). Aulton's Pharmaceutics: The Design and Manufacture of Medicines (6th ed.). Elsevier.

e Resources:

1. PubMed- <https://pubmed.ncbi.nlm.nih.gov>
2. NCBI- <https://www.ncbi.nlm.nih.gov>
3. DrugBank- <https://go.drugbank.com>
4. SWAYAM- <https://swayam.gov.in>
5. NPTEL- <https://nptel.ac.in>

Relationship Matrix for COs, POs and PSOs

Sem	Course code		Title of the course										Hours		Credit
II	PBT26009		Pharmaceutical Biotechnology										4		4
Course Outcomes (COs)	Programme Outcomes (POs)											Programme Specific Outcomes (PSOs)		Mean Score of COs	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2		
CO1	3	2	2	2	2	—	—	—	—	2	2	2	—	2.11	
CO2	3	3	3	2	2	2	—	1	—	2	2	3	2	2.30	
CO3	3	2	3	3	2	2	1	2	—	3	2	3	2	2.33	
CO4	3	3	3	3	2	3	2	3	2	2	2	3	2	2.54	
CO5	2	3	3	3	2	3	2	2	2	3	3	3	3	2.62	
Mean	2.8	2.6	2.8	2.6	2	2.5	1.7	2	2	2.4	2.6	2.8	2.2	2.4	

Sem	Course Code	Title of the Course	Course Category	L	T	P	Credits
II	PBT26010	IPR, Bioethics & Biosafety	DEC	4	0	0	4

Pre-Requisite: Basic knowledge of biotechnology and genetic engineering.

Co-Requisite: Familiarity with biotechnology applications and research practices

Progressive Course: Provides a foundation for regulatory affairs, research ethics, and biosafety management.

Course Objectives:

1. To understand the fundamentals of Intellectual Property Rights (IPR).
2. To gain knowledge on patent systems and international agreements.
3. To learn biosafety principles and risk assessment.
4. To understand ethical issues in biotechnology.
5. To apply legal, ethical, and safety principles in research and industry.

Course Outcomes:

CO1: Understand basic concepts of IPR and its significance (K1)

CO2: Explain patent systems and biotechnological applications (K2)

CO3: Describe biosafety levels and risk management practices (K2)

C04: Evaluate ethical issues in biotechnology and research (K4)

C05: Apply regulatory, ethical, and safety principles in biotechnology fields (K4)

Unit-I	Introduction to IPR	12 Hrs.
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Concept and importance of IPR - Types: patents, copyrights, trademarks, geographical indications - History and evolution of IPR - Role of IPR in biotechnology - Overview of international agreements: WTO, TRIPS.

Unit-II	Patents in Biotechnology	12 Hrs.
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Patent system: criteria and patentability - Patent application and granting process - Patent infringement and protection - Patent Cooperation Treaty (PCT) - Case studies in biotechnological patents

Unit-III	Biosafety and Risk Management	12 Hrs.
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Introduction to biosafety and biohazards - Biosafety levels (BSL-1 to BSL-4) - Risk assessment and containment strategies - Good Laboratory Practices (GLP) and GMP - Handling and disposal of hazardous materials - Cartagena Protocol on Biosafety.

Unit-IV	Bioethics	12 Hrs.
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Principles of bioethics: autonomy, beneficence, non-maleficence, justice - Ethical issues in genetic engineering, cloning, stem cell research - Human genome project and ethical concerns - Bioterrorism and biosecurity - National and international ethical guidelines.

Unit-V	Regulatory Affairs and Applications	12 Hrs.
National biosafety guidelines (India) - Regulatory bodies and frameworks - IPR issues in biodiversity and traditional knowledge - Ethical and legal issues in biotechnology applications - Applications in agriculture, medicine and industry		

Text Book(s):

1. Sateesh, M.K. (2017). *Bioethics and Biosafety*. I.K. International Publishing House Pvt. Ltd., New Delhi.
2. Deepa Goel and Shomini Parashar (2013). *Intellectual Property Rights: Principles and Practices*. PHI Learning Pvt. Ltd., New Delhi.
3. Kankanala, C. (2012). *Genetics, Bioethics and Biotechnology*. Academic Press, Elsevier.
4. B.D. Singh (2018). *Biotechnology: Expanding Horizons* (4th Edition). Kalyani Publishers, New Delhi. (Chapters on Biosafety, Bioethics and IPR)
5. Bareact Compilation (2023). *The Patents Act, 1970 with Patent Rules, 2003 (as amended)*. Universal Law Publishing Co., New Delhi.

Reference Book(s):

1. Krattiger, A., Mahoney, R.T., Nelsen, L., et al. (2007). *Intellectual Property Management in Health and Agricultural Innovation: A Handbook of Best Practices*. MIHR and PIPRA, Oxford.
2. Cornish, W.R., Llewelyn, D. and Aplin, T. (2019). *Intellectual Property: Patents, Copyright, Trade Marks and Allied Rights* (9th Edition). Sweet & Maxwell.
3. Resnik, D.B. (2012). *Environmental Health Ethics*. Cambridge University Press.
4. Shanthakumar, S. (2009). *Introduction to Intellectual Property Rights*. Central Law Publications, Allahabad.
5. Fleming, D.A. and Hunt, D.L. (2000). *Biotechnology and Safety Assessment* (3rd Edition). Academic Press.

e Resources:

1. World Intellectual Property Organization – <https://www.wipo.int>
2. National Center for Biotechnology Information – <https://www.ncbi.nlm.nih.gov>
3. PubMed – <https://pubmed.ncbi.nlm.nih.gov>
4. Department of Biotechnology India – <https://dbtindia.gov.in>
5. World Health Organization – <https://www.who.int>

Relationship Matrix for COs, POs and PSOs

Sem	Course code			Title of the course								Hours		Credit
II	PBT26010			IPR, Bioethics & Biosafety								4		4
Course Outcomes (COs)	Programme Outcomes (POs)											Programme Specific Outcomes (PSOs)		Mean Score of COs
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	
CO1	2	1	2	1	2	1	2	3	1	2	2	1	2	1.62
CO2	3	2	2	2	2	2	2	3	1	2	2	2	2	2.08
CO3	2	2	3	2	2	2	2	3	2	2	2	2	2	2.15
CO4	2	2	3	2	2	2	2	3	2	2	2	2	2	2.15
CO5	2	3	3	3	2	2	2	3	2	3	3	3	2	2.54
Mean	2.2	2	2.6		2	2	2	3	2.2	2.6	2.2	2.6	2	2.2

Unit-III	Statistical Analysis and Data Visualization	12 Hrs.
Descriptive statistics; probability concepts; sampling methods; hypothesis testing; correlation and regression analysis; experimental design; biomedical data visualization; graphical representation of biomedical datasets; introduction to R/Python for biomedical data analysis.		
Unit-IV	Machine Learning in Biomedical Data Science	12 Hrs.
Introduction to artificial intelligence; supervised and unsupervised learning; classification and clustering techniques; decision trees; random forest; support vector machines; neural networks; disease prediction models; medical image analysis; precision medicine.		
Unit-V	Applications, Ethics and Future Trends	12 Hrs.
Precision medicine; pharmacogenomics; digital health; telemedicine; clinical decision support systems; biomedical big data analytics; AI in drug discovery; explainable AI; biomedical data privacy and cybersecurity; ethical and legal issues; regulatory guidelines; future trends in biomedical data science.		

Text Book(s):

1. Kevin P. Murphy. *Machine Learning: A Probabilistic Perspective*. MIT Press.
2. Rafael A. Irizarry. *Introduction to Data Science*. CRC Press.
3. Gareth James, Daniela Witten, Trevor Hastie and Robert Tibshirani. *An Introduction to Statistical Learning*. Springer.

Reference Book(s):

1. Cathy O'Neil and Rachel Schutt. *Doing Data Science*. O'Reilly Media.
2. Peter Bruce and Andrew Bruce. *Practical Statistics for Data Scientists*. O'Reilly Media.
3. Trevor Hastie, Robert Tibshirani and Jerome Friedman. *The Elements of Statistical Learning*. Springer.
4. David L. Olson and Dursun Delen. *Advanced Data Mining Techniques*. Springer.

e Resources:

1. National Center for Biotechnology Information (NCBI): <https://www.ncbi.nlm.nih.gov>
2. Kaggle Biomedical Datasets: <https://www.kaggle.com/datasets>
3. UCI Machine Learning Repository: <https://archive.ics.uci.edu/ml>
4. The Cancer Genome Atlas (TCGA): <https://www.cancer.gov/ccg/research/genome-sequencing/tcga>
5. World Health Organization Data Repository: <https://www.who.int/data>

Relationship Matrix for COs, POs and PSOs

Semester	Course code			Title of the course								Hours		Credit
II	PBT26011			Biomedical Data Science								4		4
Course Outcomes (COs)	Programme Outcomes (POs)											Programme Specific Outcomes (PSOs)		Mean Score of COs
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	
CO1	3	2	2	–	2	–	2	–	–	–	2	3	2	2.29
CO2	2	3	3	2	3	–	–	2	–	–	2	3	3	2.56
CO3	2	3	3	2	3	–	–	2	–	–	2	3	3	2.56
CO4	3	3	3	3	3	2	2	2	2	–	2	3	3	2.62
CO5	2	2	2	3	2	3	3	2	2	2	3	2	2	2.31
Mean	2.40	2.60	2.60	2.50	2.60	2.50	2.33	2.00	2.00	2.00	2.20	2.80	2.60	2.47

Sem	Course Code	Title of the Course	Course Category	L	T	P	Credits
II	PBT26011	Genome Editing Technologies	DEC	4	0	0	4
Pre-Requirement: Molecular Biology, Genetics, Recombinant DNA Technology							
Co- Requirement: Practical in Molecular Biology							
Progressive Course: Functional Genomics, Synthetic Biology, Precision Medicine, Advanced Gene Therapy							
Course Objectives:							
1. To understand the principles and molecular basis of genome editing technologies.							
2. To study the mechanisms and applications of major genome editing platforms.							
3. To develop knowledge of advanced genome editing techniques and computational tools.							
4. To explore the applications of genome editing in medicine, agriculture, and biotechnology.							
5. To evaluate ethical, biosafety, and regulatory aspects of genome editing.							
Course Outcomes:							K Level
CO1: Explain the principles and molecular basis of genome editing technologies							K2
CO2: Compare various genome editing platforms and their mechanisms of action.							K3
CO3: Apply genome editing tools and computational resources for designing genome editing experiments.							K3
CO4: Analyze the applications of genome editing in healthcare, agriculture and biotechnology.							K4
CO5: Evaluate ethical, biosafety and regulatory aspects of genome editing technologies.							K4
Unit-I	Introduction to Genome Editing						12 Hrs.
History and evolution of genome editing; genome organization and gene function; DNA repair mechanisms including homologous recombination (HR), non-homologous end joining (NHEJ) and microhomology-mediated end joining (MMEJ); concepts of gene knockout, knock-in, gene replacement and gene correction; comparison of genome editing and conventional genetic engineering; genome editing workflow; methods for delivery of genome editing components including viral and non-viral systems.							
Unit-II	Genome Editing Platforms						12 Hrs.
Zinc Finger Nucleases (ZFNs)—structure, design and applications; Transcription Activator-Like Effector Nucleases (TALENs)—construction and mechanism; meganucleases; CRISPR-Cas systems including Cas9, Cas12 and Cas13; guide RNA design principles; protospacer adjacent motif (PAM); DNA cleavage mechanisms; strategies to minimize off-target effects; comparison of different genome editing technologies.							
Unit-III	Advanced Genome Editing Technologies						12 Hrs.

Base editing; prime editing; epigenome editing; CRISPR activation (CRISPRa); CRISPR interference (CRISPRi); RNA editing using Cas13; multiplex genome editing; genome-wide CRISPR screening; computational tools for guide RNA design, off-target prediction and genome editing data analysis.

Unit-IV	Applications of Genome Editing	12 Hrs.
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Genome editing in gene therapy, cancer immunotherapy, stem cell engineering, treatment of inherited genetic disorders and precision medicine; applications in crop improvement, development of disease-resistant and climate-resilient crops, livestock improvement and aquaculture; industrial biotechnology applications including microbial strain improvement, synthetic biology, metabolic engineering, biofuel production, environmental biotechnology and functional genomics.

Unit-V	Ethical, Regulatory and Future Perspectives	12 Hrs.
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Ethical considerations in human genome editing; germline and somatic genome editing; human embryo editing; biosafety guidelines and risk assessment; national and international regulatory frameworks governing genome editing; intellectual property rights related to genome editing technologies; clinical applications and ongoing clinical trials; artificial intelligence in genome engineering; future prospects and emerging trends in precision genome editing.

Text Book(s):

1. Brown, T.A. (2021). *Gene Cloning and DNA Analysis: An Introduction* (8th Edition). Wiley-Blackwell.
2. Primrose, S.B. & Twyman, R.M. (2019). *Principles of Gene Manipulation and Genomics* (8th Edition). Wiley-Blackwell.
3. Gaj, T., Gersbach, C.A. & Barbas, C.F. (2016). *Genome Engineering Technologies*. Academic Press.
4. Gupta, P.K. (2022). *Genomics and Genome Editing*. Rastogi Publications.

Reference Book(s):

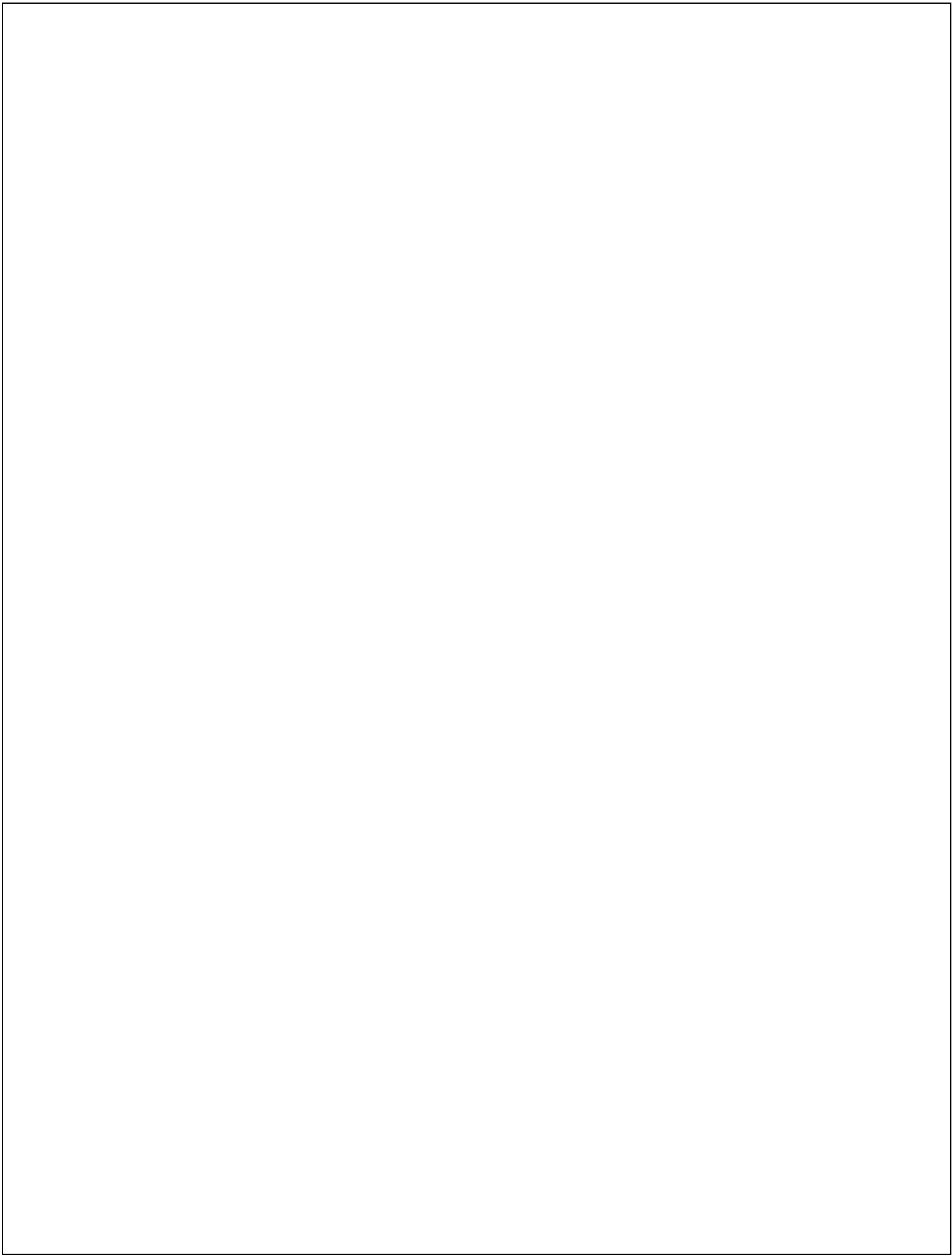
1. Doudna, J.A. & Sternberg, S.H. (2017). *A Crack in Creation: Gene Editing and the Unthinkable Power to Control Evolution*. Houghton Mifflin Harcourt.
2. Carroll, D. (2019). *Genome Editing: A Practical Guide*. Oxford University Press.
3. Alberts, B. et al. (2022). *Molecular Biology of the Cell* (7th Edition). Garland Science.
4. Lodish, H. et al. (2021). *Molecular Cell Biology* (9th Edition). W.H. Freeman.
5. National Academies of Sciences, Engineering, and Medicine (2017). *Human Genome Editing: Science, Ethics, and Governance*. National Academies Press.

e Resources:

1. [Addgene CRISPR Guide](#)
2. [Broad Institute Genetic Perturbation Platform](#)
3. [NCBI Genome Resources](#)
4. [Ensembl Genome Browser](#)
5. [CHOPCHOP CRISPR Guide RNA Design Tool](#)

Relationship Matrix for COs, POs and PSOs

Semester	Course code				Title of the course							Hours		Credit
II	PBT26012				Genome Editing Technologies							4		4
Course Outcomes (COs)	Programme Outcomes (POs)											Programme Specific Outcomes (PSOs)		Mean Score of COs
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	
CO1	3	2	–	–	2	–	–	–	–	–	–	3	2	2.40
CO2	3	3	2	–	2	–	–	–	–	–	–	3	2	2.50
CO3	2	3	3	2	3	–	–	–	–	–	1	3	3	2.86
CO4	2	3	3	3	2	2	1	–	–	–	1	3	3	2.58
CO5	2	2	2	3	2	2	3	2	1	1	2	2	3	2.08
Mean	2.40	2.60	2.50	2.67	2.20	2.00	2.00	2.00	1.00	1.00	1.33	2.80	2.60	2.48



Sem	Course Code	Title of the Course	Course Category	L	T	P	Credits
II	PBT26902	Entrepreneurship And Innovation in Life Sciences	MDC	3	0	0	3

Pre-Requisite: Basic knowledge of Biotechnology and Life Sciences

Co- Requisite: - Basic knowledge of Biotechnology, Research Methodology, and Intellectual Property Rights (IPR).

Progressive Course: - Technology Transfer and Commercialization, Biotechnology Business Management Bioprocess Scale-Up and Industrial Biotechnology.

Course Objectives:

1. To provide an understanding of entrepreneurship and innovation in life sciences.
2. To familiarize students with startup ecosystems and business models.
3. To impart knowledge on intellectual property rights and technology commercialization.
4. To develop skills in business planning and financial management.
5. To promote innovation and entrepreneurial opportunities in biotechnology and healthcare sectors.

Course Outcomes:

CO1: Explain the principles of entrepreneurship and innovation in life sciences (K2)

CO2: Analyze startup ecosystems and identify business opportunities in biotechnology (K4)

CO3: Explain intellectual property rights and technology commercialization processes (K2)

CO4: Develop business plans and evaluate funding and marketing strategies (K5)

CO5: Assess emerging trends and entrepreneurial opportunities in life sciences (K4)

Unit-I	Fundamentals of Entrepreneurship and Innovation	12 Hrs.
Concept and characteristics of entrepreneurship. Types of entrepreneurs. Innovation and creativity. Role of entrepreneurship in life sciences and biotechnology. Bioeconomy and biotechnology industries. Entrepreneurship development programs and support systems. National and international organizations promoting biotechnology entrepreneurship.		
Unit-II	Startup Ecosystem and Business Models	12 Hrs.
Startup ecosystem in India. Biotechnology startups and incubation centers. Business opportunity identification. Design thinking and innovation management. Business models and value proposition. Lean startup concept. Case studies of successful biotechnology enterprises. Role of BIRAC, DBT, Startup India and MSME schemes.		
Unit-III	Intellectual Property Rights and Technology Commercialization	12 Hrs.

Introduction to patents, copyrights, trademarks and trade secrets. Patent filing process. Technology transfer and commercialization. Licensing and franchising. Regulatory requirements for biotech products. Biosafety and bioethics. Quality assurance and Good Manufacturing Practices (GMP).

Unit-IV	Business Planning and Financial Management	12 Hrs.
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Preparation of business plans. Feasibility analysis and market research. Sources of funding and venture capital. Financial management and budgeting. Cost-benefit analysis. Marketing strategies and branding. Risk management and project management. Entrepreneurship opportunities in healthcare, agriculture, food and environmental biotechnology

Unit-V	Emerging Trends and Bioentrepreneurship	12 Hrs.
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Bioentrepreneurship and biotech ventures. Innovation in diagnostics, vaccines and biopharmaceuticals. Digital health and artificial intelligence in life sciences. Precision medicine and personalized healthcare. Sustainable biotechnology and circular bioeconomy. Ethics and social responsibilities of entrepreneurs. Recent trends and future prospects.

Text Book(s):

1. Desai, V. (2019). Dynamics of Entrepreneurial Development and Management, Himalaya Publishing House, Mumbai.
2. Hisrich, R.D., Peters, M.P. and Shepherd, D.A. (2017). Entrepreneurship, 10th Edition, McGraw-Hill Education.
3. Kumar, S. and Singh, U.B. (2015). Bioentrepreneurship and Intellectual Property Rights, CABI Publishing.

Reference Book(s):

1. Satyanarayana, U. (2020). Biotechnology, Books and Allied (P) Ltd., Kolkata.
2. Donald F. Kuratko (2021). Entrepreneurship: Theory, Process and Practice, Cengage Learning.
3. Bruce R. Barringer and R. Duane Ireland (2019). Entrepreneurship: Successfully Launching New Ventures, Pearson.
4. Peter F. Drucker (2014). Innovation and Entrepreneurship, Routledge.
5. Shimasaki, C. (2014). Biotechnology Entrepreneurship: Starting, Managing and Leading Biotech Companies, Academic Press.

e Resources:

1. Biotechnology Industry Research Assistance Council (BIRAC) – <https://birac.nic.in>
2. Startup India – <https://www.startupindia.gov.in>
3. Department of Biotechnology (DBT), Government of India – <https://dbtindia.gov.in>
4. MSME Development Institute – <https://msme.gov.in>
5. WIPO Academy (Intellectual Property) – <https://www.wipo.int/academy>

Relationship Matrix for COs, POs and PSOs

Sem	Course code		Title of the course									Hours		Credit
II	26PBT2MDC2		Entrepreneurship And Innovation in Life Sciences									5		4
Course Outcomes (COs)	Programme Outcomes (POs)											Programme Specific Outcomes (PSOs)		Mean Score of COs
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	
CO1	2	1	2	1	2	3	2	2	2	2	2	1	2	1.85
CO2	2	2	3	2	3	3	2	2	2	2	2	2	3	2.31
CO3	2	2	2	2	2	3	2	3	2	2	2	2	2	2.15
CO4	2	3	3	2	2	3	3	2	3	2	2	2	3	2.46
CO5	2	2	3	2	3	3	2	2	2	3	3	2	3	2.46
Mean	2	2	2.6	2.8	2.4	3	2.2	2.2	2.2	2.2	2.4	1.8	2.6	2.3