SRI VENKATESWARA COLLEGE OF ENGINEERING

(An Autonomous Institution, Affiliated to Anna University, Chennai - 600025)

M.Tech. Biotechnology

CURRICULUM AND SYLLABUS

REGULATION - 2022

CHOICE BASED CREDIT SYSTEM

Curriculum Revision No:		Board of Studies Recommendation Date:	03.10.2022	Academic Council Approved Date:	06.10.2022
Salient Points of the Revision:	1.	Flexible Choice Based Credit System (CBCS).			
	2.	Introduction of Integrated Theory cum Lab courses.			
	3.	Introduction of skill development courses.			
	4.	More importance to Employability Enhancement Courses.			

SRI VENKATESWARA COLLEGE OF ENGINEERING

(An Autonomous Institution, Affiliated to Anna University, Chennai - 600025)

REGULATIONS 2022

M.TECH BIOTECHNOLOGY

CHOICE BASED CREDIT SYSTEM

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

1. To prepare the students to excel and succeed in biotechnology research or industry through the latest state-of-art postgraduate education.
2. To train students with good scientific and technical knowledge so as to comprehend, analyze, design and adopt innovative and new technology that provides solutions for developing novel biotechnological products.
3. To create bioentrepreneurs with good communication and leadership skills, respect for authority and the life-long learning needed for a successful professional career.

PROGRAM OUTCOMES (POs)

PO	GRADUATE ATTRIBUTES
1.	An ability to independently carry out research /investigation and development work to solve practical problems.
2.	An ability to write and present a substantial technical report/document.
3.	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.
4.	Ability to examine the technological problems in various domains of Biotechnology apply modern engineering tools for the prediction and modeling of complex engineering problems with a focus on sustainable development.
5.	Students should be able to acquire self-management and teamwork skills to collaborate with multidisciplinary teams from academic, industry and research institutes of national or international repute, with a commitment to lifelong learning.
6.	Potential to apply biotechnological solutions by adhering to the standards of bioethics with social responsibilities.

PROGRAM SPECIFIC OUTCOMES (PSOs)

1. Demonstrate the biotechnology concepts and research approach and apply them for healthcare and industrial applications.
2. Possess scientific and technological skills to design and develop novel bioproducts for addressing the biological and healthcare challenges.
3. Analyze the socio-economical needs and possess the necessary expertise to become a bioentrepreneur.

PEO's - PO's & PSO's MAPPING:

POs/ PSOs	PEOs		
	I	II	III
PO-1	✓	✓	
PO-2		✓	
PO-3	✓	✓	✓
PO-4		✓	✓
PO-5	✓		✓
PO-6			✓
PSO-1	✓	✓	✓
PSO-2	✓	✓	✓
PSO-3	✓	✓	✓

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REGULATIONS 2022

M.TECH BIOTECHNOLOGY

CHOICE BASED CREDIT SYSTEM

CURRICULUM AND SYLLABI FOR SEMESTERS I TO IV

SEMESTER I

SL. NO	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK				TOTAL HOURS	PREREQUISITE	POSITION
				L	T	P	C			
Theory Courses										
1.	MA22181	Mathematics for Biotechnologists	BS	3	1	0	4	4	Nil	F
2.	BY22101	Advanced Bioprocess Technology	PC	3	1	0	4	4	Nil	F
3.	BY22102	Computational and Systems Biology	PC	3	0	2	4	5	Nil	F
4.	BY22103	Recombinant DNA Technology	PC	3	0	0	3	3	Nil	F
5.	-	Professional Elective I	PE	3	0	0	3	3	Nil	M
6.	-	Professional Elective II	PE	3	0	0	3	3	Nil	M
7.	BY22104	Scaffold Designing and 3D Bioprinting	EE	1	0	0	1	1	Nil	F
Practical Courses										
8.	BY22111	Recombinant DNA Technology Laboratory	PC	0	0	6	3	6	Nil	F
			Total	**19**	**2**	**8**	**25**	**29**	**-**	**-**

SEMESTER II

SL. NO	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK				TOTAL HOURS	PREREQUISITES	POSITION
				L	T	P	C			
Theory Courses										
1.	BY22201	Analytical Techniques in Biotechnology	PC	3	0	2	4	5	Nil	F
2.	BY22202	Advanced Bioseparation Technology	PC	3	0	0	3	3	BY22101	F
3.	BY22203	Immunotechnology	PC	3	0	0	3	3	BY22103	F
4.	GR22251	Introduction to Research Methodology and IPR (Common to all Branches)	RM	3	0	0	3	3	Nil	M
5.	-	Professional Elective-III	PE	3	0	0	3	3	Nil	M
6.	-	Professional Elective-IV	PE	3	0	0	3	3	Nil	M
7.	BY22204	Machine Learning for Biotechnologists	EE	1	0	0	1	1	Nil	F
Practical Courses										
8.	BY22211	Advanced Microbial and Immunotechnology Laboratory	PC	0	0	6	3	6	BY22111	F
			Total	**19**	**0**	**8**	**23**	**27**	**-**	**-**

SEMESTER III

SL. NO	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK				TOTAL HOURS	PREREQUISITES	POSITION
				L	T	P	C			
Practical Courses										
1.	BY22301	Advanced Bioprocess and Bioseparation Technology Laboratory	PC	0	0	6	3	6	BY22101 BY22202	F
2.	BY22302	Molecular Modeling and Drug Design Laboratory	PC	0	0	6	3	6	Nil	F
3.	BY22311	Project Work (Phase I)	EE	0	0	12	6	12	Nil	F
			Total	**0**	**0**	**24**	**12**	**24**	**-**	**-**

SEMESTER IV

SL. NO	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK				TOTAL HOURS	PREREQUISITES	POSITION
				L	T	P	C			
Practical Courses										
1.	BY22411	Project Work (Phase II)	EE	0	0	24	12	24	Nil	F
			Total	**0**	**0**	**24**	**12**	**24**	**-**	**-**
TOTAL CREDITS: 72										

LIST OF PROFESSIONAL ELECTIVES (PE) COURSES

PROFESSIONAL ELECTIVE-I

SL. NO	COURSE CODE	COURSE TITLE
1.	BY22001	Biology for Chemical Engineers
2.	BY22003	Chemical Engineering for Biotechnologists
3.	BY22005	Advanced Biopharmaceutical Technology
4.	BY22007	Molecular Genetics and Gene Therapy
5.	BY22009	Python Programming for Biotechnologists

PROFESSIONAL ELECTIVE-II

SL. NO	COURSE CODE	COURSE TITLE
1.	BY22011	Bioengineering and Regenerative Medicine
2.	BY22013	Plant and Animal Cell Technology
3.	BY22015	Vaccines and Therapeutic Proteins
4.	BY22017	Entrepreneurship for Biotechnologists
5.	BY22019	R Programming for Biotechnologists

PROFESSIONAL ELECTIVE-III

SL. NO	COURSE CODE	COURSE TITLE
1.	BY22002	Biomass Conversion and Biorefinery
2.	BY22004	Nanobiotechnology
3.	BY22006	Drug Delivery: Principles and Engineering
4.	BY22008	Advanced Food Processing and Packaging Technologies
5.	BY22010	OMICS Technologies

PROFESSIONAL ELECTIVE-IV

SL. NO	COURSE CODE	COURSE TITLE
1.	BY22012	Bioprocess Equipment Design and Economics
2.	BY22014	Molecular Pathogenesis and Medical Biotechnology
3.	BY22016	Advanced Cancer Biology and Therapy
4.	BY22018	Metabolic and Systems Biology
5.	BY22020	Clinical Trials, Bioethics and Biosafety

MA22181 MATHEMATICS FOR BIOTECHNOLOGISTS

L	T	P	C
3	1	0	4

OBJECTIVES:

1. Find the numerical solution of differentiation and integration.
2. Gain knowledge of the numerical solution of algebraic equations and ordinary differential equations.
3. Select the appropriate statistical procedure and apply relevant statistical tests depending on the data provided.
4. Acquire knowledge of statistical principles/methods in topics such as Correlation coefficient, Regression equations, and curve fitting.
5. Analyze the various designs of experiments.

UNIT I NUMERICAL DIFFERENTIATION AND INTEGRATION 12

Approximation of derivatives using interpolation polynomials: Lagrange's interpolation - Newton's divided difference interpolation-Newton's forward and backward difference formulae-Numerical integration using Trapezoidal, Simpson's 1/3 rule - Two point and three-point Gaussian quadrature formulae – Evaluation of double integrals by Trapezoidal and Simpson's 1/3 rules.

UNIT II NUMERICAL SOLUTION OF LINEAR SYSTEM OF EQUATIONS AND ORDINARY DIFFERENTIAL EQUATIONS 12

Solution of linear system of equations - Pivoting techniques - Gauss elimination method - Gauss Jordan Method-Solution of initial value problems for ODE: Single Step methods - Taylor's series method - Fourth order Runge-Kutta method for solving first order equations and simultaneous first order equations - Multi step methods - Milne's and Adams- Bash forth predictor corrector methods for solving first order equations.

UNIT III TESTING OF HYPOTHESIS 12

Sampling distributions and Standard error- Type I and Type II errors – Critical region– Tests based on Normal, t, χ^2 and F distributions- non-parametric test (concept only).

UNIT IV CURVE FITTING 12

Correlation coefficient, properties-problems-Regression equations and problems- curve fitting by the method of least squares-fitting curves of the form $y = ax + b$, and $y = ax^2 + bx + c$, $y = ab^x$ and $y = ax^b$- Bivariate correlation application to biological problems.

UNIT V ANALYSIS OF VARIANCE 12

Basic principles of experimentation-Analysis of variance-One-way classification – Completely Randomised design - Two-way classifications - Randomised block design-multiple comparison- Latin square design-problems.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

CO	After completion of this course, the students will be able to	RBT LEVEL
1.	Identify the appropriate numerical methods and use them to obtain approximate solutions to differentiation and integration.	3
2.	Apply numerical techniques to obtain approximate solutions of a linear system of equations and first order ordinary differential equations.	3
3.	Test a hypothesis by measuring and examining a random sample of the population.	3
4.	Compare and contrast the covariance and correlation between jointly distributed variables and interpret regression between two variables.	3
5.	Classify and apply the related analysis of variance techniques in all fields of scientific experimentation.	3

TEXTBOOKS:

1. Jain M.K., Iyengar, S.R.K. and Jain R.K., "Numerical Methods for Scientific and Engineering Computation", 6th Edition, New Age International Pvt. Ltd., Delhi, 2015.
2. Richard A. Johnson, "Miller and Freund's Probability and Statistics for Engineers, 8th Edition, Pearson Education, Asia, 2013.

REFERENCE BOOKS:

1. Gupta S.K., "Numerical Methods for Engineers", 3rd Edition, New Age international Publishers, 2015.
2. Saumyen Guha and Rajesh Srivastava, "Numerical methods for Engineering and Science", Oxford Higher Education, New Delhi, 2015.
3. Gupta S.C. and Kapoor V.K., "Fundamentals of Mathematical Statistics", 11th Edition, Sultan Chand and Sons, New Delhi, 2005
4. Ross, S. M., "Introduction to Probability and Statistics for Engineers and Scientists", 3rd Edition, Elsevier, 2005.

WEB LINKS:

1. https://nptel.ac.in/courses/111/107/111107105/
2. https://nptel.ac.in/courses/103/106/103106112/

COURSE ARTICULATION MATRIX:

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	3			2					
CO2	3			2					
CO3	3		2	2		1		2	
CO4	3		2	2				2	

CO5	3		2	2				2	

1-Weak; 2-Moderate; 3-Strong.

BY22101 ADVANCED BIOPROCESS TECHNOLOGY

L	T	P	C
3	1	0	4

OBJECTIVES:

1. To provide knowledge on material and energy balances in microbial systems.
2. To get knowledge on microbial kinetics and different structured and unstructured models.
3. To familiarize about different modes of operating ideal bioreactors.
4. To design bioreactors with efficient heat and mass transfer provisions.
5. To learn about advancement in bioreactors for non-conventional biological systems.

UNIT I STOICHIOMETRY AND ENERGETICS 9+3

Stoichiometry of growth and product formation-Elemental balances, Electron Balances, Degrees of reduction, Yield coefficients; Energy Balances-Thermodynamics of Microbial growth, Heat of Reaction, Energy balance equation for cell culture.

UNIT II MICROBIAL KINETICS AND MODELS 9+3

Michaelis-menton kinetics; Cell growth kinetics– Monod model, Models with growth inhibitors, Logistic equation; Structured models; Kinetics of product formation; Substrate uptake kinetics; Thermal death kinetics; Determination of kinetic parameters.

UNIT III IDEAL BIOREACTOR OPERATION 9+3

Batch operation of a mixed reactor, Fed-batch operation of a mixed reactor, Continuous operation of a mixed reactor, Chemostat with immobilized cells, Chemostat cascade, Chemostat with cell recycle, Continuous operation of a plug flow reactor.

UNIT IV BIOREACTOR DESIGN AND CONSTRUCTION 9+3

Practical considerations for Bioreactor construction; Bioreactor configurations; Agitator design - Power requirements for mixing, Estimation of mixing time; Oxygen transfer in Fermenters - Measurement of k_La; Heat transfer equipment - Design and Applications.

UNIT V ADVANCED BIOREACTORS AND BIOPRODUCTS 9+3

Bioreactor considerations for immobilized cell systems, Plant cell cultures, Animal cell cultures, Organized tissues; Case studies on production of Monoclonal antibodies, Recombinant insulin, Green fuels and chemicals; Case studies on medium optimization.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

CO	After completion of this course, the students will be able to	RBT LEVEL
1.	Evaluate mass and energy requirements for microbial cell growth and product formation.	3
2.	Accomplish knowledge about microbial kinetics and modeling of bioprocesses.	3
3.	Select different modes of operating bioreactors to maximize the product yield.	3
4.	Design appropriate bioreactors with efficient oxygen and heat transfer capabilities.	4
5.	Utilize bioreactors for non-conventional biological systems to produce high valuable bioproducts.	4

TEXTBOOKS:

1. Pauline D., "Bioprocess Engineering Principles", 2nd Edition, Elsevier, 2012.
2. Shuler, M.L., Kargi F., "Bioprocess Engineering", 2nd Edition Prentice Hall, 2002.
3. Bailey, J.E. and Ollis, D.F., "Biochemical Engineering Fundamentals", 2nd Edition, McGraw Hill, 2017.
4. Stanbury, P.F., Stephen J.H., and Whitaker A., "Principles of Fermentation Technology", 2nd Edition, Science & Technology Books, 2009.
5. Blanch H.W., and Clark D. S., "Biochemical Engineering", 2nd Edition, Marcel Dekker, Inc., 1997.

REFERENCE BOOKS:

1. James M. Lee, "Biochemical Engineering", Prentice Hall, 1992.
2. Ghasem D.Najafpour, "Biochemical Engineering and Biotechnology", Elsevier, 2007.
3. Irving J.Dunn, Elmar Heinzle, John Ingham and Jiri E. Prenosil, "Biological Reaction Engineering", Wiley, 2003.
4. Jens Nielson, John Villadsen and Gunnar Liden, "Bioreaction Engineering principles", Kluwer Academic/Plenum Publishers, 2003.
5. Michael C.Flickinger and Stephen W.Drew, "Encyclopedia of Bioprocess Technology: Fermentation, Biocatalysis and Bioseparation ", Volumes 1-5, John Wiley & Sons, Inc., 1999.

COURSE ARTICULATION MATRIX:

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	3	1	2	2	1		2	1	
CO2	3	1	2	2	1		2	1	
CO3	3		2	2			2		
CO4	3	1	2	2			2	1	
CO5	3		2	2	1		2	1	

1-Weak; 2-Moderate; 3-Strong.

BY22102 COMPUTATIONAL AND SYSTEMS BIOLOGY

L	T	P	C
3	0	2	4

OBJECTIVES:

1. To impart knowledge on databases and tools used in computational biology.
2. To illustrate practical aspects and application of systems biology.
3. To impart knowledge on solving ODEs using computational tools.
4. To provide hands-on training on modelling biological pathways.
5. To train students to work with genome-scale models.

UNIT I TOOLS AND DATABASES FOR COMPUTATIONAL SYSTEMS BIOLOGY 9+6

Tools and databases for modelling: Pathway databases KEGG, EMP, Metacyc, Enzyme kinetics, Database BRENDA, Gene expression databases, Biomodels database, Basics of Systems Biology Markup Language (SBML), SBML editors.

1. Biological databases: DNA, Protein and Enzymes
2. Databases for computational systems biology: Genomes, Pathways and Reactions.

UNIT II MACHINE LEARNING AND APPLICATIONS IN BIOLOGY 9+6

Machine learning techniques: Artificial Neural Networks and Hidden Markov Models: Systems Biology and its applications in whole-cell modelling, Microarrays and Clustering techniques for microarray data analysis, Informatics in Genomics and Proteomics, DNA computing.

1. Gene expression analysis
2. Microarray analysis using open-source tools

UNIT III MODELLING OF BIOLOGICAL SYSTEMS 9+6

Machine learning techniques: Artificial Neural Networks and Hidden Markov Models: Kinetic modelling of biochemical reactions, describing dynamics with ODEs, rate equations, deriving a rate equation, incorporating regulation of enzyme activity by effectors, E-cell platform and erythrocyte modelling, applications in whole cell modelling.

1. Solving ODEs using a mathematical tool box.
2. Solving enzyme kinetics using ODEs

UNIT IV BIOLOGICAL NETWORKS 9+6

Complex Biological Systems, Types of Biological networks, Intra-cellular networks: Gene-regulatory network, Protein-interaction network, Metabolic networks and Signaling network; Inter-cellular networks: Neuronal networks, Network motifs, Network medicine.

1. Creating gene-regulatory and biochemical networks.
2. Simulation and analysis of biochemical networks.

UNIT V CONSTRAINT-BASED MODELLING 9+6

Metabolic reconstruction, Flux Balance Analysis (FBA): Translating biochemical networks into linear algebra, Stoichiometric matrix, Elementary mode, Extreme pathways, Objective function, Optimization using linear programming. Genome-scale cellular models: Virtual Erythrocytes, Global human metabolic model.

1. Visualization of molecular interaction networks
2. Constraint-based modeling using Open-source tools.

TOTAL: 75 PERIODS

COURSE OUTCOMES:

CO	After completion of this course, the students will be able to	RBT LEVEL
1.	Search, retrieve and interpret the data from biological databases.	3
2.	Analyze hundreds of differentially expressed genes using Gene Ontology, pathways and perform gene set enrichment analysis.	4
3.	Apply ODEs for solving biological reactions.	3
4.	Create and analyze the biological networks using computational tools.	5
5.	Describe and interpret the Genome-scale cellular models.	5

TEXTBOOKS:

1. Eberhard O. Voit, "A first course in systems biology", 2nd Edition, Garland Science, 2018.
2. Edda Klipp, Wolfram Liebermeister, Christoph Wierling and Axel Kowald, "Systems Biology: A Textbook", 2nd Edition, 2016.
3. Edda Klipp, Ralf Herwig, Axel Kowald, Christoph Wierling and Hans Lehrach, "Systems Biology in Practice: Concepts, Implementation and Application", Wiley-Blackwell, 2015.
4. Bernhard O. Palsson, "Systems Biology Constraint-based Reconstruction and Analysis", 2nd Edition, Cambridge University Press, 2015.
5. David W Mount, "Bioinformatics: Sequence and Genome Analysis", 2nd Edition, Cold Spring Harbor Laboratory Press, 2004.

REFERENCE BOOKS:

1. Karthik Raman, "An Introduction to Computational Systems Biology Systems-Level Modelling of Cellular Networks", CRC Press, 2021.
2. Uri Alon, "An Introduction to Systems Biology: Design Principles of Biological Circuits", 2nd Edition, CRC Press, 2019.
3. Wong, Ka-Chun, "Computational biology and bioinformatics: Gene Regulation; gene, RNA, protein, epigenetics", CRC press, 2016.
4. Sumeet Dua and Pradeep Chowriappa, "Data Mining for Bioinformatics", CRC

Press, 2012.

5. Bernhard O. Palsson, "Systems Biology: Simulation of Dynamic Network States", 2nd Edition, Cambridge University Press, 2011.

COURSE ARTICULATION MATRIX:

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	2	2	2	2	1		2	1	
CO2	2	2	2	3			2	1	
CO3	2		2	3			2		
CO4	2	2	2	3			2	1	
CO5	2		2	3			2	1	

1-Weak; 2-Moderate; 3-Strong.

BY22103 RECOMBINANT DNA TECHNOLOGY

L	T	P	C
3	0	0	3

OBJECTIVES:

1. To enhance the knowledge of basic molecular tools used in rDNA technology.
2. To relate the different types of vectors used in Gene Cloning.
3. To extend the existing knowledge on techniques currently used in Gene Cloning.
4. To assess the sequencing methods of clones and methods of constructing DNA libraries.
5. To organize the knowledge attained and to produce recombinant proteins.

UNIT I BASICS OF MOLECULAR TOOLS USED IN GENE CLONING 12

Overview of Restriction and Modification system, Different restriction enzymes, Types and examples, Methylation activity of various restriction enzymes, DAM, DCM and CpG methylase activity, Star activity of restriction enzymes, Different types of ligases used in rDNA technology, *E. coli* - DNA ligase, T4 DNA ligase, T4 RNA ligase, Other important enzymes: DNA and RNA polymerases, Reverse transcriptase, Terminal transferase, DNAses-exonuclease I, exonuclease III and Mungbean Nuclease

UNIT II VECTORS USED FOR GENE CLONING 9

Introduction to cloning vectors, Plasmid biology, plasmid vectors (high copy and low copy), Phage biology, phage vectors, Cosmid vectors, Phasmid vectors, BAC vectors and YAC vectors, Yeast vectors

UNIT III TECHNIQUES USED IN GENE CLONING 9

Cloning after restriction digestion, Types of ligations, Blunt and Cohesive end ligation and case studies, Creation of restriction sites by PCR and cloning using linkers and adapters, cloning after homopolymer tailing, Strategies used in cloning PCR products - TA cloning, TOPO-TA cloning and ligation free cloning

UNIT IV SEQUENCING OF CLONES AND CONSTRUCTION OF DNA LIBRARIES 6

DNA sequencing - Chemical & Enzymatic methods, Automated sequencing, Construction of cDNA library, Construction subtractive cDNA library, Genomic library, BAC and YAC libraries

UNIT V EXPRESSION OF RECOMBINANT PROTEINS AND ITS APPLICATIONS 9

Construction of expression vectors for bacteria and yeast, Different promoters used in expression vectors, cloning of genes in the correct reading frame in the expression vector, Purification of recombinant protein using histidine tag, GST Tag, chitin-binding domain and intein with its applications, Construction of expression vectors

for plants and animal cells, Bias in codon use and codon optimization

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO	After completion of this course, the students will be able to	RBT LEVEL
1.	Critically analyze and evaluate the role and functions of restriction enzymes and vectors used in rDNA technology.	4
2.	Evaluate the different cloning strategies used for DNA and PCR products.	4
3.	Construct cDNA and genomic DNA libraries of their own.	3
4.	Synthesize recombinant DNAs suitable for expression and purification in a biological system.	5
5.	Produce recombinant proteins with expression vectors in plants and animal cells.	5

TEXTBOOKS:

1. Brown, T.A, "Gene Cloning and DNA Analysis- An Introduction, 6th edition, John Wiley & Sons, 2010.
2. Christopher Howe, "Gene Cloning and Manipulation, 2nd edition, Cambridge University Press, 2007.
3. Molecular Biotechnology, 2nd edition, S. B. Primrose, Blackwell Scientific Publishers, Oxford, 1994.

REFERENCE BOOKS:

1. Michael, R. G., Sambrook. J., "Molecular Cloning - A Laboratory Manual", 4th edition, Cold Spring Harbour Laboratory Press, 2012.
2. Milestones in Biotechnology, Classic Papers on Genetic Engineering, J. A. Davis and W. S. Reznikoff, Butterworth-Heinemann Boston 1992.
3. Route Maps in Gene Technology, M. R. Walker, and R. Rapley, Blakwell Science, Oxford, 1997.

COURSE ARTICULATION MATRIX:

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	2			2	2			3	3
CO2	2						2	3	3
CO3	2			2	2			3	3
CO4	2		2		2		2	3	3
CO5	2	2	2	2	2	2	2	3	3

1-Weak; 2-Moderate; 3-Strong.

BY22104 SCAFFOLD DESIGNING AND 3D BIOPRINTING

L	T	P	C
0	0	2	1

OBJECTIVES:

1. To introduce the concepts of bioprinting and its types.
2. To study the application of cells, crosslinking and scaffold designing in bioprinting.

UNIT I INTRODUCTION TO 3D BIOPRINTING 5

Introduction to 3D Bioprinting, understanding different types of bioprinting: Extrusion based, Inkjet based and laser assisted bioprinting.

UNIT II BIOLOGY AND BIOMATERIALS IN 3D BIOPRINTING 7

Introduction to Cells, Tissues, Organs and ECM, In-Vitro Cell Handling for 3D Bioprinting, Types of Cells used in 3D Bioprinting and their limitations, In-Depth Understanding of Hydrogels and Biomaterials.

UNIT III SCAFFOLD DESIGNING AND CROSSLINKING 3

An Introduction to Crosslinking, importance and application, Scaffolds and Scaffold Design.

TOTAL: 15 PERIODS

COURSE OUTCOMES:

CO	After completion of this course, the students will be able to	RBT LEVEL
1.	Illustrate the types of bioprinting in biological models.	2
2.	Construct the invitro model systems such as cells, tissues, organs using 3D bioprinting.	2
3.	Examine the use of hydrogels in bioprinting.	3
4.	Analyze the application of crosslinking of biomaterials in bioprinting.	4
5.	Design the 3D structures of living cells and active biomolecules on scaffold perspectives.	4

TEXTBOOKS:

1. Ibrahim Ozbolat, "3D Bioprinting - Fundamentals, Principles and Applications", 1st Edition, 2016.
2. Wai Yee Yeong and Chee Kai Chua, "Bioprinting: Principles and Applications: 1, World Scientific Series In 3d Printing, 2015.
3. Vasileios N. Papadopoulos, Vassilios Tsioukas and Jasjit S. Suri, "3D Printing: Applications in Medicine and Surgery", Volume 2, 2021.
4. Daniel X. B. Chen, "Extrusion Bioprinting of Scaffolds for Tissue Engineering Applications", 2019.
5. Pugliese R, Beltrami B, Regondi S and Lunetta C, "Polymeric biomaterials for 3D printing in medicine: An overview", Annals of 3D Printed Medicine. 2021 Jun 1;

2:100011.

REFERENCE BOOKS:

1. Chia HN and Wu BM, "Recent advances in 3D printing of biomaterials", Journal of Biological Engineering, 2015 Dec; 9(1):1-4.
2. Liliang Ouyang, "Study on Micro extrusion-based 3D Bioprinting and Bioink Crosslinking Mechanisms", 2020.
3. Mancha Sánchez E, Gómez-Blanco JC, López Nieto E, Casado JG, Macías-García A, Díaz Díez MA, Carrasco-Amador JP, Torrejón Martín D, Sánchez-Margallo FM and Pagador JB, "Hydrogels for bioprinting: a systematic review of hydrogels synthesis, bioprinting parameters, and bioprinted structures behavior", Frontiers in Bioengineering and Biotechnology, 2020 Aug 6; 8:776.
4. Gupta D and Negi NP, "3D bioprinting: Printing the future and recent advances", Bioprinting, 2022 May 18: e00211.
5. Zhang YS, Yue K, Aleman J, Mollazadeh-Moghaddam K, Bakht SM, Yang J, Jia W, Dell'Erba V, Assawes P, Shin SR and Dokmeci MR, "3D bioprinting for tissue and organ fabrication", Annals of biomedical engineering, 2017 Jan;45(1):148-63.

COURSE ARTICULATION MATRIX:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PSO1**	**PSO2**	**PSO3**
CO1	3		3	2	3	2	3	3	1
CO2	3		3		3		3	3	
CO3	3		3				3	3	
CO4	3		3	2	3	2	3	3	1
CO5	3		3	2	3	2	3	3	1

1-Weak; 2-Moderate; 3-Strong

BY22111	RECOMBINANT DNA TECHNOLOGY LABORATORY	L	T	P	C
		0	0	6	3

OBJECTIVES:

1. To enhance the practical knowledge on isolation and restriction of plasmid DNA.
2. To demonstrate ligation of DNA and transform it into a bacterial cell.
3. To illustrate the methodology of Colony PCR.
4. To demonstrate the DNA sequencing methodology.
5. To enhance the practical knowledge on BLAST and site-directed mutagenesis.

LIST OF EXPERIMENTS

1. Isolation of plasmid DNA for the vector construction
2. Restriction digestion and ligation and quality checking on the Agarose gel
3. Transformation of ligated DNA by Chemical Transformation and Electroporation of Bacteria
4. Verification of cloning by colony PCR and patching the positive colonies
5. Plasmid isolation from PCR-positive colonies
6. Confirmation of cloning by restriction digestion
7. DNA cycle sequencing
8. Purification of cycle sequencing reaction product and automated DNA sequencing
9. Sequence editing and BLAST analysis to identify the gene
10. Site-directed mutagenesis

TOTAL: 90 PERIODS

COURSE OUTCOMES:

CO	After completion of this course, the students will be able to	RBT LEVEL
1.	Construct plasmid DNA by isolation from bacterial cell.	3
2.	Critically evaluate the transformation efficiency of DNA ligation.	4
3.	Review the PCR product for positive transformed colonies.	3
4.	Evaluate the different DNA sequencing methodologies.	4
5.	Estimate the gene using online tools such as BLAST and perform its targeted mutation.	5

REFERENCE BOOKS AND WEBSITES:

1. Michael, R. G., Sambrook. J., "Molecular Cloning - A Laboratory Manual", 4th edition, Cold Spring Harbour Laboratory Press, 2012.
2. Frederick. M., Ausubel., Brent R., Kingston. R. E., Moore D.D., Seidman J. G., John A. Smith and Kevin Struhl, "Current Protocols in Molecular Biology", John

Wiley & Son, Inc., 2003.

3. http://blast.ncbi.nlm.nih.gov/Blast.cgi

COURSE ARTICULATION MATRIX:

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	2		2			2	3	3	3
CO2	2		2				3	3	3
CO3	2				2	2	3	3	3
CO4	2				2		3	3	3
CO5	2		2	2	2		3	3	3

1-Weak; 2-Moderate; 3-Strong

BY22201	ANALYTICAL TECHNIQUES IN BOTECHNOLOGY	L	T	P	C
		3	0	2	4

OBJECTIVES:

1. Developing the skills to understand the theory and practice of analytical techniques.
2. Enhancing the understanding of analytical techniques in detail to interpret results.
3. Improving the learning ability on how to analyze and separate biomolecules based on their properties.
4. Know the different radioisotope techniques used in biotechnological processes.
5. To gain the knowledge on separation of proteins, and DNA using electrophoresis and structure determination of molecules.

UNIT I SPECTROSCOPY TECHNIQUES 9+6

Working principle, instrumentation, sample preparation, and its applications - UV-Vis, AAS, NMR, ESR / EPR, IR, Raman for small molecules, Emission spectroscopy and absorption spectrometric techniques-Working principle, instrumentation, sample preparation, and its applications - AES, Fluorescence, Phosphorescence, Chemi/ Bioluminescence, MS, XRD for small molecules.

1. Determination of Lambda max for the given sample using UV visible Spectrometer.
2. Estimation of proteins and nucleic acids using UV visible Spectrometer.

UNIT II SEPARATION TECHNIQUES 9+6

Theory of chromatography and types (TLC, PC, HPTLC, GC, HPLC, and 2D) - their principles and applications. Electrophoresis- Principles, instrumentation, sample preparation, and applications of 2D - Rotophore, Optical densitometry.

1. Sample analysis using HPLC method.
2. Agar gel, Starch gel, PAGE (native and denature), and Agarose gel electrophoresis.

UNIT III MICROSCOPIC TECHNIQUES 9+6

Basics of light microscopy, Instrumentation - confocal and fluorescence microscopy, sample preparation for fluorescence microscopy, super-resolution microscopy, Basics of SEM and TEM, Specimen preparation for SEM and TEM.

1. Qualitative and Quantitative microbiological analysis of sewage water.
2. Detection of bacteria in spoiled tinned food.

UNIT IV RADIO ISOTOPE TECHNIQUES 9+6

Radioisotope techniques: Autoradiography, Radioimmunoassay (RIA), ELISA RIA, Radioreceptor assay (RRA), Liquid Scintillation counter, nature of radioactivity, detection, measurements, counters, safety aspects. Cell sorters and their applications. Hyphenated techniques, tracer techniques – solid, liquid scintillation, Alternative to radioactive techniques.

1. Enzyme-linked immunosorbent assay.
2. Analysis of bioactive molecules using FTIR Spectroscopy

UNIT V MOLECULAR TECHNIQUES 9+6

Quantification of proteins, DNA and RNA, Blotting – Southern, western and northern blotting, Gene transfer and Transfection methods, PCR and its types, Biosensors and types of biosensors

1. Isolation of DNA from Plant/Animal/Microbial source.
2. Microbiological assay of antibiotics/Minimum inhibitory concentration of antibiotics/Estimation of DNA.

TOTAL: 75 PERIODS

COURSE OUTCOMES:

CO	After completion of this course, the students will be able to	RBT LEVEL
1.	Create awareness about the hazardous chemicals and safety precautions in case of emergency.	2
2.	Learn about the qualitative and quantitative estimation of biomolecules.	4
3.	Elaborate on the working principle of instruments (pH meter and spectroscopy) used in biochemistry lab.	4
4.	Analyze the significance of biochemistry in research and clinical sample analysis.	4
5.	Demonstrate the application of spectroscopic methods in the quantification of bioproduct.	5

TEXTBOOKS:

1. Keith Wilson and John Walker, "Principles and Techniques of Biochemistry and Molecular Biology", 7th Edition, 2015
2. Pattabiraman, T.N., "Laboratory Manual in Biochemistry", 4th Ed., All India Publishers, 2004.
3. Wilson, K. & Walker, J., "Principles and Techniques of Practical Biochemistry", 5th Edition, Cambridge University Press, 2000.
4. Plummer, D.T., "An Introduction to Practical Biochemistry", 3rd Edition, Tata McGraw Hill, 2008.
5. Skoog, D.A, James H. F and Stanky R. C, "Principles of Instrumental Analysis", 6th Edition, Cengage Learning, 2016.

REFERENCE BOOKS:

1. Skoog, Holler and Crouch, "Principles of Instrumental Analysis", 6th edition Cengage Learning, 2015.
2. Nirmalendu Nath, "Biophysical Chemistry: (Principles and Techniques)", Himalaya Pub. House Mumbai, 2015.

3. Avinash Upadhyay, Kakoli Upadhyay and Philopose PM, "Analytical Biotechnology", Domihant Publishers & Distributors, New Delhi, 2016.
4. Lack C and Ewing`s, "Analytical instrumentation handbook", Marcel and Dekker Inc.
5. Boyer Rodney F, "Biochemistry laboratory: modern theory and techniques", 2nd Edition, 2015.

COURSE ARTICULATION MATRIX:

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	3		2		3				
CO2	3	2		3	3	2	2	2	
CO3	3	2						2	2
CO4	3	2					3	3	3
CO5	3	2			3	2	3	2	2

1-Weak; 2-Moderate; 3-Strong

BY22202 ADVANCED BIOSEPARATION TECHNOLOGY

L	T	P	C
3	0	0	3

OBJECTIVES:

1. To understand the physicochemical properties of bioproducts and economics of bioseparation techniques
2. To inculcate the importance of mechanical separation process for recovery of bioproducts
3. To provide the knowledge on bioproduct isolation process at laboratory and pilot scale
4. To understand the chromatographic separation processes and its selection
5. To enhance the knowledge on stabilization and formulation of biotechnology products

UNIT I BIOSEPARATION IN BIOTECHNOLOGY 9

Role and importance of bioseparation in biotechnological processes; Problems and requirements of bioproduct purification; Economics of bioseparation techniques in Biotechnology, cost-cutting strategies; Separation characteristics of proteins and enzymes – size, stability, properties; Flocculation and conditioning of broth; Process design criteria for various classes of bioproducts like high volume, low value products and low volume, high value products; Upstream production methods affecting purification strategies.

UNIT II CELL DISRUPTION AND SOLID-LIQUID SEPARATION 9

Physical, chemical, mechanical cell disruption methods for intracellular products; Removal of insoluble, biomass and particulate debris separation techniques – Filtration at constant pressure and at constant rate – Empirical equations for batch and continuous filtration – Types of filtration - Centrifugal and tangential- flow filtration – Types of filtration equipments – Centrifugation – Basic principles, design characteristics – Types of centrifuges and applications.

UNIT III MEMBRANE PROCESSES AND ENRICHMENT OPERATIONS 9

Theory, Design consideration and configuration of membrane processes – microfiltration, ultrafiltration, nanofiltration, reverse osmosis, dialysis – Structure and characteristics of membranes – Membrane modules; Enrichment Operations – Extraction – equipment for extraction – Aqueous two-phase extraction – Reverse micellar extraction – Protein precipitation – Methods of precipitation.

UNIT IV MODES OF CHROMATOGRAPHIC SEPARATION 9

Chromatography – Classification of chromatographic techniques – General description of column chromatography – Chromatographic terms and parameters – Practice of chromatography – molecular sieve, ion exchange, hydrophobic, hydroxyapatite, partition, displacement, normal-phase, reversed-phase, affinity, chiral, supercritical fluid chromatography – Scale-up of chromatography – Process

considerations in Preparative liquid chromatography and HPLC.

UNIT V FINISHING OPERATIONS AND FORMULATIONS 9

Drying – Mechanism, methods and applications, Types of dryers – Tray, spray, rotary, belt, disc; Crystallization – Nucleation, crystal growth – Types of crystallizers – Tank, scrapped surface, Oslo, Circulating-magma evaporator; Freeze drying – Principle, process, applications – Case studies Penicillin, Cephalosporin, Recombinant Streptokinase, Interferon.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO	After completion of this course, the students will be able to	RBT LEVEL
1.	Understand of the physicochemical properties of biotechnological products and economics of bioseparation techniques.	2
2.	Gain the knowledge on equipment selection and design of mechanical separation process for recovery of biotechnological products	5
3.	Identify and optimize the suitable bioproduct isolation process at laboratory and pilot scale	3
4.	Thoroughly understand the chromatographic separation methods and equipment selection	2
5.	Have complete knowledge of stability of biotechnology products and should be capable of formulation and stabilization for enhanced shelf-life. Apply principles of various unit operations used in bioseparation processes and enhance problem solving techniques.	6

TEXTBOOKS:

1. Belter, P.A., Gussler, E.L. and Hu, W.S., "Bio-separation: Downstream Processing for Biotechnology", John Wiley and Sons, 2011.
2. Roger, H., "Bio-separations Science and Engineering", Oxford University Press, 2006.
3. Forciniti, D., "Industrial Bio-separation: Principles & Practice", Blackwell, 2008.

REFERENCE BOOKS:

1. Ladisch, M.R., "Bioseparations Engineering: Principles, Practice, and Economics", John Wiley & Sons, 2001.
2. Ghosh, R., "Principles of Bio-separations Engineering", World Scientific Publishers, 2006.
3. Carta, G and Jungbauer, A., "Protein Chromatography", Wiley-VCH, 2010.

COURSE ARTICULATION MATRIX:

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	3	3	2	3	3		3	3	1
CO2	3		2	3			3	3	1
CO3	3	3	2	3			3		
CO4	3	3	2	3	3		3	3	
CO5	3	3	2	3	3		3	3	

1-Weak; 2-Moderate; 3-Strong

BY22203 IMMUNOTECHNOLOGY

L	T	P	C
3	0	0	3

OBJECTIVES:

1. To know about the immune system
2. To study about the assays of antibody detection.
3. To study the cellular immunology
4. To understand the various aspects of vaccine development.
5. To understand the development of various antibodies for immunotherapeutics.

UNIT I INTRODUCTION TO IMMUNOLOGY 9

Types of antigens, their structure, preparation of antigens for raising antibodies, handling of animals, adjuvants and their mode of action; Cells of the immune system and their development; primary and secondary lymphoid organs; humoral immune response; cell mediated immune responses; complement.

UNIT II ANTIGEN ANTIBODIES INTERACTION ASSAYS 9

Polyclonal antibodies; Monoclonal antibodies and their use in diagnostics; ELISA; Agglutination tests; radio immuno assay (RIA) principles and applications; western blot analysis, immuno electrophoresis, SDS-PAGE; Antigen detection assay; Plaque Forming Cell Assay.

UNIT III CELLULAR IMMUNOLOGY 9

PBMC separation from the blood; identification of lymphocytes based on CD markers; FACS; Lympho -proliferation assay; Mixed lymphocyte reaction; Cr51 release assay; macrophage cultures; cytokine bioassays- IL2, gamma IFN, TNF alpha; HLA typing.

UNIT IV VACCINE TECHNOLOGY AND IMMUNOPATHOLOGY 9

Basic principles of vaccine development; protein-based vaccines; DNA vaccines; Plant based vaccines; recombinant antigens as vaccines; reverse vaccinology; immuno cytochemistry – immune fluorescence, immuno enzymatic and immuno ferrtin techniques, immuno electron microscopy

UNIT V DEVELOPMENT OF IMMUNOTHERAPEUTICS 9

Engineered antibodies; catalytic antibodies; Idiotypic antibodies; combinatorial libraries for antibody isolation; immune therapy with genetically engineered antibodies

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO	After completion of this course, the students will be able to	RBT LEVEL
1.	Explains immune responses and techniques to assess immune responses.	2

2.	Experiment with antibodies to assess immune responses	3
3.	Organizes assess immune response assessment using assays.	3
4.	Distinguishes the various cases of vaccine based on its principle.	4
5.	Appraise development of engineered antibodies.	5

TEXTBOOKS:

1. Roitt and Ivan, "Essential Immunology", 9th Edition, Blackwell Scientific, 1997.
2. Roitt, I., Brostoff, J and Male, D, "Immunology", 6th Edition, Mosby, 2001.
3. Goldsby, R.A., Kindt, T.J., Osbome, B.A and Kerby, J., "Immunology", 5th Edition, W.H Freeman, 2003.
4. Weir, D.M & Stewart, J., "Immunology", 8th Edition, Churchill Livingstone, 1997.

REFERENCE BOOKS:

1. Talwar G.P., and Gupta S.K., "A hand book of practical and clinical immunology", Vol. 1 & 2, CBS Publications, 1992.
2. Tizard, "Immunology", 4th Edition, Thomson Asia Pvt. Ltd, 2004.
3. Austin J.M. and Wood K.J., "Principle of cellular and molecular immunology", Oxford univ press, Oxford, 1993.
4. lvan M. Roitt & Peter J. Delves, "Essential Immunology", 10th Edition, Blackwell Publication, 2001.

COURSE ARTICULATION MATRIX:

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	3				2				
CO2	3	3	2		1	3			3
CO3	3	3	3		2	2	3		3
CO4	3	3	1	2	2	2	3		3
CO5	2	3	1	3	3		3		3

1-Weak; 2-Moderate; 3-Strong.

GR22251	INTRODUCTION TO RESEARCH METHODOLOGY AND IPR	L	T	P	C
		3	0	0	3

OBJECTIVES:

1. To impart knowledge on formulation of research problem, research methodology, ethics involved in doing research and importance of IPR protection.

UNIT I RESEARCH METHODOLOGY 9

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations. Effective literature studies approaches, analysis Plagiarism, Research ethics

UNIT II RESULTS AND ANALYSIS 9

Importance and scientific methodology in recording results, importance of negative results, different ways of recording, industrial requirement, artifacts versus true results, types of analysis (analytical, objective, subjective) and cross verification, correlation with published results, discussion, outcome as new idea, hypothesis, concept, theory, model etc.

UNIT III TECHNICAL WRITING 9

Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

UNIT IV INTELLECTUAL PROPERTY RIGHTS 9

Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

UNIT V PATENT RIGHTS AND NEW DEVELOPMENTS IN IPR 9

Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO	After completion of this course, the students will be able to	RBT LEVEL
1.	Critically evaluate any research article based upon research methodology.	5
2.	Correlate the results of any research and develop hypothesis,	4

concept, theory and model.

3.	Developing a research proposal, research presentation and review article in the field of engineering.	3
4.	Enumerate the importance of intellectual property right in research.	4
5.	Develop proposal for patent rights and identify the new developments in IPR.	4

TEXTBOOKS:

1. Ranjit Kumar, "Research Methodology- A step by step guide for beginners", 4th edition, Pearson Education, Australia, 2014
2. Ann M. Korner, "Guide to Publishing a Scientific paper", Bioscript Press, 2008.
3. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008

REFERENCE BOOKS:

1. Kothari, C. R., "Research Methodology - Methods and Techniques", 4th Edition, New Age International publishers, New Delhi, 2019.
2. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students', Juta & Company, 1996.
3. Robert P. Merges, Peter S. Menell and Mark A. Lemley, "Intellectual Property in New Technological Age", Aspen Publishers, 2016.

COURSE ARTICULATION MATRIX:

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	3	3	3	2	3	2	3	3	
CO2	3	3	3	3	3	1	3	3	
CO3	3	3	3	3	3		3	3	
CO4	2	2	3	2	2	1	2	3	
CO5	3	3	3	2	3	2	3	3	

1-Weak; 2-Moderate; 3-Strong.

BY22204 **MACHINE LEARNING FOR BIOTECHNOLOGISTS**

L	T	P	C
2	0	0	1

OBJECTIVES:

1. To introduce students to the basic concepts and techniques of Machine Learning.
2. To have a thorough understanding of the Supervised and Unsupervised learning techniques.
3. To study the various probability-based learning techniques.
4. To understand graphical models of machine learning algorithms.
5. To importing knowledge on foundation of machine learning to solve bioinformatics problems.

UNIT I MACHINE LEARNING 15

Fundamentals of Machine Learning, Feature Engineering, Data Imputation, Dimensionality Reduction, Unsupervised Learning, Linear and Logistic Regression, Decision Trees, Random Forests and eXtreme Gradient Boosting, Extreme Learning Machines, Hidden Markov Models, Kernel Methods, Support Vector Machines, Deep Learning: Fundamentals, Embeddings, Architectures. Concept and Rule-based Learning Graphs, Ensemble, Semi-supervised Learning, Data Integration, Automated Scientific Discovery

TOTAL: 15 PERIODS

COURSE OUTCOMES:

CO	After completion of this course, the students will be able to	RBT LEVEL
1.	Understand and solve different problems in biological problems with machine learning.	4

TEXTBOOKS:

1. Michailidis, G., Perkins, T., Mitra, S., Datta, S., "Introduction to Machine Learning and Bioinformatics", United Kingdom: Taylor & Francis Group, 2019.
2. "Data Analytics in Bioinformatics: A Machine Learning Perspective", United Kingdom: Wiley, 2021.
3. Bhattacharyya, D. K., Barah, P., and Kalita, J. K., "Gene Expression Data Analysis: A Statistical and Machine Learning Perspective", United States: CRC Press, 2021.
4. Rajapakse, J. C., and Zhang, Y, "Machine Learning in Bioinformatics", Germany: Wiley, 2009.
5. Subasi, A., "Practical Machine Learning for Data Analysis Using Python", Netherlands: Elsevier Science, 2020.

REFERENCE BOOKS:

1. Brunak, S., Baldi, P., Baldi, P. P., "Bioinformatics, Second Edition: The Machine

Learning Approach", India: Bradford, 2001.

2. Baldi, P., "Deep Learning in Science", India: Cambridge University Press, 2021.
3. Alkhalifa, S., "Machine Learning in Biotechnology and Life Sciences: Build Machine Learning Models Using Python and Deploy Them on the Cloud", United Kingdom, Packt Publishing, 2022.
4. Nwanganga, F., and Chapple, M., "Practical Machine Learning in R", United Kingdom: Wiley, 2020.
5. Bush, E., and Libeskind-Hadas, R., "Computing for Biologists: Python Programming and Principles", (n.p.): Cambridge University Press, 2014.
6. Jones, M., "Biological Data Exploration with Python, Pandas and Seaborn: Clean, Filter, Reshape and Visualize Complex Biological Datasets Using the Scientific Python Stack", Poland: Independently Published, 2020.

COURSE ARTICULATION MATRIX:

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	3	2		3	2		2	2	2
CO2	3	2		3	2		2	2	2
CO3	3	2		3	2		2	2	2
CO4	2	2		3	2		2	2	2
CO5	3	2		3	2		2	2	2

1-Weak; 2-Moderate; 3-Strong.

BY22211	ADVANCED MICROBIAL AND IMMUNOTECHNOLOGY LABORATORY	L	T	P	C
		0	0	6	3

OBJECTIVES:

1. Develop skills and competencies in standard microbiological laboratory techniques.
2. Comprehend the ethical consideration and techniques for observing, collecting, and handling live animals and their tissues.
3. Isolation of mononuclear cells and splenocytes for immunological studies.
4. Identification of lymphocytes using immunological techniques.
5. Develop an immunodiagnostic prototype.

LIST OF EXPERIMENTS

1. Disinfection, safety instructions; Preparation of media and Sterilization.
2. Screening and isolation of antibiotic producing microbes from soil.
3. Enumeration of microorganisms by serial dilution.
4. Growth curve, measure of bacterial population by turbidometry.
5. Ethics, selection and handling of animals for immunological experiments (Eg. Mice, Rats, Rabbits).
6. Preparation of antigen and immunization through different routes (Eg. Intra-peritoneal, Sub-cutaneous, Intramuscular, Intra-nasal, Oral).
7. Methods of bleeding (Eg. Tail bleeding, Intravenous, Intraorbital).
8. Collection of serum, storage and purification of total IgG (salt precipitation).
9. Separation of splenocytes and proliferation against mitogens.
10. Separation of mononuclear cells by Ficoll-Hypaque.
11. Measurement of cytokines secreted from immune cells by ELISA.
12. Immunofluorescence staining of B-cell and T-cell populations of mouse spleen and thymus.
13. Analysis of CD4 expression using RT-PCR and Agarose Gel Analysis.
14. Flow cytometry and FACS analysis of mouse splenocytes and thymocytes.
15. Methods for prototype development of Immunodiagnostics (ICT card).

TOTAL: 90 PERIODS

COURSE OUTCOMES:

CO	After completion of this course, the students will be able to	RBT LEVEL
1.	Equip with the knowledge to handle microbes and basic instrumentation and techniques used in microbiological laboratory.	3

2.	Illustrate ethical guidelines and techniques for the use of animals in research.	3
3.	Demonstrate the mononuclear cells isolation, mitogen-stimulated cell proliferation and cytokine production in immune cells.	4
4.	Apply the immunological techniques identify the lymphocytes.	3
5.	Demonstrate the isolation of PBMC and splenocytes for proliferation test and develop immunodiagnostics prototype.	4

REFERENCE BOOKS:

1. Collee, J.G., Fraser, A.G., Marmion, B.P., Simmons, A., Mackie and McCartney, "Practical Medical Microbiology", 14th Edition, Churchill Livingstone, 1996.
2. John, E. C., "Current Protocols in Immunology", Wiley Interscience, 2003.
3. Freshney, R. Ian, "Culture of animal cells: a manual of basic technique and specialized applications", John Wiley & Sons, 2015.
4. Lawson, P. Timothy, ed. Assistant Laboratory Animal Technician, American Association for Laboratory Animal Science, 1998.
5. Melamed, Myron R., Tore Lindmo, Mortimer L. Mendelsohn, and Robert D. Bigler, "Flow cytometry and sorting", 2nd Edition, John Wiley & Sons, 1991.

COURSE ARTICULATION MATRIX:

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	3		1		1		2		
CO2		3	1			3	1	1	
CO3	1	1				2	2	2	
CO4	3	2		3	2	2	1		2
CO5		3		2		3	1	2	3

1-Weak; 2-Moderate; 3-Strong.

BY22301	ADVANCED BIOPROCESS AND BIOSEPARATION TECHNOLOGY LABORATORY	L	T	P	C
		0	0	6	3

OBJECTIVES:

1. To inculcate students on the fundamentals of bioprocessing of industrial bioproducts.
2. To equip students with skills required from basic characterization to commercialization of bioproducts

LIST OF EXPERIMENTS

1. Immobilized enzyme kinetics: Effect of pH and temperature-Michaelis-Menton kinetic parameters.
2. Bioprocess media optimization techniques: Plackett Burman Design, Response Surface Methodology.
3. Batch and Fed batch cultivation of *E.coli*: Growth rate, substrate utilization kinetics, product analysis after induction, Metabolite analysis by HPLC.
4. Continuous cultivation of *E.coli*: x-d construction, kinetic parameter evaluation, gas analysis, carbon balancing.
5. Bioreactor studies: Sterilization kinetics, k_La determination, residence time distribution, sensors for bioprocess monitoring.
6. Animal cell culture production: T-flask, spinner flask, bioreactor.
7. Cell separation methods: Centrifugation, microfiltration and ultrafiltration.
8. Cell disruption methods: Ultrasonication, homogenization.
9. Product concentration: Ammonium sulphate precipitation, Aqeous two phase extraction.
10. High resolution purification and polishing: Ion exchange, affinity and gel filtration chromatography, Freeze drying.

TOTAL: 90 PERIODS

COURSE OUTCOMES:

CO	After completion of this course, the students will be able to	RBT LEVEL
1.	Select the appropriate enzymes used for reactions and bioreactors in its immobilized form.	3
2.	Perform optimization of media components and process parameters for different kinds of bioreactors.	3
3.	Inspect the importance of mixing time, residence time and oxygen demand in the growing cultures.	4
4.	Experiment with the different kinds of bioreactors for animal cell culture production	5

5. Make use of various separation techniques for product purification and preservation 5

REFERENCE BOOKS:

1. Bailey, J.E & Ollis, D.F., "Biochemical Engineering Fundamentals", 3rd edition, McGraw Hill, 2011.
2. Belter, P.A., Cussler, E.L., and Houhu, W "Bioseparations – Downstream Processing for Biotechnology", Wiley Interscience Publication, 2011.
3. Janson J.C. and L. Ryden, "(Ed.) – Protein Purification – Principles, High Resolution Methods and Applications", 3rd Edition, Wiley-VCH Publication, 2011.

COURSE ARTICULATION MATRIX:

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	3	1	2	2	1		2	1	
CO2	3	1	2	2	1		2	1	
CO3	3		2	2			2		
CO4	3	1	2	2			2	1	
CO5	3		2	2	1		2	1	

1-Weak; 2-Moderate; 3-Strong.

BY22302	MOLECULAR MODELLING AND DRUG DESIGN LABORATORY	L	T	P	C
		0	0	6	3

OBJECTIVES:

1. To provide practical knowledge on annotation and modelling of proteins.
2. To design and find activity of drugs based on physical and chemical properties.
3. To model and validate the structure of proteins.
4. To find protein-protein interaction networks in biological pathways.
5. To understand binding affinity of drugs and inhibitors with the target receptors.

LIST OF EXPERIMENTS

1. Small molecules from Biological Databases – PUBCHEM, Drugbank, ZINC15
2. Checking Lipinki's rule five and ADME properties – SWISSADME
3. Drawing Chemical molecules - ACD Chemsketch
4. Protein Sequence and Structure Annotation – Genpept, UniprotKB, PDB
5. Pairwise and Multiple Sequence Alignment – BLAST, CLUSTALW
6. Modeling of Proteins & Structure Assessment – SWISS Modeller
7. Phylogenetic Analysis – PHYLIP
8. QSAR Analysis – QSAR toolbox
9. Pharmacophore generation & Mapping – Pharm-mapper
10. Pathways search - KEGG, Protein-Protein Interactions – StringDB
11. Network pathways – Cytoscape
12. Bioinformatics Toolbox – MATLAB
13. Molecular Docking – Autodock
14. Protein- Protein Docking – Patchdock, Firedock
15. Docking Analysis and Validation – Discovery Studio

TOTAL: 90 PERIODS

COURSE OUTCOMES:

CO	After completion of this course, the students will be able to	RBT LEVEL
1.	Design both small and large biomolecules	4
2.	Check drug likeness, ADME properties of small molecules.	3
3.	Perform Sequence Alignment, Phylogenetic Analysis and search network pathways	3
4.	Perform Pharmacophore generation, QSAR analysis.	3

5. Perform Molecular docking and it analysis. 3

REFERENCE BOOKS:

1. Rebecca C. Wade and Outi M.H. Salo- Ahen, "Molecular Modeling in Drug Design", MDPI publishers, 2019.
2. Anand Solomon K, "Molecular Modelling and Drug Design", 1st Ediiton, MJP Publishers, 2015.
3. Om Silakari, Pankaj Kumar Singh, "Concepts and Experimental Protocols of Modelling and Informatics in Drug Design", Academic Press Inc., 2020.
4. Shao Li, "Network Pharmacology", 1st Ediiton, Springer Verlag, 2021.
5. Rastogi S.C, Rastogi Paraag and Namita Medritta, "Bioinformatics: Methods and applications – Genomics, Proteomics and Drug Discovery", 5th Edition, PHI Learning Pvt. Ltd, 2022.

COURSE ARTICULATION MATRIX:

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	3	1	2	3	2		2	2	1
CO2	3	1	2	3	2		2	2	1
CO3	3	1	2	3	2		2	2	1
CO4	3	1	2	3	2		2	2	1
CO5	3	1	2	3	2		2	2	1

1-Weak; 2-Moderate; 3-Strong.

BY22001 BIOLOGY FOR CHEMICAL ENGINEERS

L	T	P	C
3	0	0	3

OBJECTIVES:

1. Introduce the molecular basis of life.
2. Provide the basis for classification of living organisms.
3. Describe the transfer of genetic information.
4. Introduce the techniques used for modification of living organisms.
5. Describe the applications of biomaterials

UNIT I INTRODUCTION TO BIOLOGY 9

Comparison of eye and camera, flying bird and aircraft, Biological observations and major discoveries - genera, species and strains, and Classification of living organisms: Cellularity, Ultrastructure, carbon and energy sources, excretion, habitat and molecular taxonomy.

UNIT II BIOMOLECULES AND ITS APPLICATIONS 10

Water, Biomolecules: sugars, starch and cellulose, Amino acids and proteins, lipids, Nucleotides and DNA/RNA, structure and functions of proteins and nucleic acids, haemoglobin, antibodies and enzymes, Industrial applications of enzymes, Fermentation and its industrial applications

UNIT III BIOCHEMISTRY 9

Bioenergetics, Respiration: Glycolysis and TCA cycle, Electron transport chain and oxidative phosphorylation, Mechanism of photosynthesis, Human physiology, neurons, synaptic and neuromuscular junctions.

UNIT IV GENETICS 9

Mendel's laws, gene mapping, Mitosis and Meiosis, Epistasis, single gene disorders in humans, Genetic code, DNA replication, Transcription, Translation.

UNIT V RECOMBINANT DNA TECHNOLOGY 8

Recombinant DNA Technology: recombinant vaccines, transgenic microbes, plants and animals, animal cloning, biosensors, biochips.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO	After completion of this course, the students will be able to	RBT LEVEL
1.	Compare biological organisms and manmade systems.	2
2.	Interpret the relationship between the structure and function of biomolecules and its industrial applications.	3
3.	Apply thermodynamic principles to biological systems.	4
4.	Explain the medical importance of gene and their disorders.	2

5. Outline the principles and importance of recombinant DNA technology. 3

TEXTBOOKS:

1. Campbell, N.A., Reece, J.B., Urry, L., Cain, M.L., and Wasserman, S.A., "Biology: A global approach", Pearson Education Ltd, 2018.
2. Arthur T.J., Biology for Engineers, CRC press, 2011.
3. Mitchell, W. J., and Slaughter, J. C., "Biology and biochemistry for chemists and chemical engineers", Halsted Press, 1989.

REFERENCE BOOKS:

1. Khan, F. A., "Biotechnology Fundamentals", 3rd Ed, CRC Press, 2020.
2. Conn, E.E., Stumpf, P.K., Bruening, G., and Doi, R.H., "Outlines of Biochemistry", John Wiley & Sons, 2009.
3. Waite, G.N., "Applied cell and molecular biology for engineers", McGraw-Hill Education, 2007.

COURSE ARTICULATION MATRIX:

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	1		1						
CO2				2	2		2	1	
CO3	1		1	2					
CO4	2			3		1	1	1	
CO5	2		1			1	2		1

1-Weak; 2-Moderate; 3-Strong.

BY22003 **CHEMICAL ENGINEERING FOR BIOTECHNOLOGISTS**

L	T	P	C
3	0	0	3

OBJECTIVES:

1. To enhance the knowledge on basic chemical engineering principles
2. To relate and compare the various unit operations
3. To impart the basic concepts of material balance and energy balance
4. To solve the engineering problems related to fluid flow in a bioprocess industry
5. To learn the basic principles of heat transfer

UNIT I INTRODUCTION 9

Introduction to chemical engineering sciences and its role in the design & analysis of chemical processes. Units and conversion factor. Process Data Representation and Analysis - interpolation and extrapolation, curve-fitting and least squares method, fitting a line to scattered data.

UNIT II UNIT OPERATIONS 9

Overview of unit operations and processes in the chemical industry. Size reduction, sedimentation, centrifugation, filtration, extraction, drying, distillation, evaporation, Absorption, adsorption, Crystallization and Dialysis.

UNIT III MATERIAL AND ENERGY BALANCES 9

Introduction to gas laws. Stoichiometry - conversion and yield. Overall and component material balances - Material balances without chemical reactions - Material balances with chemical reactions - combustion calculations - recycle operations. Energy balances - Entropy - Latent heat - Chemical reactions - combustion. Concepts of chemical thermodynamics. Humidity and Application of Psychrometric Chart.

UNIT IV TRANSPORTATION OF FLUIDS 9

Properties of fluids, Fluid rheology. Fluid flow concepts – Multiphase flow, non-Ideal behaviours. Continuity equation and Bernoulli's equation. Different types of pumps, compressors and valves. Measurement of fluid flow. Types of agitators, flow patterns in agitated vessels, calculation of power consumption – applications in bioreactor design.

UNIT V HEAT TRANSFER 9

Nature of heat flow - Conduction, convection, radiation. Steady state conduction, Principles of heat flow in fluids, Heat transfer by forced convection in laminar and turbulent flow. Heat exchange equipment- principles and design. Types of heat exchangers.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO	After completion of this course, the students will be able to	RBT LEVEL
1.	Recall the various unit conversions and analyze the given data.	2
2.	Select and make use of appropriate unit operations.	3
3.	Apply concepts of material and energy balance in bioprocess calculations.	3
4.	Develop the knowledge on fluids, fluid rheology and fluid transport.	4
5.	Analyze the principles and applications of heat transfer operations.	4

TEXTBOOKS:

1. Bhatt, B.I. & Vora, S.M., "Stoichiometry", 3rd Ed., Tata McGraw-Hill Inc., 1977.
2. McCabe W.L., Smith, J.C. & Harriott, P., "Unit Operations in Chemical Engineering", 6th Ed., McGraw-Hill Inc., 2001.
3. Geankoplis, C.J., "Transport Processes and Unit Operations", 3rd Ed., Prentice Hall India, 2003.

REFERENCE BOOKS:

1. Himmelblau D.M., "Basic Principles and Calculations in Chemical Engineering", 6th Ed., Prentice Hall India, 2015.
2. Coulson J.M and Richardson J. F., "Chemical Engineering-Vol I", 6th Ed, Butterworth-heinemann, 1991
3. Coulson J.M and Richardson J. F., "Chemical Engineering-Vol II", 5th Ed, Butterworth-heinemann, 2002
4. Coulson J.M and Richardson J. F., "Chemical Engineering-Vol 3A", 3rd Ed, Butterworth-heinemann, 2017

COURSE ARTICULATION MATRIX:

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	3		3	3					
CO2	3		3	3				2	
CO3	3		3	3				2	
CO4	3		3	3				2	3
CO5	3		3	3				2	3

1-Weak; 2-Moderate; 3-Strong.

BY22005 **ADVANCED BIOPHARMACEUTICAL TECHNOLOGY**

L	T	P	C
3	0	0	3

OBJECTIVES:

1. Core responsibilities for the development and monitoring of the drug and the preparation of medicines according to the norms.
2. Gain knowledge in physicochemical properties, pharmacology and the formulation of commonly used biopharmaceuticals.
3. Equip the students about biosimilars.
4. Analyse the different drug delivery approaches.
5. Apply the advanced technology for point of care diagnosis.

UNIT I INTRODUCTION 9

Drugs discovery and Development phases; Drugs and Cosmetics ACT and regulatory aspects; Definition: Generics and its advantages; Biogenerics and Biosimilars; The role of patents in the drug industry; Protein-based biopharmaceuticals; Introduction to pharmacokinetics and pharmacodynamic principles (factors affecting the ADME process); bioavailability, bioequivalence.

UNIT II DOSAGE FORMS 9

Definition of Dosage forms, Classification of dosage forms (solid unit dosages – Tablets, capsules; liquids – solutions, lotions, suspension etc; semi-solid – ointments, creams, gel, suppositories, etc; Parenterals, Aerosols etc).

UNIT III ADVANCED DRUG DELIVERY SYSTEMS 9

Controlled release dosage forms – Rationale – Principle and factor influencing – Design and Fabrication – Microencapsulation – Liposomes – Niosomes – Transdermal drug delivery – Ocular, Vaginal and Uterine controlled release.

UNIT IV BIOSIMILARS 9

Biosimilar medicine – Importance – INN nomenclature system – Key trends in biosimilar product development – Production of biosimilar products – Difficulties with biosimilar drugs – Non clinical and clinical study – Regulation and approval process – Future prospects.

UNIT V NANOTECHNOLOGY IN PHARMACOLOGY 9

Nanotechnology in point-of-care diagnostics, Nanopharmacology & drug targeting, Cellular uptake mechanisms of nanomaterials, In vitro methods to study antibacterial and anticancer properties of nanomaterials.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO	After completion of this course, the students will be able to	RBT LEVEL
1.	Acquire the knowledge about the legal steps involved in progressing	2

a new drug to market and to grab the current regulatory acts and safety norms of the modern pharmaceutical industries and understand the mechanism of drug action and pharmacokinetics of a given drug.

2. Understand and evaluate different pharmaceutical parameters for the current and future biotechnology related products on the market. 2
3. Gain the knowledge about the different types of drug delivery systems. 3
4. Elaborate their knowledge on pharmacodynamics of pharmaceutical products and current medicines. 3
5. Analyze the novel biotechnological and pharmaceutical products, current medicines and their applications in therapeutic and diagnostic fields. 4

TEXTBOOKS:

1. Loyd V.Allen, Jr. Nicholas G. Popvich, Howard C. Ansel, "Ansels pharmaceutical dosage forms and drug delivery systems", 9th edition, Wolters Kluwer publishers,New Delhi, 2011.
2. Crommelin Dwan J.A., Robert D. Sindelar and Bernd Meibohm, "Pharmaceutical Biotechnology: Fundamentals and application", Springer, 4th Edition, 2013.
3. Katzung B.G., "Basic and Clinical Pharmacology", 11th Edition, Tata MaGraw-Hill, India, 2009.

REFERENCE BOOKS:

1. Gary Walsh, "Pharmaceutical Biotechnology concepts and applications", Wiley India Pvt Ltd. New Delhi, 2011.
2. Karen Whalen, Carinda Field and Rajan Radhakrishnan "Lippincott's Illustrated Reviews Pharmacology" 7th Edition, Wolters Kluwer / Lippincott Williams & Wilkins, 2019.
3. Brahmankar D. M., Sunil B. Jaiswal, "Biopharmaceutics and Pharmacokinetics A Treatise", Vallabh Prakashan, India, 2005.

COURSE ARTICULATION MATRIX:

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1		2				1	3		2
CO2	2				2		3	3	
CO3			3	3			3		
CO4			3	3	2		3	3	2
CO5	2	2	3	3			3	3	

1-Weak; 2-Moderate; 3-Strong.

BY22007 MOLECULAR GENETICS AND GENE THERAPY

L	T	P	C
3	0	0	3

OBJECTIVES:

1. To impart knowledge on genome organization in prokaryotes and eukaryotes
2. To educate students on the principles of DNA replication and transcription.
3. To provide knowledge on translation and gene regulation.
4. To explain the principles of post transcriptional regulation and mutation.
5. To educate students on the principles of gene therapy and its applications.

UNIT I GENOME ORGANIZATION 9

Properties and evolution of genetic material, flow of genetic information, Organization of viral, bacterial genomes and Eukaryotic genome.

UNIT II REPLICATION AND TRANSCRIPTION 9

Replication: Prokaryotic and Eukaryotic, DNA polymerases, Replicons, origin and termination, Replisome, Genes controlling replication, Transcription, Prokaryotic RNA polymerase, sigma factors, initiation and termination, Eukaryotic RNA polymerases and their promoters, Processing of transcripts.

UNIT III TRANSLATION AND GENE REGULATION 9

Translation, General mechanism, Role of rRNA in translation, Regulation of gene expression, Regulation of transcription initiation, Operon and regulon, Positive and negative regulation, Enhancers and promoters, Transcription factors: types, DNA binding motifs, Regulation by attenuation and anti-termination.

UNIT IV POST TRANSCRIPTIONAL REGULATION AND MUTATION 9

Post transcriptional regulation, Alternative splicing, Transport and targeting of RNA, Post-transcriptional gene silencing, Translational control and targeting of proteins, Mechanism of steroid hormone and stress induced gene expressions, Mutation: Types and detection.

UNIT V GENE THERAPY 9

Gene therapy types – somatic cell gene therapy, germline gene therapy, ex vivo gene therapy, in vivo gene therapy, gene therapy strategies, Gene delivery methods, Viral and Non-Viral vectors, Gene correction using CRISPR, Cystic Fibrosis, Duchenne muscular dystrophy, bleeding disorders, Tyrosinemia, SCID, gene therapy of non-heritable disorders.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO	After completion of this course, the students will be able to	RBT LEVEL
1.	Compare the prokaryotic and eukaryotic genome organization.	3

2.	Explain the principles of DNA replication and transcription	3
3.	Outline the steps in translation and types of gene regulation.	3
4.	Inspect the post transcriptional gene regulation and mutations in prokaryotes and eukaryotes.	3
5.	Develop products based on gene delivery for therapeutic purpose.	3

TEXTBOOKS:

1. Levine, M., Losick, R., Baker, T. A., Gann, A., Watson, J. D., Bell, S. P., "Molecular Biology of the Gene", Pearson, 2014.
2. Goldstein, E. S., Krebs, J. E., Kilpatrick, S. T., "Lewin's Essential Genes", Jones & Bartlett Learning, 2020.
3. Weaver, D. R. F., "Molecular Biology", United Kingdom: McGraw-Hill Education, 2012.
4. Wessler, S. R., Griffiths, A. J., Carroll, S. B., Doebley, J., "An Introduction to Genetic Analysis", W. H. Freeman, 2015.

REFERENCE BOOKS:

1. Maloy, S. R., Freifelder, D., Cronan, J. E., "Microbial genetics. Jones and Bartlett Publishers", 1994.
2. Trun, N., Trempy, J., "Fundamental Bacterial Genetics", Wiley, 2009.
3. Latchman, D. S., "Gene Regulation: A Eukaryotic Perspective", United Kingdom: Nelson Thornes, 2002.

COURSE ARTICULATION MATRIX:

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	3		3	3		3	3	3	3
CO2	3		3	3		3	3	3	3
CO3	3		3	3		3	3	3	3
CO4	3		3	3		3	3	3	3
CO5	3		3	3		3	3	3	3

1-Weak; 2-Moderate; 3-Strong.

BY22009 **PYTHON PROGRAMMING FOR BIOTECHNOLOGISTS**

L	T	P	C
3	0	0	3

OBJECTIVES:

1. To solve algorithmic problems
2. To abstract and specify problems
3. To compose programs in Python using iteration and recursion
4. To construct programs in Python using functions
5. To store and retrieve information from Python dictionaries

UNIT I INTRODUCTION TO PROGRAMMING 9

Programming environment: Computer – hardware and software, operating systems, interpreter, editor; Programming notation: pseudo code, flow chart, programming languages; Programming constructs: statements, state, control flow, functions, iteration, and recursion.

UNIT II DATA, EXPRESSION, STATEMENT, CONDITIONAL 9

Python interpreter and interactive mode; data and types: int, float, boolean, string, list; variables, expressions, statements, tuple assignment, precedence of operators; comments; inbuilt modules and functions; Conditional: boolean values and operators, conditional (if), alternative (if-else), case analysis (if-elif-else).

UNIT III ITERATION, FUNCTION, STRINGS 9

Iteration: while, for, break, continue, pass; Functions: function definition, function call, flow of execution, parameters and arguments, return values, local and global scope, recursion; Strings: string slices, immutability, string functions and methods, string module.

UNIT IV LISTS, TUPLES 9

Lists: list operations, list slices, list methods, list loop, mutability, aliasing, cloning lists, list parameters, nested lists, list comprehension; Tuples: tuple assignment, tuple as return value, tuple operations.

UNIT V DICTIONARIES, FILES 9

Dictionaries: operations and methods, looping and dictionaries, reverse lookup, dictionaries and lists; Files: Text files, reading and writing files, format operator, file names and paths; command line arguments.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO	After completion of this course, the students will be able to	RBT LEVEL
1.	Understand programming environment and constructs.	3
2.	Think logically to solve programming problems and write solutions in pseudo code or flow charts.	4

3.	Read and write Python programs functions and call them.	3
4.	Develop programs using conditionals and loops and Do input/output with files.	3
5.	Use Python data structures -- lists, tuples, dictionaries.	3

TEXTBOOKS:

1. Webster, G., Lancaster, A., "Python for the Life Sciences: A Gentle Introduction to Python for Life Scientists", Germany: Apress., 2019
2. Boucher, W., Stevens, T. J., "Python Programming for Biology: Bioinformatics and Beyond", United Kingdom: Cambridge University Press, 2015
3. Hasija, Y., Chakraborty, R., "Hands on Data Science for Biologists Using Python", United States: CRC Press, 2021.
4. Jones, M. O., "Advanced Python for Biologists". Luxembourg: CreateSpace Independent Publishing Platform.
5. Bassi, S., "Python for Bioinformatics", United Kingdom: CRC Press, 2017.

REFERENCE BOOKS:

1. Libeskind-Hadas, R., Bush, E., "Computing for Biologists: Python Programming and Principles", (n.p.): Cambridge University Press, 2014.
2. Jones, M., "Python for Biologists", Germany: Create Space Independent Publishing Platform, 2013.
3. Allesina, S., Wilmes, M., "Computing Skills for Biologists: A Toolbox", United States: Princeton University Press, 2019.
4. Jones, M., "Effective Python Development for Biologists: Tools and Techniques for Building Biological Programs", United Kingdom: Create Space Independent Publishing Platform, 2016.
5. Via, A., Rother, K., and Tramontano, A., "Managing Your Biological Data with Python", United Kingdom: CRC Press LLC., 2017.

COURSE ARTICULATION MATRIX:

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	3	2		3	2		2	2	2
CO2	3	2		3	2		2	2	2
CO3	3	2		3	2		2	2	2
CO4	2	2		3	2		2	2	2
CO5	3	2		3	2		2	2	2

1-Weak; 2-Moderate; 3-Strong.

BY22011 **BIOENGINEERING AND REGENERATIVE MEDICINE**

L	T	P	C
3	0	0	3

OBJECTIVES:

1. To learn the fundamentals of tissue engineering.
2. To understand the components of tissue engineering.
3. To apply the basic concept behind tissue engineering focusing on stem cells, biomaterials and their applications.
4. To apply the concept of tissue engineering in regenerative medicine.
5. To evaluate the translational approaches of Tissue engineering using regulatory principles.

UNIT I INTRODUCTION 9

Introduction to tissue engineering: cells as therapeutic agents, enumeration of cell numbers and growth rates, measurement of cell characteristics morphology, number viability, motility and functions. Tissue appearance and measurement of tissue characteristics, cellular component, ECM components, mechanical measurements and physical properties.

UNIT II TISSUE ARCHITECTURE 9

Tissue types and Tissue components, Tissue repair, Engineering wound healing and sequence of events. Basic wound healing Applications of growth factors: VEGF/angiogenesis, Cell-Matrix& Cell-Cell Interactions, Self-renewal, Control of cell migration in tissue engineering.

UNIT III BIOMATERIALS AND SCAFFOLD FABRICATION 9

Scaffold fabrication strategies- 2D planar and hollow organs, Design of 3D scaffolds and 4D bioprinting, Nanocomposite scaffolds, Tailoring of biomaterials, Bioreactors in fabrication of scaffolds- Artificial blood vessels, artificial liver and artificial pancreas.

UNIT IV REGENERATIVE MEDICINE AND ITS ADVANCEMENTS 9

Regenerative Therapy –Introduction, Applications of Regenerative Medicine in the nervous system, eye, heart, lung, liver, kidney, pancreas and kidney, large scale manufacturing of cells, tissues and organs, Artificial organs, Engineered Tissues and Regenerative Medicine, Personalized therapies in Regenerative Medicine.

UNIT V ETHICS AND REGULATORY APPROVALS 9

Translational Approaches of Tissue Engineering - Animal Study Protocols, Hurdles in Translation of Therapies to the Clinic and Solutions, Engineered Scaffolds and Matrices - Principles of Biomedical Ethics, Funding of Research, Regulatory Mechanisms, Business of Regenerative Medicine.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO	After completion of this course, the students will be able to	RBT LEVEL
1.	Describe different types of stem cells and their specific characteristics	2
2.	Describe methods of applications to replace damaged or destroyed cells including tissue engineering	3
3.	Account for regenerative medicine applications to human diseases	3
4.	Account for and evaluate current theories, methods and techniques within the research field, their practical execution and application	5
5.	Compile, critically analyse and evaluate research results and present the concepts based on regulatory mechanisms.	4

TEXTBOOKS:

1. Bernhard O.Palsson, Sangeeta N.Bhatia, "Tissue Engineering" Pearson Publishers 2009
2. Meyer, U.; Meyer, Th.; Handschel, J.; Wiesmann, H.P., "Fundamentals of Tissue Engineering and Regenerative Medicine", 2009.
3. Bernard N. Kennedy (editor), "Stem cell transplantation, tissue engineering, and cancer applications ", New York: Nova Science Publishers, c2008.

REFERENCE BOOKS:

1. Robert Lanza et al., "Principles of Tissue Engineering", 3rd Edition. Academic Press, 2007.
2. Naggy N. Habib, M.Y. Levicar, L. G. Jiao, and N. Fisk, "Stem Cell Repair and Regeneration", volume-2, Imperial College Press, 2007.
3. Bernard N. Kennedy (editor). "Stem cell transplantation, tissue engineering, and cancer applications", Nova Science Publishers, 2008.
4. Hossein Baharvand (Editor) and Nasser Aghdami (Editor), "Regenerative Medicine and Cell Therapy (Stem Cell Biology and Regenerative Medicine)", Humana Press; 2013 edition (August 8, 2012).
5. J.J. Mao, G. Vunjak-Novakovic et.al., "(Eds): Translational Approaches In Tissue Engineering & Regenerative Medicine", Artech House, INC Publications, 2008.

COURSE ARTICULATION MATRIX:

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	3	2	2	3	3	2	3		2
CO2	3	2		3	3	2	3	3	2
CO3	3	2	2	3	3	2	3	3	2
CO4	3	2	2	3	3	2	3	3	2

CO5	3	2	2	3	3	2	3	3	2

1-Weak; 2-Moderate; 3-Strong.

BY22013 PLANT AND ANIMAL CELL TECHNOLOGY

L	T	P	C
3	0	0	3

OBJECTIVES:

1. To impart knowledge on animal cell culture technologies.
2. To educate students on the concept of transgenic animals and its protein products.
3. To provide knowledge on plant tissue culture.
4. To explain the principles of gene delivery in plants.
5. To apply the principles of genetic engineering in creation of transgenic plants.

UNIT I ANIMAL CELL CULTURE TECHNIQUES 10

Animal Cell Culture: History of Animal Cell Culture, Characteristics of animal cell, metabolism, regulation and nutritional requirements, Culture Media and Growth Conditions, Development of Primary Culture and Cell Lines, Suspension Culture, Characterization and maintenance of cell lines, Cryopreservation, Common Cell Culture Contaminants, Marker Gene Characterization, Transfection and Transformation of Cells. Growth and Scale Up: Need for scaling-up of cells for vaccine or antigen or pharmaceutical protein production, Hybridoma Technology, Cell culture reactors, Scale-Up in suspension and monolayer cultures, Factors affecting cell growth, Growth Monitoring, Mass Transfer.

UNIT II TRANSGENIC ANIMALS 7

Animal Biotechnology: Concept of transgenic animals, Methods of transgene delivery, Microinjection of recombinant DNA into fertilized eggs/stem cells, Animal Pharming, Organ Culture, Regenerative Medicine, Human Embryonic Stem Cell research, Ethical Concerns and Biosafety.

UNIT III PLANT TISSUE CULTURE 10

Conventional methods of crop improvement, selection, mutation, polyploidy and clonal selection. Green revolution in India. Introduction to marker assisted breeding and selection. Plant tissue culture: History of plant tissue culture, plasticity and totipotency. Laboratory setup for a typical plant tissue culture facility. Sterilization methods used in plant tissue culture. Types of nutrient media and plant growth regulators in plant regeneration. Pathways for in vitro regeneration: organogenesis, somatic and gametic embryogenesis; protoplast isolation, culture and regeneration; culture of other explants, somatic hybridization; Haploid and triploid production and their applications. Applications of micro-propagation, meristem culture, embryo rescue, somaclonal and androclonal variations. Methods for Plant Conservation, Cryopreservation, synseed production.

UNIT IV GENE DELIVERY AND TESTING IN PLANTS 8

Principles and methods of genetic transformation: Introduction to Agrobacterium biology and biotechnology. Mechanism of T-DNA transfer to plants and Agro infection. A. rhizogenes and its application. Transplastomics and its utility. Methods for direct gene transfer, Marker and reporter genes; Promoters used in plant vectors.

Plant viral vectors. Molecular techniques for analysis of transgenics (copy number, transgene stability, silencing; segregation). Marker-free transgenics and environmental, social and legal issues associated with transgenic plants.

UNIT V TRANSGENIC PLANTS AND GENOME EDITING 10

Case studies for genetic engineering in plants for traits of agronomic value, biotic, abiotic stresses and herbicide tolerance. Transgenic crops for production of antibodies, viral antigens and peptide hormones in plants, Edible vaccines and Nutraceuticals. Plant Biotechnology for biofuels. The history of targeted mutations in plants. Use of ZFNs and TALENs as early tools for genome editing. Discovery of CRISPR-Cas system and its applications. Recent innovations in the technology and case studies where CRISPR-Cas has been used for plant improvement.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO	After completion of this course, the students will be able to	RBT LEVEL
1.	Demonstrate the methods of animal cell culture.	3
2.	Extend the principles of animal cell culture for creating transgenic animals.	3
3.	Utilize the plant tissue culture techniques for creating transgenic plants.	3
4.	Make use of the gene delivery techniques for creating transgenic plants.	3
5.	Develop transgenic plants for the production of high value products.	3

TEXTBOOKS:

1. Freshney, R. I., "Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications", Wiley, 2016.
2. John Masters, "Animal Cell Culture: A Practical Approach", Oxford University Press, 2000.
3. Freshney, R.I., "Animal Cell Culture: A Practical Approach", Oxford University Press, 1992.
4. Razdan, M. K., "Introduction To Plant Tissue Culture". Oxford & IBH Publishing Company, 2002.
5. Fowler, M., Slater, A., and Scott, N., "Plant biotechnology: the genetic manipulation of plants", Oxford University Press, 2008.

REFERENCE BOOKS:

1. "Animal Cell Culture Techniques", Germany: Springer Berlin Heidelberg, 2012.
2. Sadava, D. E., Chrispeels, M. J., "Plants, Genes, and Crop Biotechnology", Jones and Bartlett Publisher, 2003.

3. Chawla, H. S., “Introduction to plant biotechnology”, Science Publishers, 2002.

COURSE ARTICULATION MATRIX:

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	3		3				3		
CO2	3	3	3	3		3	3	3	3
CO3	3						3		
CO4	3			3			3	3	3
CO5	3	3	3	3		3	3	3	3

1-Weak; 2-Moderate; 3-Strong.

BY22015 VACCINES AND THERAPEUTIC PROTEINS

L	T	P	C
3	0	0	3

OBJECTIVES:

1. To acquire fundamental knowledge about types of Vaccines.
2. To acquaint the student with knowledge on antibodies and cell-based vaccines.
3. To gain the knowledge on vaccine immunology.
4. To provide prerequisite on therapeutic enzymes.
5. To understand basics of therapeutic proteins.

UNIT I VACCINES AND ITS TYPES 9

Active and passive immunization; Live, killed, attenuated, sub unit vaccines; Vaccine technology- Role and properties of adjuvants, recombinant DNA and protein-based vaccines, plant-based vaccines, reverse vaccinology; Peptide vaccines, conjugate vaccines.

UNIT II ANTIBODIES AND CELL BASED VACCINES 9

Antibody genes and antibody engineering- chimeric and hybrid monoclonal antibodies; Catalytic antibodies and generation of immunoglobulin gene libraries, Cell based vaccines, Cell culture technology in production of animal viral vaccines.

UNIT III VACCINE IMMUNOLOGY 9

Rational vaccine design based on clinical requirements: Hypersensitivity, Immunity to Infection, Autoimmunity, Transplantation, Tumor immunology, immunodeficiency; Transfusion of immunocompetent cells, Stem cell therapy.

UNIT IV THERAPEUTIC ENZYMES 9

Therapeutic and clinical analysis-production and use of glucose isomerase, amidase/amidopetidase, amylase, cellulase, penicillin acylase, lipase, oxidoreductase, hydantoinase, epoxide hydrolase, nitrlase, hydoxylase, alolases, decaboxylases etc. for production of different types of drugs and drug intermediates.

UNIT V THERAPEUTIC PROTEINS 9

Erythropoietin, Insulin analogs and its role in diabetes, Recombinant human growth hormone, Streptokinase and urokinase in thrombosis, Interleukin-2, GMCSF, Recombinant coagulation factors; Factor VII, VIII and IX.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO	After completion of this course, the students will be able to	RBT LEVEL
1.	Understand the types of vaccines and its mechanism.	2
2.	Describe the types of antibodies and cell-based vaccines.	2
3.	Gain the knowledge on vaccine immunology.	2

4.	Know about fundamentals of production, therapeutic and clinical analysis of therapeutic enzymes.	3
5.	Gain the knowledge on therapeutic applications of therapeutic proteins.	3

TEXTBOOKS:

1. Punt, Stranford, Jones, Owen, Kuby, "Immunology", 8th Ed., W.H. Freeman Macmillan Learning, 2019.
2. W. John W. Morrow, Nadeem A. Sheikh, Clint S. Schmidt, D. Huw Davies, "Vaccinology: Principles and Practice", Wiley Blackwell, 1st Ed, 2012.
3. Goodman & Gilman's., "The Pharmacological Basis of Therapeutics", 11th Ed., McGraw-Hill Medical Publishing Division, 2006
4. Sarfaraz K. Niazi., "Handbook of Biogeneric Therapeutic Proteins: Regulatory, Manufacturing, Testing, and Patent Issues", CRC Press, 2006.
5. Vashishtha Vipin M, "IAP textbook of Vaccines", Jaypee Brothers Medical Publishers, 2nd Ed, 2020.

REFERENCE BOOKS:

1. Hironori Nakagami, "Therapeutic Vaccines as Novel Immunotherapy: Biological and Clinical Concepts", Springer, 1st Ed, 2019.
2. Megan Coffee, Sharon Perkins, "Vaccines for Dummies", John Wiley & Sons, 1st Ed, 2021.
3. Rossen Donev, "Therapeutic Proteins and Peptides", Academic Press, 1st Ed, 2018.

COURSE ARTICULATION MATRIX:

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	2	1	2		2	2	3	3	
CO2	2	1	2		2	2	3	3	
CO3	2	1	2		2	2	3	3	
CO4	2	1	2		2	2	3	3	
CO5	2	1	2		2	2	3	3	

1-Weak; 2-Moderate; 3-Strong.

BY22017 **ENTREPRENEURSHIP FOR BIOTECHNOLOGISTS**

L	T	P	C
3	0	0	3

OBJECTIVES:

1. To enable the students to understand the sources of innovation opportunities and development of the skills to identify and analyse these opportunities for entrepreneurship and innovation in Biotechnology
2. To develop personal skills set for creativity, innovation and entrepreneurship and specific concepts and tools for combining and managing creativity in organization
3. To help students to understand the strategies of business plan
4. To give in-depth knowledge on management of business in Biotechnology
5. To support the students to know the legal aspect to start and run a business successfully in Biotechnology

UNIT I **KEYS OF ENTREPRENEURSHIP** **9**

Definition – Types of Entrepreneurs. Project identification, selection and financing. Project report - Content and significance, Planning Commission's guidelines for formulating project reports. Methods of project appraisals.

UNIT II **MARKET NEEDS OF BIOTECHNOLOGY ENTREPRENEURSHIP** **9**

Should You Become an entrepreneur? What Skills Do Entrepreneurs Need? Identify and Meet a Market Need; Entrepreneurs in a Market Economy; Select a Type of Ownership in Biotechnology

UNIT III **MARKET MANAGEMENT IN BIOTECHNOLOGY ENTREPRENEURSHIP** **9**

Develop a Business Plan; Choose Your Location and Set Up for Business; Market Your Business; Hire and Manage a Staff in Biotechnology

UNIT IV **BUSINESS MANAGEMENT IN BIOTECHNOLOGY ENTREPRENEURSHIP** **9**

Finance, Protect and Insure Your Business; Record Keeping and Accounting; Financial Management

UNIT V **LEGAL ASPECTS IN BIOTECHNOLOGY ENTREPRENEURSHIP** **9**

Meet Your Legal, Ethical, Social Obligations in Biotechnology; Growth in Today's Marketplace in Biotechnology

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO	After completion of this course, the students will be able to	RBT LEVEL
1.	Determine relevant licensing and regulatory issues for a specific small business plan.	5
2.	Develop the marketing plan component for a specific bio – industry and the operation plan component for a bio-industry.	3
3.	Develop the customer service plan component and to present and defend business reports in a professional manner.	3
4.	Develop strategies for on-going personal and professional development and advancement.	3
5.	Motivates on importance of legal aspects in businesses.	4

TEXTBOOKS:

1. Allen, Kathleen. "Entrepreneurship for Dummies. Foster City, CA", IDG Books Worldwide, Inc., 2001.
2. Bygrave, William, D. and Andrew, Zacharakis. "The Portable MBA in Entrepreneurship", 3rd Edition. Hoboken, NJ: John Wiley & Sons, 2004.
3. Cohen, William A. "The Entrepreneur & Small Business Problem Solver", 3rd Edition. Hoboken, NJ: John Wiley & Sons, 2006.
4. Hiam, Alexander Watson and Karen Wise Olander. "The Entrepreneur's Complete Sourcebook", Englewood Cliffs, NJ: Prentice Hall, 1996.

REFERENCE BOOKS:

1. BAREACT. Indian Patent Act 1970 Acts & Rules, Universal Law Publishing Co. Pvt. Ltd., 2007.
2. Kankanala, C. Genetic Patent Law & Strategy, 1st Ed., Manupatra Information Solution Pvt. Ltd., 2007.
3. Kanka, S.S. Entrepreneurship Development, 1st Ed., S. Chand and Co, 1997

COURSE ARTICULATION MATRIX:

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	1		2		2	2	3		
CO2	3	2	2		3	3	2		2
CO3	2	3	1	2	2	2	3	3	3
CO4	3	3	3	3		1		3	2
CO5	3	2	3	1				3	

1-Weak; 2-Moderate; 3-Strong.

BY22019 R PROGRAMMING FOR BIOLOGISTS

L	T	P	C
3	0	0	3

OBJECTIVES:

1. To impart the knowledge on fundamentals of R
2. To understand the various data types, operators and functions in R
3. To apply the R programming to analyse the biological data
4. To analyse the biological data to extract information
5. To create the charts and graphs using statistic functions.

UNIT I R – INTRODUCTION 9

Introduction to R: What is R? – Why R? – Advantages of R over Other Programming Languages - R Studio: R command Prompt, R script file, comments – Handling Packages in R: Installing a R Package, Few commands to get started: installed.packages(), package Description(), help(), find.package(), library() - Input and Output – Entering Data from keyboard – Printing fewer digits or more digits – Special Values functions : NA, Inf and –inf.

UNIT II R - DATA TYPES & OPERATORS 9

R Data Types: Vectors, Lists, Matrices, Arrays, Factors, Data Frame – R - Variables: Variable assignment, Data types of Variable, Finding Variable ls(), Deleting Variables - R Operators: Arithmetic Operators, Relational Operators, Logical Operator, Assignment Operators, Miscellaneous Operators - R Decision Making: if statement, if – else statement, if – else if statement, switch statement – R Loops: repeat loop, while loop, for loop - Loop control statement: break statement, next statement.

UNIT III R – FUNCTIONS 9

R-Function : function definition, Built in functions: mean(), paste(), sum(), min(), max(), seq(), user-defined function, calling a function, calling a function without an argument, calling a function with argument values - R-Strings – Manipulating Text in Data: substr(), strsplit(), paste(), grep(), toupper(), tolower() - R Vectors - Sequence vector, rep function, vector access, vector names, vector math, vector recycling, vector element sorting - R List - Creating a List, List Tags and Values, Add/Delete Element to or from a List, Size of List, Merging Lists, Converting List to Vector - R Matrices – Accessing Elements of a Matrix, Matrix Computations: Addition, subtraction, Multiplication and Division- R Arrays: Naming Columns and Rows, Accessing Array Elements, Manipulating Array Elements, Calculation Across Array Elements - R Factors –creating factors, generating factor levels gl().

UNIT IV R - DATA ANALYSIS 9

Data Frames –Create Data Frame, Data Frame Access, Understanding Data in Data Frames: dim(), nrow(), ncol(), str(), Summary(), names(), head(), tail(), edit() functions - Extract Data from Data Frame, Expand Data Frame: Add Column, Add Row - Joining columns and rows in a Data frame rbind() and cbind() – Merging Data

frames merge() – Melting and Casting data melt(), cast(). Loading and handling Data in R: Getting and Setting the Working Directory – getwd(), setwd(), dir() - R-CSV Files - Input as a CSV file, Reading a CSV File, Analyzing the CSV File: summary(), min(), max(), range(), mean(), median(), apply() - Writing into a CSV File – R -Excel File – Reading the Excel file.

UNIT V R - GRAPHICAL PLOTS 9

Descriptive Statistics: Data Range, Frequencies, Mode, Mean and Median: Mean Applying Trim Option, Applying NA Option, Median - Mode - Standard Deviation - Correlation - Spotting Problems in Data with Visualization: visually Checking Distributions for a single Variable - R –Pie Charts: Pie Chart title and Colors – Slice Percentages and Chart Legend, 3D Pie Chart – R Histograms – Density Plot - R – Bar Charts: Bar Chart Labels, Title and Colors.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO	After completion of this course, the students will be able to	RBT LEVEL
1.	Build programming logic and thereby developing skills in Programming.	3
2.	Understand the basics of R.	3
3.	Perform the loading and retrieval of data in R.	3
4.	Analyse and visualize data using statistic functions.	4
5.	Understand on how to organize data and analyse data using real time examples.	3

TEXTBOOKS:

1. de Freitas Souza, R., Favero, L., Belfiore, P., "Data Science, Analytics and Machine Learning with R", United Kingdom: Elsevier Science, 2022.
2. Nwanganga, F., and Chapple, M., "Practical Machine Learning in R. United Kingdom: Wiley, 2020.
3. Lantz, B., "Machine Learning with R: Expert Techniques for Predictive Modeling", 3rd Edition. United Kingdom: Packt Publishing, 2019.
4. Hartvigsen, G., "A Primer in Biological Data Analysis and Visualization Using R", United States: Columbia University Press, 2021.
5. Irizarry, R. A., and Love, M. I., "Data Analysis for the Life Sciences with R", United States: CRC Press, 2016.

REFERENCE BOOKS:

1. Childs, D. Z., Beckerman, A. P., Petchey, O. L., "Getting Started with R: An Introduction for Biologists" United Kingdom: Oxford University Press, 2017.
2. Welton, R. A. K., Quicke, D. L. J., Butcher, B. A., "Practical R for Biologists: An Introduction", United Kingdom: CABI, 2021.

3. Curry, E., “Introduction to Bioinformatics with R: A Practical Guide for Biologists”, United States: CRC Press, 2020.
4. Hector, A., “New Statistics with R: An Introduction for Biologists”, United Kingdom: Oxford University Press, 2015.
5. Akalin, A., “Computational Genomics with R”, United States: CRC Press, 2020.

COURSE ARTICULATION MATRIX:

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	3	2		3	2		2	2	2
CO2	3	2		3	2		2	2	2
CO3	3	2		3	2		2	2	2
CO4	2	2		3	2		2	2	2
CO5	3	2		3	2		2	2	2

1-Weak; 2-Moderate; 3-Strong.

BY22002 BIOMASS CONVERSION AND BIOREFINERY

L	T	P	C
3	0	0	3

OBJECTIVES:

1. To provide an insight into biomass, their structure and composition.
2. To understand various biomass pretreatment methods for effective biofuel production.
3. To study about various conversion technologies such as physical, chemical and microbial.
4. To know about various products such as biofuels, platform chemicals, polymers etc.
5. To get knowledge on integrated biorefineries and type of biorefinery.

UNIT I INTRODUCTION TO BIOMASS 9

Virgin biomass production and selection; Waste biomass; Dedicated energy crops; Annual crops; Perennial herbaceous crops; Short rotation woody crops; Oil crops and their biorefinery potential; Microalgae as feedstock for biofuels; Enhancing biomass properties for biofuels, Challenges in conversion.

UNIT II BIOREFINERY AND BIOMASS PRE-TREATMENT 9

Basic concept, types of biorefineries, biorefinery feedstocks and properties, economics; Barriers in lignocellulosic biomass conversion, pre-treatment technologies such as acid, alkali, autohydrolysis, hybrid methods, role of pre-treatment in the biorefinery concept.

UNIT III CONVERSION PROCESSES 9

Physical and Thermal Conversion Processes: Types, fundamentals, equipment and applications; thermal conversion products, commercial success stories; Microbial Conversion Process: Types, fundamentals, equipment and applications, products, commercial success stories.

UNIT IV BIOFUELS 9

Biodiesel: Diesel from vegetable oils, microalgae and syngas; transesterification; FT process, catalysts; biodiesel purification, fuel properties; Biooil and Biochar: Factors affecting biooil, biochar production, fuel properties, biooil upgradation; Bioethanol and Biobutanol: Corn ethanol, lignocellulosic ethanol, microorganisms for fermentation, current industrial ethanol production technology.

UNIT V INTEGRATED BIOREFINERY 9

Concept, corn/soybean/sugarcane biorefinery, lignocellulosic biorefinery, aquaculture and algal biorefinery, waste biorefinery, hybrid chemical and biological conversion processes, techno- economic valuation, life-cycle assessment.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO	After completion of this course, the students will be able to	RBT LEVEL
1.	Identify various types of biomass used for biofuel production.	2
2.	Evaluate various pre-treatment techniques of biomass in biorefinery.	3
3.	Assess various conversion technologies and biofuels obtained through them.	3
4.	Explain the concept of Integrated biorefinery and types of biorefineries.	3
5.	Develop necessary skills to design appropriate biomass-based fractionation technique as per the need.	4

TEXTBOOKS:

1. Donald L. Klass, "Biomass for Renewable Energy, Fuels, and Chemicals", Academic Press, Elsevier, 2006.
2. Prabir Basu, "Biomass Gasification, Pyrolysis and Torrefaction", Academic Press, Elsevier, 2013.
3. A.A. Vertes, N. Qureshi, H.P. Blaschek, H. Yukawa (Eds.), "Biomass to Biofuels: Strategies for Global Industries", Wiley, 2010.
4. S. Yang, H.A. El-Enshasy, N. Thongchul (Eds.), "Bioprocessing Technologies in Biorefinery for Sustainable Production of Fuels, Chemicals and Polymers", Wiley, 2013.
5. Shang-Tian Yang (Ed.), "Bioprocessing for Value Added Products from Renewable resources", Elsevier, 2007.

REFERENCE BOOKS:

1. Moheimani, N. R, Boer M. P. M. K, Parisa A, and Bahri, "Biofuel and Biorefinery Technologies", Volume 2, Springer, 2015.
2. Robert C. Brown, "Biorenewable Resources: Engineering New Products from Agriculture", Wiley-Blackwell Publishing, 2003.
3. Luque, R, Campelo, J, and Clark, J, "Handbook of biofuels production", Woodhead Publishing Limited, 2011.
4. Ckert C. A. and Trinh C T. "Biotechnology for Biofuel Production and Optimization", Elsevier, 2016
5. Lee S, Shah Y.T, "Biofuels and Bioenergy". CRC, Taylor & Francis, 2013.

COURSE ARTICULATION MATRIX:

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	3	1	2	2	1		2	1	
CO2	3	1	2	2	1		2	1	

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

1-Weak; 2-Moderate; 3-Strong.

BY22004 **NANOBIOTECHNOLOGY**

L	T	P	C
3	0	0	3

OBJECTIVES:

1. To enable students to grasp the basics of nanotechnology
2. Basic theoretical and practical knowledge related to modern materials chemistry, materials physics, energy physics, and nanotechnology
3. To introduce students to inter- and multi-disciplinary science and engineering
4. Get exposed to potential applications of nanobiotechnology in sensing and biomedical applications
5. To access the risks involved in the use of nanomaterials for healthcare applications

UNIT I **INTRODUCTION OF THE "NANO" WORLD AND NANOMATERIALS** **9**

Origin and concepts, interfacial phenomenon, Surface & quantum effects, chemical and biolo9gical principles involved in nanomaterial performance, Structure-property relationships with respect to mechanical, electrical, optical, electrochemical, chemical sensing & magnetic, rheological and thermodynamic properties.

UNIT II **NANOSCALE FABRICATION ENGINEERING** **9**

Approaches, nanolithography, self-assembly, physical, chemical and biological methods, their advantages and drawbacks, biomimetic synthesis technologies based on Bacterial complex-S layer protein, Microbial alginates, bacterial spores, Magnetosomes.

UNIT III **NANOMANIPULATION AND ITS APPLICATIONS** **9**

Relevance of Probe microscopies, STM, AFM, SEM, TEM. Spectroscopic and X-ray diffraction analysis. Biologically important nanomaterials: Structures, properties and biological applications of 2D and 3D materials including CNT, Fullerenes, pure metal and core-shell nanoparticles, quantum dots, liposomes and dendrimers

UNIT IV **TOXICITY EVALUATION OF NANOMATERIALS** **9**

Routes of exposure and limits of nanomaterials, Nanopathology project and its relevance, their interactions at the cellular level and cell responses, Nanoparticles disposal methods and risk management.

UNIT V **NANOBIOTECHNOLOGY IN HEALTH CARE, MEDICINE AND RECENT ADVANCEMENTS** **9**

Devices, instruments and materials used in the doctor-patient interface, medical research labs, hospital environments, and pharmaceutical industry. The present state of the art and future potential, business contexts and regulatory constraints. Nanobots, nanosensors, and nanomedicine

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO	After completion of this course, the students will be able to	RBT LEVEL
1.	Discover basic concepts and theories of the subject	2
2.	Relate and explain the importance of reduction in materials dimensionality, and its relationship with materials properties.	3
3.	Demonstrate applications of analytical techniques in examining nanostructures/ particles.	3
4.	Demonstrate the potential of nanobiotechnology in consumer and biomedical applications.	3
5.	Formulate strategies for risk assessment of nanostructures/ particles in various applications.	4

TEXTBOOKS:

1. Ramsden J, "Essentials of Nanotechnology", Ramsden and Ventus Publishing ApS, 2011.
2. Tatsuya Okuda, Ben-Shung Chow, "Nanobiotechnology: Concepts Applications and Perspectives", Scitus Academics LLC, 2018.
3. Arunava Goswami, Samrat Roy Choudhury, "Nanobiotechnology: Basic and Applied Aspects", Anthem Press, 2017.
4. Christof M. Niemeyer, Chad A. Mirkin, "Nanobiotechnology: Concepts, Applications and Perspectives", Wiley, 2004

REFERENCE BOOKS:

1. Ramsden J, "Nanotechnology: An introduction", William Andrew publisher 2011.
2. Niemeyer CM and Mirkin CA, "Nanobiotechnology I: Concepts, applications and perspectives", Wiley-VCH Verlag GmbH & Co., KgaA, Weiheim, 2005.
3. Niemeyer CM, Mirkin CA, "Nanobiotechnology II: More concepts, applications perspectives", Wiley-VCH Verlag GmbH & Co., KgaA, Weiheim, 2007.

COURSE ARTICULATION MATRIX:

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1		2	3	2	3	3		2	2
CO2	3			2	2	2	3	2	2
CO3	3	2	2	2	2	2	3	2	2
CO4	3		2		2	2	3	2	2
CO5	3	2	2			2	3	2	2

1-Weak; 2-Moderate; 3-Strong.

BY22006 **DRUG DELIVERY: PRINCIPLES AND ENGINEERING**

L	T	P	C
3	0	0	3

OBJECTIVES:

1. To acquire fundamental knowledge about pharmacokinetics.
2. To acquaint the student with knowledge on different Biopolymers and Hydrogels.
3. To gain the knowledge on nano and micro-particles.
4. To provide prerequisite for tissue engineering and route specific delivery.
5. To understand basics of drug delivery.

UNIT I **PHARMACOKINETICS** **9**

Pharmacokinetics: Bioavailability, Elimination, Therapeutic Index, Prodrugs, Controlled release, Polymers: Synthesis, properties, characterization, crystallinity and amorphousness.

UNIT II **BIOPOLYMERS AND HYDROGELS** **9**

Biopolymers: Natural and Synthetic, biocompatibility, Biodegradation, commonly used biopolymers, Polymer-Drug conjugates, PEGylation, Diffusion controlled systems, Ficks laws, Reservoir systems, non-erodible matrix systems, Bio-erodible Systems, Hydrogels: Physical or chemical, pore-size calculation, in-situ crosslinking.

UNIT III **NANO AND MICRO-PARTICLES** **9**

Nano and Micro-particles: Dendrimers, Liposomes, Micelles, Metal and polymeric particles, effect of particle shape, charge and elasticity.

UNIT IV **TISSUE ENGINEERING AND ROUTE SPECIFIC DELIVERY** **9**

Protein Adsorption and tissue engineering, Drug delivery in tissue engineering, Implant associated infections, Route specific delivery: Oral, Subcutaneous, Intramuscular, transdermal, inhalation, intravenous.

UNIT V **DRUG DELIVERY** **9**

Vaccines, Cancer vaccines, Cell and gene delivery, Smart responsive drug delivery, Targeted drug delivery, Nanotoxicology and market translation.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO	After completion of this course, the students will be able to	RBT LEVEL
1.	Understand the mechanism of drug action and pharmacokinetics of a given drug.	2
2.	Describe the physical and chemical properties of biopolymers and hydrogels.	3
3.	Gain the knowledge on Nano and Micro-particles.	2

4. Know about fundamentals of tissue Engineering and various routes of drug delivery. 2

5. Know the types of drug delivery. 3

TEXTBOOKS:

1. W. Mark Saltzman, "Drug Delivery: Engineering Principles for Drug Therapy", Oxford University Press, 2001
2. Anya M. Hillery and Kinam Park, "Drug Delivery: Fundamentals and Applications", 2nd Edition, CRC Press, 2016
3. Lord V. Allen Jr., Nicholas G. Popvich and Howard C. Ansel, "Ansels pharmaceutical dosage forms and drug delivery systems", 9th Edition, Wolters Kluwer publisers, New Delhi, 2011.
4. Brahmankar D.M, "Biopharmaceutics and Pharmacokinetics- A Treatise, Vallabh Prakasan", India, 1995.
5. Sinko, PJ, "Martin's Physical Pharmacy and Pharmaceutical Sciences", 7th Ed, Lippincott Williams & Wilkins, Philadelphia PA, 2017.

REFERENCE BOOKS:

1. Raffiul Haque MD, Swati Mittal, "Textbook on Novel Drug Delivery Systems", CBS Publishers & Distributors PVT Ltd, 2021.
2. Rajesh Tekade, "Drug Delivery Systems", 1st Edition, Elsevier Academic Press, 2019.
3. Arun Kumar Madathala, "Concepts and Methods of Polymers and Drug Delivery System", Lambert Academic Publishing, 2019.
4. Ali Seyfoddin, Seyedehsara Masoomi Dezfooli, Carol Ann Greene, "Engineering Drug Delivery Systems", Woodhead Publishing, 1st Edition, 2019.

COURSE ARTICULATION MATRIX:

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	3	1	2	2	2	2	3	2	
CO2	3		2	2			3	2	
CO3	3		2		2		3	2	1
CO4	3	1	2	2	2		3	2	
CO5	3	1	2	2	2		3	2	

1-Weak; 2-Moderate; 3-Strong.

BY22008 **ADVANCED FOOD PROCESSING AND PACKAGING TECHNOLOGIES**

L	T	P	C
3	0	0	3

OBJECTIVES:

1. To understand the various constituents present in food and the importance of microorganisms in food processing.
2. To familiarize the importance of thermal food processing methods in enhancing the shelf life of food.
3. To impart the role of non-thermal food processing methods in improving the shelf life of food.
4. To inculcate the principles and importance of preservation techniques used in food processing.
5. To understand the materials and types of packaging for different type of foods.

UNIT I FOOD CHEMISTRY AND MICROBIOLOGY 9

Constituent of food – contribution to texture, flavour and organoleptic properties of food; Sources and activity of microorganisms associated with food; food borne diseases – infections and intoxications, food spoilage.

UNIT II THERMAL FOOD PROCESSING METHODS 9

Newer methods of thermal processing; batch and continuous; application of infra-red microwaves; ohmic heating; control of water activity; Extrusion, advances in extrusion and co-extrusion processes, advances in extruded and other ready to eat food products.

UNIT III ATHERMAL FOOD PROCESSING METHODS 9

Super critical technology for Preservation - chemical preservatives, preservation by ionizing radiations, ultrasonics, high pressure, fermentation, curing, pickling, smoking, membrane technology, hurdle technology.

UNIT IV FOOD PRESERVATION 9

Use of high temperatures – sterilization, pasteurization, blanching, aseptic canning; frozen storage – freezing curve characteristics. Factors affecting quality of frozen foods; irradiation preservation of foods.

UNIT V FOOD PACKAGING 9

Primary packaging media – properties and application, paper boards, metals, plastics, wood and plywood, glass, vacuum packaging, gas flush packaging, CAP & MAP, aseptic & retort packaging, box in box. Food products-General classification and packaging types, varieties and trends, Storage handling and distribution of packages-including pallets & containers.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO	After completion of this course, the students will be able to	RBT LEVEL
1.	Identify the various food constituents and the role of microorganisms in food processing	2
2.	Apply the knowledge gained on various thermal food processing methods to improve the shelf life of food products	3
3.	Choose the non-thermal food processing methods for producing food products with enhanced shelf life	3
4.	Select the appropriate preservation techniques used in food preservation	3
5.	Opt the suitable packaging media and packaging type for storing food products	3

TEXTBOOKS:

1. Coultate, T.P., "Food – The chemistry of its components", 6th Ed., Royal society, 2016.
2. Sivasankar, B., "Food processing and preservation", Prentice Hall of India Pvt. Ltd., 2002
3. Robertson, G.L. "Food Packaging: Principles and Practice", 2nd Edition. Taylor & Francis, 2006.

REFERENCE BOOKS:

1. Rahman, M. Shafiur. "Handbook of Food Preservation". Marcel & Dekker, 2006.
2. Zeuthen, Peter and Bogh-Sarensen, Leif. "Food Preservation Techniques". CRC / Wood Head Publishing, 2003.
3. Ranganna, S. "Handbook of Canning and Aseptic Packaging". Tata McGraw-Hill, 2000.

COURSE ARTICULATION MATRIX:

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	2	2	2	3					3
CO2	2		2	3	2		2	2	3
CO3	2	2	2	3	2		2	2	3
CO4	2		2	3	2		2	2	3
CO5	2	2	2	3	2		2	3	3

1-Weak; 2-Moderate; 3-Strong.

BY22010 **OMICS TECHNOLOGIES**

L	T	P	C
3	0	0	3

OBJECTIVES:

1. To impart knowledge on genomic sequencing technologies.
2. To educate students on the concept of gene expression analysis using microarrays.
3. To provide knowledge on proteome analysis and its application.
4. To explain the principles of mass spectrometry in protein identification.
5. To find the metabolites in the metabolome using NMR and other techniques.

UNIT I **GENOMICS** **12**

Genomic DNA fundamentals, Major genome sequencing projects, Overview of Next Generation Sequencing (NGS) technologies; Principles of NGS by Roche/454, Illumina, Life Technologies, Pacific Biosciences, Ion Torrent technologies; Next Generation Sequencing technologies, File formats, Basic pipeline for data analysis – quality check, adaptor trimming, Genome assembly, Genome annotation, Concepts of sequencing coverage and sequencing depth, phred score, N50, Introduction to different tools and algorithms, Data repositories and databases, Choice of sequencing platforms, metagenomics, ATAC sequencing, Applications of genomics in disease diagnosis and personalized medicine (case studies)

UNIT II **TRANSCRIPTOMICS** **8**

Introduction to typical wet lab workflow, library preparation, and analysis pipeline, Choice of sequencing methods and tools for read mapping, assembly, identification of splicing variants and differential expression analysis, Tools available for pathways analysis, Gene Ontology, Hypergeometric enrichment analysis, Biogenesis, characteristics and analysis of small RNA like microRNAs and phasiRNAs, Analysis of long non-coding RNAs, Target prediction and functional prediction for small RNAs and lncRNAs, Microarrays, types, Designing and production of microarrays; cDNA microarray technology; Oligonucleotide arrays; Sample preparation, labeling, hybridization, generation of microarray data. Transcriptomics using cDNA and oligonucleotide arrays. RNA sequencing. Chip-Seq, DNAse-Seq, ATAC-seq, MNase-seq, FAIRE-seq.

UNIT III **PROTEOMICS** **7**

Types of protein arrays; Protein microarray fabrication; Experimental analysis of proteins arrays. Data acquisition and processing; Applications of protein microarray types. Principles and methods in yeast two-hybrid system, Advances in yeast two hybrid system and its applications. Sample preparation, First dimension IEF with IPG; Second dimensional separation of proteins; Image analysis of 2-DE gels; DIGE, Protein expression profiling and comparative proteomics of complex proteomes using 2-DE, Determination of protein sequence (Edman degradation).

UNIT IV QUANTITATIVE PROTEOMICS 8

Basics of Mass-spectrometry (MS) and bimolecular analysis; Common ionization methods for peptide/protein analysis; Principles of Time of Flight (TOF), Ion Trap (IT), and Orbitrap mass analyzers; Mass Spectrometry based proteomics: MALDI-TOF, Nano-LC-MS; Gas- chromatography coupled to Mass spectrometry; Mass-spectrometry analysis of Post-Translational Modifications of proteins. Peptide mass fingerprinting.

UNIT V METABOLOMICS 10

Metabolites and metabolite profiling, Basics of NMR, Fundamentals of the NMR phenomenon, relationship between NMR spectra and molecular structure. Recording of routine spectra (1H and 13C), essentials of data processing (e.g., weighting functions). 1D NMR, 2D NMR techniques, Metabolomics - applications and its role in systems biology with case studies, Tools and techniques available for metabolomics analysis, targeted vs non-targeted metabolomics, General work flow including quenching and sample preparation, Detection and quantification of metabolites by advanced analytical techniques (NMR/Mass spectroscopy, HPLC). Pathways, metabolome databases and software tools available for metabolomics analysis.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO	After completion of this course, the students will be able to	RBT LEVEL
1.	Demonstrate the process of sequencing whole genome.	3
2.	Experiment with microarray and identify the differentially expressed genes.	3
3.	Examine the interaction between different proteins and separate proteins present in the proteome.	3
4.	Make use of the mass spectrometer for identifying the peptides and proteins.	3
5.	Identify the metabolites present in the metabolome using HPLC, NMR and Mass spectrometer.	4

TEXTBOOKS:

1. Schena Mark, “DNA Microarrays: A Practical Approach”, Oxford University Press, 2000.
2. Rinaldis E. D. and Lahm A., “DNA Microarrays”, Horizon bioscience, 2007.
3. Muller H. J. and Roder T., “Microarrays”, Elsevier Academic Press, 2006.
4. Causton H. C., Quackenbush J., and Brazma A., “Microarray Gene Expression Data Analysis: A Beginner's Guide”, Blackwell Publishing, 2004.
5. Mark Schena, “Protein Microarrays”, Jones and Bartlett Publishers, 2004.

REFERENCE BOOKS:

1. Nielsen, J., "Metabolomics: A Powerful Tool in Systems Biology", Springer, 2007
2. Smedsgaard, J., Roessner-Tunali, U., Nielsen, J., Hansen, M. A. E., Villas-Boas, S. G., "Metabolome Analysis: An Introduction", Wiley, 2007.
3. O'Connor C. D. and Hames B. D., "Proteomics", Scion Publishing Ltd., 2008.
4. De Hoffmann, E., Stroobant, V., "Mass Spectrometry: Principles and Applications", Wiley, 2013.
5. Mazzola, E. P., Lambert, J. B., "Nuclear Magnetic Resonance Spectroscopy: An Introduction to Principles, Applications, and Experimental Methods", Pearson Education, 2004.

COURSE ARTICULATION MATRIX:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	3	3			3	3	3
CO2	3	3	3	3			3	3	3
CO3	3	3	3	3			3	3	3
CO4	3	3	3	3			3	3	3
CO5	3	3	3	3			3	3	3

1-Weak; 2-Moderate; 3-Strong.

BY22012 **BIOPROCESS EQUIPMENT DESIGN AND ECONOMICS**

L	T	P	C
3	0	0	3

OBJECTIVES:

1. To impart knowledge efficient utilization of the principles in bioprocess technology
2. To educate the underlying concepts of equipment design and safety
3. To understand the principles of equipment design in bioprocess industries
4. To analyse the possible economic issues in bioprocess industries
5. To improve the decision-making skills

UNIT I **PLANT DESIGN** **9**

Feasibility Survey, plant location, plant layout, processes design, flow diagram, Plant utilities and environmental considerations. Piping and instrumentation Utilities for plant and their design, mass and energy balance.

UNIT II **PROCESS EQUIPMENT DESIGN AND SAFETY** **9**

Material of construction for bioprocess plants. Mechanical design of process equipment, Mechanical fittings in a bioreactor, vessel, agitation system materials, piping and valves for biotechnology. Process and materials hazards, Analysis of Product and Process Safety. Pressure Vessels, Vessel Supports, Pressure-Relief Devices.

UNIT III **DESIGN OF VESSELS FOR BIOTECHNOLOGY APPLICATION** **9**

Design of fermenters, Design of Upstream and Down Stream process equipment, design consideration for maintaining sterility of process streams and processing equipment. Selection and specification of equipment for handling fluids and solids; Selection and basic concepts of design of heat exchangers used in bioprocess industries. Design of facilities for cleaning of process equipment used in biochemical industries.

UNIT IV **PROCESS ECONOMICS** **9**

Process economics, Materials usage and cost, Cost estimate, Estimating equipment costs by scaling 6/10 Factor Rule, Introduction to Interest and types of Interest, Present worth and cashflow diagrams. Fixed and working capital. Cost Indexes, Investments, Depreciation, Profitability, and replacements. Banking and foreign exchange.

UNIT V **CASE STUDIES** **9**

Case Study in Process Equipment Design and Costing of Equipment in each of the following categories: Material Transfer, Handling and Treatment Equipment.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO	After completion of this course, the students will be able to	RBT LEVEL
1.	Identify the requirements of a bioprocess industry	2
2.	Design equipment with safety considerations	3
3.	Analyse the requirements of specific equipment	3
4.	Calculate and analyse process economics involved in bioprocess industry	4
5.	Relate theory to practice	4

TEXTBOOKS:

1. Peters, M., Timmerhaus, K & West, R., "Plant Design and Economics for Chemical Engineers", 4th Ed., McGraw-Hill Publishing Company Limited, 1991.
2. Bhattacharya B. C; "Introduction of Chemical Equipment Design", CBS Publisher, 2003.
3. Stanbury P F and Whitaker A, "Principles of Fermentation Technology," 2nd edition, Elsevier, 1995.

REFERENCE BOOKS:

1. M.V. Joshi, "Process Equipment Design", McMillan India, New Delhi, 1976.
2. R.K. Sinnot, "An Introduction to Chemical Engineering Design", Pergamon Press, Oxford, 1989.
3. R. Smith, "Chemical Process Design", McGraw Hill, 1995.
4. F.C. Jelen and J.H. Black., "Cost and Optimization Engineering", 3rd Edition, McGraw Hill, 1992.

COURSE ARTICULATION MATRIX:

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	3		3	3			3		
CO2	3		3	3	2		3		
CO3	3		3	3	2		3		
CO4	3			3	2				3
CO5	3		3	3	2				3

1-Weak; 2-Moderate; 3-Strong.

BY22014 **MOLECULAR PATHOGENESIS AND MEDICAL BIOTECHNOLOGY**

L	T	P	C
3	0	0	3

OBJECTIVES:

1. Discuss the mechanisms involved in the viral pathogenesis and various diseases caused by viruses.
2. Explain the immunological pathogenesis of fungal infection.
3. Describe the bacteria–host interactions mechanism at the cellular and systemic level.
4. Elucidate the molecular approaches involved to control immunopathogenesis.
5. Comprehend the latest research involving medical biotechnology.

UNIT I VIRAL PATHOGENESIS 9

Various pathogen types and modes of entry - Viral dissemination in the host - Viral virulence - Injury induced by virus - Host susceptibility of viral disease - Pattern of infection - Acute infection - Persistent infection - Latent infection - Slow infection - Methods for the study of pathogenesis - Foot and mouth disease virus, Pestiviruses, Arteriviruses, Blue tongue virus and Animal herpesviruses

UNIT II FUNGAL PATHOGENESIS 9

Innate humoral immunity to fungi – Acquired cellular immunity – Mucosal immunity – Intracellular pathogenesis of Histoplasma capsulatum – Facultative intracellular pathogen of Cryptococcus neoformans – Fungal interaction with leukocytes – Fungal vaccine development – Host defence against chronic disseminated Candidiasis – Study fungal virulence by using Genomics – Functional genomic approaches to fungal pathogenesis.

UNIT III BACTERIAL PATHOGENESIS 9

Epidemiology and Clinical disease – Clinical course and basic immunology – In vitro models of Salmonella virulence – Antibiotic resistant Salmonella – Salmonella based vaccines – Shigella cellular models of infection – Influenza virus – Pathogenic Escherichia coli – Vibrio cholerae – Streptococcal disease – Haemophilus influenzae infection

UNIT IV MOLECULAR APPROACHES TO CONTROL 9

Clinical importance of understanding host defence – Interference with cytokine and Chemokine function – impairment of host mediated killing of infected cells – inhibition of apoptosis – Immunological structure of proteins – Class I and II MHC mediated antigen – Evasion from natural killer cells.

UNIT V MOLECULAR MEDICINE 9

Classical approaches based on serotyping – Modern diagnosis based on highly conserved virulence factors, immune and DNA based techniques – New therapeutic strategies based on recent findings on molecular pathogenesis – Nucleic Acid Therapeutic Agents – Protein Therapeutic Agents – Viral Vaccines – Immune

modulators – New vaccine technology.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO	After completion of this course, the students will be able to	RBT LEVEL
1.	Expound the virus–host interactions at the cellular level.	3
2.	Comprehend the interplay between fungal virulence factors and host immune responses.	3
3.	Explicate the balance between bacterial pathogenicity and host resistance.	3
4.	Describe the molecular approaches to recognize relevant and emerging infectious diseases.	3
5.	Demonstrate the latest research to diagnose and manipulate the molecular processes underlying disease and health.	4

REFERENCE BOOKS:

1. Flint, S.J., Racaniello, V.R., Rall, G.F., Hatziioannou, T., and Skalka, A. M, "Principles of virology, Volume 2: pathogenesis and control", John Wiley & Sons, 2020.
2. Calderone, R., "Fungal pathogenesis: principles and clinical applications", CRC Press, 2001
3. Wilson, B.A., Winkler, M., and Ho, B. T., 'Bacterial pathogenesis: A molecular approach", John Wiley & Sons, 2020.
4. Glick, B.R., Patten, C.L., and Delovitch, T.L., "Medical Biotechnology", American Society of Microbiology Press, 1st Edition, 2013.
5. Firdos A.K., "Biotechnology in Medical Sciences", Taylor and Francis, CRC Press, 1st Edition, 2014.

COURSE ARTICULATION MATRIX:

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1			2				2		
CO2			2				2		
CO3			2				2		
CO4	1			2			3		
CO5	1	1		2		1	3		

1-Weak; 2-Moderate; 3-Strong.

BY22016 ADVANCED CANCER BIOLOGY AND THERAPY

L	T	P	C
3	0	0	3

OBJECTIVES:

1. To enhance the students with basic biology of cancer.
2. To support students to know the impact of antibodies against cancer in the human body.
3. To impart advanced knowledge on tumor suppressor gene is cancer suppression.
4. To help students to know biology of DNA defects and metabolisms.
5. To give idea on enhanced immunology-based detection methods and imaging techniques for cell based and cytokine-based immunotherapy against cancer treatment.

UNIT I INTRODUCTION 9

Definition for Cancer- Mutagens, carcinogens, and mutations Tumor viruses and the discovery of oncogenes- Tumor cells possess genetic abnormalities- Mechanisms of oncogene activation- Role of growth factors and receptors in carcinogenesis- Role of Immune system in cancer – Role of individual immune cell types against cancer

UNIT II CELLULAR MECHANISM 9

Cellular senescence- Telomeres- cellular immortalization- and tumorigenesis- multi-step tumorigenesis and the evolution of cancer- Tumor-promoting stimuli- Cancer stem cells- Detection and processing by immune cell types through MHC- Cancer cell death strategies induced by immune cells

UNIT III TUMOR SUPPRESSOR GENES 9

RAS signaling in cancer- Familial cancer syndromes and the discovery of tumor suppressors- Cell cycle control and the pRb tumor suppressor- Apoptosis and the p53 tumor suppressor- Correlating pathway specific deregulations in self-tolerance machinery and Immune surveillance as a risk factor/potential target towards autoimmune disorders and cancer in case of failure of tumor suppressor genes.

UNIT IV DNA DEFECTS AND METABOLISM 9

DNA repair mechanisms- DNA repair defects and their relationship to cancer- Angiogenesis- Metastasis- Tumor Immunology- Cancer cell metabolism- Role of environment in influencing DNA defect.

UNIT V DIAGNOSIS AND TREATMENT 9

Treatment- traditional chemotherapeutics- Treatment- Immunotherapies Treatment-targeted therapy- New Genomic and proteomic technologies- Applications of new technologies in prevention- assessing risk- diagnostics and treatment- Use of cytokines as biological response modifiers – Cell based therapy against cancer.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO	After completion of this course, the students will be able to	RBT LEVEL
1.	Identify the role of genetics and immune system in cancer	4
2.	Explain tumorigenesis and interactions of immune cells with cancer.	2
3.	Evaluate role of tumor suppressor gene and tolerance machinery.	5
4.	Analyze the failures of different mechanism leading to un repairable DNA damage	4
5.	Create medical applications using immune cells against cancer	3

TEXTBOOKS:

1. Thomas, J. Kindt, Barbara, A. Osborne and Richard, Goldsby, Kuby. "Immunology", 6th Edition. W.H. Freeman, 2007.
2. Stella, Pelengaris and Michael, Khan. "The Molecular Biology of Cancer", 2nd Edition. Wiley – Blackwell, 2013.
3. Roitt, I, Brostoff, J. and Male, D. "Immunology", 6th Edition, Mosby, 2001.
4. Tannock, I. and Hill, R.P. "The basic science of oncology", 3rd Edition, McGraw-Hill, 1998.

REFERENCE BOOKS:

1. Kuby J, "Immunology", WH Freeman & Co., 7th Edition, 2012.
2. Ashim K. Chakravarthy, "Immunology", Tata McGraw-Hill, 2006.
3. Coico, Richard, "Immunology: A Short Course", 7th Edition. John Wiley, 2015.
4. Khan, Fahim Halim, "Elements of Immunology", Pearson Education, 2009.
5. Abul K. Abbas, Andrew H. H. Lichtman, Shiv Pillai, "Cellular and Molecular Immunology", 8th Edition, Elsevier, 2014.

COURSE ARTICULATION MATRIX:

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	1					3			
CO2	3		2			3			
CO3	3		3		3	3			2
CO4	3	3	2	2	1	1	1		3
CO5	3	3	2	3	1	2	3		3

1-Weak; 2-Moderate; 3-Strong

BY22018 METABOLIC AND SYSTEMS BIOLOGY

L	T	P	C
3	0	0	3

OBJECTIVES:

1. To introduce the concepts of modern systems biology approaches for studying metabolism
2. To study the aspects of computational, statistical and analytical methods and tools
3. To provide knowledge on metabolic profiling and measuring *in-vivo* reaction rates
4. To study the application of metabolomics on metabolic engineering.
5. To apply the fluxomics concepts on metabolic modeling.

UNIT I INTRODUCTION TO SYSTEMS BIOLOGY AND METABOLISM 9

Components of Biological systems (DNA, RNA, Protein, Metabolites), their properties and function. Overview of cellular metabolism, enzyme kinetics and metabolic pathways. Online resources and Tools to study metabolism – KEGG, ECOCYC etc.

UNIT II IMPORTANCE OF OMICS ON METABOLITE STUDY 9

Biological networks and their significance – at the level of genome, transcriptome, proteome, metabolome and fluxome. Metabolomics - applications and its role in systems biology. Analytical methods for detecting and quantifying metabolites. General work flow and Statistical methods in metabolomics. Pathway and metabolome databases. Case study of metabolomics on risk assessment and toxicology.

UNIT III METABOLIC PATHWAYS AND NETWORK RECONSTRUCTION 9

Pathways of central and secondary metabolism in selected model systems (microbes, plant and animal), Reconstruction of metabolic networks, Stoichiometric matrix. Topological analysis of metabolic network with Elementary flux modes and/or Extreme pathways.

UNIT IV CONSTRAINT BASED FLUX ANALYSIS 9

Introduction to Constraint based metabolic modelling and Flux Balance analysis. Related software tools and online resources. Case study/studies on Constraint based flux analysis from literature with applications in metabolic engineering and/or drug target identification.

UNIT V METABOLIC FLUX ANALYSIS 9

Metabolic Phenotypes, Fundamentals of Metabolic Flux analysis. Current practices of 13C Metabolic Flux Analysis – Stable isotope labelling, steady state vs Non-stationary, Isotopomer analysis, Carbon transition networks, mathematical modelling for quantifying fluxes (in-vivo reaction rates), Flux maps. Software tools and online resources. Case study/studies on 13C metabolic flux analysis from literature with

applications in metabolic engineering and/or understanding metabolic features in diseases such as cancer.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO	After completion of this course, the students will be able to	RBT LEVEL
1.	Demonstrate the tools for metabolic study	2
2.	Construct the application of omics on metabolomics	2
3.	Organize the topology of metabolic networks and elementary flux analysis	3
4.	Make use of constraint-based flux analysis on metabolic modeling	3
5.	Analyse the metabolites through fluxomics	4

TEXTBOOKS:

1. Bernhard O. Palsson, "Systems Biology: Properties of Reconstructed Networks", Cambridge University Press, 2006.
2. Choi, Sangdun, "Introduction to Systems Biology", Springer Publishers, 2007.
3. J.Nielsen and M.C. Jewett, "Metabolomics - A powerful Tool in Systems Biology", Springer Publishers, 2007
4. Jens O. Krömer, Lars K. Nielsen, Lars M. Blank, "Metabolic Flux Analysis-Methods and protocols", Springer Publishers, 2014.
5. Miguel A. Aon, Valdur Saks, Uwe Schlattner, "Systems Biology of Metabolic and Signaling Networks", Springer Publishers, 2014.

REFERENCE BOOKS:

1. Preeti Arivaradarajan, Gauri Misra, "Omics Approaches, Technologies and Applications: An Integrative Approaches for Understanding Omics Data" Springer Publishers, 2018.
2. Bernhard Ø. Palsson, "Systems Biology: Constraint-based Reconstruction and Analysis", 2015.
3. Christina Smolke, "The Metabolic Pathway Engineering Handbook: Tools and Applications", 2017.
4. Hernández-Mesa M, Le Bizec B, Dervilly G., "Metabolomics in chemical risk analysis–A review", Analytica Chimica Acta, 2021 Apr 15; 1154:338298.
5. Olesti E, González-Ruiz V, Wilks MF, Boccard J, Rudaz S., "Approaches in metabolomics for regulatory toxicology applications", Analyst. 2021;146(6):1820-34.

COURSE ARTICULATION MATRIX:

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3

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

1-Weak; 2-Moderate; 3-Strong.

BY22020 **CLINICAL TRIALS, BIOETHICS AND BIOSAFETY**

L	T	P	C
3	0	0	3

OBJECTIVES:

1. To impart knowledge on clinical trials and regulatory issues related to clinical trials.
2. To provide insights into clinical trial protocol development and data collection.
3. To impart knowledge on ethical theories, ethical issues in medicine, health care and life sciences.
4. To provide insights about Biosafety and various levels of biosafety.
5. To impart knowledge on various biosafety guidelines and monitoring/governing committees, its composition and roles.

UNIT I FUNDAMENTALS OF CLINICAL TRIALS 9

Introduction to clinical trials; History of clinical research; Clinical trial phases - Phase I, II, III & IV; CPCSEA guideline & pre-clinical trials; Clinical Trial Registry-India; ICMR policy on research integrity and publication ethics; Multicenter Trials; Regulatory Issues; Case studies.

UNIT II CLINICAL TRIAL DESIGN AND METHODOLOGY 9

Clinical trial study protocol; Patient selection; The consent process; Choice of interventions; Choice of design; Assigning the interventions; Statistical considerations; Randomization; Recruitment of Study Participants; Data Collection and Quality Control; Data and Safety Monitoring; Analysis and reporting

UNIT III BIOETHICS 9

Moral theory in bioethics; Basic law bioethics; Justice and the right to care; Autonomy and individual responsibility; Informed consent; Informed refusal and the right to refuse treatment; Issues in human reproduction; Medical research- clinical trials; Transplantation ethics.

UNIT IV BIOSAFETY 9

Introduction; Historical Background; Introduction to Biological Safety Cabinets; Primary Containment for Biohazards; Biosafety Levels; Biosafety Levels of Specific Microorganisms; Recommended Biosafety Levels for Infectious Agents and Infected Animals; Research principles for Biosafety; Animal biosafety issues: Hazards associated with animal work - Housing and caging systems - PPE.

UNIT V BIOSAFETY GUIDELINES 9

Government of India; Definition of GMOs & LMOs; Roles of Institutional Biosafety Committee, RCGM, GEAC, BRAI, CRNBio etc. for GMO applications in food and agriculture; Environmental release of GMOs; Biosafety guidelines for genetic engineering/recombinant DNA technology; Risk Analysis; Risk Assessment; Risk management and communication; Overview of National Regulations and relevant International Agreements.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO	After completion of this course, the students will be able to	RBT LEVEL
1.	Understand about phases of clinical trials and regulatory issues related to clinical trials.	2
2.	Describe the various ways in which clinical trials can be designed and the advantages and disadvantages of each approach.	3
3.	Apply relevant ethical principles and provide a rational justification for ethical decisions.	3
4.	Apply various biosafety levels required for performing biological experiments.	3
5.	Describe the biosafety guidelines to be followed and the regulatory authorities responsible for biosafety guidelines.	4

TEXTBOOKS:

1. David Machin, Peter M. Fayers, Bee Choo Tai, "Randomised Clinical Trials - Design, Practice and Reporting", 2nd Edition, John Wiley & Sons Ltd, 2021.
2. NIH guidelines for research involving recombinant or synthetic nucleic acid molecules, 2019.
3. Gary E Jones, Joseph P DeMarco, "Bioethics in Context: Moral, Legal, and Social Perspectives", Broadview Press, 2016.
4. Lawrence M Friedman, Curt D Furberg, David L DeMets, David M Reboussin, "Fundamentals of Clinical Trials", 5th Edition, Springer International Publishing, 2015.
5. Dawn P. Wooley, Karen B. Byers, "Biological Safety: Principles and Practices", 5th Edition, ASM Press, 2017.

REFERENCE BOOKS:

1. Timothy M. Pawlik, Julie A. Sosa, "Clinical Trials", 2nd Edition, Springer, 2020.
2. ICMR policy on research integrity and publication ethics, 2019
3. Carl Elliott, "A Philosophical Disease Bioethics, Culture, and Identity", Routledge Press, 1999.
4. Regulations & Guidelines for Recombinant DNA Research and Biocontainment, DBT, GoI, 2017
5. Laboratory biosafety manual, 4th edition, WHO, 2020.

COURSE ARTICULATION MATRIX:

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	2	2	2	1		3	2	2	1

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

1-Weak; 2-Moderate; 3-Strong.