RAJALAKSHMI ENGINEERING COLLEGE

DEPARTMENT OF BIOTECHNOLOGY

CURRICULUM AND SYLLABUS REGULATIONS – 2023

M.TECH –BIOTECHNOLOGY

CHOICE BASED CREDIT SYSTEM

RAJALAKSHMI ENGINEERING COLLEGE

(An Autonomous Institution Affiliated to Anna University Chennai)

DEPARTMENT OF BIOTECHNOLOGY

CURRICULUM AND SYLLABUS REGULATIONS – 2023

M.TECH –BIOTECHNOLOGY

CHOICE BASED CREDIT SYSTEM

VISION OF THE INSTITUTION

To be an institution of excellence in Engineering, Technology and Management Education & Research.

To provide competent and ethical professionals with a concern for society.

MISSION OF THE INSTITUTION

To impart quality technical education imbibed with proficiency and humane values

To provide right ambience and opportunities for the students to develop into creative, talented and globally competent professionals

To promote research and development in technology and management for the benefit of the society

VISION OF THE DEPARTMENT

To be a department of academic excellence focused on education, research and development and to conquer the frontiers of biotechnology, benefitting the society.

MISSION OF THE DEPARTMENT

- To impart quality technical education
- To continuously enhance and enrich the teaching / learning process
- To provide an ambience for overall development of the students to be more creative, innovative and globally competent ethical professionals
- To promote research and develop technologies and products for the sustenance and wellbeing of the society

PROGRAMME EDUCATIONAL OBJECTIVES

I. This program will strengthen the graduates' foundation in different facets of biotechnology, enhance their knowledge, hone their research skills and prepare them for higher studies and become ideal teachers in reputed academic institutes.

II. This program will inspire, motivate, guide and train graduates to become globally competent and find employment in pharma, food and other biotech industries in R&D, quality control, process control and product development sectors.

III. This program will help graduates with their creative thinking, analytical and managerial skills imbibed with ethical values to develop products, become successful entrepreneurs and serve the society.

PROGRAMME OUTCOMES

1. An ability to research, investigate, critically analyse and solve problems in the different areas of Biotechnology
2. An ability to write and present precise and accurate data, publish papers and communicate the findings to scientific community and society
3. An ability to impart knowledge to enthusiastic young minds and become ideal teachers in reputed academic institutions
4. An ability to find employment in pharma, food and other biotech industries in R&D, quality control, process control and product development sectors or become entrepreneurs imbibed with ethical and humane values

CURRICULUM

SEMESTER I

S. No	COURSE CODE	COURSE TITLE	CONTACT PERIODS	L	T	P	C	Category
THEORY								
1	MH23131	Statistical Techniques for Biotechnologist	5	3	0	2	4	BS
2	BY23111	Gene Manipulation and DNA analysis	3	3	0	0	3	PC
3	BY23112	Enzyme Technology and Fermentation Technology	3	3	0	0	3	PC
4	PG23111	Research Methodology and IPR	3	3	0	0	3	HS
5		Professional Elective I	3	3	0	0	3	PE
6		Professional Elective II	3	3	0	0	3	PE
7	AC23111	Audit Course I (English for Research Paper Writing)	3	3	0	0	0	MC
PRACTICAL								
8	BY23121	Preparative and Analytical Techniques in Biotechnology	4	0	0	4	2	PC
9	BY23122	Recombinant DNA Technology Laboratory	6	0	0	6	3	PC
		TOTAL	**33**	**21**	**0**	**12**	**24**	

SEMESTER II

S. No	COURSE CODE	COURSE TITLE	CONTACT PERIODS	L	T	P	C	Category
THEORY								
1	BY23211	Bio separation Technology	3	3	0	0	3	PC
2	BY23212	Bioreaction Engineering	3	3	0	0	3	PC
3	BY23213	Biopharmaceuticals and Biosimilars	3	3	0	0	3	PC
4	BY23214	Immunotechnology	3	3	0	0	3	PC
5	BY23215	Advanced Genomics and Proteomics	3	3	0	0	3	PC
6		Professional Elective III	3	3	0	0	3	PE
7	AC23211	Audit Course II (Constitution of India)	3	3	0	0	0	MC
PRACTICAL								
8	BY23221	Immunotechnology Laboratory	4	0	0	4	2	PC
9	BY23222	Bioprocess and Downstream processing Laboratory	6	0	0	6	3	PC
10	BY23223	Artificial Intelligence and Machine Learning Laboratory for Biotechnologist	2	0	0	2	1	PC
		TOTAL	**33**	**21**	**0**	**12**	**24**	

SEMESTER III

S. No	COURSE CODE	COURSE TITLE	CONTACT PERIODS	L	T	P	C	Category
PRACTICAL								
1		Professional Elective IV	3	3	0	0	3	PE
2		Open elective I	3	3	0	0	3	OE
PROJECT								
4	BY23321	Project Phase – I	12	0	0	12	6	EEC
		TOTAL	**18**	**6**	**0**	**12**	**12**	

SEMESTER IV

S. No	COURSE CODE	COURSE TITLE	CONTACT PERIODS	L	T	P	C	Category
PROJECT								
1	BY23421	Project Phase – II	24	0	0	24	12	EEC
		TOTAL	**24**	**0**	**0**	**24**	**12**	

TOTAL NO. OF CREDITS: 72

PROFESSIONAL ELECTIVES - I (SEMESTER I)

S. No	COURSE CODE	COURSETITLE	CONTACT PERIODS	L	T	P	C
1	BY23P11	Biomaterials	3	3	0	0	3
2	BY23P12	Analytical Techniques in Biotechnology	3	3	0	0	3
3	BY23P13	Food Processing and Technology	3	3	0	0	3
4	BY23P14	Bionanotechnology	3	3	0	0	3

PROFESSIONAL ELECTIVES - II (SEMESTER I)

S. No	COURSE CODE	COURSETITLE	CONTACT PERIODS	L	T	P	C
1	BY23P15	Advances in Animal Biotechnology	3	3	0	0	3
2	BY23P16	Oncogenetics	3	3	0	0	3
3	BY23P17	Plant Tissue Culture and Gene Manipulation	3	3	0	0	3
4	BY23P18	Bioconjugate Technology	3	3	0	0	3
5	BY23P19	Advances in Molecular pathogenesis	3	3	0	0	3

PROFESSIONAL ELECTIVES -III (SEMESTER II)

S. No	COURSE CODE	COURSETITLE	CONTACT PERIODS	L	T	P	C
1	BY23P21	Bioreactor Design and Analysis	3	3	0	0	3
2	BY23P22	Bioprocess Modeling and Simulation	3	3	0	0	3
3	BY23P23	Biosafety and Bioethics	3	3	0	0	3
4	BY23P24	Bioenergy and Biofuels	3	3	0	0	3
5	BY23P25	Advances in Environmental Biotechnology	3	3	0	0	3

PROFESSIONAL ELECTIVES - IV (SEMESTER III)

S. No	COURSE CODE	COURSETITLE	CONTACT PERIODS	L	T	P	C
1	BY23P31	Tissue Engineering	3	3	0	0	3
2	BY23P32	Stem Cell Technology	3	3	0	0	3
3	BY23P33	Vaccinology	3	3	0	0	3
4	BY23P34	Data mining and machine learning for bioinformatics	3	3	0	0	3

SUMMARY OF CREDIT DISTRIBUTION

S.NO	SUBJECT AREA	CREDITS PER SEMESTER				CREDITS TOTAL
		I	II	III	IV	
1	BS	4				4
2	HS	3				3
3	PC	11	21			32
4	PE	6	3	3		12
5	OE			3		3
6	EEC			6	12	18
7	MC	*	*			
TOTAL		24	24	12	12	72

MH23131	STATISTICAL TECHNIQUES FOR BIOTECHNOLOGIST	Category	L	T	P	C
		BS	3	0	2	4

Course Objectives: This course will enable the students
• To analyse data pertaining to discrete and continuous variables and to interpret the results.
• To provide the principles underlying sampling as a means of making inferences about a population and different methods of estimation.
• To exhibit proficiency with statistical analysis of data and to apply data science concepts and methods to solve problems in real-world contexts.
• To describe mathematical background of the nonparametric statistical methods.
• To plan, design and conduct experiments including different types and analysis of variance (ANOVA), to draw valid conclusions

UNIT-I	**RANDOM VARIABLE AND PROBABILITY DISTRIBUTION**	9
Conditional Probability, Random variables – Probability mass function – Properties – Probability density function – Properties – Moments: Mean and variance with properties – Measures of Skewness and Kurtosis - Simple Problems. Introduction to analysis of DNA Sequence.		
UNIT-II	**SAMPLING DISTRIBUTIONAND ESTIMATION THEORY**	9
Random sampling – Sample mean and variance – Standard error – Simple problems –Estimator: Unbiasedness – Maximum likelihood estimation – Method of moments – Curve fitting by the method of least squares: Fitting curves of the form$y = ax + b$, $y = ax^2 + bx + c$, $y = ab^x$, and $y = ax^b$ – Multiple Regression.		
UNIT-III	**DATA ANALYSIS AND INTERPRETATION**	9
Cluster analysis: Clustering by partitioning methods, hierarchical clustering, overlapping clustering, K-Means Clustering – Profiling and Interpreting Clusters – Factor analysis: Factor analysis model, Extracting common factors, determining number of factors, Factor scores.		
UNIT-IV	**NON PARAMETRIC STATISTICS**	9
One sample sign test – Sign test for paired samples – Signed rank test – Rank-sum test: The U-test – Rank-sum test: The H-test – Test based on runs.		
UNIT-V	**DESIGN OF EXPERIMENTS**	9
Completely random design – Randomized complete block design – Analysis of variance: One-way and two – way classifications – Latin square design - 2^2 −factorial design.		
Total Contact Hours: 45		

S.No.	**List of Experiments (using Data Analysis Lab with R)**	**Total Contact Hours: 30**
1	Introduction to R, Functions, Control flow and Loops	
2	Working with Vectors and Matrices	
3	Reading in and Writing Data	
4	Working with Data	
5	Graphics in R	

6	Differentiation and Integration
7	Simulation
8	Linear model
9	Data Frame – Factor analysis
10	Cluster analysis

Course Outcomes:

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

- Apply the basic concepts of probability, one dimensional and two dimensional random variables in engineering problems.
- Use the principles underlying sampling as a means of making inferences about a population and different methods of estimation.
- Demonstrate proficiency with statistical analysis of data and to apply data science concepts and methods to solve problems in real-world contexts.
- Illustrate the nonparametric tests for solving various statistical problems.
- Apply the concept of ANOVA in decision making in the lab testing and clinical trials.

SUGGESTED ACTIVITIES

- Problem solving sessions
- Activity Based Learning
- Implementation of small module

SUGGESTED EVALUATION METHODS

- Tutorial problems
- Assignment problems
- Quizzes
- Class Presentation/Discussion

Text Book(s):

1.	Veerarajan T, Probability, statistics and random process with queueing theory and queueing networks, 4th edition, McGraw - Hill Publishing Company Limited.
2.	Spiegel Libschutz, "Probability and Statistics", 4th Edition, McGraw Hill, New Delhi, 2010.
3.	Miller I and Miller M., "Mathematical Statistics", 7th Edition, Pearson Education Inc. (10th impression), 2012.
4.	Warren J. Ewens, Gregory R. Grant, "Statistical Methods in Bioinformatics: An Introduction", Second Edition, Springer New York, 2005.

Reference Books(s) / Web links:

1.	Jay L. Devore," Probability and Statistics for Engineering and Sciences", 8th Edition, Cengage Learning Pvt. Ltd., New Delhi, 2014.
2.	Johnson, R.A and Gupta C. B., "Miller and Freund's Probability and Statistics for Engineers", Pearson Education Int., Asia, 8th Edition, 2011.
3.	Gupta, S.C. and Kapoor, V. K, "Fundamentals of Mathematical Statistics", Sultan Chand and Sons, 14th Edition, 2016.

4.	D.A. Belsey, E. Kuh and R.E. Welsch ,"Regression Diagnostics , Identifying Influential Data and Sources of Collinearety".
5.	M.R. Anderberg, "Cluster Analysis for Applications", Academic Press.

PO / CO	PO1	PO2	PO3	PO4
MH23131.1	2	1	2	3
MH23131.2	2	1	2	3
MH23131.3	2	1	2	3
MH23131.4	2	1	2	3
MH23131.5	2	1	2	3
Average	**2**	**1**	**2**	**3**

BY23111	**GENE MANIPULATION AND DNA ANALYSIS**	**Category**	**L**	**T**	**P**	**C**
		PC	**3**	**0**	**0**	**3**

Course objectives:
This course will enable the students

- To develop an understanding of the cloning vectors
- To provide knowledge on the gene isolation and screening strategies
- To analyze DNA sequencing techniques
- To comprehend mutation and the different PCR techniques
- To explain the fundamentals of gene therapy

UNIT I	**CLONING AND EXPRESSION OF GENES**	**9**

DNA Manipulative enzymes, cloning vectors: plasmids – Host range, copy number. λ phage – Insertional and Replacement vectors, in vitro packaging. Single strand DNA vector – M13 Phage. Cosmids, BAC. Yeast vectors-YRp,YEp,Yip and YAC. Mammalian vector-SV40. Insect vector-transposon.

UNIT-II	**CONSTRUCTION OF DNA LIBRARIES**	**9**

cDNA library construction : Full length cDNA cloning – CAPture method and Oligo capping. Strategies for Genomic DNA library construction and screening strategies. Overview on microarray and its applications.

UNIT-III	**DNA SEQUENCING**	**9**

DNA sequencing –Chemical & Enzymatic methods, Next Generation Automated Sequencing, Pyrosequencing, Automated sequence, Genome sequencing methods – top down and bottom up approach. Metagenomics

UNIT-IV	**PCR AND MUTAGENESIS**	**9**

PCR – Principle and applications. Different types of PCR – Hot start PCR, Touchdown PCR, Multiplex PCR, Nested PCR, Colony PCR, , RACE PCR – Primer design strategies, Real-time PCR, SYBR Green assay, Taqman probes. Site directed mutagenesis by PCR Kunkels'method.

UNIT-V	**GENE TRANSFER& GENE THERAPY**	**9**

Introduction of foreign genes into animal cells – DNA Microinjection, Retroviral vectors, Trasnsfection of Embryonic stem cells. Transgenic plants -Ti Plasmid, Co integrate and Binary vectors. Gene therapy.

	Total Contact Hours	**:**	**45**

Course outcomes: Upon completion of the course, the students will be able to	
•	Understand the cloning vectors
•	Gain knowledge about the gene isolation and screening strategies.
•	Analyze DNA sequencing techniques
•	Analyse the importance of mutation and the various PCR techniques
•	Apply the fundamentals of gene therapy

SUGGESTED ACTIVITIES
● Activity Based Learning
SUGGESTED EVALUATION METHODS
● Assignment problems ● Quizzes ● Class Presentation/Discussion

Text books:	
•	T A Brown "Gene cloning and DNA analysis"2006.
•	Mullis kary B, Ferre Francois, Gibbs "The polymerase chain reaction"1994

Reference books:	
•	Primrose SB and R. Twyman "Principles Of Gene Manipulation & Genomics Blackwell Science Publications, 2006.
•	Genomes 3 by T.A.Brown, Fourth Edition 2017 (Garland Science Publishing)

PO / CO	PO1	PO2	PO3	PO4
BY23111.1	2	3	3	3
BY23111.2	3	3	3	3
BY23111.3	2	3	3	3
BY23111.4	3	3	3	3
BY23111.5	3	3	3	3
Average	**2.6**	**3**	**3**	**3**

BY23112	**ENZYME TECHNOLOGY AND FERMENTATION TECHNOLOGY**	**Category**	**L**	**T**	**P**	**C**
		PC	**3**	**0**	**0**	**3**
Course objectives: This course will enable the students						
•	To realise the importance of fundamental concepts and important parameters in fermentation processes					
•	To acquire advanced knowledge about the use of fermentation processes in enzyme production					

•	To comprehend the process involved in the production of various enzymes and metabolites
•	To investigate enzyme kinetics
•	To assess different industrial applications of enzymes

UNIT I	**FUNDAMENTALS OF FERMENTATION**	**9**
Overview of fermentation – Microbial biomass – Microbial Enzymes – Microbial Metabolite – Recombinant products – Media for industrial fermentations – Medium optimization – Medium sterilization – Types of culture medium – Oxygen requirements of industrial fermentation.		
UNIT-II	**INDUSTRIAL FERMENTATION PROCESSES**	**9**
Aerobic and anaerobic fermentations – Development of inocula for industrial fermentation – Batch culture, continuous culture, fed batch culture – Comparison of batch and continuous culture – Submerged and solid state fermentation for the production of enzymes – case study, – Immobilization of enzymes – Biotransformation with crude enzymes and whole cells.		
UNIT-III	**PRODUCTION OF ENZYMES AND METABOLITES**	**9**
Production of Proteases, Cellulases, Lipase, Amylase, Glucose isomerase, Pectinase, Peroxidase – Production of organic acids (Citric acid, Lactic acid) – Production of antibiotics (Penicillin, streptomycin) – Production of vitamins (Vitamin B12, Riboflavin) – production of amino acids (Glutamic acid, Lysine).		
UNIT-IV	**ENZYME KINETICS**	**9**
Overview of enzyme and its action – Time course of enzymatic reactions – Effects of substrate concentration on velocity – Steady state model of enzyme kinetics – Significance of *kcat* and *Km* –Case study on experimental measurement of *kcat* and *Km* – Linear transformations of enzyme kinetic data – Bi Bi reaction mechanisms – Modes of reversible inhibition.		
UNIT-V	**APPLICATIONS OF ENZYMES**	**9**
Enzymes in organic synthesis – Enzymes as biosensors – Enzymes for food, pharmaceutical, tannery, textile, paper and pulp industries applications – Enzyme for environmental applications – Enzymes for analytical and diagnostic applications – Enzymes for molecular biology research. Case studies on bioproduct formation imbibing free enzymes/immobilized enzymes.		
	Total Contact Hours : 45	

Course outcomes: Upon completion of the course, the students will be able to	
•	Outline the fundamentals and important parameters in fermentation processes
•	Apply the knowledge of industrial fermentation process for enzyme production
•	Access the production process of industrially important enzymes and metabolites
•	Comprehend enzyme kinetics for research and industrial applications
•	Evaluate the applications of enzymes in various industries

Text books:	
•	Buchholz, K., Kasche, V. and Bornscheuer, U., "Biocatalysts and Enzyme Technology", WILEY–VCH, 2005.
•	Mansi, E.M.T.EL., Bryce, C.F.A., Demain, A.L. and Allman, A.R., "Fermentation Microbiology and Biotechnology", Taylor and Francis, 2006.
•	Michael L. Shuler, Fikret Kargi, Matthew DeLisa, Bioprocess Engineering 3rd edition, Pearson Education, 2017.

Reference books:	
•	Copeland, R. A., "Enzymes", 2 nd Edition, WILEY–VCH, 2008.
•	Najafpour, G.D., "Biochemical Engineering & Biotechnology", Elsevier, 2007.
•	McNeil, B., Harvey, L., "Practical Fermentation Technology", John Wiley & Sons, 2008.
•	Trevor Palmer , Enzymes 2nd edition, Horwood Publishing Ltd., 2007
•	Peter F. Stanbury, A. Whitaker & Stephen J. Hall , Principles of Fermentation Technology, 3rd edition, Elsevier Ltd., 2016.
Weblink:	
•	https://nptel.ac.in/courses/102106053

SUGGESTED EVALUATION METHODS

- Assignment/Case study
- Quizzes
- Class Presentation/Discussion
- Question/Problem Formulation

PO / CO	PO1	PO2	PO3	PO4
BY23112.1	2	2	2	2
BY23112.2	2	2	2	2
BY23112.3	2	2	2	2
BY23112.4	3	3	2	3
BY23112.5	3	3	2	3
Average	**2.4**	**2.4**	**2**	**2.4**

PG23111	**RESEARCH METHODOLOGY AND IPR**	**Category**	**L**	**T**	**P**	**C**
		HS	**3**	**0**	**0**	**3**

Course objectives:
This course will enable the students

•	To understand the research problem formulation and analyse the research related information by following research ethics.
•	To understand today's computer, information technology and also understand tomorrows world of ideas and creativity.
•	To Emphasize the role of IPR in individual and nations growth

UNIT I	**INTRODUCTION TO RESEARCH METHODOLOGY**	**9**
Objectives and Motivation of Research - Types of Research - Defining and Formulating the Research Problem - Errors in selecting a research problem - Features of research design, Different Research Designs- Criteria of good research - Problems encountered by researchers in India - Benefits to the society in general.		
UNIT-II	**DATA ANALYSIS AND HYPOTHESIS TESTING**	**9**
Data collection: Primary data - Secondary data - Data organization - Sample design - Estimation of population - Parametric vs. non parametric methods - Measures of central tendency and dispersion. ANOVA; Principles of least squares-Regression and correlation; Normal Distribution Properties of Normal Distribution; Testing of Hypothesis – Hypothesis Testing Procedure, Types of errors, t-Distribution - Chi-Square Test as a Test of Goodness of Fit - Use of statistical softwares.		
UNIT-III	**LITERATURE REVIEW AND RESEARCH REPORT WRITING**	**9**

Effective literature studies approaches- Importance of literature survey - Sources of information– analysis – Plagiarism - Research ethics. Interpretation and Report Writing - Techniques and Precautions; Report Writing – Significance - Different Steps – Layout - Types of reports, Mechanics of Writing a Research Report - Precautions in Writing Reports; Format of the research report		
UNIT-IV	**INTRODUCTION TO INTELLECTUAL PROPERTY, TRADE MARKS, GRAPHICAL INDICATION AND INDUSTRIAL DESIGN**	**9**
Importance of intellectual property rights; types of intellectual property-international organizations; Purpose and function of trademarks - acquisition of trade mark rights - protectable matter - selecting and evaluating trade mark - trade mark registration processes. Industrial designs and IC Layout design - Registrations of designs-Semiconductor Integrated circuits and layout design Act - Geographical indications-potential benefits of Geographical Indications.		
UNIT-V	**LAW OF COPYRIGHTS & PATENTS**	**9**
Fundamental of copy right law - originality of material - rights of reproduction - rights to perform the work publicly -copy right ownership issues - copy right registration -notice of copy right, international copy right law. Law of patents: Foundation of patent law, patent searching process - ownership rights and transfer New Developments in IPR: Administration of Patent System.		
	Total Contact Hours : 45	

Course outcomes: Upon completion of the course, the students will be able to	
•	Analyze the research problems and research processes
•	To formulate the hypothesis, data collection and processing, analyzing the data using statistical methods
•	Interpret the observations and communicating the novel findings through a research report.
•	Apply the conceptual knowledge of intellectual property rights for filing patents and trade mark registration process.
•	Understand the adequate knowledge on copyright and patent law and rights.

Text/Reference books:	
•	C.R. Kothari, Research Methodology: Methods and Techniques, 2nd revised edition, New Age International Publishers, New Delhi, 2004.
•	Deborah, E. Bouchoux, Intellectual property right, 5th edition, Cengage learning, 2017.
•	R. Panneerselvam, Research Methodology, PHI learning Pvt. Ltd., 2009.
•	Prabuddha Ganguli, Intellectual property right - Unleashing the knowledge economy, Tata McGraw Hill Publishing Company Ltd, 2001.
•	Donald R. Cooper and Ramela S. Schindler, Business Research Methods, Tata McGraw- Hill Publishing Company Limited, New Delhi, 2000
•	Uma Sekaran, Research Methods for Business, John Wiley and Sons Inc., New York, 2000.
•	Ranjit Kumar, Research Methodology, Sage Publications, London, New Delhi, 1999.
•	T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand, 2008

PO / CO	PO1	PO2	PO3	PO4
PG23111.1	1	3	3	2
PG23111.2	1	3	3	2
PG23111.3	1	3	3	2
PG23111.4	1	3	3	2
PG23111.5	1	3	3	2
Average	**1**	**3**	**3**	**2**

AC23111	**ENGLISH FOR RESEARCH WRITING**	**Category**	**L**	**T**	**P**	**C**
			3	**0**	**0**	**0**

Objectives:	
●	To facilitate the students to express technical ideas in writing
●	To train the students in using language structures appropriately
●	To enable students to plan and organize the research paper
●	To assist the students in understanding the structure and familiarise the mechanics of organised writing
●	To equip the students to improvise academic English and acquire research writing skills

UNIT-I	**INTRODUCTION TO RESEARCH WRITING**	**9**
Research – Types of Research - Selecting the Primary resources - Categorizing secondary sources - Discovering a researchable area and topic – Need Analysis - Research Question - Focussing on the Research Problem- Developing Research Design – Framing the Hypothesis – Identifying the Scope of the Research - Writing – General and Academic Writing		
UNIT-II	**LANGUAGE OF WRITING**	**9**
Active reading – text mining – use of academic words – jargons – ambiguities – use of expression – use of tense - proper voices – third person narration – phraseology – use of foreign words – use of quotes – interpreting quotes.		
UNIT-III	**THE FORMAT OF WRITING**	**9**
Types of Journals - different formats and styles - IEEE format - Structure – Margins - Text Formatting - Heading and Title - Running Head with Page Numbers - Tables and illustrations - Paper and Printing - Paragraphs - Highlighting – Quotation – Footnotes		
UNIT-IV	**ORGANISING A RESEARCH PAPER**	**9**
Title- Abstract – Introduction – Literature review - Methodology - Results –Discussion –Conclusion - Appendices - Summarising - Citation and Bibliography		
UNIT-V	**PUBLISHING PAPER**	**9**
Finding the Prospective publication or Journal - analysing the credits - Reviewing - Revising – Plagiarism Check - Proofreading - Preparing the Manuscript- Submitting - Resubmitting - Follow up - Publishing		
	Total Contact Hours :	**45**

Course Outcomes: At the end of the course the learner will be able to:	
●	Compile the basic structure of research work
●	Apply proper use of language in writing paper
●	Comprehend different formats of journal paper
●	Follow the process of writing a research paper and write one
●	Emulate the process of publishing journal paper and publish papers

SUGGESTED ACTIVITIES

- Group Discussions
- Writing review of literature
- Presentations
- Case study
- Writing a paper

SUGGESTED EVALUATION METHODS

- Assignment topics
- Quizzes
- Class Presentation/Discussion
- Continuous Assessment Tests

References	
1	Adrian Wallwork: "English for Writing Research Papers", Springer Science Business Media, Second Edition, LLC 2011
2	Stephen Howe and Kristina Henrikssion: "Phrasebook for Writing Papers and Research in English", The Whole World Company Press, Cambridge, Fourth edition 2007
3	The Modern Language Association of America: "MLA Handbook for Writers of Research Papers" 8th Edition, The Modern Language Association of America, 2016
4	Rowena Murray: The Handbook of Academic Writing: A Fresh Approach, Sarah Moore Open University Press, 2006
5	Stephen Bailey: Academic Writing: A Practical Guide for Students Routledge Falmer: 2003
6	Joseph M. Moxley: Publish, Don't Perish: The Scholar's Guide to Academic Writing and Publishing, Praeger Publishers, 1992

PO / CO	PO1	PO2	PO3	PO4
AC23111.1	1	1	1	1
AC23111.2	2	2	2	2
AC23111.3	3	3	3	3
AC23111.4	3	3	3	3
AC23111.5	3	3	3	3
Average	**2.4**	**2.4**	**2.4**	**2.4**

BY23121	**PREPARATIVE AND ANALYTICAL TECHNIQUES IN BIOTECHNOLOGY**	**Category**	**L**	**T**	**P**	**C**
		PC	**0**	**0**	**4**	**2**

Course objectives: This course will enable the students

•	To learn and understand the principles behind the qualitative and quantitative estimation of biomolecules
•	To gain hands-on experience in spectroscopic and chromatographic methods of analysis
•	To comprehend the principle behind spectroscopic analysis and its application in biomolecule identification and assay of enzyme activity
•	To acquire practical experience by performing recovery and subsequent purification of target biological products through chromatographic techniques

•	To excel in all advanced preparative and analytical techniques required for future research or industry based work

LIST OF EXPERIMENTS	
1	Preparation of Acetate, Tris and Phosphate Buffer. Validation of Henderson Hasselbach equation.
2	Reactions of amino acids with Ninhydrin reagent.
3	Differential estimations of carbohydrates – reducing vs non-reducing, polymeric vs oligomeric, hexose vs pentose.
4	Estimation of protein concentration using Lowrys' method and Dye-binding method.
5	DNA determination by UV-Vis Spectrophotometer – hyperchromic effect.
6	Separation of lipids by TLC.
7	Preparative and quantitative estimation of biomolecules by HPLC analysis.
8	Assay of enzyme activity and specific enzyme activity.
9	Assessing purity of proteins using SDS-PAGE Gel Electrophoresis
10	Preparation of Casein using Isoelectric precipitation and its estimation
11	Separation and identification of water soluble colours in foods by paper chromatography
12	FTIR and GC-MS analysis of biomolecules –Demonstration
	TOTAL PERIODS: 60

Course outcomes: Upon completion of the course, the students will be able to	
•	Analyze the principles of buffer preparation, the qualitative and quantitative estimation of carbohydrates, aminoacids and DNA
•	Evaluate spectroscopic and chromatographic methods of analysis
•	Validate spectroscopic analysis and its application in biomolecules and enzyme activity studies
•	Apply chromatographic techniques for purification and recovery of target biological products
•	Execute preparative and analytical techniques for future research or industry based work

Text/Reference books:	
•	Principles and Techniques of Biochemistry and Molecular Biology, Author: Wilson, K. and Walker, J., Cambridge University Press, 8th Edition, 2018.
•	Advances in chemical Bioanalysis –Bioanalytical reviews, edited by Frank –Michael Matysik, Springer, first edition 2016.
•	High throughput Bioanalytical sample preparation: Methods and Automation Strategies, Author: David A .Wells Elsevier Second Edition, 2020.

PO / CO	PO1	PO2	PO3	PO4
BY23121.1	3	2	3	3
BY23121.2	3	2	3	3
BY23121.3	2	2	3	3
BY23121.4	3	2	3	3
BY23121.5	3	2	3	3
Average	**2.8**	**2**	**3**	**3**

BY23122	RECOMBINANT DNA TECHNOLOGY LABORATORY	Category	L	T	P	C
		PC	0	0	6	3

Course objectives:
This course will enable the students

- To understand the principles behind the cloning and expression of a gene
- To perform nucleic acid assays
- To study the recombinant protein expression
- To illustrate the principles of cloning and expression of a gene
- To execute nucleic acid assays

LIST OF EXPERIMENTS

1	Isolation of Genomic DNA and Plasmid DNA from bacteria
2	Restriction Digestion and ligation of the plasmid vector
3	Transformation to *E.coli*
4	Polymerase chain reaction.
5	Colony PCR
6	Gel elution of DNA fragments.
7	Optimisation of inducer time and concentration for recombinant protein expression.
8	Western blotting analysis
9	Extraction of RNA
10	cDNA preparation from RNA
11	Real Time PCR
12	Southern blotting – Non radioactive

TOTAL PERIODS: 90

Course outcomes:
Upon completion of the course, the students will be able to

- Summarize the basic principles of molecular biotechnology and assays
- Analyze the nucleic acid molecules both quantitatively and qualitatively
- Illustrate the concept of genetic engineering
- Apply PCR techniques for quantification of genes
- Design techniques to develop recombinant products

Reference books:

- Green M.R and Sambrook J Molecular cloning -A laboratory manual 4th Edition, Cold spring habor laboratory press, USA, 2012.
- Zyskind J.W and Bernestin S.I Recombinant DNA laboratory manual Revised edition, Academic press, USA, 1992.

PO / CO	PO1	PO2	PO3	PO4
BY23122.1	3	2	1	3
BY23122.2	2	3	3	1
BY23122.3	3	3	3	2
BY23122.4	2	1	3	3
BY23122.5	3	2	3	3
Average	**2.6**	**2.2**	**2.6**	**2.4**

BY23211	BIO SEPARATION TECHNOLOGY	Category	L	T	P	C
		PC	3	0	0	3

Course objectives:
This course will enable the students

•	To analyze the methods for purification of proteins and enzymes for product development and research
•	To impart knowledge and experience on downstream processes to produce therapeutic proteins
•	To educate the principle involved in membrane separations and enrichment operations
•	To promote the applicability of chromatographic techniques in Biological products separation
•	To educate about the finishing operations and formulations of commercial applications

UNIT I	DOWNSTREAM PROCESSING	9

Introduction to downstream processing principles- Range and characteristics of bioproducts and bioprocesses. Fundamental properties of biological substances- Size, Molecular weight, diffusivity, Sedimentation coefficient, osmotic pressure, electrostatic charge, solubility, partition coefficient, light absorption and fluorescence. Cell disruption for product release – mechanical methods – Bead mill-Ultrasonicator, French press and Rotor- stator- released product concentration calculation- Non mechanical methods. RIPP Scheme for high volume, low value products and low volume, high value products.

UNIT-II	SOLID-LIQUID SEPARATION TECHNIQUES	9

Introduction - Filtration process- filtration equipment's – Rotary drum filter, plate and frame filter press and leaf filter- constant pressure and constant rate- filter medium, specific cake resistance and total filtration cycle time calculation-Centrifugation – Basic principles, classification -Industrial centrifuges – Tubular bowl, Multichamber bowl and Disc bowl centrifuge- applications.

UNIT-III	ISOLATION OF PRODUCTS	9

Membrane separation process principle –Microfiltration, ultra filtration, dialysis and Reverse osmosis – Structure and characteristics of membranes – Membrane models –Extraction methods–Solvent extraction, Dissociative extraction, selective extraction and Aqueous two-phase extraction process – Adsorption isotherms and break through curve in fixed bed adsorption technique – Protein precipitation – Methods of precipitation- Applications.

UNIT-IV	PRODUCT PURIFICATION	9

Chromatography – Classification of chromatographic techniques – General description of column chromatography – Chromatographic terms and parameters – Normal-phase, reversed-phase chromatography, size exclusion chromatography, Ion exchange chromatography, hydrophobic and Bio-affinity chromatography – HPLC.

UNIT-V	FINAL PRODUCT FORMULATION, POLISHING AND FINISHING OPERATIONS	9

Drying – Mechanism, and applications, Types of dryers – Tray, spray, rotary drum and Tunnel dryer – Crystallization –mechanism, Nucleation , growth of crystal – Habit modifiers in crystallization – Freeze drying – Principle, process, applications – Case studies - Major downstream processing steps in ethanol fermentation, Citric acid manufacture, production of an intracellular enzyme, production of an antibiotic.

	Total Contact Hours	:	45

Course outcomes: Upon completion of the course, the students will be able to	
•	Apply the methods to obtain pure proteins, enzymes and in general product development and research
•	Analyze the various downstream processes to isolate therapeutically important proteins
•	Articulate membrane separations and enrichment operations
•	Execute chromatographic techniques for separation of biological products
•	Evaluate the importance of finishing operations and formulations of commercial applications
Suggested Activities	
•	Problem solving sessions
Suggested Evaluation Methods	
•	Quizzes
•	Class Presentation / Discussion
•	Tutorial Problems
Text books:	
•	Belter, P.A., Gussler, E.L. and Hu, W.S., "Bio-separation: Downstream Processing for Biotechnology", John Wiley and Sons, 2011.
•	Sivasankar, B. "Bioseparations: Principles and Techniques". PHI, 2005.
•	Ghosh, R., "Principles of Bioseparations Engineering", World Scientific Publishers, 2006.
Reference books/ Weblinks:	
•	R.O. Jenkins, (Ed.) – Product Recovery In Bioprocess Technology – Biotechnology By Open Learning Series, Butterworth-Heinemann (1992).
•	Roger, H., "Bio-separations Science and Engineering", Oxford University Press, 2006
•	Ladisch, M.R., "Bioseparations Engineering: Principles, Practice, and Economics", John Wiley & Sons, 2001.
•	https://archive.nptel.ac.in/courses/102/106/102106022

PO / CO	PO1	PO2	PO3	PO4
BY23211.1	3	3	2	3
BY23211.2	3	3	2	3
BY23211.3	3	3	2	3
BY23211.4	3	3	2	3
BY23211.5	3	3	2	3
Average	**3**	**3**	**2**	**3**

BY23212	**BIOREACTION ENGINEERING**	**Category**	**L**	**T**	**P**	**C**
		PC	**3**	**0**	**0**	**3**
Course objectives: This course will enable the students						
•	To apply the stoichiometry and balances of substrate and biomass					
•	To analyze and find the different modes of cultivation parameters and its kinetics					
•	To evaluate the various structured kinetic models and its application techniques					

•	To solve the practical problems arising on the performance of bioreactors
•	To work on immobilized bed bioreactors

UNIT I	**METABOLIC STOICHIOMETRY AND ENERGETICS**	**9**
Mass and energy balance in biological system – Stoichiometry of cell growth and product formation – Elemental balances, degrees of reduction of substrate and biomass, available electron balances, yield coefficients of biomass and product formation – Maintenance coefficients – Oxygen consumption and heat evolution in aerobic cultures – Thermodynamic efficiency of growth.		
UNIT-II	**MICROBIAL GROWTH, KINETICS, MAINTENANCE AND PRODUCT FORMATION**	**9**
Phases of cell growth in batch cultures – Growth associated and non-growth associated product formation kinetics – Monod and Leudeking-Piret models – Effects of inhibition – Determination of kinetic parameters by batch, fed batch and continuous culture and analysis of chemo state performance – Role of maintenance and endogenous metabolism in substrate utilization and growth.		
UNIT-III	**UNSTRUCTURED AND STRUCTURED MODELS**	**9**
Simple unstructured kinetic models for microbial growth – Substrate utilization and product formation, Structured models for growth and product formation – Compartmental and metabolic models, Chemically and genetically structured models – Kinetics of growth and product formation by filamentous organisms – Considerations for the production of r-DNA products.		
UNIT-IV	**MASS TRANSFER IN BIOLOGICAL SYSTEMS**	**9**
Interphase Gas-Liquid mass transfer – General oxygen balances for Gas-Liquid transfer – Volumetric mass transfer co-efficient – problems - Scale up of bioreactors – problems - Models for oxygen transfer in large scale bioreactors – Case studies for large scale bioreactors – Model for oxygen gradients in air lift bioreactor.		
UNIT-V	**IMMOBILIZED BIOCATALYST SYSTEMS**	**9**
External mass transfer – Internal diffusion and reaction within biocatalysts – Derivation of finite difference model for diffusion – Reaction systems – Dimensionless parameters from diffusion – Reaction models – Effectiveness factor concept – Case study for diffusion with biological reaction. Case study on animal and plant cell cultivation in bioreactors.		
	Total Contact Hours : 45	

Course outcomes: Upon completion of the course, the students will be able to	
•	Perform the balances of substrate and biomass and stoichiometric calculations
•	Work on different modes of cultivation parameters and kinetics
•	Evaluate various structured kinetic models and its application techniques
•	Solve the practical problems arising on the performance of bioreactors
•	Work on immobilized bed bioreactors
Suggested Activities	
•	Problem solving sessions
Suggested Evaluation Methods	
•	Quizzes
•	Class Presentation / Discussion
•	Tutorial Problems
Text books:	
•	Dunn, I.J., Heinzle, E., Ingham, J. and Prenosil, J.E., "Biological Reaction Engineering", 2nd Edition, WILEY-VCH publications, 2003.
•	Dutta, R., "Fundamentals of Biochemical Engineering", Springer, 2008.

•	Shuler, M.L. and Kargi, F., Bioprocess Engineering: Basic concepts, 2nd Ed., Prentice-Hall, 2002.
•	Doran Pauline M, Bioprocess Engineering Principles, 2nd Ed., Academic Press, 1995.
•	Nielsen,J.,and Villadsen,J., Bioreaction Engineering Principles,2nd Ed.,Springer, 2007.
•	Blanch, H.WandClark D.S., Biochemical Engineering, 2nd Ed., MarcelDekker,1997.
Reference books/ Weblinks:	
•	Najafpour, G.D., "Biochemical Engineering & Biotechnology", Elsevier, 2007.
•	Truskey, G.A., Yuan, F. and Katz, D.F., "Transport Phenomena in Biological Systems", Pearson Prentice Hall, 2004.
•	Katoh, S. and Yoshida, F., "Biochemical Engineering – A Text Book for Engineers, Chemists and Biologists", Wiley publications, 2009.
•	https://onlinecourses.nptel.ac.in/noc22_bt19

PO / CO	PO1	PO2	PO3	PO4
BY23212.1	2	2	3	2
BY23212.2	2	2	3	2
BY23212.3	2	2	3	2
BY23212.4	2	2	3	2
BY23212.5	2	2	3	2
Average	**2**	**2**	**3**	**2**

BY23213	**BIOPHARMACEUTICALS AND BIOSIMILARS**	**Category**	**L**	**T**	**P**	**C**
		PC	**3**	**0**	**0**	**3**
Course Objectives:						
●	To enhance the fundamental knowledge of regulatory frameworks in drug development					
●	To analyse the commercial strategies behind the development of recombinant products					
●	To investigate the production and regulatory processes associated with the development of biosimilars					
●	To understand the principle behind lyophilization and tests for lyophilized products					
●	To evaluate the formulation of dosage forms and controlled release systems					
UNIT-I	**DRUG DEVELOPMENT**					9
Drug development-Drug regulating authorities, Pharmacokinetics – Absorption, Distribution, Metabolism and Excretion-Renal excretion and Non-renal excretion. Pharmacodynamics, Prodrugs-drug targeting, Protein binding of drugs, Bioavailability, Bioequivalence, Pharmacovigilance.						
UNIT-II	**RECOMBINANT BIOPHARMACEUTICALS**					9
Commercial development of biological drugs– Factor VIII – Human insulin – Human Growth hormone(HGH), Somatostatin, Hepatitis-B vaccine, Erythropoietin**,** t-PA, Novel proteins, Interleukin-2.						
UNIT-III	**BIOSIMILARS**					9
Biosimilar medicine-INN nomenclature system – key trends in biosimilar product development – Production of biosimilar products –Non clinical and clinical study – Regulation and approval process.						
UNIT-IV	**LYOPHILIZATION AND PRODUCT ANALYSIS**					9
Lyophilization equipment –schematic diagram of lyophilizer, Triple point, applications. Endotoxin and other pyrogenic contaminants-LAL test, Rabbit test.						
UNIT-V	**DOSAGE FORMS AND CONTROLLED RELEASE MEDICATION**					9
Formulation of tablet –Gelatin capsules-Hard gelatin capsule, Soft gelatin capsule, Suspension and						

Emulsion, Controlled release medication –oral osmotic pump and osmotic pressure activated drug delivery systems. Transdermals.			
	Contact Hours	**:**	**45**
Course Outcomes:			
On completion of the course, the students will be able to			
●	Apply the knowledge of clinical trial and develop new drugs		
●	Develop production techniques and evaluate the commercial development of key recombinant drugs		
●	Investigate the methodologies and regulatory processes involved in the development of biosimilars.		
●	Apply the principle of lyophilization to preserve the bioproducts.		
●	Design and develop innovative dosage forms and advanced controlled release drug delivery systems		
Suggested Activities			
●	Case studies		
Suggested Evaluation Methods			
●	Quizzes		
●	Class Presentation / Discussion		
Text Book(s):			
●	Walsh, G., "Pharmaceutical Biotechnology-Concepts and Application", John Wiley and Sons Publishers, 2007.		
●	Crommelin, D.J.A., Sindelar, R.D. and Meibohm, B., "Pharmaceutical Biotechnology: Fundamentals and application", 3rd Edition, Informa Health care, 2007.		
●	Schijns, V.E.J.C. and Ohagan, D.T., "Immunopotentiators in Modern Vaccines", Elsevier academic press, 2006		
●	K D Tripathi: Essentials of Medical Pharmacology.		
Reference Books(s) / Web links:			
●	Carter, S.J., "Cooper and Gunn's Dispensing for Pharmaceutical Students", CBS Publishers & Distributors, 2008.		
●	Gad, S.C., "Handbook of Pharmaceutical Biotechnology" John Wiley & sons, 2007.		
●	Reminton .The Science and Practice of Pharmacy, 21st edition		

PO / CO	PO1	PO2	PO3	PO4
BY23213.1	2	3	3	3
BY23213.2	2	3	3	3
BY23213.3	2	3	3	3
BY23213.4	3	3	3	3
BY23213.5	2	3	3	3
Average	**2**	**3**	**3**	**3**

BY23214	**IMMUNOTECHNOLOGY**	**Category**	**L**	**T**	**P**	**C**
		PC	**3**	**0**	**0**	**3**
Course objectives: This course will enable the students						
•	To impart knowledge of immune cells and their function					
•	To articulate on antigen and antibody interaction					

•	To explain the principle and interpretation of immunological techniques
•	To interpret various types of vaccines and their working principle
•	To familiarize the student in the area of immune therapy

UNIT I	**INTRODUCTION TO IMMUNE SYSTEM**	**9**
Hematopoiesis- Cells of the immune system and– Primary and secondary lymphoid organs – Immunity and their types - Humoral immune response – Cell mediated immune responses – Inflammation reaction- Tolerance – Autoimmunity - Cytokines and Complements- Immune cell markers.		
UNIT-II	**ANTIGEN AND ANTIBODY REACTION**	**9**
Antigen – Classification of antigen based in chemical and properties. Antibody- Properties and classification of antibody – Preparation and characterization of polyclonal and monoclonal antibodies – Purification of antibody – Analysis of antigen and antibody reactions (Agglutination and precipitation tests ELISA - ELISpot– RIA – Western Blot – Hybridization – Immunofluorescence- Immuno- lateral flow assay).		
UNIT-III	**IMMUNO CELL BASED ASSAY**	**9**
PBMC separation from the blood – Ficoll-hypaque method – Identification of lymphocytes based on CD markers – FACS – Lymphoproliferation assay – Cr5I release assay – Macrophage detection assays – Rosette assay – Cytokine bioassays: IL2, IFNγ, TNFα – Mixed lymphocyte reaction – HLA typing – .Diagnosis of immediate and delayed hypersensitivity- Complement-dependent cytotoxicity assay- Neutralization assays.		
UNIT-IV	**VACCINE BIOLOGY**	**9**
Principles in vaccine development – Adjuvant, Immunization (Active and Passive immunization) – Vaccine validation – Protein based vaccines – DNA vaccines – Edible vaccine – Recombinant antigens as vaccines – Multivalent subunit vaccine – Reverse vaccinology –Cancer vaccine – corona virus vaccine.		
UNIT-V	**IMMUNOTHERAPEUTICS**	**9**
Engineered antibodies – Catalytic antibodies, idiotypic antibodies, plantibodies – Combinatorial libraries for antibody isolation. Cancer immunotherapy and Immunosuppressive therapy – Cytokine therapy – Immunoglobulin therapy-Immune check point inhibitors- Dendritic cells based immunotherapy		
	Total Contact Hours : 45	

Course outcomes:
Upon completion of the course, the students will be able to

•	Comprehend the role of the immune system in pathogen elimination
•	Illustrate advanced immunological techniques and be able to interpret their results
•	Analyze the immune cells based on CD markers and be able to explain the role of MHC in HLA typing.
•	Validate the role of vaccine principle and their advancement.
•	Assess applications of immunotherapy in the modern world.

Suggested Activities

●	Discussion sessions

Suggested Evaluation Methods	
•	Quizzes
•	Class Presentation

Text books:	
•	Goldsby, R.A., Kindt, T. J., Kuby, J. and Osborne, B. A., "Immunology", Fifth Edition, W H Freeman, 2006.
•	Abbas, A.K., Lichtman, A.H. and Pillai, S., "Cellular and Molecular Immunology", 6th Edition, Elsevier, 2007.
•	Roitt,Ivan.Essential Immunology,9th Ed.,BlackwellScientific,1997.
•	Roitt, I.,Brostoff ,J & Male,D.Immunology,6th Ed.Mosby,2001.
•	Goldsby, R.A., Kindt, T.J., Osbome, B.A&Kerby, J. Immunology, 5th Ed., W.HFreeman,2003.
•	Weir, D.M&Stewart,J.Immunology, 8th Ed.,ChurchillLivingstone,1997.
Reference books:	
•	Fleisher, Dr., "Clinical Immunology Principle", 3rd Edition, Elsevier,2008.
•	Rabson, A., Roitt, I.M. and Delves, P.J. "Really Essential Medical Immunology". 2nd Edition, Blackwell Publishing, 2005.
•	Domitzer, P.R., Mandl, C.W. and Rappuoli, R., "Replicating Vaccine – A New Generation", Springer, 2011.
•	Kenneth Murphy: Janeway'sImmunobiology, 8th Ed. Garland Science, 2011, ISBN:9780815342434.
•	Ajoy Paul: Immunology, Books & Allied (P) Ltd, Kolkata, 2016. ISBN:978-93-84294-72-4.

PO / CO	PO1	PO2	PO3	PO4
BY23214.1	2	2	2	2
BY23214.2	3	3	3	3
BY23214.3	2	3	2	3
BY23214.4	2	2	2	2
BY23214.5	2	2	2	2
Average	**2.2**	**2.4**	**2.2**	**2.4**

BY23215	**ADVANCED GENOMICS AND PROTEOMICS**	**Category**	**L**	**T**	**P**	**C**
		PC	**3**	**0**	**0**	**3**

Objectives: This course provides a broad outline of the goals, methods, and applications for genomics and proteomics in the life sciences. By the end of this course, each student should be:	
•	Familiar to the basic biology of modern genomics and the experimental tools that can be used to measure it.
•	Able to discuss the key technological developments that enabled modern genomic and proteomics
•	Understand principles and technologies for generating genomic information for biotechnological applications.
•	Aware of the immense volumes of –omics data
•	Carryout genomics and proteomics related research work

UNIT I	INTRODUCTION TO GENOME AND GENE STRUCTURE	9
Introduction: Genome, Genomics, Omics and importance, History of genome projects, Organization and structure of genomes in prokaryotes, eukaryotes, and organelles (chloroplast, mitochondrion); Genome mapping methods (Genetic Mapping –i)Cross breeding and pedigree analysis, ii)DNA markers – RFLPs, SSLPs, SNPs and Physical Mapping – Restriction mapping, Fluorescent in situ hybridization, Radiation hybrid mapping and Sequence tagged site mapping); Advances in gene finding and functional prediction.		
UNIT II	**LARGE SCALE GENOME DATA ANALYSYS/GENOMICS**	**9**
Introduction of Next Generation Sequencing (NGS). Genome projects: The Human genome project, HapMap Project, The 1000 genome project, and The ENCODE Project. Structural genomics: Assembly of a contiguous DNA sequence- shotgun method, clone contig method, and whole –genome shotgun sequencing, Computational Algorithm in assembly of sequencing data Genome-wide association (GWA) analysis, Application of Computational method in genetic study; Comparative Genomic Hybridization (CGH); Massively parallel Signature Sequencing (MPSS); Whole genome shot-gun sequencing and its applications. Pharmacogenetics – High throughput screening in genome for drug discovery-identification of gene targets, Pharmacogenetics and drug development.		
UNIT III	**COMPARATIVE TRANSCRIPTOMICS**	**9**
Gene expression analysis by cDNA and oligonucleotide arrays; DNA microarray: understanding of microarray (experimental analysis and data analysis), normalizing microarray data, detecting differential gene expression, correlation of gene expression data to biological process and computational analysis tools (especially clustering approaches). Methylome analysis using microarray; ChIP-on Chip analysis. Bioinformatic analysis of large-scale microarray data and RNA-seq data for comparative transcriptomics, Data analysis for RNA.		
UNIT IV	**COMPARATIVE PROTEOMICS**	**9**
Comparative proteomics based on global in-vitro and in-vivo labelling of proteins/peptides followed by Mass-spectrometry. Analysis of post translational modification (PTM) of proteins; Protein microarrays. Application of Bioinformatics in Proteomics Data analysis.		
UNIT V	**METAGENOMICS, PHARMACOGENOMICS, METABOLOMICS**	**9**
Metagenomics: approaches for metagenomics analysis; Functional metagenomics. Different software packages to analyze the metagenomics data. Pharmacogenomics; Genetic variability in drug response; Clinical applications and challenges in Pharmacogenomics; Impact of pharmacogenomics in future drug development. Metabolomics and application of MS. Raw data analysis and measurement methods.		
Total Contact Hours: 45		

Course outcomes: Upon completion of the course, the students will be able to
• Illustrate the methods used for genomics and proteomics.
• Apply functional genomics techniques in the laboratory
• Familiar with how the methods are applied in real-life scientific research.
• Review the immense volumes of –omics data
• Develop the methods and approaches in genomics and proteomics areas which help them to carry out cutting edge academic and industrial research

Suggested Activities	
●	Discussion sessions
●	Lab oriented sessions
Suggested Evaluation Methods	
●	Quizzes
●	Class Presentation
●	Assignments

Textbooks:	
•	S.P. Hunt and F. J. Livesey, (2000) Functional Genomics
•	N. K. Spur, B. D. Young, and S. P. Bryant (1998) ICRF Handbook of Genome Analysis Volume 1 & 2.
•	G. Gibson and S. V. Muse (2002) A primer of Genome Science
•	R. J. Reece (2004) Analysis of Genes and Genomes
•	Rinaldis E. D. And Lahm A (2007) DNA Microarrays. Horizon bioscience.
•	Simpson R. J. "Proteins and Proteomics – A Laboratory Manual"Cold Spring Harbour Laboratory Press, 2002
•	Twyman R. M. "Principles of Proteomics". Taylor & Francis, 2004
•	O'Connor C. D. And Hames B. D. "Proteomics". Scion, 2008.
Reference books:	
•	Schena M. "Protein Microarrays". Jones and Bartlett, 2005.
•	Smejkal G. B. And Lazarev A. V. "Separation methods in Proteomics". CRC Press, 2006.

PO / CO	PO1	PO2	PO3	PO4
BY23215.1	2	2	3	3
BY23215.2	3	3	3	3
BY23215.3	3	2	3	3
BY23215.4	3	3	3	3
BY23215.5	3	3	3	3
Average	**2.8**	**2.6**	**3**	**3**

BY23221	**ADVANCED IMMUNOTECHNOLOGY LABORATORY**	**Category**	**L**	**T**	**P**	**C**
		PC	**0**	**0**	**4**	**2**
Course objectives: To provide training						
•	To collect blood and to separate serum and plasma.					
•	To analyze the immune cells based on the morphological features					
•	To isolate the lymphocytes and to prepare the microbial antigen for the generation of monoclonal antibody.					
•	To carry out various immune diagnostic assay and to interpret the results					
•	To determine concentration of antigen or antibody the sample using the ELISA					

LIST OF EXPERIMENTS	
1	Total lecukocyte count by using the Leishman & Giemsa stain
2	Isolation and identification of lymphocytes.
3	Latex Agglutination Assay
4	C- Reactive protein assay kit
5	Purification of IgG by Precipitation Technique
6	Slide and tube agglutination reaction (Widal test)

7	Hepatitis B Virus (HBsAg) Test using ELISA
8	Estimation of cytokines by ELISA
9	Preparation of a microbial antigen
10	Determination of the molecular weight of immunoglobin by SDS PAGE.
11	Characterization of antigens by western blotting
12	Identification of antigen by Immunofluorescent assay
13	Complement fixation test
	Total periods: 60

Course outcomes:	
Upon completion of the course , the students will be able to	
•	Isolate, identify, and characterize the immune cells.
•	Interpret the results of an immunodiagnostic assay with reference to immunology.
•	Demonstrate the importance of antigen-antibody interaction in the immunodiagnostic assay.
•	Purify the immunoglobin and characterize them.
•	Articulate the acquired knowledge in immunological research and diagnosis.

Reference books:	
•	Antibodies: A Laboratory Manual, Ed Harlow, David P Lane, Cold Spring Harbor Laboratory Press, 2nd Edition, 1998
•	Current protocols in immunology / editorial board John E. Coligan .et al,. 2003, New York : Wiley Interscience,2003
•	Ashim K. Chakravarthy, Immunology, TataMcGraw-Hill, 1998.
•	Noel R. Rose, Herman Friedman, John L. Fahey. Manual of Clinical Laboratory Immunology. ASM. 3rd ed., 1986.
•	GP Talwar, A Handbook of Practical & Clinical Immunology, Vol.2, 2nd edition.

PO / CO	PO1	PO2	PO3	PO4
BY23221.1	3	3	3	3
BY23221.2	3	3	3	3
BY23221.3	3	3	3	3
BY23221.4	3	3	3	3
BY23221.5	3	2	3	3
Average	**3**	**2.8**	**3**	**3**

BY23222	**BIOPROCESS AND DOWNSTREAM PROCESSING LABORATORY**	**Category**	**L**	**T**	**P**	**C**
		PC	**0**	**0**	**6**	**3**

Course objectives:	
This course aims to provide hands on training in Bioprocess and Downstream Processing Lab	
•	To perform enzyme kinetics and optimization of parameters
•	To provide expertise on enzyme immobilization techniques and media optimization
•	To perform experiments on different modes of cultivation
•	To make the students analyze the different methods involved in isolation, extraction of components, purification and preservation of products.
•	To perform different types of chromatography

LIST OF EXPERIMENTS	
1	Enzyme kinetics, inhibition, factors affecting reaction pH, temperature.
2	Enzyme immobilization studies – Gel entrapment and adsorption immobilisation.
3	Optimization techniques – Plackett Burman, Response surface methodology.
4	Batch cultivation – recombinant *E.coli* – growth rate, substrate utilization kinetics.
5	Fed batch cultivation -*E.coli*, *Pichiapastoris*
6	Batch sterilization design
7	Bioreactor studies: Sterilisation kinetics.
8	kLa determination-sodium sulphite method, power correlation method, residence time distribution
9	Cell separation methods; Centrifugation and microfiltration
10	Ultrasonication
11	Aqueous two phase extraction of biologicals.
12	High resolution purification; Ion exchange, affinity and Gel filtration chromatography, Freeze drying
13	Protein precipitation by salting –out method (ammonium sulphate).
14	Aqueous two phase extraction of biologicals.
	TOTAL PERIODS: 90

COURSE OUTCOMES: Upon completion of the course, the students will be able to	
•	Carryout experiments on enzyme kinetics
•	Perform immobilization techniques and optimization methods
•	Evaluate the growth kinetics of microorganisms
•	Execute isolation, extraction and purification techniques
•	Validate on chromatography techniques
Reference books:	
•	Shuler, M.L. and Kargi, F., Bioprocess Engineering: Basic concepts, 2nd Ed., Prentice-Hall, 2002.
•	Doran Pauline M, Bioprocess Engineering Principles, 2nd Ed., Academic Press, 1995.

PO / CO	PO1	PO2	PO3	PO4
BY23222.1	3	2	1	3
BY23222.2	2	3	3	1
BY23222.3	3	3	3	2
BY23222.4	2	1	3	3
BY23222.5	3	2	3	3
Average	**2.6**	**2.2**	**2.6**	**2.4**

Subject Code	ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING LABORATORY FOR BIOTECHNOLOGIST	Category	L	T	P	C
BY23223			0	0	2	1

Objectives:

- To know the fundamental usage of machine learning in biotechnology.
- Be familiar with regression models.
- Organize classification based machine learning problems.
- Articulate clustering based machine learning problems.
- Apply PCA and dimensionality reduction in modeling biological datasets.

List of Experiments

1	Linear regression
2	Logistic regression
3	Single layer perceptron
4	Multi-layer perceptron with back propagation
5	Decision tree
6	KNN and K-means
7	Dimensionality reduction – PCA

Contact Hours : 30

Course Outcomes:

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

- Understand usage of machine learning in biotechnology field.
- Apply linear regression to model biological datasets.
- Understand and explore the machine learning algorithms with classification.
- Apply machine learning algorithms with clustering method on biological data.
- Apply deep learning algorithms for solving biotechnological problems.

Suggested Activities

- Problem solving sessions

Suggested Evaluation Methods

- Interactive Quizzes
- Programming assignments

Text Book(s):

1	Aurélien Géron - Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, 2nd Edition. September 21019, Reilly Media, Inc., ISBN: 9781492032649.
2	Stephen Marsland, ―Machine Learning – An Algorithmic Perspective, Second Edition, Chapman and Hall/CRCMachine Learning and Pattern Recognition Series, 2014.
3	Shai Shalev-Shwartz and Shai Ben-David," Understanding Machine Learning: From Theory to Algorithms",Cambridge University Press 2014.

Reference Books(s) / Web links:

1	Alex Smola and S.V.N. Vishwanathan," Introduction to Machine Learning", Cambridge University Press 2008.
2	Andreas C. Müller and Sarah Guido," Introduction to Machine Learning with Python: A Guide for Data Scientists", O'Reilly Media, Inc,2016.
3	S. Russel and P. Norvig, "Artificial Intelligence: A Modern Approach", Third Edition, Prentice Hall, 2009.
4	C. M. Bishop, "Pattern Recognition and Machine Learning", Springer, 2007.
5	https://www.coursera.org/lecture/python-machine-learning/introduction-4f2So
6	https://nptel.ac.in/courses/106/106/106106139/

PO/PSO / CO	PO1	PO2	PO3	PO4
BY23223.1	2	2	3	3
BY23223.2	3	2	3	1
BY23223.3	3	2	3	1
BY23223.4	3	2	3	1
BY23223.5	3	2	2	2
Average	**2.8**	**2**	**2.8**	**1.6**

PROFESSIONAL ELECTIVES

BY23P11	**BIOMATERIALS**	**Category**	**L**	**T**	**P**	**C**
		PE	**3**	**0**	**0**	**3**

Course objectives:
This course will enable the students to

- Learn characteristics and classification of Biomaterials
- Understand different metals, ceramics and nanomaterial's characteristics as biomaterials
- Learn polymeric materials and its combinations that could be used as a tissue replacement implants
- Get familiarized with the concepts of host reactions to biomaterials
- Understand the concept of biocompatibility for artificial organs

UNIT I	**INTRODUCTION TO BIO-MATERIALS**	**9**

Definition and classification of biomaterials, Characterization of biomaterials: mechanical properties, surface properties, physical properties of materials, wound healing process, body response to implants, Effects of physiological fluid on the properties of biomaterials, blood compatibility.

UNIT-II	**METALLIC, CERAMIC MATERIALS AND POLYMERIC IMPLANT**	**9**

Metallic implants: Stainless steels, co-based alloys, Ti-based alloys, shape memory alloy. Ceramic implant: bioinert, biodegradable or bio resorbable, bioactive ceramics, applications of ceramic and metallic implants. Polymerization, factors influencing the properties of polymers, polyamides, Acryrilic polymers, rubbers, high strength Thermoplastic, Bio polymers: Collagen and Elastin, Medical Textiles: Silica, Chitosan, PLA composites, medical applications

UNIT-III	**TISSUE REPLACEMENT IMPLANTS**	**9**

Soft tissue replacements, sutures, surgical tapes, adhesive, Percutaneous and skin implants, maxillofacial augmentation, Vascular grafts, hard tissue replacement Implants, Internal fixation device, joint replacements.

UNIT-IV	**HOST REACTIONS TO BIOMATERIALS**	**9**

– Inflammation; Wound healing and the foreign body response; Systemic toxicity and Hypersensitivity; Blood coagulation and Blood-materials Interactions; Tumorigenesis. Degradation of Materials in Biological Environment: Degradation of Polymers, Metals and Ceramics.

UNIT-V	**ARTIFICIAL ORGANS AND BIOCOMPATIBILITY**	**9**

Artificial blood, Artificial skin, Artificial Heart, Cardiac pacemaker, Prosthetic Cardiac Valves, Artificial lung (oxygenator), Artificial Kidney (Dialyser membrane), Dental Implants. biocompatibility, blood compatibility and tissue compatibility. Toxicity tests: acute and chronic toxicity studies (in situimplantation, tissue culture, haemolysis, thrombogenic potential test, systemic toxicity, intracutaneous irritation test), sensitization, carcinogenicity, mutagenicity and special tests.

	Total Contact Hours	**:**	**45**

Course outcomes:	
Upon completion of the course, the students will be able to	
•	Analyze different types of biomaterials and their classification and apply the concept of nanotechnology towards biomaterials use.
•	Overcome challenges in developing metallic and ceramic materials
•	Identify significant gap to redress challenges in the development of polymeric materials
•	Create combination of materials that could be used as a tissue replacement implant
•	Analyze the testing standards applied for biomaterials.

Text books:	
•	Sujata V. Bhatt, Biomaterials, Second Edition, Narosa Publishing House, 2005.
•	Sreeram Ramakrishna, MuruganRamalingam, T. S. Sampath Kumar, and Winston O. Soboyejo, Biomaterials: A Nano Approach, CRC Press, 2010.

Reference books:	
•	Myer Kutz, Standard Handbook of Biomedical Engineering and Design, McGraw Hill, 2003
•	John Enderle, Joseph D. Bronzino, Susan M.Blanchard, Introduction to Biomedical Engineering, Elsevier, 2005.
•	Park J.B., Biomaterials Science and Engineering, Plenum Press, 1984.
•	A.C Anand, J F Kennedy, M.Miraftab, S.Rajendran,Woodhead Medical Textiles and Biomaterials for Healthcare, Publishing Limited 2006.
•	D F Williams, Materials Science and Technology: Volume 14, Medical and Dental Materials: A comprehensive Treatment Volume, VCH Publishers 1992.

SUGGESTED EVALUATION METHODS

- Assignment/Case study
- Quizzes
- Class Presentation/Discussion
- Continuous Assessment Tests

PO / CO	PO1	PO2	PO3	PO4
BY23P11.1	3	2	3	2
BY23P11.2	2	2	3	2
BY23P11.3	2	2	3	2
BY23P11.4	3	2	3	2
BY23P11.5	3	2	3	2
Average	**2.6**	**2**	**3**	**2**

BY23P12	ANALYTICAL TECHNIQUES IN BIOTECHNOLOGY	Category	L	T	P	C
		PE	3	0	0	3

Course objectives:

This course will enable the students

•	To get basic knowledge about the principle and methods of protein crystallization and use of micro fluidics enables crystallization of protein that is available in very small amount.
•	To acquire knowledge on the different chromatographic methods, immune precipitation and for separation of biological compounds which can be used for high-end research?
•	To understand the principle behind 2D gel electrophoresis, the different staining methods and their use in estimating the molecular weight of proteins.
•	To understand the construction and application of various types of microscopy.
•	To familiarize with different spectroscopic techniques, NMR, FTIR which can be used for characterization of the purified proteins.

UNIT I	PROTEIN CRYSTALLOGRAPHY	9

Biological macro-molecules – Principle of protein crystallization – Method – Testing – Cryotechniques – Influence of heterogeneity on crystallization – Progress in structural genomics – Micro crystallization – Utility of microfluidics for crystallization

UNIT-II	PROTEIN AND PEPTIDE PURIFICATION	9

Chromatographic methods for protein and peptide purification – Multidimensional chromatography – High throughput screening of soluble recombinant proteins – Immunoprecipitation – Affinity chromatography for antibody purification – Role of reverse phase HPLC in proteomic research.

UNIT-III	ELECTROPHORETIC TECHNIQUES	9

Strategies – Separation of proteins using 2D gel electrophoresis – Electrophoresis method for purifying proteins – *in situ* enzyme detection – Staining method – Separation of peptide mixture – Pulse field gel electrophoresis – Denaturing gradient gel electrophoresis

UNIT-IV	MICROSCOPY	9

Microscopy with light and electrons – Electrons and their interaction with the specimen – Electron diffraction

– Instrument, specimen preparation and application of TEM and SEM – Fluorescence microscopy – Laser confocal microscopy – Phase contrast – Video microscopy – Scanning probe microscopy.

UNIT-V	SPECTROSCOPY	9

Methods for characterizing purified proteins – IR absorption process, IR spectrometer and sample preparation

– Instrumentation and applications of UV – Over view of mass spectrometry, ionization methods, mass analysis, detection and quantitation – Circular dichroism (CD) spectroscopy – NMR – Fourier transform infrared spectroscopy (FTIR).

	Total Contact Hours	:	45

Course outcomes:

Upon completion of the course, the students will be able to

•	Apply protein crystallography principles and techniques for structural genomics and crystallization advancements in biotechnology.
•	Develop proficiency in chromatographic methods for purification of proteins, peptides, and antibodies in proteomic research.
•	Employ electrophoretic techniques for separation and detection of proteins.
•	Acquire skills on instrumentation and applications of microscopic techniques for sample analysis.

•	Demonstrate various spectroscopic methods for characterization of proteins.

Text books:	
•	Bhowmik, G. and Bose, S., "Analytical Techniques in Biotechnology", Tata McGraw-Hill Publishers, 2011.
•	Simpson, R.J., "Purifying Proteins for Proteomics", Cold Spring Harbor Lab Press, 2004.
Reference books:	
•	Chandler, D. and Roberso, R.W., "Bioimaging: Current Techniques in Light & Electron Microscopy", Jones and Bartlett publishers, 2008.
•	Babine, R.E. and Abdel-Meguid, S.S., "Protein Crystallography in Drug Discovery", Willy-VCH Verlag GmbH& Co., 2004.
•	Pavia, D.L., Lampman, G.M., Kriz, G.S. and Vyvyan, J.R., "Introduction to Spectroscopy", 4th Edition, Brooks/Cole Cengage Learning, 2008.

SUGGESTED EVALUATION METHODS

- Assignment/Case study
- Quizzes
- Continuous Assessment Tests

PO / CO	PO1	PO2	PO3	PO4
BY23P12.1	2	3	3	2
BY23P12.2	2	3	3	2
BY23P12.3	2	3	3	2
BY23P12.4	2	3	3	2
BY23P12.5	2	3	3	2
Average	**2**	**3**	**3**	**2**

BY23P13	**FOOD PROCESSING AND TECHNOLOGY**	**Category**	**L**	**T**	**P**	**C**
		PE	**3**	**0**	**0**	**3**

Course objectives:
This course will enable the students

•	To know about the constituents and additives present in the food.
•	To gain knowledge about the microorganisms, which spoil food and food borne diseases.
•	To comprehend different techniques used for the preservation of foods.

UNIT I	**FOOD CHEMISTRY**	**12**
Constituent of food – water , carbohydrates, lipids, proteins, vitamins and minerals, dietary sources, role and functional properties in food, contribution to texture, flavor and organoleptic properties of food; food additives – intentional and non-intentional and their functions.		
UNIT-II	**FOOD MICROBIOLOGY**	**8**
Food fermentation; food chemicals and enzymes; food borne diseases – infections and intoxications,		

Microbiology and spoilage of milk & milk products, meat, fish, poultry & egg, fruits & vegetable, confectionary.		
UNIT-III	**FOOD PROCESSING OPERATIONS AND PRESERVATION**	**8**
Raw material characteristics; cleaning, sorting and grading of foods; physical conversion operations – mixing, emulsification, extraction, filtration, centrifugation, membrane separation, crystallization, heat processing. Use of high temperatures – sterilization, pasteurization, blanching, canning; evaporation and drying; frozen storage – freezing curve characteristics. Factors affecting quality of frozen foods; irradiation preservation of foods and preservation using chemicals.		
UNIT-IV	**MANUFACTURE OF FOOD PRODUCTS**	**8**
Bread and baked goods, dairy products – milk processing, cheese, butter, ice-cream, vegetable and fruit products; edible oils and fats; meat, poultry and fish products; beverages.		
UNIT-V	**APPLIED FOOD SCIENCE AND QUALITY MANAGEMENT**	**9**
Concept of balanced Diet, Food Groups: Food adulteration- common adulterants, techniques used identify the food adulterants, Food quality and Safety Management System- ISO 22000, GMP, GHP, HACCP, FSMS, FSSAI, Entrepreneurial development- Business opportunity Identification, Assessment, development of entrepreneurial skills and become a successful entrepreneur.		
	Total Contact Hours : 45	

Course outcomes:

Upon completion of the course, the students will be able to

- Apply the techniques followed in food processing
- Integrate food fermentation & the role of enzymes in food processing
- Learn about different fermented foods produced
- Work with different preservation techniques and aware of food spoilage
- Comprehend the process of quality control in foods

Text books:

- Fellows, P.J., "Food Processing Technology: Principles and Practice", 3rd Edition, CRC Press, 2009.
- Pometto A, Shetty K, Paliyath G and Levin R. E., "Food Biotechnology", 2nd Edition, CRC press, 2005.

Reference books:

- Hutkins R. W., "Microbiology and Technology of Fermented Foods", IFT Press series, Volume 32 of Institute of Food Technologists Series, Wiley-Blackwell, 2006.
- ZeuthenP. and Bogh-Sorensen, L., "Food Preservation Techniques", 1stEdition, CRC Press, 2003.
- Adams M., Adams M. R. and Robert Nout M. J., "Fermentation and food safety", Springer, 2001.
- Da-Wen S., "Emerging Technologies for Food Processing", Academic Press, 2005.
- Coultate, T.P. Food – The chemistry of its components, 2nd Ed., Royal society, 1992.
- Sivasankar, B. Food processing and preservation, Prentice Hall of India Pvt. Ltd., 2002.
- Fennema, O.R. Principles of food science: Part I, Food chemistry, Marcel Dekker, 1976.
- Frazier, W.C. &Westhoff, D.C. Food Microbiology, 4th Ed. McGram-Hill Book Co., 1988.
- Brenner, J.G., Butters, J.R., Cowell, N.D. & Lilly, A.E.V. Food Engineering Operations, 2nd Ed., Applied Sciences Pub. Ltd., 1979.
- Pyke, M. Food Science and Technology, 4th Ed., John Murray, 1981.

SUGGESTED EVALUATION METHODS

- Assignment/Case study
- Quizzes
- Class Presentation/Discussion
- Continuous Assessment Tests

PO / CO	PO1	PO2	PO3	PO4
BY23P13.1	2	2	3	3
BY23P13.2	2	2	3	3
BY23P13.3	2	1	1	3
BY23P13.4	3	2	2	3
BY23P13.5	2	1	-	3
Average	**2.2**	**1.6**	**1.8**	**3**

BY23P14	**BIONANOTECHNOLOGY**	**Category**	**L**	**T**	**P**	**C**
		PE	**3**	**0**	**0**	**3**

Course objectives:

This course will enable the students

- To understand Biological Assembly/Structures in nanoscale
- To know principles of structural and functional bionanotechnology
- To gain knowledge on artificial bio assemblies.
- To understand Biomimetic fabrication
- To understand the concept of nanomedicine, nanopharmaceuticals and bionanosensor.

UNIT I **BIOLOGICAL ASSEMBLY AND STRUCTURES ATTHENANO-SCALE** **9**

Concepts in nanotechnology – Interface between Nanotechnology and Biotechnology – Theoretical basis for Self-Assembly – Combination of Bionanotechnology and Nanobiotechnology – Self-Assembly and Self- Organization of bacterial S-Layers, Viruses, Phospholipids membrane, Fibrillar Cytoskeleton, Nucleic Acids, Oligosaccharides and Polysaccharides, Amyloid Fibrils, Silk, Ribosome – Biological Activity through Self- Assembly – Affinity and Specificity of Biological Interactions – Antibodies as the Molecular Sensors of Recognition.

UNIT-II **STRUCTURAL AND FUNCTIONAL PRINCIPLES OF BIONANOTECHNOLOGY** **9**

Biomolecular structure and stability – Protein folding – Self-assembly – Self-organization – Molecular recognition – Flexibility – Information – Driven nanoassembly – Energetics – Chemical transformation – Regulation – Biomaterials – Biomolecular motors – Traffic across membranes – Biomolecular sensing – Self- replication – Machine-phase bionanotechnology.

UNIT-III **BIOTEMPLATING AND ARTIFICIAL BIOASSEMBLIES** **9**

Experimental strategies of porinMspA as a Nanotemplate – Nanostructuring by deposition of the MspAporin MspA-Nanochannels generated by the porin/polymer-template Method – Porin-Transport Assay – Scaffolds as Quantum dots, Organic Chains, polymers, DNA structures, Immobile DNA Junctions, Order in DNA and Proteins – Genetically Engineered S-Layer Proteins and S-Layer-Specific Hetero polysaccharides –Versatile molecular construction kit for applications in Nanobiotechnology.

UNIT-IV **DNA-BASED NANOSTRUCTURES** **9**

DNA-Protein nanostructures – Effective Models for Charge Transport in DNA Nanowires - DNA-Based Nanoelectronics - Biomimetic fabrication of DNA based metallic nanowires and networks – DNA-Gold nanoparticle conjugates – Nanoparticles as non-viral transfection agents - Nanocomputing.

UNIT-V **NANOMEDICINE,NANOPHARMACEUTICALS AND NANOSENSING** **9**

Relationships of biotechnology, nanotechnology, and medicine – Promising nanobiotechnologies for applications in medicine – Role of nanotechnology in methods of treatment – Nanomedicine according to therapeutic areas – Nano-Sized Carriers for Drug Delivery and drug carrier systems – Gene and Drug delivery system with soluble inorganic carriers – Cellular behaviors during drug delivery – Nanosensors design using Molecules, Cells, Materials – Bionanosensors in Bioanalytical Technology.

Total Contact Hours : 45

Course outcomes: Upon completion of the course, the students will be able to	
•	Apply the concept of bionanotechnology.
•	Relate the principle of bionanotechnology.
•	Apply the knowledge of bio assemblies to design new device.
•	Integrate the concept of biomimetic fabrication
•	Apply the knowledge of nanotechnology in medicine, pharmaceuticals and biosensors

Text books:	
•	Niemeyer, C.M. and Mirkin, C.A., "Nanobiotechnology: Concepts, Applications and Perspectives", Wiley- VCH, 2004.
•	Goodsell, D.S., "Bionanotechnology", John Wiley and Sons, 2004.
Reference books:	
•	Shoseyov, O. and Levy I., "Nanobiotechnology: Bioinspired Devices and Materials of the Future", Humana Press, 2007.
•	Bhushan, B., "Springer Handbook of Nanotechnology", Springer-Verlag Berlin Heidelberg, 2004.
•	Freitas Jr, R.A., "Nanomedicine", Vol. II, 1st Edition, Landes Biosciences, 2004.
•	Kohler, M. and Fritzsche, W., "Nanotechnology – An Introduction to Nanostructuring Techniques", Wiley-VCH, 2004.
•	Rosenthal, S.J. & Wright, D. W. NanoBiotechnology Protocols (Methods in Molecular Biology), 1st Ed, Humana Press, 2005.
•	Madhuri, S., Maheshwar, S., Pandey, S. &Oza, G. Bio-Nanotechnology Concepts and applications, 1st Ed, Ane Books Pvt Ltd, 2012.
•	Clarke, A.R. &Eberhardt, C.N. Microscopy Techniques for Material Science, 1st Ed, CRC Press, 2002.

SUGGESTED EVALUATION METHODS

- Assignment/Case study
- Quizzes
- Class Presentation/Discussion
- Continuous Assessment Tests

PO / CO	PO1	PO2	PO3	PO4
BY23P14.1	2	3	3	2
BY23P14.2	2	3	3	2
BY23P14.3	2	3	3	2
BY23P14.4	2	3	3	2
BY23P14.5	2	3	3	2
Average	**2**	**3**	**3**	**2**

BY23P15	ADVANCES IN ANIMAL BIOTECHNOLOGY	Category	L	T	P	C
		PE	3	0	0	3

Course objectives:

This course will enable the students

- To understand the fundamentals of animal cell culture, details of the diseases and therapy
- To provide the knowledge about the micromanipulation and transgenic animals

UNIT I	CELL CULTURE TECHNOLOGY	12

History and Scope of Animal Biotechnology, primary and secondary cell culture, cell lines, Scaling up of animal cell culture-monolayer culture: Multiarray disks, spirals and tubes; Roller culture; Microcarriers; Perfused monolayer cultures; Membrane perfusion; Hollow fibre perfusion; Matrix perfusion; Microencapsulation, Suspension culture: Fluidized bed reactors for suspension, Air-lift fermentor, Chemostat/Turbidostat, Bioreactor process control. Chicken embryo fibroblast culture, Chicken liver and kidney culture.

UNIT-II	THERAPEUTIC PRODUCTS FROM ANIMAL CELL CULTURE	5

Animal Biotechnology for production of regulatory proteins, blood products, viral vaccines, hormones and other therapeutic proteins, Hybridoma technology.

UNIT-III	MOLECULAR BIOLOGY AND GENETIC ENGINEERING	9

Types of animal viral vectors- SV40, adeno virus, retrovirus, vaccinia virus, herpes virus, adeno associated virus and baculo virus. Molecular diagnostics for detection of animal diseases –PCR, Nucleic acid hybridization, DNA based methods for identification of animal species, DNA biosensor chips for GMO detection. Metagenomics in animal gastro intestinal ecosystems.

UNIT-IV	REPRODUCTIVE BIOTECHNOLOGY	12

Biotechnological approaches to reproduction, methodology of super ovulation, Oestrus Synchronization and Timed Artificial Insemination, preparation of sperm for IVF; In vitro maturation; Fertilization and culture of embryos; embryo splitting, embryo sexing by different methods and their limitations; Genetics and Epigenetic alterations involved in Assisted Reproductive Technologies (ARTs), Multiple Ovulation and Embryo Transfer; Rate of Genetic Improvement using AI, MOET, ONBS; Embryo transfer in large and small ruminants. Laparoscopic and Laparoscope guided ET. Cryopreservation of sperm and embryos.

UNIT-V	APPLICATIONS	7

Knockout mice and mice model transgenesis- methods of transferring genes into animal oocytes, eggs, embryos and specific tissues by physical, chemical and biological methods; Transgenic animals (Mice, Cows, Pigs, Sheep, Goat, Birds and Insects); Biopharming, application of stem cells in animal biotechnology.

Total Contact Hours	:	45

Course outcomes:

Upon completion of the course, the students will be able to

- Learn the scope of animal biotechnology and develop cell culture based products
- Design animal cell culture based bioreactors
- Create molecular tools like probes and diagnose animal diseases
- Analyze the efficiency of different gene transfer methods and gain knowledge on micromanipulation technology.
- Relate the use of different transgenic animals in various research areas.

Text books:

- Watson, J.D., Gilman, M., WitowskiJ.andZoller, M. Recombinant DNA, 2nd ed., Scientific American Books, 1983

•	Lewin, B. Genes VIII , Pearson Prentice Hall, 2004
•	Davis J.M. Basic Cell Culture: A Practical Approach, IRL Press, 1998 5. Freshney R.I. Animal Cell Culture- a practical approach,1987
•	Freshney R.I. Animal Cell Culture- a practical approach,1987

Reference books:	
•	Portner R Animal cell biotechnology: Methods and Protocols, Humana Press, 2014.
•	Glick, B.R. and Pasternack, J.J. Molecular Biotechnology, 3rd ed., ASM Press, 2003

PO / CO	PO1	PO2	PO3	PO4
BY23P15.1	3	1	3	2
BY23P15.2	-	2	2	3
BY23P15.3	1	3	2	1
BY23P15.4	3	2	3	1
BY23P15.5	2	3	3	1
Average	**2**	**2**	**3**	**2**

BY23P16	**ONCOGENETICS**	**Category**	**L**	**T**	**P**	**C**
		PE	**3**	**0**	**0**	**3**

Course objectives:	
•	To enable the students to know cell cycle dys regulation in cancer and various stages of carcinogenesis.
•	To understand the molecular basis of cancer and propose new treatment options for cancer patients

UNIT I	**PRINCIPLES OF CANCER BIOLOGY**	**9**
Cancer: Definition, causes, properties, classification, clonal nature – Cell Cycle: Regulation of cell cycle, cell proliferation and apoptosis – Signal transduction pathways – Apoptosis: apoptotic pathways, signal molecules, effects on receptor, signal switches – Modulation of cell cycle in cancer – Mechanism of spread.		
UNIT-II	**PRINCIPLES OF CARCINOGENESIS**	**9**
Cancer risk factors – Theory of carcinogenesis – Chemical carcinogenesis – Physical carcinogenesis: x-ray radiation – mechanisms of radiation carcinogenesis – Stages of cancer: initiation, promotion, progression.		
UNIT-III	**MOLECULAR BIOLOGY OF CANCER**	**9**
Signal targets and cancer – Growth factors – Transformation – Activation of kinases – Oncogenes: c-Myc, Ras, Bcl-2 family – Mechanism of oncogene activation – Retroviruses and oncogenes – Detection of oncogenes – Oncogenes/proto oncogene activity – Tumor suppressor genes: Rb, p53, APC, BRCA paradigms. Telomerases.		
UNIT-IV	**CANCER METASTASIS**	**9**
Clinical significances of invasion – Heterogeneity of metastatic phenotype – Metastatic cascade: basement membrane disruption, invasion – Recent approach to identify key factors controlling metastasis – Angiogenesis.		
UNIT-V	**CANCER THERAPY**	**9**

Therapy forms – Surgery, chemotherapy, radiation therapy - Detection of cancers – Prediction of aggressiveness of cancer – Advances in cancer detection – Tumor markers; New approaches of cancer therapy mAbs, vaccines, gene therapy, stem cell therapy.			
	Total Contact Hours	**:**	**45**

Course outcomes: Upon completion of the course, the students will be able to	
•	Describe signal transduction pathways and cell cycle in cancer
•	Analyze the risk factors and stages of cancer
•	Integrate oncogenes and tumour suppressor genes
•	Evaluate cancer metastasis and angiogenesis
•	Analyse chemo, radiation and advanced therapy for cancer

Text books:	
•	Ruddon, R.W., "Cancer Biology", 2nd Edition, Oxford University Press, 2007
•	Weinberg, R.A., "The Biology of Cancer", Taylor & Francis, Garland Science, 2007

Reference books:	
•	Schulz, W.S., "Molecular Biology of Human Cancers – An Advanced Students Text Book", Springer, 2005.
•	Pelengaris, S. and Khan, M., "The Molecular Biology of Cancer", Blackwell Publishing, 2006.
•	Fialho, A. and Chakrabarty, A., "Emerging Cancer Therapy: Microbial Approaches and Biotechnological Tools" 1st Edition, Wiley, 2010.

PO / CO	PO1	PO2	PO3	PO4
BY23P16.1	3	2	3	2
BY23P16.2	3	2	3	3
BY23P16.3	3	2	3	3
BY23P16.4	3	2	3	2
BY23P16.5	3	2	3	3
Average	**3**	**2**	**3**	**2.6**

BY23P17	**PLANT TISSUE CULTURE AND GENE MANIPULATION**	**Category**	**L**	**T**	**P**	**C**
		PE	**3**	**0**	**0**	**3**

Course objectives:	
•	To enable the students to understand details of plant cells, genome and their functions
•	To provide the basics of agrobacterium and applications of plant biotechnology.

UNIT I	**INTRODUCTION TO PLANT MOLECULAR BIOLOGY**	**9**
Genetic material of plant cells, nucleosome structure and its biological significance; transposons,; outline of transcription and translation, alternative and trans splicing, constitutive and differentially expressed genes in plants.		
UNIT-II	**CHLOROPLAST AND MITOCHONDRIA**	**9**
Structure, function: Light and dark reaction and genetic material; rubisco synthesis and assembly, coordination, regulation and transport of proteins. Mitochondria: Genome, cytoplasmic male sterility and import of proteins, comparison and differences between mitochondrial and chloroplast genome, chloroplast transformation.		
UNIT-III	**PLANT METABOLISM AND METABOLIC ENGINEERING**	**9**
Nitrogen fixation, Nitrogenase activity, nod genes, nif genes, bacteroids, plant nodulins, production of secondary metabolites, flavanoid synthesis and metabolic engineering.		
UNIT-IV	**AGROBACTERIUM AND PLANT VIRUSES**	**9**
Pathogenesis, crown gall disease, genes involved in the pathogenesis, Ti plasmid – T-DNA, importance in genetic engineering. Plant viruses and different types, Viral Vectors: Gemini virus, cauliflower mosaic virus, viral vectors and its benefits, vectors used for plant transformation, Methods used for transgene identification.		
UNIT-V	**APPLICATIONS OF PLANT BIOTECHNOLOGY**	**9**
Outline of plant tissue culture, transgenic plants, herbicide and pest resistant plants, molecular pharming , therapeutic products, RNA i, Transgene silencing ,ethical issues.		
	Total Contact Hours : 45	

SUGGESTED EVALUATION METHODS

- Assignment/Case study
- Quizzes
- Class Presentation/Discussion
- Continuous Assessment Tests

Course outcomes: Upon completion of the course, the students will be able to	
•	Relate the fundamentals of plant cells, structure and functions
•	Articulate nitrogen fixation mechanism and significance of viral vectors
•	Organize viral vectors and agrobacterium based vectors in creating transgenic plants
•	Review the plant tissue culture and transgenic plants
•	Design methods for the development of therapeutic products
Text books:	
•	Grierson D. and Covey, S.N. Plant Molecular Biology, 2nd ed.,Blackie,1988
•	Slater A et al. Plant Biotechnology : The Genetic Manipulation of Plants, Oxford University Press, 2003 (1st and 2ndedition)
•	Gamburg O.L., Philips G.C. Plant Tissue & Organ Culture: Fundamental Methods. Narosa, 1995.
•	Heldt, Hans-Walter, Plant Biochemistry & Molecular Biology, Oxford University Press, 1997.
Reference books:	
•	Wilkins M.B .Advanced Plant Physiology, ELBS, Longman, 1987.

PO / CO	PO1	PO2	PO3	PO4
BY23P17.1	2	2	3	3
BY23P17.2	2	2	3	3
BY23P17.3	2	2	3	3
BY23P17.4	2	2	3	3
BY23P17.5	2	2	3	3
Average	**2**	**2**	**3**	**3**

BY23P18	**BIOCONJUGATE TECHNOLOGY AND APPLICATIONS**	**Category**	**L**	**T**	**P**	**C**
		PE	**3**	**0**	**0**	**3**

Objectives:

- To understand the derivatization processes of amino acids in proteins
- To demonstrate about the active functionalities and their derivatization
- To apply knowledge about bioconjugate reagents.
- To explain enzyme and nucleic acid modification and their conjugation
- To create strategies for the preparation of various conjugates and their applications

UNIT-I **FUNCTIONAL TARGETS** 9

Amino acids - structure and nature. Derivatization of amino acids – Asp, Glu, Lys, Tyr and C and N terminal amino acids – Important functional groups of polypeptide – Protection of the native conformation and activity of proteins – Oxidative modifications of Pro, Arg, Lys, Tyr, Phe, Cys, & Met – Detection of protein oxidation

UNIT-II **CHEMISTRY OF ACTIVE GROUPS** 9

Sugar functional groups – Derivatization of sugars, polysaccharides, and glycoconjugates - Amine, Thiol, and Photoreactive chemical reactions.

UNIT-III **BIOCONJUGATE REAGENTS** 9

Zero length cross-linkers – Definition, examples, and reactions of carbodiimides – Homo and Hetero bifunctional cross-linkers – Classification, structure, properties, and uses - Trifunctional cross-linkers – Definition, examples – Cleavable reagent systems.

UNIT-IV **ENZYME AND NUCLEIC ACID MODIFICATION AND CONJUGATION** 9

Characteristics of common enzymes used for conjugation – Preparation of activated enzymes for conjugation – Chemical modification of nucleic acids – Biotin labeling of DNA – Enzyme conjugation to DNA.

UNIT-V **BIOCONJUGATE APPLICATIONS** 9

Preparation of hapten-carrier immunogen conjugates – Antibody modification and conjugation – Immunotoxin conjugation techniques – Conjugation of protein to liposome – Preparation of different sizes of colloidal gold – Preparation of colloidal gold-labeled proteins and their applications.

Contact Hours : 45

Course Outcomes:

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

- Compile functional targets for the derivatization of proteins, polypeptide, and amino acids
- Illustrate active functional groups and their derivatization process
- Demonstrate and apply bioconjugate reagents for the preparation bioconjugates
- Perform enzymes and nucleic acid modification and conjugation
- Create and apply strategies for the preparation of various bioconjugates

Suggested Activities	
●	Group Discussion
Suggested Evaluation Methods	
●	Quizzes
●	Class Presentation / Discussion
Text/Reference Books(s) / Web links:	
1	Bioconjugate Techniques, G.T. Hermanson, Academic Press, 1999.

PO / CO	PO1	PO2	PO3	PO4
BY23P18.1	2	2	3	2
BY23P18.2	2	2	3	2
BY23P18.3	2	2	3	2
BY23P18.4	2	2	3	2
BY23P18.5	2	2	3	2
Average	**2**	**2**	**3**	**2**

BY23P19	**ADVANCES IN MOLECULAR PATHOGENESIS**	**Category**	**L**	**T**	**P**	**C**
		PE	**3**	**0**	**0**	**3**

Course objectives:	
•	To understand the key concepts of host defense against pathogens and microbial defense strategies
•	To learn the techniques of molecular approach to control the microbial pathogens

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 – Persistant infection – Latent infection – Slow infection – Methods for the study of pathogenesis – Foot and mouth disease virus, Pestiviruses, Arteriviruses, Blue tongue virus and Animal herpes viruses		
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 defense against chronic disseminated *Candidiasis*– Study fungal virulence by using Genomics – Functional genomic approaches to fungal pathogenesis.		
UNIT-III	**BACTERIAL PATHOGENESIS**	**9**
Epidemology and Clinicaldisease–Clinicalcourseandbasicimmunology–*Invitro*modelsof*Salmonella* virulence – Antibiotic resistant *Salmonella*–*Salmonella* based vaccines – *Shigella*cellular models of infection Influenza virus – Pathogenic *Escherichia coli* – *Vibrio cholerae*– Streptococcal disease – *Haemophilus influenza* infection.		
UNIT-IV	**MANIPULATION OF HOST CELLS AND IMMUNE FUNCTION BY VIRAL PROTEINS**	**9**
Clinical importance of understanding host defense – 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 APPROACHES TO CONTROL**	**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 – Viral Vaccines – Immune modulators – New vaccine technology.		
	Total Contact Hours : 45	

Course outcomes:	
Upon completion of the course, the students will be able to	
•	Describe the basic feature of pathogenesis and how virus involved in disease progress.
•	Predict host defense strategy against pathogens and fungi defense strategies.
•	Analyze molecular mechanism of virulence and the ability to perform the cause of bacterial infections.
•	Assess molecular mechanism of pathogen (virus) invasion of the host.
•	Evaluate different molecular techniques to control the mechanism of microbial pathogens.

Text books:	
•	Groismen, E.A., "Principles of Bacterial Pathogenesis", Academic Press, 2001.
•	Norkin, L.C., "Virology: Molecular Biology and Pathogenesis", ASM Press, 2009.

Reference books:	
•	Gyles, C.L., Prescott, J.F., Songer, J.G. and Thoen C.O., "Pathogenesis of Bacterial Infections in Animals", 3rd Edition, Wiley-Blackwell, 2004.
•	Flint, J., Enquist, L.W., Krug, R.M., Racaniello, V.R. and Skalka, A.M., "Principles of Virology: Molecular Biology, Pathogenesis and Control", American Society of Microbiology, 2003.
•	Mettenleitter, T.C. and Sobrino, F,"Animal Viruses: Molecular Biology", Caister Academic Press, 2008.

PO / CO	PO1	PO2	PO3	PO4
BY23P19.1	3	3	3	2
BY23P19.2	3	3	3	3
BY23P19.3	3	3	2	3
BY23P19.4	3	3	3	2
BY23P19.5	3	3	3	3
Average	**3**	**3**	**2.8**	**2.6**

BY23P21	BIOREACTOR DESIGN AND ANALYSIS	Category	L	T	P	C
		PE	3	0	0	3

Course objectives:

This course will enable the students

- To understand and develop mathematical models for batch and CSTR bioreactors by application of substrate, biomass, and product mass balances
- To know and apply the transport phenomena principles to bioreactors
- To measure and control the process variables involved in the process
- To frame the requirements needed for the design of reactor
- To analyse the scale up and scale down aspects of bioreactors

UNIT I BASIC BIOREACTOR CONCEPTS **9**

Modes of Operation – Batch operation, semi-continuous and fed-batch operation, Continuous Operation – Chemostat, turbidostat – General balances – Tank-type biological reactors, biomass productivity – Case studies – Continuous Fermentation with Biomass Recycle, Enzymatic Tanks-in-series, Tubular plug flow bioreactors.

UNIT-II AERATION AND AGITATION IN BIOPROCESS SYSTEMS **9**

Mass transfer in agitated tanks – Balance between oxygen supply and demand, Correlations with k_La in Viscous liquids– Power number, Power requirement for mixing in aerated and non-aerated tanks for Newtonian and non-Newtonian liquids – Mixing time in agitated reactor, residence time distribution – Shear damage, bubble damage, Methods of minimizing cell damage – Laminar and Turbulent flow in stirred tank bioreactors –Case studies for aeration and agitation

UNIT-III BIOREACTOR INSTRUMENTATION AND CONTROL **9**

Methods of measuring process variables –Temperature – Flow measurement and control – liquids and gases– Pressure measurement and control, safety valves – Agitation – shaft power, rate of stirring – Foam sensing and control – Microbial biomass – Measurement and control of Dissolved oxygen – Inlet and outlet gas analysis – pH measurement and control, automatic control systems.

UNIT-IV SELECTION AND DESIGN OF BIOPROCESS EQUIPMENT **9**

Materials of construction for bioprocess plants – Design considerations for maintaining sterility of process streams processing equipments, selection, specification – Design of heat and mass transfer equipment used in bioprocess industries – Requirements, design and operation of Bioreactor for microbial, plant cell and animal cell- Case studies

UNIT-V SCALE UP AND SCALE DOWN OF BIOREACTORS **9**

Effect of scale on oxygenation, mixing, sterilization, pH, temperature, inoculum development, nutrient availability and supply – Bioreactor scale-up based on constant power consumption per volume, mixing time, impeller tip speed (shear), mass transfer co-efficients – Scale up of downstream processes – Adsorption (LUB method), Chromatography (constant resolution etc.), Filtration (constant resistance etc.), Centrifugation (equivalent times etc.), Extractors (geometry based rules) – Scale–down related aspects – Case Studies in Bioreactor Scaleup and Scale-down aspects

Total Contact Hours : 45

Course outcomes:

Upon completion of the course, the students will be able to

- Select appropriate bioreactor configurations and operation modes based upon the nature of bio products
- Apply their knowledge of transport phenomena in designing field
- Plan a research career or to work in the biotechnology industry with strong foundation.
- Integrate research lab and Industry; identify problems and seek practical solutions for large scale implementation of Biotechnology with process control expertise
- Design bioreactor, scale up and troubleshooting the problems in bioreactors

Suggested Activities

- Problem solving sessions

Suggested Evaluation Methods	
•	Quizzes
•	Class Presentation / Discussion
•	Tutorial Problems

Text books:	
1	E. M. T. El-Mansi, C. F. A. Bryce, Arnold L. Demain, A.R. Allman.,"Fermentation Microbiology and Biotechnology", 3rd edition (revised), Taylor & Francis , 2011.
2	Mann, U., "Principles of Chemical Reactors Analysis & Design: New tools for Industrial Chemical Reactor Operations ", Willey–VCH, 2009.
Reference books/ Web links:	
1	Impre, J.F.M.V., Vanrolleghem, P.A. and Iserentant, D.M., "Advanced Instrumentation, Data Interpretation and Control of Biotechnological Processes", Kluwer Academic Publishers, 2010.
2	Shuler, M.L. and Kargi, F., "Bioprocess Engineering: Basic Concepts", 2nd Edition, Prentice Hall, 2001.
3	Towler, G. and Sinnott, R., "Chemical Engineering Design: Principles, Practice, Economics of Plant and Process Design", Butterworth – Heinemann ltd., Elsevier, 2008.
4	https://archive.nptel.ac.in/courses/102/106/102106086/

PO / CO	PO1	PO2	PO3	PO4
BY23P21.1	2	2	3	2
BY23P21.2	2	2	3	2
BY23P21.3	2	2	3	2
BY23P21.4	2	2	3	2
BY23P21.5	2	2	3	2
Average	**2**	**2**	**3**	**2**

BY23P22	**BIOPROCESS MODELING AND SIMULATION**	**Category**	**L**	**T**	**P**	**C**
		PE	**3**	**0**	**0**	**3**

Course objectives:
This course will enable the students

- To understand the basic concepts and principles in bioprocess modelling.
- To know about the different modelling aspects in bioprocess
- To study in detail about the non-ideal behaviour of different types of bioreactors
- To apprehend the dynamic simulation of biochemical reactors
- To use the different software solution strategies for solving bioprocess parameters and models

UNIT I	**CONCEPTS AND PRINCIPLES**	**9**

Introduction to modelling – Systematic approach to model building – Material and energy balance – Classification of models – General form of dynamic models dimensionless models – Conservation principles thermodynamic principles of process systems.

UNIT-II	**MODELLING APPROACHES FOR BIOLOGICAL SYSTEMS AND PROCESSES**	**9**

Growth Kinetic models – Structured and Unstructured models – Compartmental models (two and three) – Product formation -Genetically structured models–Stochastic model for thermal sterilization of the medium – Modelling for activated sludge process – Model for anaerobic digestion – Models for lactic fermentation and antibiotic production.

UNIT-III	**MODELLING OF BIOREACTORS**	**9**

Non ideality in bioreactors – Tanks-in-series and Dispersion models – Modelling of PFR and other first order processes – Analysis of packed bed and membrane bioreactors, Recombinant Cell Culture

Processes – Plasmid stability in recombinant Cell Culture limits to over-expression- Case studies		
UNIT-IV	**MONITORING OF BIOPROCESSES**	**9**
On-line data analysis for measurement of important physico-chemical and biochemical parameters – Parameter estimation techniques for biochemical processes – Biochemical reactors-model equations – Steady-state function – Dynamic behavior-Linear and non-linear estimation of the kinetic parameters ,		
UNIT-V	**SOLUTION STRATEGIES**	**9**
Solution strategies for lumped parameter models – Stiff differential equations – Solution methods for initial value and boundary value problems – Euler's method – R-K method – shooting method – Finite difference methods –Software packages for simulation of bioprocesses – MATLAB-SIMULINK, Creating bioprocess models in MATLAB and Simulink environment.- Case studies		
	Total Contact Hours : 45	

Course outcomes: Upon completion of the course, the students will be able to	
•	Apply the concepts and principles in bioprocess modelling.
•	Apply different modelling aspects in bioprocess
•	Study non-ideal behaviour of different types of bioreactors
•	Simulate the dynamics of biochemical reactors
•	Execute different software solution strategies for solving bioprocess parameters and models
Suggested Activities	
•	Problem solving sessions
Suggested Evaluation Methods	
•	Quizzes
•	Class Presentation / Discussion
•	Tutorial Problems
Text books:	
1	Hangos, K.M. and Cameron, I.T., "Process Modelling and Simulation", 2001.
2	Heinzle, E., Biwer, A.P. and Cooney, C.A.L., "Development of Sustainable Bioprocess: Modeling", Wiley, 2007.
Reference books/Web links:	
1	Boudreau, M.A. and McMillan, G.K.," New Directions in Bioprocess Modelling and Control", ISA, 2006.
2	Bequette, B.W., "Process Control:Modeling, Design & Stimulating", Prentice Hall,2003.
3	Bailey, J.A. and Ollis, D. F., Fundamentals of Biochemical Engineering", McGraw Hill–1986.
4	https://archive.nptel.ac.in/courses/103/105/103105215/

PO / CO	PO1	PO2	PO3	PO4
BY23P22.1	3	2	3	1
BY23P22.2	3	2	3	2
BY23P22.3	3	2	3	2
BY23P22.4	3	2	3	2
BY23P22.5	3	2	3	3
Average	**3**	**2**	**3**	**2**

BY23P23	BIOSAFETY AND BIOETHICS	Category	L	T	P	C
		PE	3	0	0	3

Course objectives:

This course will enable the students

- To know about the importance of safety in industries
- To learn about the concept of containment
- To comprehend the guidelines for biosafety
- To grasp the knowledge of bioethics
- To impart the awareness of bioethics among the public

UNIT I	INTRODUCTION	9

Need for safety in industries; Safety Programmes – components and realization; Potential hazards – extreme operating conditions, toxic chemicals; safe handling

UNIT-II	BIOLOGICAL SAFETY CABINETS	9

Primary Containment for Biohazards; Biosafety Levels; Biosafety Levels of Specific Microorganisms; Recommended Biosafety Levels for Infectious Agents and Infected Animals; Case studies

UNIT-III	BIOSAFETY GUIDELINES	9

Government of India; Definition of GMOs & LMOs; Roles of Institutional Biosafety Committee, RCGM, GEAC etc. for GMO applications in food and agriculture; Environmental release of GMOs; Risk Analysis; Risk Assessment; Risk management and communication; Overview of National Regulations and relevant International Agreements including; Cartegana Protocol.

UNIT-IV	BIOETHICS	9

Research ethics and Bioethics - Principles of research ethics; Ethical issues in clinical trials; Use of humans in Scientific Experiments; Ethical committee system including a historical overview; the informed consent; Introduction to ethical codes and conduct; Introduction to animal ethics; Animal rights and use of animals in the advancement of medical technology; Introduction to laws and regulation regarding use of animals in research, ethical dimensions of IPR, technology transfer and other global biotech issues

UNIT-V	BIOTECHNOLOGY AND SOCIAL RESPONSIBILITY	9

The legal, institutional and socioeconomic impacts of biotechnology; biotechnology and social responsibility, Public education to increase the awareness of bioethics with regard to generating new forms of life for informed decision making, Ethical implications of biotechnological products and techniques. Social and ethical implications of biological weapons-Case studies

	Total Contact Hours	:	45

Course outcomes:

Upon completion of the course, the students will be able to

- Adopt the safety handling procedures
- Apply the concept of biosafety levels
- Outline the regulations and guidelines framed for biosafety
- Discuss ethical issues
- Comprehend the ethical implications of biotechnological products

Suggested Activities

- Industrial visit

Suggested Evaluation Methods

- Quizzes
- Class Presentation / Discussion
- Assignment/case study

Text books:

1. Fawatt, H.H. and Wood, W.S., "Safety and Accident Prevention in Chemical Operation", Wiley Interscience, 1965.
2. Lee, Chi-Jen; etal., "Clinical Trials or Drugs and Biopharmaceuticals." CRC / Taylor &Francis,2011.

3	Fleming, D.O. and Hunt, D.L., "Biological Safety: Principles and Practices", 4th Edition, American Society for Microbiology, 2006
Reference books:	
1	Matoren, Gary M. "The Clinical Research Process in the Pharmaceutical Industry."Marcel Dekker, 1984.
2	Young, T., "Genetically Modified Organisms and Biosafety: A Background Paper for DecisionMakers and Others to Assist in Consideration of GMO Issues" 1st Edition, World Conservation Union, 2004.

PO / CO	PO1	PO2	PO3	PO4
BY23P23.1	1	1	3	3
BY23P23.2	1	2	3	3
BY23P23.3	2	2	3	3
BY23P23.4	2	2	3	3
BY23P23.5	2	2	3	3
Average	**1.6**	**1.8**	**3**	**3**

BY23P24	**BIOENERGY AND BIOFUELS**	**Category**	**L**	**T**	**P**	**C**
		PE	**3**	**0**	**0**	**3**

Course objectives:
This course will enable the students

- To gain knowledge about Physical and chemical pretreatment of lignocellulosic biomass
- To know the engineering strains for ethanol production from variety of carbon sources to improved productivity
- To describe the Energetics of biodiesel production and effects on greenhouse gas emissions Issues of Eco toxicity and sustainability
- To understand the production of Biodiesel from microalgae
- To learn the impacts of biofuels to the environment

UNIT I	**INTRODUCTION**	**9**

Cellulosic Biomass availability and its contents. Lignocellulose as a chemical resource. Physical and chemical pretreatment of lignocellulosic biomass. Cellulases and lignin degrading enzymes.

UNIT-II	**ETHANOL**	**9**

Ethanol as transportation fuel and additive; bioethanol production from carbohydrates; engineering strains for ethanol production from variety of carbon sources to improved productivity.

UNIT-III	**BIODIESEL**	**9**

Chemistry and Production Processes; Vegetable oils and chemically processed biofuels; Biodiesel composition and production processes; Biodiesel economics; Energetics of biodiesel production and effects on greenhouse gas emissions. Issues of ecotoxicity and sustainability with; expanding biodiesel production.

UNIT-IV	**OTHER BIOFUELS**	**9**

Biodiesel from microalgae and microbes; Biohydrogen production; bioelectricity production, Biorefinery concepts, Biobutanol, Biopropanol, Bioglycerol –Principles, materials and feedstocks - Process technologies and techniques-Advantages and Limitations.

UNIT-V	**APPLICATIONS OF BIOFUEL**	**9**

Hybrid models, Life cycle environmental impacts of biofuels and co products – Environmental sustainability of biofuels – Energy security and supply, Economic sustainability of biofuels.

	Total Contact Hours	**:**	**45**

Course outcomes:
Upon completion of the course, the students will be able to

- Have knowledge about Physical and chemical pretreatment of lignocellulosic biomass
- Know the engineering strains for ethanol production from variety of carbon sources to improved productivity
- Describe the Energetics of biodiesel production and effects on greenhouse gas emissions Issues of Eco toxicity and sustainability
- Replace fossil-based products with biodiesel
- Analyze the impacts of biofuels to the environment

Suggested Activities

- Industrial visit

Suggested Evaluation Methods

- Quizzes
- Class Presentation / Discussion
- Assignment/Case study

Text books:

1	Gupta. V. K. and Tuohy. M. G. Biofuel Technologies, Springer, 2013.
2	Luque, R., Campelo, J.and Clark, J. Handbook of biofuels production, Woodhead Publishing Limited 2011
3	Moheimani, N. R., Boer, M, P, M, K, Parisa A. and Bahri, Biofuel and Biorefinery Technologies, Volume 2, Springer, 2015.
4	David M. Mousdale, "Biofuels: Biotechnology, Chemistry, and Sustainable Development "CRC Press, 2008.

Reference books/ Web links:

1	Lee, Sunggyu; Shah, Y.T. "Biofuels and Bioenergy". CRC / Taylor & Francis, 2013.
2	Eckert, C, A. and Trinh, C, T. Biotechnology for Biofuel Production and Optimization, Elsevier, 2016.
3	Bernardes, M, A, D, S. Biofuel production – recent developments and prospects, InTech, 2011.
4	Samir K. Khanal, "Anaerobic Biotechnology for Bioenergy Production: Principles and Applications", Wiley-Blackwell Publishing, 2008.
5	https://onlinecourses.nptel.ac.in/noc19_bt16/preview
6	https://nptel.ac.in/courses/112106318

PO / CO	PO1	PO2	PO3	PO4
BY23P24.1	1	2	3	2
BY23P24.2	1	2	3	3
BY23P24.3	1	3	3	3
BY23P24.4	2	3	3	3
BY23P24.5	2	2	3	3
Average	**1.4**	**2.4**	**3**	**2.8**

BY23P25	ADVANCES IN ENVIRONMENTAL BIOTECHNOLOGY	Category	L	T	P	C
		PE	3	0	0	3

Course objectives:

This course will enable the students

- To learn the concept of biodegradation
- To study the various microbial processes for wastewater treatment
- To understand the biological treatment of wastewater
- To know the concepts of air pollution
- To apply the biotechnological process for green environment

UNIT I	BIODEGRADATION	9

Aerobic degradation of aliphatic and aromatic compounds – Metabolic degradation of organopollutants – Anaerobic degradation of aromatic compounds, halogenated organics and sulfonates – Biodegradation of herbicides and pesticides –Biodesulphurization of coal and oil – Bioleaching, bioprecipitation, bioaccumulation and biosorption of heavy metals.

UNIT-II	MICROBIAL METABOLISM IN WASTEWATER TREATMENT	9

Decomposition of organic compounds in natural and manmade ecosystems – Mass and energy balance for aerobic and anaerobic reactions – Hydrolysis of biopolymers by aerobic and anaerobic microorganisms – Anaerobic degradation of carbohydrates, proteins, fats and lipids – Nitrogen removal – Ammonification, nitrification, denitrification, anaerobic ammonia oxidation – Enhanced biological phosphorus removal

UNIT-III	BIOLOGICAL TREATMENT OF WASTEWATER	9

Physico-chemical characteristics of wastewater – Overview of aerobic and anaerobic treatment processes – Process design of aerobic and anaerobic system – Design of Activated sludge process – Design of Trickling filter – Rotating biological contactors – Fluidized bed reactor – Design of Upflow anaerobic sludge blanket reactor (UASB) – Membrane bioreactors – Algal photosynthesis in wastewater treatment

UNIT-IV	BIOTECHNOLOGY FOR AIR POLLUTION AND SOLID WASTE MANAGEMENT	9

Air pollution control and treatment strategies – Biotechnology for treating air pollutants – Biofilters and Bioscrubbers – Biotechnology for the management of agricultural, plastic, dairy, paper and pulp, textile, leather, hospital and pharmaceutical industrial wastes..

UNIT-V	BIOPRODUCTS FROM RENEWABLE SOURCES	9

Overview of renewable sources – Production of biocompost and vermicompost – Production of biofertilizers and biopesticides – Production of biomethane, bioethanol, biohydrogen, biodiesel – Production of bioplastics and biopolymers – Bioelectricity generation and value added products from renewable sources.

Total Contact Hours	:	45

Course outcomes:

Upon completion of the course, the students will be able to

- Identify the importance of biodegradation
- Recognise the microbial processes for the treatment of wastewater
- Develop the various biological processes for wastewater treatment
- Integrate the biotechnology concepts for the control of air pollution
- Apply the knowledge for the development of bioproducts from renewable sources and develop the biotechnological process for a clean and green environment

Suggested Activities

- Problem solving sessions

Suggested Evaluation Methods

- Quizzes
- Class Presentation / Discussion
- Tutorial Problems

•	Assignment/Case study
Text books:	
1	Jordening, H.J. and Winter, J., "Environmental Biotechnology: Concepts and Application", Wiley-VCH Verlag GmbH & Co., 2005.
2	Evans, G.G. and Furlong, J., Environmental Biotechnology: Theory and Application, 2nd Edition, John Wiley & Sons, 2011.
3	Alan .H. Scragg., Environmental Biotechnology,2nd Edition, Longman publisher., 2005.
Reference books:	
1	Henze, M., Harremoes, P., Jansen, J.C. and Arvin, E., "Wastewater Treatment: Biological and Chemical Processes", 2 nd Edition, Springer, 2013.
2	Zarook, S. and Ajay,S., Biotechnology for Odor and Air Pollution Control, Springer, 2005.
3	Wong J.W-C., Tyagi R.D., and Pandey. A., "Current Developments in Biotechnology and Bioengineering Solid waste" Elsevier, 2016.
4	https://onlinecourses.nptel.ac.in/noc21_bt41/preview

PO / CO	PO1	PO2	PO3	PO4
BY23P25.1	2	3	3	3
BY23P25.2	2	3	3	3
BY23P25.3	2	3	3	3
BY23P25.4	2	3	3	3
BY23P25.5	2	3	3	3
Average	**2**	**3**	**3**	**3**

BY23P31	**TISSUE ENGINEERING**	**Category**	**L**	**T**	**P**	**C**
		PE	**3**	**0**	**0**	**3**

Objectives:

- To gain knowledge on the type of stem cells and growth factors involved in tissue repairing and stem cell associated ethical issues.
- To study the construction of biomaterials and measurement of its physical and mechanical properties.
- To be familiar with the stem cell interaction with biopolymer and microfluidics system
- To acquire knowledge on clinical applications of tissue engineering in drug delivery using biopolymers.
- To explore synthesis of potential scaffolds for tissue engineering and organ bioprinting in regenerative medicine.

UNIT I **FUNDAMENTAL OF TISSUE ENGINEERING** **11**

Cells and tissue grade organization in living system - Cell cycle – Stem cells – Types – Embryonic stem cells, mesenchymal stem cells (MSC), adult stem cells, markers for detection of stem cells –, growth factors influencing stem cells formation, cell adhesion – Extracellular matrix – Glycans, laminin, fibronectin, collagen, elastin, extracellular matrix functions – Cell Signalling – Types, cell trafficking and signal transduction –*In vitro* cell viability and cell proliferation studies – Risks with the use of stem cells – – Application of stem cells in tissue engineering and Scope of tissue engineering.

UNIT-II **BIOMATERIALS FOR TISSUE ENGINEERING** **7**

Preparation of biomaterials and their types – Measurement of mechanical properties of biomaterials Measurement of protein adsorption – Direct and indirect methods, fibrinogen adsorption –Displaceable and non-displaceable – Changes in protein conformation upon adsorption – Vroman effect principle to maximize the amount of fibrinogen adsorption. Devices for tissue engineering transplant cells

UNIT-III	**DELIVERY OF MOLECULAR AGENTS AND CELL INTERACTIONS WITH POLYMERS**	**9**
Molecular agents in tissue engineering – Controlled released of agents – Future applications of controlled delivery – Microfluidic systems – Cell interactions – Factors influencing cell interactions – Cell interactions with polymer surfaces and suspension – Cell interactions with two and three-dimensional polymer.		
UNIT-IV	**POLYMERS FOR CONTROLLED DRUG DELIVERY**	**7**
Synthesis of bio polymer - Natural and synthetic biodegradable polymers – Structural and chemical properties, Biodegradable polymers in drug delivery –Polymeric drug delivery systems – Applications of biodegradable polymers.		
UNIT-V	**SCAFFOLDS ENGINEERED TISSUES AND ORGAN BIOPRINTING**	**11**
Scaffolds-sources and processing methods , Assessment of scaffolds mechanical properties and biodegradability – Biocompatibility and host response – Application of scaffolds in tissue engineering – Engineered tissues – Skin regeneration – Nerve regeneration, Liver, cartilage, bone and heart .Bioprinting –Classification –Inkjet, extrusion and Laser Bioprinting, Types of Bioinks, Tissue designing strategies (2D,3D,4D and Insitu organ printing.		
	Total Contact Hours :	**45**

Course Outcomes:	
On completion of the course, the students will be able to	
●	Classify the components of tissue architecture, application of stem cells in tissue engineering and associated ethical issues.
●	Explore the construction of biomaterials and measurement of its physical and mechanical properties.
●	Familiarize in the stem cell interaction with biopolymer and microfluidics system.
●	Drug delivery mechanisms using biopolymers.
●	Assess the role of tissue engineering and organ bioprinting in regenerative medicine.
Suggested Activities	
●	Flowchart presentation for various tissue implants preparation protocols
Suggested Evaluation Methods	
●	Quizzes
●	Seminar presentation based on case study
●	Debate Discussion
Text Book(s):	
1	Pallua, N. and Suscheck, C.V., “Tissue Engineering: From Lab to Clinic” Springer,2010
2	Saltzman, W.M., “Tissue Engineering”, Oxford University Press,2004.
3	Meyer, U.; Meyer, Th.; Handschel, J.; Wiesmann H.P. Fundamentals of Tissue Engineering and Regenerative Medicine.2009.
Reference Books(s) / Web links:	
1	Palsson, B., Hubbell, J.A., Plonsey, R. and Bronzino, J.D., “Tissue Engineering”, CRC Press, 2003.
2	Palsson, B.O. and Bhatia, S., “Tissue Engineering”, Pearson Prentice Hall, 2004.
3	Scheper, T., Lee, K. and Kaplan, D., “Advances in Biochemical Engineering / Biotechnology – Tissue Engineering I”, Volume 102, Springer-Verlag Berlin Heidelberg, 2006.
4	https://onlinecourses.nptel.ac.in/noc23_bt49/unit?unit=82&lesson=83

PO / CO	PO1	PO2	PO3	PO4
BY23P31.1	2	2	3	2
BY23P31.2	3	2	3	2
BY23P31.3	2	2	3	2
BY23P31.4	2	2	3	2
BY23P31.5	3	2	3	3
Average	**2**	**2**	**3**	**2**

BY23P32	**STEM CELL TECHNOLOGY**	**Category**	**L**	**T**	**P**	**C**
		PE	**3**	**0**	**0**	**3**

Objectives:

- To learn basics of stem cells
- To understand the different types stem cells
- To learn the multipotential of stem cells
- To know the clinical importance of stem cells
- To understand the ethical concerns, and applications of stem cells.

UNIT-I **STEM CELLS BASICS AND CONCEPTS** 9

Introduction to stem cells, Definition of Stem cells, Basics and concepts of stem cells- potency and plasticity of stem cells. Culture of stem cell and ethical concerns of stem cells. Stem cell markers. Trans differentiation and their role.

UNIT-II **SOURCES AND TYPS OF STEM CELLS** 9

Sources of stem cells- Embryonic, cord blood, bone marrow, peripheral blood. Embryonic stem cells, isolation and characterization. Adult stem cells- Skeletal muscle stem cells, Intestinal stem cells, Mammary stem cells, Corneal stem cells, Hair follicle stem cells. Neuronal stem cells. Induced pluripotency stem cells and limitations. Factors influencing adult and embryonic stem cells. Cancer stem cells – isolation and characterization.

UNIT-III **BONE MARROW STEM CELLS** 9

Mesenchymal stem cells- biological properties, immunogenic, isolation, characterization, ex vivo expansion. Regulations of mesenchymal stem cells. Properties of Hematopoietic stem cells, isolation, characterization and regulations. Hematopoietic stem cells differentiation pathways.

UNIT-IV **STEM CELL THERAPEUTICS AND APPLICATIONS** 9

The role of stem cells in neurodegenerative diseases- Parkinson disease, Alzheimer disease, spinal cord injury and muscular dystrophies. Tissue engineering- Triad, biomaterials types, properties and uses in regenerative medicine. Applications of stem cells in cancer treatment. Bone marrow transplantation and limitations.

UNIT-V **SAFTEY REGULATIONS AND EHTICS OF STEM CELLS** 9

Safety regulations of stem cells. Ethical issues of stem cells usage in clinical. Creation of genetically reprogrammed stem cells and their role in stem cell technology.

Contact Hours : 45

Course Outcomes:

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

- Compile basic concepts of stem cell technology
- Classify the types of sources and types of stem cells
- Learn fundamental and gain knowledge about bone marrow stem cells
- Identify the therapeutic potentials of stem cells
- Interpret ethical concerns of stem cells usage

Suggested Activities

- Problem solving sessions

Suggested Evaluation Methods	
●	Quizzes
●	Class Presentation / Discussion
Text/Reference Books(s) / Web links:	
1	CS. Potten. Stem cells - Elsevier: 1997.
2	Robert Paul Lanza, Essentials of stem cell biology, 2006.
3	Clive Svendensen and Allison D. Ebert, Encyclopedia of stem cell research, volume 1.
4	Stem cell basics and application" Ed. By K. D. Deb and S. M. Totey, Tata McGraw Hill Pvt. Ltd, 2011.
5	Berger A.C. Beachy S.H and Olson S .Stem Cells Therapies, National Academic press, Washington DC, USA 2014.
6	Daniel R. Marshak, ―Stem cell biology‖ cold spring laboratory press.
7	Robert Lanza, ―Essentials of stem cell biology, Elsevier, 2001
8	Stem cell therapy for organ failures- Edited by S. Indumathi, Springer Verlag, 2015.

PO / CO	PO1	PO2	PO3	PO4
BY23P32.1	3	2	2	3
BY23P32.2	3	2	2	3
BY23P32.3	3	2	2	3
BY23P32.4	3	2	2	3
BY23P32.5	3	2	2	3
Average	**3**	**2**	**2**	**3**

BY23P33	**VACCINOLOGY**	**Category**	**L**	**T**	**P**	**C**
		PE	**3**	**0**	**0**	**3**

Course objectives:	
•	To provide knowledge on conventional and recent technologies of vaccine production.
•	To provide immunological background on vaccine production.
•	To describe the immune response to vaccines.
•	To impart the regulatory requirements for vaccine formulations.
•	To articulate the modern methods for vaccine development

UNIT I	**INTRODUCTION TO VACCINE**	**9**
Historical aspects of vaccination, vaccine are a tool for prevention of infectious diseases, human vaccines manufacturer and licensed vaccines. Over view of bacterial and viral vaccines and their importance. Epidemiology and pathophysiology of vaccine preventable diseases with special emphasison Diphtheria, Tetanus and Pertussis.		
UNIT-II	**VACCINE RSEARCH**	**9**
Fundamental aspect of rational vaccine design. Antigen identification, T-Cell expression cloning for identification of vaccine targets for intracellular pathogens, Fundamentals of Immune recognition, implications for manipulating the T-Cell repertoire, Targeting Macrophage; a rational approach for Vaccine development, Cellular basis of T- Cell memory, Rational design of new vectors.		
UNIT-III	**VACCINE PRODUCTION**	**9**
Seed strain characterization for vaccine production. Adjuvants: types, mechanisms and current achievements. New vaccines development and prominent delivery systems. Production of inactivated		

bacterial vaccines with respect to Diphtheria, Tetanus and Whole cell pertussis (DTwP).Immune response(s) to vaccines. Immunization strategies for disease control and eradication.		
UNIT-IV	**REGULATROTY ASPECTS**	**9**
Overview of national and international regulatory requirements for vaccine approval and guidance for production, quality control and Current Good Manufacturing Practices (cGMP) implementation. Importance and implementation of cGMP in the production of safe and efficacious biological products/vaccines, and clean-in-place(CIP)cycle development for process equipment.		
UNIT-V	**QUALITY CONTROL**	**9**
Consistency approach for vaccine quality improvement. Toxicity and potency evaluation of bacterial and viral vaccines: overview of currently approved methods and alternative methods under development.		

Total Contact Hours	**:**	**45**

Course outcomes: Upon completion of the course, the students will be able to	
•	Describe the role of vaccine in prevention and eradication of infectious diseases.
•	Explain the role of adjuvant in vaccines production.
•	Demonstrate the immunization strategies for disease control
•	Articluate the international regulatory requirements for vaccine approval.
•	Comprehend adverse effect of vaccination

Text books:	
•	Ronald W. Ellis, "New Vaccine Technologies", Landes Bioscience, 2001.
•	Cheryl Barton, "Advances in Vaccine Technology and Delivery", Espicom Business Intelligence, 2009.
•	Male, David et al., "Immunology", 7th Edition, Mosby Publication, 2007.

Reference books:	
•	Coico, R. etal., "Immunology: A Short Course", 5th Edition, Wiley – Liss, 2003.
•	Parham, Peter "The Immune System", 2nd Edition, Garland Science, 2005.
•	Abbas, A.K. etal., "The Cellular and Molecular Immunology", 6th Edition, Sanders / Elsevier, 2007.
•	Weir, D.M. and Stewart, John "Immunology", 8th Edition, Churchill Pvt. Ltd., 2000

PO / CO	PO1	PO2	PO3	PO4
BY23P33.1	2	2	3	3
BY23P33.2	3	2	3	3
BY23P33.3	2	2	3	3
BY23P33.4	3	2	3	3
BY23P33.5	3	2	3	3
Average	**2.6**	**2**	**3**	**3**

BY23P34	DATA MINING AND MACHINE LEARNING TECHNIQUES FOR BIOINFORMATICS	Category	L	T	P	C
		PE	3	0	0	3

Objectives:

- To understand the importance of data mining procedures for bioinformatics analysis.
- To learn different algorithms available for machine learning.
- To familiarize with different data formats available in industry.
- To model different types of biological data.
- To apply ML on available bioinformatics data.

UNIT-I **INTRODUCTION TO BIOINFORMATICS DATA MINING** 9

Mining chemical compounds – protein localization – gene mapping – Modeling sequence data – sequence alignment – structure comparison – phyloinformatics – Data cleaning – Data transformation - Data formats.

UNIT-II **REGRESSION MODELS** 9

Linear classification – univariate linear regression - bivariate regression – multivariate linear regression – regularized regression – Logistic regression. Naive Baye's – Discriminant Functions -Probabilistic Generative Models –Probabilistic Discriminative Models – Bayesian Logistic Regression.

UNIT-III **TREE MODELS** 9

Decision trees: Training and Visualizing a Decision Tree - Making Predictions - Estimating Class Probabilities – The CART Training Algorithm - Computational Complexity - Gini Impurity or Entropy - Ensemble methods: Bagging - Boosting- Boosting AdaBoost - Gradient Boosting – Xg boost.

UNIT-IV **SUPERVISED LEARNING** 9

Perceptron: – multilayer neural networks – back propagation - learning neural networks structures – support vector machines: – soft margin SVM – going beyond linearity – generalization and over fitting – regularization – validation.

UNIT-V **UNSUPERVISED LEARNING** 9

Clustering: Nearest neighbor models – K-means – clustering around Medoids. Dimensionality Reduction: – Linear Discriminant Analysis – Principal Component Analysis – Factor Analysis – Independent Component Analysis.

Contact Hours : 45

Course Outcomes:

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

- Download bioinformatics data in proper usable format.
- Choose the right ML algorithm to use with the data.
- Clean and transform the data and make it suitable for modelling.
- Fine tune a machine learning model depending on validation parameters.
- Apply ML concept to varied biological problems.

Suggested Activities

- Problem solving sessions using google colab

Suggested Evaluation Methods

- Quizzes
- Class Presentation / Discussion

Text/Reference Books(s) / Web links:

1. Tan, Steinbach and Vipin Kumar, Introduction to Data Mining, Pearson Education, 2nd Edition, 2021.
2. Jason, Mohammed, Hannu, Dennis, Data Mining in Bioinformatics, Springer. 2005.
3. Shastry, K.A., Sanjay, H.A, Machine Learning for Bioinformatics. In: Srinivasa, K., Siddesh, G., Manisekhar, S. (eds) Statistical Modelling and Machine Learning Principles for Bioinformatics Techniques, Tools, and Applications. Algorithms for Intelligent Systems. Springer. 2020.
4. https://www.futurelearn.com/courses/linux-for-bioinformatics/5

PO / CO	PO1	PO2	PO3	PO4
BY23P34.1	3	2	3	3
BY23P34.2	3	2	3	3
BY23P34.3	3	2	3	3
BY23P34.4	3	2	3	3
BY23P34.5	3	2	3	3
Average	**3**	**2**	**3**	**3**