SunRise University
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M. Tech - Biotechnology

EPARTMENT OF BIOTECHNOLOGY
SCHEME OF INSTRUCTION AND SYLLABUS

First Semester

Semester -I												
Code	**Subject**	**Cr**	**Hrs. /Week**			**Exam Hrs.**	**Maximum Marks**				
			L	**T**	**P**		**MS1**	**MS2**	**END TERM**	**IA**	**Total**
Theory											
1MTBT01	Bioprocess Engineering and Process Biotechnology	3	3	1	0	3	10	10	60	20	100
1MTBT02	Animal, Plant and Microbial Biotechnology	3	3	1	0	3	10	10	60	20	100
1MTBT03	Biocomputing and Computational Biology	3	3	1	0	3	10	10	60	20	100
1MTBT04	Bioprocess control & Instrumentation	3	4	1	0	3	10	10	60	20	100
Practicals & Sessionals											
Code	Subject	Cr	Hrs. /Week			Exam Hrs.	IA (60%)		EA (40%)		Total
			L	T	P		MP1 30%	MP2 30%			
1MTBT05	Bioprocess Engineering and Process	2	0	0	2	2	30	30	40		100

	Biotechnology Laboratory									
									Total	500

Second Semester

Semester - II											
Code	**Subject**	**Cr**	**Hrs. /Week**			**Exam Hrs.**	**Maximum Marks**				
			L	**T**	**P**		**MS1**	**MS2**	**END TERM**	**IA**	**Total**
Theory											
2MTBT01	Bioseparation and Bioanalytical Technology	3	3	1	0	3	10	10	60	20	100
2MTBT02	Molecular Cell Biology & Recombinant DNA Technology	3	3	1	0	3	10	10	60	20	100
2MTBT03	Biostatistics & Quantitative Biology	3	3	1	0	3	10	10	60	20	100
2MTBT04	Biomaterials Engineering Security	3	4	1	0	3	10	10	60	20	100
Practicals & Sessionals											
			Hrs. /Week				IA (60%)				

Code	Subject	Cr	L	T	P	Exam Hrs.	MP1 30%	MP2 30%	EA (40%)	Total
2MTBT05	Bioseparation and Bioanalytical Technology Laboratory	2	0	0	2	2	30	30	40	100
									Total	500

Third Semester

Semester - III											
Code	**Subject**	**Cr**	**Hrs. /Week**			**Exam Hrs.**	**Maximum Marks**				
			L	**T**	**P**		**MS1**	**MS2**	**END TERM**	**IA**	**Total**
Theory											
3MTBT01	Comprehensive Viva Voce	3	3	1	0	3	10	10	60	20	100
3MTBT02	Research Methodology	3	3	1	0	3	10	10	60	20	100
Practicals & Sessionals											
Code	Subject	Cr	Hrs. /Week			Exam Hrs.	IA (60%)		EA (40%)		Total
			L	T	P		MP1 30%	MP2 30%			
3MTBT03	Dissertation I	2	0	0	2	2	30	30	40		300
									Total		500

Fourth Semester

Code	Subject	Cr	Hrs. /Week			Exam Hrs.	IA (60%)		EA (40%)	Total
			L	T	P		MP1 30%	MP2 30%		
4MTBT01	Dissertation II	2	0	0	2	2	30	30	400	400
									Total	400

SCHEME OF INSTRUCTION

M. Tech. (BIOTECHNOLOGY) Course Structure

M. Tech Biotechnology I Year I Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	BT5101	Bioprocess Engineering and Process Biotechnology	3	0	0	3	PCC
2	BT5102	Animal, Plant and Microbial Biotechnology	3	0	0	3	PCC
3	BT5103	Biocomputing and Computational Biology	3	0	0	3	PCC
4		Elective – I	3	0	0	3	DEC
5		Elective – II	3	0	0	3	DEC
6		Elective – III	3	0	0	3	DEC
7	BT5104	Bioprocess Engineering and Process Biotechnology Laboratory	0	0	3	2	PCC
8	BT5105	Biocomputing and Computational Biology Laboratory	0	0	3	2	PCC
9	BT5141	Seminar-I	0	0	2	1	PCC
		Total	18	0	8	23	

I Year II Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	BT5151	Bioseparation and Bioanalytical Technology	3	0	0	3	PCC
2	BT5152	Molecular Cell Biology & Recombinant DNA Technology	3	0	0	3	PCC
3	BT5153	Biostatistics & Quantitative Biology	3	0	0	3	PCC
4		Elective - IV	3	0	0	3	DEC
5		Elective - V	3	0	0	3	DEC
6		Elective - VI	3	0	0	3	DEC
7	BT5154	Bioseparation and Bioanalytical Technology Laboratory	0	0	3	2	PCC
8	BT5155	Experimental Techniques in Molecular Biotechnology Laboratory	0	0	3	2	PCC
9	BT5191	Seminar-II	0	0	2	1	PCC
		Total	18	0	8	23	

II Year I semester

S. No.	Course Code	Course Title	Credits	Cat. Code
1	BT6142	Comprehensive Viva Voce	2	PCC
2	BT6149	Dissertation Part-A	9	
		Total	11	

II Year II Semester

S. No.	Course Code	Course Title	Credits	Cat. Code
1	BT6199	Dissertation Part-B	18	
		Total	18	

ELECTIVES

I Year I Semester

Elective-I, Elective-II, Elective-III

BT5111 Advances in Fermentation Technology
BT5112 Bioprocess control & Instrumentation
BT5113 Modelling Simulation and optimization of Bioprocess
BT5114 Molecular Immunology
BT5115 OMICS Technology
BT5116 Protein Engineering
BT5117 Statistical Programming
BT5118 Systems and Synthetic Biology
BT5119 Tissue Engineering and Stem Cell Technology

I Year II Semester

Elective-IV, Elective-V, Elective-VI

BT5161 Agriculture Biotechnology
BT5162 Biomaterials Engineering
BT5163 Entrepreneurship, IPR, Biosafety & Bioethics
BT5164 Environmental Biotechnology, Biofuels & Bioenergy
BT5165 Enzyme Engineering
BT5166 Molecular Pathogenesis
BT5167 Nanotechnology for Medical and Healthcare
BT5168 Pharmaceutical Biotechnology

BT5169 Research Methodology

PROGAM EDUCATIONAL OBJECTIVES

PEO1.
Pursue successful industrial, academic and research careers in specialized fields of Biotechnology
PEO2.
Apply the knowledge of advanced topics in Biotechnology to meet industrial and research needs
PEO3.
Use modern computational, analytical tools and techniques to address biotechnological challenges.
PEO4.
Identify issues related to ethics, society, safety and environment in the context of Biotechnology applications
PEO5.
Engage in lifelong learning for career and professional growth for society and the environment

PROGRAM OUTCOMES

PO1
Carryout independent research/investigation and development work to solve practical problems

PO2
Write and present a substantial technical report/document

PO3
Design modern Biotechnological methods for bioprocess plant and allied processes.

PO4
Apply research based knowledge and biotechnological methods to investigate complex biological problems

PO5
Identify measures for energy, environment, health, safety and society following ethical principles.

PO6
Pursue life-long learning to enhance knowledge and skills for professional advancement

BT5101	Bioprocess Engineering and Process Biotechnology	PCC	3 – 0 – 0	3 Credits

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

CO1	Apply Kinetics and Statistics to bioprocesses
CO2	Design different types of bioreactors
CO3	Develop the bioprocess economics to industrial bioprocesses
CO4	Analyze the bioreactors detailed design of bioprocess industry equipment

Mapping of course outcomes with program outcomes

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

1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Basics of Industrial microbiology. Principles of enzyme catalysis; Michaelis-Menten kinetics; Kinetics and Statistics; Inhibition; Effect of pH and temperature; Enzymology; Immobilized enzymes: methods, mass transfer considerations; Production of Industrial enzymes.

Introduction to bioreactors; Batch and Fed-batch bioreactors, Continuous bioreactors; Immobilized cells; Bioreactor operation; Sterilization; Aeration; Sensors; Instrumentation; Culture-specific design aspects: plant/ mammalian cell culture reactors.

Description of industrial Bioprocesses; Bioprocess flow sheeting; Bioprocess economics. Analysis of Bioreactors, Scale-up and scale-down of bioprocesses, Simple structure models; detailed design of bioprocess industry equipment. Bioreactor design and rheology Case studies of the current research in bioprocess engineering and process biotechnology.

Readings:

1. Michael Shuler and Fikret Kargi, Bioprocess Engineering: Basic Concepts, 2nd Edition, Prentice Hall, Englewood Cliffs, NJ, 2002.

2. Pauline Doran, Bioprocess engineering principles, Latest Edition, Academic Press, 2018.

3. Colin Ratledge, Bjorn Kristiansen, Basic Biotechnology, 2nd Edition, Cambridge University Press, 2001.

4. Roger Harrison et al., Bioseparations Science and Engineering, Oxford University Press, 2003.

BT5102	Animal Plant and Microbial Biotechnology	PCC	3-0-0	3 Credits

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

CO1	Explain the significance of plant tissue culture and plant-based product development.
CO2	Apply the transgenic approach for improving the crop quality.
CO3	Formulate cell culture media for cell growth and product development
CO4	Apply genetic engineering techniques to modify animal cell and production of transgenic animal.

Mapping of the Course Outcomes with Program Outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3					
CO2				2		
CO3			3			
CO4						3

1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Isolation and Screening of industrially important Microbes; Large scale cultivation of industrial microbes; Recombinant Protein production in microbes; Commercial issues pertaining to the production of recombinant products from microbes; downstream processing approaches; Industrial Microbes as cloning hosts. Environmental Application of microbes; Ore leaching; Toxic waste removal; Soil remediation. Microbial application in food and health care industries; Food Processing and food preservation; Antibiotics and enzymes of pharmaceutical use.

Introduction to plant cell and tissue culture, types of tissue culture media composition and preparation. Cyto differentiation *invitro*, Callus and Organogenessis, Micropropagation, Somaclonal variation and application in crop improvement, cellular totipotency, Plant transformation technologies: physical, chemical and biological methods of gene transfer, Cell line selection, Selectable markers, Reporter genes, Transgene stability, selection and expression, Elicitor- induction, Biotransformation using plant cell cultures, Secondary Metabolite production.

Introduction to animal cell culture and Equipment, basic laboratory design, animal cell culture, Cell culture media Preparation and sterilization methods. Primary cell culture and subculture and maintenance of animal cell cultures, properties of cell lines. Cryopreservation, Measurement of cell death: cytotoxicity and cell viability assays. Cloning and gene transfer to animal cell, knockout mice, and recombinant products: recombinant approaches to vaccine production, hybridoma technology.

Reading:

1. Biotechnology in Crop Improvement, HSChawla. International Book Distributing Company 2008
2. Practical Application of Plant Molecular Biology. RJ Henry. Chapman and Hall

2007

3. R. Verpoorte and A.W. Alfermann, *Metabolic Engineering of Plant Secondary Metabolism*, Kluwer Academic Publishers, 2000
4. Animal Cell Culture & Technology, 2nd Edition, Author: Michael Butler, Mike Butler, M. Butler,2002
5. Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications 6th Edition, Author: R. Ian Freshney,2007

BT5103	Biocomputing & Computational Biology	PCC	3 – 0 – 0	3 Credits

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

CO1	Device programs in Perl, Python, MATLAB and SQL languages
CO2	Apply machine learning for prediction and pattern recognition applications
CO3	Comprehend benefits of bigdata analytics in health care sector
CO4	Identify concerns in structural biology and structural bioinformatics techniques

Mapping of course outcomes with program outcomes

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

1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus: Biocomputing:

Scripting language(s): Introduction to PERL, main PERL features, PERL components, introduction to PYTHON, history of PYTHON, python features, mathematical programming, MATLAB computational environment, MATLAB scripts, graphical output, functions, systems of linear and non-linear equations, differential equations, use of the Bioinformatics Toolbox, problems.

Database management language: Introduction to SQL, role of SQL, SQL features and benefits, SQL basics; execution of queries. R programming, business analytics.

Machine Learning: Machine learning with MATLAB, Introducing Machine Learning, including supervised and unsupervised learning, choosing the right algorithm, and practical examples. Unsupervised learning, hard and soft clustering algorithms, common dimensionality reduction techniques for improving model performance. Supervised Learning, classification and regression algorithms, feature selection, feature transformation, and hyper parameter tuning.

Big Data Analysis: Introduction to bigdata, volume, variety, combining multiple data sets, velocity, veracity, data quality, data availability, data discovery, privacy in bigdata, benefits of bigdata analytics in health care sector, data commons and large biomedical dataset, molecular diagnostics in the era of big data and precision medicine.

Computational Biology in Drug Discovery and Development: Structural bioinformatics, Protein visualization programs; Structural biology techniques Template and non-template based protein structure prediction methods, Homology modeling, CADD, SBDD, LBDD, docking, QSAR, molecular dynamics and simulations.

Readings:

1. Steven Holzner, "PERL Black Book", Second Edition, Dreamtech Press; 2007.
2. Richard L., Halterman, "Learning to Program with PYTHON", 2011.

3. Jason Kinser, “PYTHON for Bioinformatics”, (Jones and Bartlett Series in Biomedical Informatics) Jones and Bartlett Publishers, Inc; 1st edition, 2009.

4. Leonid Burstein, "MATLAB in Bioscience and Biotechnology (Woodhead Publishing series in Biomedicine), Woodhead Publishing; 1st edition, 2011.
5. Rajendra Akerkar "Big Data Computing", Chapman & Hall/CRC; 1st edition 2013.
6. William T. Loging, Bioinformatics and Computational Biology in Drug Discovery and Development, Cambridge University Press; Reprint edition, 2018.

BT5104	Bioprocess Engineering and Process Biotechnology Laboratory	PCC	0 – 0 – 3	2 Credits

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

CO1	Demonstrate the effect of different process parameters on growth of micro-organisms
CO2	Improve secondary metabolites production using different media
CO3	Screen process variables by using single dimensional search, Plackett Burman design and RSM
CO4	Assess enzyme activity on immobilized and free enzyme

Mapping of course outcomes with program outcomes

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

1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

1. Media design and strain selection
2. Effect of different process parameters on growth-estimation of energy of activation and Arrhenius constant for micro-organisms. Batch, fed batch and continuous cultures a) Estimation of Monod parameters b) Pure and mixed cultures.
3. Production of secondary metabolite by plant cells in a photo bioreactor.
4. Production of wine by yeast.
5. Production of Amino acid.
6. Screening of process variables by single dimensional search, Plackett Burman design, RSM etc.
7. Study of rheology of fermentation broth and power determination in laboratory scale bioreactor.

8. Production of secondary metabolites by feed batch culture, Production of secondary metabolites in synthetic and complex industrial media..
9. Comparison of enzyme activity on immobilized and free enzyme.

Reading:

1. Paulin M. Doran, Bioprocess Engineering Principles, Elsevier Science & Technology Books, 2008.
2. Bailey, J.E. and Ollis, D.F, Biochemical Engineering Fundamentals, McGraw Hill, 2006
3. Shuler M. and Kargi F., Bioprocess Engineering: Basic Concepts, PHI, 2012.

BT5105	Biocomputing & Computational Biology Laboratory	PCC	0 – 0 – 3	2 Credits

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

CO1	Execute string manipulation and sorting programs in Linux environment
CO2	Write programs/protocols in Perl, Python, MATLAB script languages and SQL database language
CO3	Construct neural networks for prediction and pattern recognition applications
CO4	Apply software tools and techniques in Drug Design

Mapping of the Course Outcomes with Program Outcomes

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

1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

1. Module 1: Introduction to the Linux operating system and software installation, use of Linux and Linux shell commands, application to bioinformatics problems.
2. Module 2&3: Introduction to the Perl programming and software installation, use of Perl and Perl scripts, application to bioinformatics problems.
3. Module 4&5: Introduction to the Python programming and software installation, use of Python and Python scripts, application to bioinformatics problems.
4. Module 6&7: Introduction to the MATLAB programming and software installation, use of MATLAB coding and MATLAB TOOLBOX, application to bioinformatics problems.
5. Module 8&9: Introduction to Machine Learning, construction of neural networks and application to feature selection and classification problems of biological big data.
6. Module 10: Introduction to the SQL Database language and software installation, use of SQL in database management and application to bioinformatics problems.
7. Module 11&12: Introduction to CBDD and software installation, use of SBDD and LBDD tools, application to bioinformatics problems.

Reading:

1. Mark G. Sobell, “Practical Guide to Linux Commands”, Editors, and Shell Programming, Prentice

Hall; 3rd edition, 2012.
2. Martin C Brown, “Perl: The Complete Reference”, 2nd edition, Tata McGraw Hill, 2001.
3. Jason Kinser, “PYTHON for Bioinformatics”, (Jones and Bartlett Series in Biomedical

Informatics) Jones and Bartlett Publishers, Inc; 1st edition, 2009.
4. Stormy Attaway, "MATLAB: A Practical Introduction to Programming and Problem Solving", Butterworth-Heinemann; 5th edition 2018.
5. Yanqing Zhang, Jagath C. Rajapakse, "Machine Learning in Bioinformatics (Wiley Series in Bioinformatics)" Wiley-Blackwell; 1st edition, 2017.

BT5151	Bioseparation & Bioanalytical Technology	PCC	3 – 0 – 0	3 Credits

Prerequisites: Basics of Biochemistry and Biochemical engineering

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

CO1	Classify techniques used in bioseparation processes
CO2	Design optimal bioseparation processes
CO3	Explain the principles of major unit operations and analytical techniques used in bioseparations
CO4	Select appropriate technique and equipment for a given bioseparation processes

Mapping of the Course Outcomes with Program Outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3					
CO2			3			
CO3					2	
CO4						3

1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Role and importance of bio separation technology in biotechnological processes, Problems and requirements of bio product purification, characteristics of biotechnology products. Economics of bio separation in Biotechnology. Cost-cutting strategies.

Cell disruption methods for intracellular products – physical methods (osmotic shock, grindingwith abrasives, solid shear, liquid shear) – chemical methods (alkali, detergents)– enzymatic methods.

Centrifugation, different type of centrifuges and their theory. Membrane based separations micro and ultra-filtration theory, design and configuration of Membrane separation equipment, applications, Precipitation; Extraction and Drying

Chromatography – Classification of chromatographic techniques, size exclusion, ion exchange, hydrophobic, affinity chromatography – Scale-up of chromatography – Process considerations in Preparative liquid chromatography and HPLC

Analytical Techniques -Separation of proteins using 2D gel electrophoresis – Electrophoresis method for purifying proteins – *in situ* enzyme detection – Staining method –Denaturing gradient gel electrophoresis.

Reading:

1. Belter, P.A., Gussler, E.L. and Hu, W.S., "Bioseparations"2007
2. Downstream Processing for Biotechnology, Paul A. Belter,Wiley-Blackwell, 2008
3. Product Recovery in Bioprocess technology, BIOTOL series, Butterworth –Heinemann, 2010
4. Principles of Downstream processing, by Ronald & J.Lee, Wiley Publications, 2007
5. Bhowmik, G. and Bose, S., "Analytical Techniques in Biotechnology", Tata McGraw-Hill Publishers, 2011.

BT5152	Molecular Cell Biology & Recombinant DNA Technology	PCC	3 – 0 – 0	3 Credits

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

CO1	Illustrate basic structures and cell biology-related mechanisms in a eukaryote cell.
CO2	Explain the mechanisms of cell signaling, cell division, cell death and renewal.
CO3	Outline the cloning strategies, expression of recombinant molecules and DNA sequencing technology
CO4	Apply advanced molecular biology techniques for biotechnological and biomedical applications.

Mapping of course outcomes with program outcomes

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

1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Universal properties of the cell. Organelles and membrane systems; their structure and function., Plasma Membrane, Cytoskeleton and cell motility, cell organelles involved in bioenergetics and metabolism, Protein sorting and transport system in the cell.

Cell signaling: receptors, transduction proteins, secondary messengers, signal integration, Overview of cell cycle; Cell cycle regulation, Cell death and cell renewal: Programmed cell death.

Cloning and expression Vectors: Plasmids and Phage Vectors, Cosmids, phagemid and other advanced vectors: phage-derived PACs, BACs and YACs, Selection and screening of clones, Overexpression and tagging of recombinant proteins in *E. coli*. cDNA cloning, genomic libraries, screening of libraries and recombinant clone selection, hybridization with differential expression and subtractive techniques.

Changing genes – site directed mutagenesis, reverse mutagenesis, cassette mutagenesis. gene knockout,

RNA interference, CRISPR-Cas9. Gel retardation assay, DNA foot printing, yeast one- two and three-

hybrids assay, ChIP-chips, Co-immunoprecipitations. Phage display.
Gene expression analysis by Northern Blotting, RT-PCR, EST analysis, Enzymatic and bioluminescent reporters, Reporters used in protein localization and trafficking studies, Promoters analysis, mapping transcriptional start sites, Transcriptome analysis, DNA microarrays (cDNA arrays and oligo arrays), Serial Analysis of Gene Expression (SAGE). Next generation sequencing technologies. Genomics.

Readings:

1. *Lodish, Harvey.* Molecular cell biology 8th edition. New York, NY: W. H. Freeman, 2016.
2. Geoffrey M. Cooper, Robert E. Hausman, The cell: a molecular approach, 5th ed. 2009, Washington, D.C. : ASM Press
3. Old RW and Primrose SB .Sixth edition, "Principles of gene manipulation ", Blackwell Scientific Publications, 2001.
4. Brown T. A., Gene Cloning and DNA Analysis: An Introduction, Blackwell Publishing's,2000

BT5153	Biostatistics & Quantitative Biology	PCC	3 – 0 – 0	3 Credits

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

CO1	Summarize biological data using statistical methods
CO2	Explain the application of statistical learning in biology
CO3	Apply the principles of quantitative genetics to understand the complex traits
CO4	Analyze genome data using statistical methods

Mapping of course outcomes with program outcomes

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

1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Introduction to types data, Graphical presentation of data, measurers of central tendency and dispersion, probability distributions, Introduction of Bayesian statistic, Central limit theorem, Testing hypothesis (Parametric and Non-parametric), characteristics of a data for parametric and nonparametric procedures. chi square test, sign test, Wilcoxon sign rank test, Wilcoxon rank sum test. Method of least squares, curve fitting, Correlation analysis (pearson and spearman), test of significance for correlation, regression analysis: Linear, multiple and logistic regression. Principle component analysis, cluster analysis, sampling techniques, concept of experimental design. Experimental approach in quantitative biology and high-throughput experiments. Introduction to genomic data. Data normalization, Differential gene expression analysis, concept of genetic

correlation. Genetic Dominance: Genotype-Phenotype Relationships, Mendelian Genetics: Patterns of

Inheritance and Single-Gene Disorders, beyond Mendelian Genetics, Genome-wide association studies.

Linkage analysis, Association analysis, linkage disequilibrium, linkage disequilibrium in human genome, quantitative trait locus (QTL), genetic polymorphism, biomarker, statistical model in genetic, evaluation of model: Sensitivity and Specificity. Biocomputing and computational biology

Readings:

1. Sanford Bolton, Charles Bon, Pharmaceutical Statistics, Practical and Clinical Applications, 4th Edition, Marcel Dekker, Inc. U.S.A.2004,
2. Daniel Wayne W., Biostatistics: A Foundation for Analysis in the Health Sciences, 9th Ed., John Wiley & Sons, 2008.
3. Rosner Bernard, Fundamentals of Biostatistics, 7th Ed., Brooks/Cole, 2011.
4. Motulsky H, Intuitive Biostatistics, 2nd Ed., Oxford University Press, 2009.
5. The Fundamentals of Modern Statistical Genetics (Statistics for Biology and Health) 2011th Edition by Nan M. Laird (Author), Christoph Lange (Author)
6. Handbook of Statistical Genetics (2 volume set) 3rd Edition by David J. Balding (Editor), Martin Bishop (Editor), Chris Cannings (Editor)

BT 5154	**Bio separation & Bioanalytical Technology Laboratory**	**PCC**	**0 – 0 – 3**	**2 Credits**

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

CO1	Estimate the concentration of intra and extra cellular proteins from biological samples.
CO2	Evaluate cell disruption using mechanical, chemical and enzymatic methods
CO3	Formulate the fractionate proteins using precipitation methods
CO4	Apply different chromatographic techniques for protein purification

Mapping of the Course Outcomes with Program Outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3					
CO2		3				
CO3				2		
CO4					3	

1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

1. Cell disruption: Enzymatic, Chemical and Physical methods
2. Ammonium Sulfate precipitation
3. Desalting of protein sample using dialysis
4. Tangential filtration methods
5. Ion-exchange Chromatography
6. Gel Filtration Chromatography
7. Affinity Chromatography
8. Aqueous two phase extraction of biologicals
9. Drying - Lyophilization.
10. High performance Liquid Chromatography
11. Gas Column Chromatography
12. Assessing purity by Gel Electrophoresis
13. Assessment of enzyme activity

Readings:

1. J.C. Janson – Protein Purification – Principles, High Resolution Methods And Applications, 3rd Edition, Wiley, 2011.
2. Handbook of Bio separations, Satinder Ahuja, Academic Press,2000
3. Downstream Processing of Proteins: Methods and Protocols, Mohamed A.Desai,Humana Press,2012
4. Protein Purification: Principles and Practice: 3rd Edition, Springer, Robert K Scopes, 2014

BT5155	**Experimental Techniques in Molecular Biotechnology Laboratory**	**PCC**	**0 – 0 – 3**	**2 Credits**

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

CO1	Demonstrate safe laboratory practices and handle the equipment safely
CO2	Demonstrate basic methods of genetic manipulation
CO3	Construct, screen and express recombinant molecules
CO4	Elaborate methods to study gene expression

Mapping of course outcomes with program outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1					3	
CO2			3			
CO3				2		
CO4						3

1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

1. Introduction to lab safety, handling and disposal of molecular wastes.
2. Isolation of RNA and RNA electrophoresis
3. Reverse Transcriptase PCR to study the gene expression
4. Isolation of plant DNA from different sources
5. Amplification bacterial gene by PCR
6. Isolation of Plasmid DNA
7. Cloning of amplified gene to pUC 18 or pUC 19 plasmid
8. Transformation of recombinant clone to bacteria
9. Recombinant screening of clone (blue white screening or colony PCR)
10. Multiplex PCR
11. Transformation of DNA to Yeast cell
12. Phage Titration: to study the virulent property of phage
13. Analysis of reporter gene expression by enzymatic assay

Readings:

Molecular Cloning: A Laboratory Manual (3 Volume Set) 2nd Edition
by J. Sambrook , E.F. Fritsch , T. Maniatis.2002

BT5111	**Advances in Fermentation Technology**	**DEC**	**3 – 0 – 0**	**3 Credits**

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

CO1	Explain the chronological development of the fermentation industry
CO2	Outline working principle of various Bioreactors.
CO3	Demonstrate Fermentation kinetics
CO4	Formulate media for fermentation
CO5	Design and construction of bioreactor

Mapping of course outcomes with program outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3					
CO2		2				
CO3				2		
CO4			3			
CO5						3

1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Overview of fermentation industry, general requirements of fermentation processes, basic configuration of fermenter and ancillaries, main parameters to be monitored and controlled in fermentation processes, Gaden's Fermentation classification, Design and operation of fermenters, Basic concepts for selection of a

reactor, Rheology of fermenter. Fermentation Kinetics: Continuous fermentation, advantages and limitations, theory of single and two stage continuous fermentation systems application

Media formulation and preparations-complex and synthetic media, sterilization. Isolation, selection and improvement of cultures – screening methods, culture preservation. Studies on growth kinetics in batch, continuous and fed batch cultures. Details of Industrial manufacture of important biotechnological products.

Bath culture, Continuous culture, Multistage system, Feedback systems, Comparison of batch and continuous culture in industrial process, Biomass productivity, Metabolite productivity Continuous brewing, Continuous culture and biomass production, Comparison of batch and continuous culture investigative tools, Fed-batch culture, Variable volume fed-batch culture, Fixed volume fed-batch culture, Cyclic fed-batch culture, Application of fed-batch culture, Examples of the use of fed-batch culture, Ideal bioreactors, various configurations, Mechanical construction, various parts and accessories - Introduction to Mass and Heat transfer: Agitation and aeration, Modes of reactor operations, Wave bioreactors

Reading:

1. Bailey, J.E. and Ollis D.F., Biochemical Engineering Fundamentals, Mcgraw Hill Higher Education; 2nd edition, 2001
2. Stanbury, P.E., Whitaker, A., Hall, S., Principles of Fermentation Technology 2nd edition, Butterworth-Heinemann, 2002
3. Pirt, S. J., Principles of Microbe and Cell Cultivation. Wiley, John & Sons, Reprint, 2005
4. Moo-Young, M., Comprehensive Biotechnology, Vol. 1–4, Pergamon Press, Reprint, 2004

BT5112	**Bioprocess Control & Instrumentation**	**DEC**	**3 – 0 – 0**	**3 Credits**

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

CO1	Explain the process measurement principles
CO2	Distinguish between P,PD,PI, and PID controllers
CO3	Analyze stability of control system
CO4	Apply process control principles for bioreactor operation

Mapping of course outcomes with program outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3					
CO2		3				
CO3				2		
CO4						3

1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Processes measurements; Biochemical process variables and their measurements; Control principles and their application in bioreactors; Theory of electrode processes and their applications. Response of first

order system to standard forcing function; first order system in series- interacting and non-interacting

system, response of second order system to standard forcing function.

Primary on-line sensors, at-line sensors; Control of pH, temperature; Gas analysis, dissolved oxygen, dissolved carbon dioxide, redox potential, foam in fermenters; Agitation and capacity coefficient in fermenters; Broth composition measurements; Virtual sensors for cell mass and primary carbon substrate; Multivariable control; Model reference control; Adaptive control

Introduction to Control system, open loop controller, closed loop controller - P,PI,PID, controller mechanism, final control element- control valve, valve characteristics, Block diagram reduction, transient response of simple control system, stability analysis -Routh stability

Programmed batch bio-reaction; Design and operation strategies for batch plants; Continuous process control; Instrumentation for monitoring the current status of bioprocess plants; Measurement of process variables as the basis of bioprocess control. Applications of artificial intelligence (AI) approaches including fuzzy control, artificial neural network (ANN), and expert systems, to bioprocess control. Safety locks, interlock systems.

Readings:

1. Bailey J.E. and Ollis,D.F. " Biochemical Engineering Fundamentals" 2nd Edition, McGraw Hill Book CO.,Singapore. 2006.
2. Donald R.Coughanowr, "Process Systems Analysis and Control", Mcgraw-Hill, 2009
3. Shuler and Kargi, "Bioprocess engineering", Prentice Hall, 2002
4. George stephanopolus., Chemical Process Control, 2nd Edition, Prentice Hall of India Pvt. Ltd,1999

BT5113	**Modelling Simulation and optimization of Bioprocess**	**DEC**	**3 – 0 – 0**	**3 Credits**

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

CO1	Explain the Modelling Principles
CO2	Develop mass, energy and momentum balance equations
CO3	Analyze models for batch, semi continuous or fed batch operation
CO4	Develop enzyme and growth kinetic models
CO5	Develop and simulate models for biological systems

Mapping of course outcomes with program outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3					
CO2		2				
CO3				3		
CO4						3
CO5				2		

1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Modelling principles, use of models for understanding, design and optimization of bioreactors, general aspects of the modelling approach, general modelling procedure, simulation tools, uncertainty, and scenario and sensitivity analysis.

Formulation of balance equations, types of mass balance equations, balancing procedure, continuous stirred tank bioreactor, tubular reactor, component balances for reacting systems, constant volume continuous stirred tank reactor, semi-continuous reactor with volume change, steady-state oxygen balancing in fermentation, inert gas balance to calculate flow rates, stoichiometry, elemental balancing and the yield coefficient concept.

Information for bioreactor modelling, batch operation, semi continuous or fed batch operation, continuous operation, summary and comparison, biological kinetics, michaelis-menten equation, other enzyme kinetic models, deactivation, sterilization, modelling of mutualism kinetics, kinetics of anaerobic degradation.

Bioreactor modelling, the batch fermenter, the chemostat, the fed batch fermenter, biomass productivity, modelling of tubular plug flow bioreactors, gas absorption with bioreaction in the liquid phase,liquid-liquid extraction with bioreaction in one phase, steady-state gas balance for the biological uptake rate, determination of k_la using the sulfite oxidation reaction determination of k_la by a dynamic method, model for oxygen gradients in a bubble column bioreactor, model for a multiple impeller fermenter.

Simulation examples of biological reaction Dynamic simulation of batch, fed-batch steady and transient culture metabolism; Numerical optimization of bioprocess using mathematical models. Processes using berkeley madonna, batch fermentation (batferm), chemostat fermentation (chemo), fed batch fermentation (fedbat), kinetics of enzyme action (mmkinet), repeated fed batch culture (repfed), lineweaver-burk plot (lineweav), steady-state chemostat (chemosta), variable volume fermentation (varvol and varvold), penicillin fermentation using elemental balancing (penferm), fluidized bed recycle reactor (fbr)

Design of Experiments and model validation

Reading:

1. I. J. Dunn, E. Heinzle, J. Ingham, J. E. Pfenosil "Biological Reaction Engineering: Dynamic Modelling Fundamentals with Simulation Examples" WILEY-VCH Verlag GmbH & Co. KGaA, Weinheitn ,2003
2. J.R. Leigh, Modeling and Control of fermentation Processes, Peter Peregrinus, London, 2000

Syam S. Sablani et al. Hand book of food and bioprocess modelling techniques, Taylor & Francis Group, LLC,2006

BT5114	Molecular Immunology	DEC	3 – 0 – 0	3 Credits

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

CO1	Comprehend basic concepts of immune system
CO2	Analyze antigen-antibody interactions
CO3	Relate immune response to cancer and infectious diseases
CO4	Apply immuno techniques for theranostics

Mapping of course outcomes with program outcomes

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

1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Introduction to Immune System, Innate & Adaptive Immunity, Cells of the Immune system, Organs of the Immune system: Structure and Functions, Immunoglobulin Structure, Immunoglobulin Isotypes: Structure and Functions, Concept of Epitope, Isotype, Allotype and Idiotype, Complement system, Monoclonal & Polyclonal antibodies, Antibody Engineering, Abzymes.

Organization and Expression of Immunoglobulin genes: Antibody Diversity: Somatic variation theory, Germ line theory, Tonegawa's bombshell: Immunoglobulin genes rearrange, Immunoglobulin Light chain (Kappa, Lambda) rearrangement, Immunoglobulin Heavy chain rearrangement, Immunoglobulin Class Switching, B-cell & T-cell Maturation, MHC: Structure and Functions, Antigen processing and presentation, B-cell activation by TI and TD antigens, T-cell activation: Cell mediated cytotoxic responses.

Antigen-antibody interactions: Concept of avidity, affinity & cross-reactivity, Agglutination, Precipitation, Immunodiffusion, ELISA, Immuno electrophoresis, Immunoprecipitation, ELISPOT assay, Radioimmunoassay, Immunofluorescence, Flow cytometry.

Autoimmune disorders, Immune response to infectious diseases, AIDS and other immune deficiencies, Immunodiagnosis of infectious diseases, Principles and strategy for developing vaccines, Transplantation & Immunosuppressive Therapy, Cellular therapy, Tumor Immunology.

Readings:

1. Kuby Immunology, 6th Edition by R.A. Goldsby, Thomas J. Kindt, Barbara, A. Osbarne (Freeman), 2007.
2. Cellular & Molecular Immunology, 7th Edition by Abul K Abbas, Andrew H. Lichtman, Shiv Pillai, 2011.
3. Roitt's Essential Immunology, 12th Edition by Peter J Delves, S. J. Martin, I. M. Roitt.2003

BT5115	OMICS Technology	DEC	3 – 0 – 0	3 Credits

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

CO1	Comprehend structural organization and sequencing methods of genomes
CO2	Apply suitable proteomic techniques for identification, purification, and modifications of proteins
CO3	Apply metabolomics principle for extraction and derivatization of metabolites

CO4	Analyze metabolites and their pathways

Mapping of course outcomes with program outcomes

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

1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Genomics: structure, organization and features of prokaryotic and eukaryotic genomes, genome polymorphism, molecular markers – RFLP, RAPD, SNP markers, genome sequencing methods, sanger sequencing, shotgun sequencing and next generation sequencing methods, genome sequence databases and gene annotation methods, methods for analyzing gene expression, basic and high throughput techniques.

Proteomics: protein purification techniques, analysis of protein – protein interactions, basic and high throughput techniques, analysis of proteome – 2D Gel electrophoresis, MALDI – TOF principles and applications, peptide mass fingerprinting, analysis of post-translational modifications in proteins, proteome databases, BLAST and sequence alignments.

Metabolomics: basic sample preparation methods, extraction, derivatization method for lipidomics, transcriptomics, glycomics, use of mass spectrometer, targeted metabolomics, assay development for small molecules, metabolomics data analysis, structural confirmation of metabolites, analysis of metabolic pathways, metabolite analysis.

Readings:

1. Primrose SB, Twyman RM, "Principles of gene manipulation and genomics" John Wiley Blackwell; 7th edition, 2014.
2. Hon-Chiu Eastwood Leung, Tsz-Kwong Man, & Ricardo J. Flores, "Integrative proteomics" InTechOpen, latest edition 2012.
3. John C. Lindon, Jeremy K. Nicholson, & Elaine Holmes, "The Handbook of Metabonomics and Metabolomics" Elsevier Science; 1st edition, 2006.

BT5116	**Protein Engineering**	**DEC**	**3 – 0 – 0**	**3 Credits**

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

CO1	Relate Protein structure to protein function
CO2	Comprehend protein folding pathways
CO3	Select appropriate techniques for protein engineering
CO4	Understand the protein characterization techniques.

Mapping of course outcomes with program outcomes

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

1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Protein synthesis, protein structure, protein function and structure-function relationships. Ramachandran Plot; Motifs of protein structures and their packing; Schematic and topology diagrams; Families of protein structures: alpha, alpha/beta,beta, small etc.

Protein folding pathways in prokaryotes and eukaryotes; Single and multiple folding pathways; Protein folding of single domain and multi-domain proteins; Inclusion bodies and recovery of active proteins; Osmolyte assisted protein folding; Structure of chaperones and role of chaperones in protein folding

Strategies for protein engineering; Random and site-directed mutagenesis; Various PCR based strategies; Role of low-fidelity enzymes in protein engineering; Gene shuffling and Directed evolution of proteins; Protein backbone changes; Antibody engineering;

Similar structure and function of homologous proteins; Role of multiple alignment; Homology and ab-initio method for protein structure prediction; Phage display systems; Structure based drug design and case studies, Rational protein design Different databases and their uses

Introduction to the concept of proteome, components of proteomics, proteomic analysis, importance of proteomics in biological functions, protein arrays, cross linking methods, affinity methods, yeast hybrid systems and protein arrays.

Protein identification Post translational modification, Proteome analysis: The impact of stable isotope labeling: Sample preparation, 2-D gel separation and analysis, Mass spectrometry: protein identification using MS data, Gel matching, Protein chips and applications. Functional Proteomics tools.

Readings:

1. Introduction to Protein structure, 2nd Ed by Carl Branden and John Tooze, Garland Press, 1999.
2. Structure and Mechanism in Protein Science, Alan Fersht, Freeman, 1999.
3. Protein engineering in Industrial biotechnology, Ed. Lilia Alberghina, Harwood Academic Publishers, 2002
4. Creighton T.E. “Proteins” 2nd Edition. W.H. Freeman, 1993.
5. Pennington, S.R and M.J. Dunn, “Proteomics: Protein Sequence to Function”. Viva Books, 2002

BT5117	Statistical programming	DEC	3 – 0 – 0	3 Credits

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

CO1	Comprehend basic principles of statistics for data management
CO2	Construct and operate matrices, data frames and arrays
CO3	Write programs using R for data processing

CO4	Visualize and plot data output

Mapping of course outcomes with program outcomes

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

1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Introduction to statistics, Introduction to R, R-studio, features of R; Calculating with R , Named storage, Functions, Listing the objects in the workspace, logical operators, arithmetic operators, boolean operators, vectors, extracting elements from vectors, vector arithmetic, simple patterned vectors, character vectors, factors, extracting elements from vectors, numeric vector, logical vector, subsetting vectors, named vectors, telling the class of vectors, converting vectors.

Matrices(Creating a matrix, Naming rows and columns, Subsetting a matrix, unit matrix, cross matrix, Computing covariance and correlation matrix, Using apply-family functions Lapply, sapply, vapply, mapply, dates and times, Built-in examples. Data frames Data frames Creating a data frame, Naming rows and columns, Subsetting a data frame, Subsetting a data frame as a list, Subsetting a data frame as a matrix, Filtering data, Setting values, Setting values as a list, Setting values as a matrix factors, useful functions for data frames, Loading and writing data on disk

Arrays, array indexing, subsections of an array, the array function, mixed vector and array arithmetic. the recycling rule, the outer product of two arrays, generalized transpose of an array, matrix facilities, matrix multiplication, linear equations and inversion, eigenvalues and eigenvectors, singular value decomposition and determinants, least squares fitting and the QR decomposition, forming partitioned matrices, cbind and rbind, the concatenation function, frequency tables from factors.

Data Handling; Reading and writing data, Reading and writing text-format data in a file, Importing data, Importing data using built-in functions, Importing data using the readr package, Reading and writing Excel/csv worksheets, Reading and writing native data files, Reading and writing a single object in native format, Saving and restoring the working environment Loading built-in datasets, Visualizing data, Creating scatter plots, Customizing chart elements, Plotting lines in multiple periods, Plotting lines with points, Plotting a multi-series chart with a legend, Creating bar charts, pie charts, histogram and density plots, box plots.

Readings:

1. Learning R Programming. By Kun Ren, Packt Publishing Ltd. 2002
2. Beginning R , an introduction to statistical programming. Larry Pace, Apress.1998
3. Hands-On Programming with R: Write Your Own Functions and Simulations. Garrett Grolemund, O'Reilly.2004
4. R Programming for Bioinformatics. Robert Gentleman, CRC press.2007

BT5118	Systems and Synthetic Biology	DEC	3 – 0 – 0	3 Credits

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

CO1	Illustrate basic principles of systems and synthetic biology
CO2	Analyze biological networks
CO3	Develop mathematical models for biological systems
CO4	Design synthetic biological networks

Mapping of course outcomes with program outcomes

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

1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Introduction to systems biology; high throughput experimental techniques: gene array, protein array, two-hybrid systems; steepness, threshold phenomenon, ultra-sensitivity, steady state, dynamic (spatial-temporal) and stochastic models in system biology.

Molecular networks - Emergent properties

Biological Networks: types, elements, complexity, Feedback Loops; Emergent behavior: adaptability, bistability, robustness, and evaluability; Noise in gene expression.

Molecular networks -Network Motifs

Network motifs: dynamics and response time of simple gene regulation, autoregulation, feed forward loops (FFLs), temporal expression programs and global structure.

Introduction to synthetic biology, application and tools; Simple synthetic networks – building and analysis; Synthetic genetic networks; Programmed population control, Bacterial Cell controlled by chemically synthesized genome. Synthetic Metabolic Pathway Engineering of microbes for various applications.

Signal transduction networks, *E. coli* chemotaxis network, Disease infection model, Robustness patterning in development- morphogen profiles, fruit fly patterning, Oscillatory systems - Circadian rhythm, synthetic oscillator; Bistable systems – Lac/ Trp Operon, Type II diabetes model, synthetic switch; Whole cell modelling, Systems pharmacology, Personalized models.

Readings:

1. Introduction to Systems Biology. URI ALON. Chapman and Hall/CRC Mathematical and Computational Biology, 2007.

2. Systems Modeling in Cellular Biology: From Concepts to Nuts and Bolts, Edited By ZOLTAN SZALLASI, JÖRG STELLING, VIPUL PERIWAL. Princeton Hall of India. ISBN: 978-81-203-

3172-3, 2007.
3. Computational Analysis of Biochemical Systems. EBERHARD O VOIT, Cambridge University Press, 2000.
4. Systems Biology and Synthetic Biology. PENGCHENG FU and SVEN PANKE (Editors). Wiley Publications, ISBN: 978-0-471-76778-7, 2009.

BT5119	Tissue Engineering and Stem Cell Technology	DEC	3 – 0 – 0	3 Credits

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

CO1	Classify different stem cells
CO2	Explain the construction of connective tissues
CO3	Select the process for isolation and identification of stem cells
CO4	Examine the construction of biomaterials
CO5	Identify regulatory considerations for design of biomaterials

Mapping of the Course Outcomes with Program Outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3					
CO2		3				
CO3			3			
CO4					3	
CO5					3	

1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Introduction to the balanced salt solutions and simple growth medium. Brief discussion on the chemical, physical and metabolic functions of different constituents of culture medium, Serum & protein free defined media and their application,

Biology and characterization of cultured cells, Maintenance and management of cell lines

Scale-up of animal cells in culture, Scale-up of anchorage dependent cells and suspension cultures:

Bioreactor for tissue engineering – Introduction, Design and scale up, Hollow fiber systems, Micro carrier based systems.

Stem Cells: Definition, classification and sources, Properties and application of embryonic stem cells. Cell adhesion – Extracellular matrix, *In vitro* cell proliferation. Induced pluripotent stem cells.

Application of stem Cells: Overview of embryonic and adult stem cells for therapy

Neurodegenerative diseases; Parkinson's, Alzheimer, Spinal Code Injuries and other brain

Syndromes;. Applications of stem cells in medicine and different disease models,
Biosafety and Stem cell research, Regulatory considerations and FDA requirements for stem cell therapy.

Reading:

1. Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications, Sixth Edition, R. Ian Freshney, 2011
2. Stem Cell Biology, David Gottlieb, Cold Spring Harbor, 2002
3. Essentials of Stem Cell Biology 3rd Edition,Robert Lanza Anthony Atala,2013
4. Principles of Tissue Engineering,Robert Lanza, Robert Langer and Joseph Vacanti, Elsevuer, 2013
5. Tissue Engineering,Academic Press,by Clemens van Blitterswijk, 2008

BT5161	**Agricultural Biotechnology**	**DEC**	**3-0-0**	**3 Credits**

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

CO1	Explain the concepts of Plant tissue culture techniques
CO2	Outline the technology of plant transformation
CO3	Illustrate the applications of biotechnology in the field of agriculture
CO4	Assess biosafety regulations in genetically modified crops

Mapping of the Course Outcomes with Program Outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2					
CO2		3				
CO3			3			
CO4					3	

1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus

An introduction, role of biofertilizers and bio-pesticides in sustainable agriculture. Mass cultivation of microbial inoculants, plant growth promoting rhizobacteria, diazotrophic microorganism, Free living and symbiotic nitrogen fixing microbes, Molecular basis of legume *rhizobium* symbiosis. Molecular aspects of abiotic stress responses and genetic engineering for drought, salinity and Temperature. Insect resistance – BT gene applications. Non-BT like protease inhibitors, alpha amylase inhibitors and lectins. Virus resistance – coat protein mediated, nucleocapsid gene and RNAi approach. Fungal resistance – PR proteins-1- chitinase, -3 beta glucanases. Nematode resistance - Nematode infestation and engineering for nematode resistance. Long shelf-life of fruits and flowers: use of ACC synthase, polygalacturanase, ACC oxidase. Male sterile lines: barstar and barnase systems. Genetic improvement of nutritional quality of oils-Molecular approaches, Molecular Pharming, Pheromone biotechnology.

Endophytes: plant-associated microbes as a new source of bioactive compounds, Bioprospecting: the search for bioactive lead structures from herbs, Biotechnological approaches for the production of plant-based chemotherapeutics and secondary metabolites, selection of high-yielding cell lines, Production of therapeutic antibodies in plants. Modern breeding of medicinal plants, Improvement

of a plant population by selection, Improvement of selection response by specific techniques, Characterization of medicinal plants, Biochemistry of flavor compound sand essential oils, Biotechnological applications of flavor compounds.

Readings:

1. Agricultural Biotechnology by Arie Altman. Marcel Dekker, Inc. 2012
2. S.B. Primrose. 1994. Molecular Biotechnology (2nd Edn), Blackwell ScietificPub.Oxford.
3. J.A. Davies and WS Reznikoff. 1992. Milestones in Biotechnology. Classic papers on Genetic Engineering. Butterworth-Heinemann, Boston, 1992.
4. D. Balasubramanian 2005. Concepts of Biotechnology new edition..
5. A. Old and S.B. Primrose. 2002. Principles of Gene Manipulation by Blackwell, Oxford

BT5162	BIOMATERIALS ENGINEERING	DEC	3 – 0 – 0	3 Credits

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

CO1	Classify biomaterials based on structure, properties and morphology.
CO2	Select methods to modify surfaces of biomaterials
CO3	Relate interactions between biomaterials, cells and tissues
CO4	Identify appropriate equipment for tissue engineering applications

Mapping of the Course Outcomes with Program Outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3					
CO2			3			
CO3					2	
CO4					3	

1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Introduction to biomaterials; need for biomaterials; classification of biomaterials and medical devices; Metallic implant materials, ceramic implant materials, polymeric implant materials, composites as biomaterials; Orthopedic, dental and other applications. Properties of materials; synthesis, characterization, and fabrication methods– Inert, biodegradable, hydrogels, Natural, Genetically engineered and Bioactive; Ceramics and glasses; Metals

Biocompatibility of Biomaterials: Protein structure, interaction of proteins with synthetic materials. Surface engineering for biocompatibility; Characterization of cell material interactions; inflammatory responses; acute inflammation, chronic inflammation, foreign body response, assessment of material performance

Biomaterial applications: Scaffolds for tissue engineering and regenerative medicine applications,

Biomaterials for drug delivery: Controlled Release. Cardiovascular implants. Artificial vascular grafts.

Biomaterials for ophthalmology, Skin repair/replacement materials

Bioreactors for tissue engineering and bone engineering applications, Spinner flask bioreactor, rotating wall bioreactor, direct perfusion bioreactor and Hollow fiber bioreactor
Ethical and legal Issues in Biomaterials and Medical Devices.

Readings

1. Buddy D. Ratner, *Biomaterials Science*: An Introduction to Materials in Medicine 3rd Edition, Academic Press, 2014
2. Sujatha V. Bhat, Biomaterials, 2nd Edition , Narosa Publishing house,2010
3. Fredrick H. Silver Medical Devices and Tissue engineering: An integrated approach 1st edition , chapman and Hall Publications,1993
4. Biomaterials Science and Biocompatibility, Fredrick H. Silver and David L. Christiansen, Piscataway, Springer, New Jersey.2002
5. Biological Performance of Materials: Fundamentals of Biocompatibility, Janathan Black, Marcel Dekker, Inc., New York and Basel, 1981.

BT5163	**Entrepreneurship, IPR & Biosafety, Bioethics**	**DEC**	**3 – 0 – 0**	**3 Credits**

Pre-requisites:

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

CO1	Explain the importance of embarking on self-employment
CO2	Understand company Law and commercial knowhow for biotechnological ventures
CO3	Identify issues in protection of biotechnology inventions
CO4	Adapt biosafety and bioethics principles

Mapping of course outcomes with program outcomes

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

1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Introduction to biotechnology entrepreneurship: strategies in biotechnology led ventures, biotechnology driven business opportunities, major hurdles and barriers in biotechnology driven ventures and their solutions, understanding company Law and commercial knowhow for biotechnological ventures, costing and capital budgeting in biotechnological ventures. Investing in biotechnology driven business, concept of biotechnology incubation center for knowledge-based industry.

Biotechnology and Intellectual issues: Introduction to Biotechnology in agriculture, medicine and industry, Biotechnology and its development in developing countries, patent eligibility issues in life science innovations: case study, checks and balances in biotechnology related patents, the importance of entrepreneurship in biotechnology, Intellectual property issues in agriculture, industrial and Pharmaceutical Biotechnology.

Biohazard identification: microbial flora of human and microbial virulence factors, indigenous and pathogenic agents of research animals, laboratory, growth chamber and green house microbial safety, epidemiology of laboratory associated infections, biohazard assessment, risk assessment of biological

hazards, biohazard control, administrative control, special considerations for Biosafety.

Bioethics, guidelines for conducting research with human subjects, Nuremberg code, Belmont report, Declaration of Helsinki.

Readings:

1. Craig Shimasaki, Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies, Academic Press, 2014
2. James F. Jordan, Innovation, Commercialization, and Start-Ups in Life Sciences, CRC Press; 1 edition 2014
3. Frank S. David, The Pharmagellan Guide to Biotech Forecasting and Valuation, Pharmagellan; 1st edition, 2017
4. Harikesh Bahadur Singh, Intellectual Property Issues in Biotechnology, CABI 1st edition, 2016
5. Kshitij Kumar Singh, Biotechnology and Intellectual Property Rights: Legaland Social Implications, Springer Nature; 2015 edition
6. Matthew Rimmer, Intellectual Property & Biotechnology: Biological Inventions, Edward Elgar, 2008
7. Goel and Parashar, IPR, Biosafety and Bioethics, Pearson Education India; First edition 2013 Diane O. Fleming (Editor), Debra L. Hunt, Biological Safety: Principles And Practices, ASM Press, 4th Edition

BT5164	**Environmental Biotechnology, Bioenergy & Biofuels**	**DEC**	**3 – 0 – 0**	**3 Credits**

Pre-requisites: Microbiology

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

CO1	Identify biotechnological processes in managing hazardous waste
CO2	Familiarize with biofuel policies, law, demand and supply barriers for energy
CO3	Identify potential biomass sources for biofuel generation.
CO4	Extend the Concept of biorefinery for replacing the oil dependent economy
CO5	Apply the synthetic biology and metabolic engineering principles for biofuels production
CO6	Elaborate the standards and life cycle assessment of biofuels

Mapping of course outcomes with program outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3					
CO2		3				
CO3			2			
CO4				3		
CO5						3

1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Bioremediation, pollution monitoring, Xenobiotics, Factors affecting bioaccumulation, Measurement of bioaccumulation, Waste water treatment, BOD, COD, Microbial removal of Nitrogen and Phosphorous, Waste water treatment in dairy and sugar industries, Activated sludge process, Biological nutrient removal, Wastewater treatment efficiency treatment. Solid waste management, Biotechnological process

in managing hazardous waste, Biomedical waste, Textile industry waste, Use of microbes in bioleaching, Metal recovery, Microbial recovery of phosphate and petroleum.

Introduction to oil economy, production and transportation, working principle of IC engines, significance of biofuels and bioenergy. Biofuels in the global energy scene, national biofuel policy and law. Biomass

structure and composition of biomass. Methods for biomass composition analysis.
Biomass conversion technologies: Biomass to liquid fuels and gaseous fuels thermochemical and biochemical technologies and processes. Biomass degrading enzymes and microorganisms.
First, second, third and advanced biofuels production technologies/process and challenges. Consolidated bioprocess engineering (CBP) for biofuels. Concept of Bio refinery: Biomass to value added compounds. Synthetic biology and metabolic engineering approaches (case studies) for biofuels production. Microbial fuel cells
Standards of biofuels, Life Cycle assessment of biofuels, Exergy analysis of biofuels, Photo bioreactor

Readings:

1. Vijai K. Gupta et al. Bioenergy Research: Advances and Applications Elsevier B.V. Netherlands 119, 2014. ISBN 978-0-444-59561-4.
2. Dahiya, A. (2015). Bioenergy: biomass to biofuels. Paperback ISBN: 9780124079090
3. Vaughn C. Nelson, Kenneth L. Starcher Introduction to Bioenergy (Energy and the Environment) by CRC Press ISBN 13: 978-1-4987-1699-4
4. Vijai K. Gupta et al. Biofuel Technologies- Recent Developments Springer-Verlag Berlin Heidelberg ISBN 978-3-642-34519-7
5. Kazuyuki Shimizu. Metabolic Regulation and Metabolic Engineering for Biofuel and Biochemical Production. ISBN 9781498768375 – CRC Press, 2017.
6. Keith Scott and Eileen Hao Yu. Microbial electrochemical and fuel cells _ fundamentals and applications (2015, Woodhead).

BT5165	Enzyme Engineering	DEC	3 – 0 – 0	3 Credits

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

CO1	Explain mechanism and function of enzymes
CO2	Assess enzymatic reaction kinetics
CO3	Identify methods for improving performance of enzymes
CO4	Explain the industrial applications of enzymes

Mapping of course outcomes with program outcomes

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

1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Nomenclature and classification of enzymes; Factors affecting the enzyme activity. Mechanism and regulation of enzyme activity; Production and degradation of the enzyme; Enzyme production by microbial fermentation. Methods for increasing the yield of enzymes in microorganisms.
Enzyme activity calculations; Kinetics of a single-substrate enzyme catalyzed reaction; Michaelis-menten - type rate expressions (single and multiple enzymes, autocatalysis, single and multiple substrates,

multiphasic systems, etc.), Km, Vmax, Plots for finding kinetic constants, Turnover number, Kcat; Kinetics of Enzyme Inhibition; Kinetics Allosteric enzymes; Statistical analysis of rate expressions;

Assessment of data, fitting of models to data, and generation of data; Physicochemical modulation of reaction rate.

Methods to improve enzyme performance: Mechanisms and methods of stabilizing enzyme; Immobilization of enzymes; Immobilized enzyme reactions; Mass transfer, Film and Pore diffusion effects on kinetics of immobilized enzyme reactions, Regeneration of cofactors; Enzymes in non-conventional media. Protein engineering of enzymes: Site directed mutagenesis; Random mutagenesis; Rational design; De novo enzyme design; Designer enzymes; Engineering substrate specificity.

Applications of enzymes for commercial biotransformation processes, synthesis of fine chemicals, food processing, biofuels, energy and environment; Bio-medical applications of enzymes; Design of enzyme electrodes; Biosensors.

Readings:

1. Palmer, T., Bonner, P., "Enzymes Biochemistry, Biotechnology, Clinical chemistry", 2nd edition, Wood Head Publishing, 2008.
2. Allan Svendsen, "Understanding Enzymes: Function, Design, Engineering, and Analysis", CRC Press, Taylor & Francis Group, 2016, ISBN: 978-981-4669-33-7
3. Yoo, Y.J., Feng, Y., Kim, Y.-H., Yagonia, C, "Fundamentals of Enzyme Engineering", 1st edition, Springer Netherlands, 2017, ISBN: 978-94-024-1026-6
4. Klaus Buchholz, Volker Kasche, Uwe Theo Bornscheuer, "Biocatalysts and Enzyme Technology", 2nd Edition, Wiley Publishing, 2012
5. James M Lee, "Biochemical Engineering", Prentice Hall of India Pvt. Ltd, 2009

BT5166	**Molecular Pathogenesis**	**DEC**	**3 – 0 – 0**	**3 Credits**

Pre-requisites: Microbiology

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

CO1	Understand the evolutionary aspects of pathogenesis
CO2	Simplify the molecular mechanisms of pathogenesis.
CO3	Understand the host pathogen interaction
CO4	Identify approaches to control pathogens

Mapping of course outcomes with program outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1				2		
CO2		2				
CO3					3	
CO4			2			

1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Microbes and diseases: Koches Postulets, Modern alternatives to Koch's Postulates, Human – microbe interactions, Molecular Koch's Postulates, Virulence, Role of genetic modifications in pathogen evolution.

Molecular mechanisms causing pathogen persistence. Pathogenic mechanisms in bacteria and protozoan parasite infection. Mechanisms of virulence gene regulation, Gene rearrangement, Transcriptional and Translational regulations, Quorum sensing in bacterial pathogens, Mechanisms of antibiotic resistance Molecular mechanisms of cell death, Acute and chronic inflammation induces disease pathogenesis, Infection and host response, Neoplasia, Basic concepts in human molecular genetics, Understanding molecular pathogenesis: Implications for improved treatment of human disease.

Readings:

1. Bacterial Pathogenesis: A Molecular Approach, 3rd ed. Brenda A Wilson et al, ASM Press, 2011.
2. Molecular Pathology: The Molecular Basis of Human Disease, 2nd Edition, William Coleman& Gregory Tsongalis, Academic Press, 2017.

BT5167	**Nanotechnology for Medicine and Healthcare**	**DEC**	**3 – 0 – 0**	**3 Credits**

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

CO1	Illustrate the basic principles of nanotechnology
CO2	Classify physical, chemical and biological methods for synthesis of nano materials
CO3	Apply the concepts of nanotechnology for biosensors
CO4	Identify nanostructures for drug delivery and gene therapy.

Mapping of course outcomes with program outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3					
CO2		2				
CO3				3		
CO4						2

1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Introduction to Nanotechnology, Types of nanomaterials: Nanoparticles, Nanowires, Nanotubes, Thin films and Multilayers. Synthesis of nanomaterials by physical and chemical methods, Synthesis of nanomaterials by biological methods, Characterization of nanomaterials. Functionalization of nanomaterials for biological applications.

Applications of nanomaterials in optical biosensors and imaging, quantum dots, Nanomaterials in electrochemical biosensors, Nanomaterials in bioseparation. Nanotechnology for cancer diagnosis.

Nanostructures for drug delivery, Nanovesicles; Nanospheres; Nanocapsules, Magnetic nanoparticles; Liposomes; Dendrimers, Concepts, Targeting, Routes of delivery and advantages, Cellular uptake

mechanisms of nanomaterials gene therapy.

Recent trends in nanobiotechnology, Biomolecules as Nanostructures, Molecular Motors, DNA nanotechnology, Nanotechnology in tissue engineering, Drug-Photodynamic therapy, Nanotoxicology

Readings:

1. M.Ratner and D.Ratner,Nanotechnology –a gentle introduction to the next big idea, Pearson education , Latest edition.2007.
2. Nanobiotechnology: Concepts, Applications and Perspectives *by Christof M. Niemeyer, Chad A. Mirkin.*Wiley, John & Sons.*2004. 1st Edition.*
3. L.E.Foster, Nanotechnology-Science, Innovation and opportunity, Person education inc, Latest edition. 2007
4. Jain, K.K., "The Handbook of Nanomedicine", Humana press. (2008)
5. Lamprecht, A., "Nanotherapeutics: Drug Delivery Concepts in Nanoscience", Pan Stanford Publishing Pte. Ltd. (2009)

BT5168	**Pharmaceutical Biotechnology**	**DEC**	**3 – 0 – 0**	**3 Credits**

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

CO1	Explain the strategies in new drug discovery process.
CO2	Extend the knowledge of pharmaceutical manufacturing
CO3	Outline the concept of pharmacodynamics and pharmacokinetics
CO4	Analyze the quality control procedures in the production of various biopharmaceuticals

Mapping of the Course Outcomes with Program Outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3					
CO2		3				
CO3			2			
CO4						3

1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

An overview and history of biopharmaceutical industry. The business and the future of Biopharmaceuticals. Drug regulation and control. Scope and applications of biotechnology in pharmacy. Strategies for new drug discovery, finding a lead compound, combinatorial approaches to new drug discovery, pre-clinical and clinical trials.

Routes of drug administration, membrane transport of drugs, absorption, distribution, metabolism and excretion of drugs. Factors modifying drug action, mechanism of drug action on human beings, receptor theory of drug action, pharmacogenomics, adverse effects of drugs and toxicology, Drug interactions.

Production of pharmaceuticals by genetically engineered cells- hormones and vaccines. Regulatory issues

in pharmaceutical products.
Quality control of antibiotic and non-antibiotic formulations using titrimetric, spectrophotometric,

chromatographic methods as per IP/US Pharmacopoeia. Microbiological assays of vitamins and antibiotics. Sterility testing and stability testing of parenteral formulations.

Reading:

1. Walsh, G., Biopharmaceuticals: Biochemistry and Biotechnology, Wiley (1998).
2. Gennaro, A.R., Remington: The Science and Practice of Pharmacy. Lippincott Williams and Wilkins (2005).
3. Tripathi, K.D., Essentials of Medical Pharmacology, Jaypee Brothers Medical Publishers (2008).
4. Pharmaceutical Biotechnology, Editor(s): Dr. Oliver Kayser, Prof. Dr. Rainer H. Müller, Wiley, 2004
5. Pharmaceutical Biotechnology, second edition. Crommelin J.A., Sindelar R.D. Routledge-Taylor&Francis, London, New York, 2003

BT5169	Research Methodology	PCC	3 – 0 – 0	3Credits

Pre-requisites: Basic biology

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

CO1	Illustrate history and methodologies of scientific research
CO2	Summarize the practice scientific reading, writing and presentations
CO3	Design of research problem and methods with scientific tools
CO4	Adapt scientific ethics and IPR

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3					
CO2		3				
CO3			3			
CO4					3	

1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Introduction to research: Motivation and objectives, research methods vs methodology. Types of research – descriptive vs analytical, applied vs fundamental, quantitative vs qualitative, conceptual vs empirical.

Research formulation: Defining and formulating the research problem, selecting the problem, literature review and technical reading, analysis and synthesis of prior art, bibliographic databases.

Research design and methods: basic principles, features of good design, observation and facts, laws and theories, Prediction and explanation, development of models, developing research plan – exploration, description, diagnosis, and experimentation. Execution of the research, data collection and analysis: Aspects of method validation, sampling methods, data processing and analysis strategies and tools.

Reporting and thesis writing: Structure and components of scientific reports, types of report, Thesis writing – different steps and software tools in the design and preparation of thesis, layout, structure

(chapter plan) and language of typical reports, Illustrations and tables, bibliography, referencing and footnotes. Oral presentation – planning, software tools, use of visual aids, importance of effective communication.

Research ethics, IPR and scholarly publishing: Ethics – ethical issues, ethical committees (human &animal); Scholarly publishing – IMRAD concept and design of research paper, citation and acknowledgement, plagiarism, reproducibility and accountability.

Readings:

1. C.R. Kothari, Research Methodology: Methods and Techniques New Age International (P) Ltd., Publishers, 2004
2. Dipankar Deb, RajeebDey, Valentina E. BalasEngineering Research Methodology, a Practical Insight for Researchers. ISSN 1868-4394 ISSN 1868-4408 (electronic) Springer Nature Singapore Pte Ltd. 2019.
3. PetterLaake, Haakon BreienBenestad, and BjørnReinoOlsenResearch Methodology in the Medical and Biological Sciences. ISBN: 978-0-12-373874-5, Elsevier 2007.