ACADEMIC CURRICULA

UNDERGRADUATE/ INTEGRATED POST GRADUATE DEGREE PROGRAMMES

(With exit option of Diploma)

(Choice Based Flexible Credit System)

Regulations 2021

Volume – 8
(Syllabi for Biotechnology Programming Courses)
(Revised on August 2024)

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

ACADEMIC CURRICULA

Engineering Science Courses

Regulations 2021

SRM INSTITUTE OF SCIENCE & TECHNOLOGY
(Deemed to be University u/s 3 of UGC Act, 1956)

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

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Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21CHS251T	Course Name	BASIC CHEMICAL ENGINEERING	Course Category	S	ENGINEERING SCIENCES	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Chemical Engineering*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*describe the basic principles of process calculation*
CLR-2:	*explain the concepts of Stoichiometry equations and material balances*
CLR-3:	*demonstrate the behavior of fluids and fluid flow phenomena*
CLR-4:	*describe the principles of filtration, working of filtration equipment's and concept of agitation*
CLR-5:	*illustrate the basic concepts and laws of thermodynamics*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*perform unit conversions and stoichiometric calculations*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*interpret material balance for non-reactive unit operations*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*apply fluid properties, continuity and Bernoulli equation for fluid flow*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*formulate the concepts of filtration and agitation in processes*	*1*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*comprehend the basic concepts and laws of thermodynamics for different processes*	*2*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-

Unit-1 - Fundamental Concepts of Stoichiometry	***9 Hour***
Concept of units and dimensions, system of units, unit conversions, basis of calculation, concept of mole, expressing composition of mixture of solids, liquids and gases - percentage by weight, mole and volume and density calculation, concentrations - molality, molarity, normality, ppm, predicting P-V-T properties of gases using ideal gas law	
Unit-2 - Material Balance in Unit Operations	***9 Hour***
Introduction to material balance, material balance for non-reactive chemical process systems - Mixing, Drying, Crystallization, Extraction, Chemical reactions and stoichiometric equations - limiting reactant, excess reactant, conversion, degree of completion, selectivity and yield, concept of recycle, purge and bypass stream	
Unit-3 - Fluid Flow Phenomena	***9 Hour***
Fluid, properties of fluids, type of fluids and flow, Fluid statics - hydrostatic equilibrium, Pressure measurement by manometers - simple U-tube, differential U-tube, inclined differential manometers, Reynolds number, continuity equation, Bernoulli equation	
Unit-4 - Filtration and Agitation	***9 Hour***
Concept of Filtration, Filter media, filter aid, principles of cake filtration, pressure drop through filter cake, Compressible and incompressible filter cakes, filter medium resistance, Constant pressure filtration, constant rate filtration, Filtration equipment's - principle and working of filter press, Vacuum leaf filter, rotary drum filters. Introduction to agitation, agitation equipment, impeller, turbines, flow patterns, prevention of swirling, draft tubes	
Unit-5 - Basic Concepts in Thermodynamics	***9 Hour***
Chemical Engineering Thermodynamics- System, surrounding, boundary, Work, Energy, Heat, Internal energy, Intensive and Extensive properties, State and path functions, processes and its type, equilibrium, enthalpy. Heat capacity- derivation for constant volume and constant pressure processes. First Law of Thermodynamics-Mathematical statement, sign convention, problems, Limitations of First Law of Thermodynamics, Energy balance for closed system. statement of second law of thermodynamics, concept of entropy, Third law of thermodynamics	

Learning Resources	1. *Himmelblau D.H. and James B. Riggs, Basic Principles and Calculations in Chemical Engineering, 8th Edition, Prentice Hall, 2012* 2. *Bhatt, B.I. and Thakore S.M., Stoichiometry, 5th Edition, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2010* 3. *Warren L. McCabe, Julian C. Smith and Peter Harriott, "Unit Operations of Chemical Engineering", 7th Edn., McGraw Hill Education (India) Edition, 2022*	4. *Noel de Nevers, Fluid Mechanics for Chemical Engineers, 2nd ed., McGraw Hill International Editions, 1991* 5. *Smith, J.M., Van Ness, H.C., Abbott, M.M., Introduction to Chemical Engineering Thermodynamics, 8 th ed., McGraw Hill International Edition, 2018*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd*	1. *Dr. Lima Rose Miranda, Anna University*	1. *Dr. S. Kiruthika, SRMIST*
2. *Mr. S. Stalin, Course Director, Chem Skill Development Centre*	2. *Dr. N. Anantharaman, Former Professor, NIT Trichy*	2. *Dr. E. Poonguzhali, SRMIST*

Course Code	21CHS252J	Course Name	CHEMICAL ENGINEERING PRINCIPLES	Course Category	S	ENGINEERING SCIENCE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Chemical Engineering*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*describe the various modes of heat transfer and evaluate the rate of steady state heat transfer*
CLR-2:	*explain and analyze the basic concepts of convection as applied to various flows and geometry*
CLR-3:	*illustrate principles of mass transfer, Diffusion phenomena, and calculate mass transfer rates*
CLR-4:	*elucidate the principles of drying, different types of drier and calculate drying time for different drying periods*
CLR-5:	*demonstrate the concept of distillation, extraction and adsorption*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*analyze steady state heat conduction and calculate the rate of heat transfer*	*2*	*2*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
CO-2:	*apply the basic concepts of convection and calculate the heat transfer coefficient*	*-*	*3*	*3*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
CO-3:	*interpret mass transfer principles and solve diffusion problems*	*-*	*2*	*3*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
CO-4:	*calculate drying time for different periods of drying*	*-*	*2*	*2*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
CO-5:	*comprehend the various types of distillation, extraction and adsorption for different processes*	*-*	*2*	*2*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*

Unit-1 - Conduction	***15 Hour***
Introduction to various modes of heat transfer, Concept of rate of heat transfer, heat flux, conduction, Fourier's law of heat conduction, Thermal conductivity, Steady state heat conduction through plane wall, composite wall, hollow cylinder, coaxial cylinders	
Unit-2 - Convection and Heat Exchangers	***15 Hour***
Concept of heat transfer by convection, Newton's law of cooling, Natural and forced convection- Dimensional analysis- Empirical correlations, Heat exchange equipment, Parallel and counter flow, LMTD, heat transfer area	
Unit-3 - Mass Transfer and Diffusion	***15 Hour***
Introduction to Mass Transfer, Diffusion, Types, Fick's law of Diffusion, Molecular diffusion in gases: steady state diffusion of A through non-diffusing B, Gas phase equimolal counter diffusion, Diffusion in Multicomponent gas mixtures, Molecular diffusion in liquids: steady state diffusion of A through non-diffusing B, Liquid phase equimolal counter diffusion, Effect of temperature and pressure on diffusivity	
Unit-4 - Drying	***15 Hour***
Drying - Importance of drying in processes, principles of drying, wet Basis, dry basis, Free moisture, equilibrium moisture, bound and unbound moisture, Mechanism of drying, drying curve, Calculation of drying time under constant drying conditions: constant rate and falling rate period, Total drying time, Classification of dryers, solids handling in dryers, tray, rotary, spray and fluidized bed drier	
Unit-5 - Distillation, Leaching and Adsorption	***15 Hour***
Introduction to Distillation, principle, Raoult's law, relative volatility, Types of distillation, batch distillation - Rayleigh's equation, flash and steam distillation, General principles of extraction, choice of solvent, mixer-settler, Introduction to leaching, adsorption – isotherm	

Practice	
Practice 1: Heat transfer through composite wall *Practice 2: Heat Transfer through composite lagged pipe* *Practice 3: Heat transfer by natural convection* *Practice 4: Heat transfer by forced convection* *Practice 5: Stefan-Boltzmann apparatus* *Practice 6: Double pipe heat exchanger* *Practice 7: Shell and tube heat exchanger*	*Practice 8: Estimation of Diffusivity* *Practice 9: Drying characteristics* *Practice 10: Batch distillation* *Practice 11: Steam distillation* *Practice 12: Single stage leaching* *Practice 13: Multi stage leaching* *Practice 14: Soxhlet Extractor* *Practice 15: Adsorption*

Learning Resources	1. *Robert E. Treybal, "Mass-Transfer Operations", 3rd Edn., McGraw Hill Education (India) Edition, 2012.* 2. *Warren L. McCabe, Julian C. Smith and Peter Harriott, "Unit Operations of Chemical Engineering", 7th Edn, McGraw Hill Education (India) Edition, 2022.* 3. *Christie John Geankoplis, "Transport Processes and Separation Process Principles (Includes Unit Operations)", 4thEdn, Pearson India Education Services Pvt. Ltd., 2015.*	4. *Binay K. Dutta, "Principles of Mass transfer and Separation Processes", Prentice- Hall of India, New Delhi, 2016.* 5. *N. Anantharaman and K. M. Meera Sheriffa Begum, "Mass Transfer Theory and Practice", Prentice Hall of India Pvt. Ltd., New Delhi, 2017.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd*	1. *Dr. Lima Rose Miranda, Anna University*	1. *Dr.S. Kiruthika, SRMIST*
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ACADEMIC CURRICULA

Professional Core Courses

Regulations 2021

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21BTC201L	Course Name	BIOCHEMISTRY LABORATORY	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							0	0	4	2

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biotechnology*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the preparation of laboratory reagents with competence and proficiency*
CLR-2:	*analyze the different forms of carbohydrates in samples qualitatively using different chemical tests*
CLR-3:	*determine the types of fatty acids, and use a variety of tests and reagents*
CLR-4:	*become familiar with chromatographic methods and use them to isolate and characterize various biological substances*
CLR-5:	*recognize the fundamentals of various reagents and how they interact with biomolecules for measurement*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*perform basic professional skills related to solutions, pH, and buffer preparation, as well as numerical calculations, focusing on the laboratory*	*3*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-
CO-2:	*identify the various ways in which different types of carbohydrates respond to chemical tests*	-	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-
CO-3:	*explain how various chemicals interact with fatty acids to determine the distinct types*	*3*	*3*	-	*3*	-	-	-	-	-	-	-	-	-	-	*3*
CO-4:	*develop methods for separating and detecting amino acids*	*3*	*3*	-	*3*	-	-	-	-	-	-	-	-	-	*3*	-
CO-5:	*describe the measurement of biomolecules in clinical and dietary samples*	-	*3*	-	*3*	-	-	-	-	-	-	-	-	-	*3*	-

Unit-1 - Basics of Analytical Biochemistry — ***12 Hour***

Practice:

1. Stoichiometric calculations – Molecular weight calculation, Molarity, Normality, Molality, % solution, w/w, v/w, v/v, etc.
2. Verifying the influence of H+ and OH- ions in the test solutions by pH meter.
3. Preparation of biological buffers.

Unit-2 - Qualitative Analysis of Biomolecules - Carbohydrates — ***12 Hour***

Practice:

1. Differentiate between aldose and ketose sugars with standards and natural food samples.
2. Identify whether the given sugar is pentose/reducing sugar or not with standards and food samples.
3. Distinguishes between mono or disaccharides also to check to reduce or non-reducing disaccharides with standards and food samples such as milk, malted sugars, and sugarcane juice/Jaggery.

Unit-3 - Qualitative Analysis of Biomolecules- Carbohydrates, Fatty Acids /Lipids — ***12 Hour***

Practice:

1. Verifying the given carbohydrate is starch – polysaccharide.
2. Qualitative analysis of fatty acids and cooking oils/fish oils.

Unit-4 - Separation of Biomolecules and Quantitative Analysis of Biomolecules	***12 Hour***
Practice: *1. Separation of amino acids from the mixture and boiled legumes as test samples by TLC and detection by using ninhydrin solution.* *2. Estimation of reducing sugar-glucose from the blood by 3, 5-Dinitrosalicylic acid (DNS) method.*	
Unit-5 - Quantitative Analysis of Biomolecules	***12 Hour***
Practice: *1. Estimation of protein from food samples by Lowry's method.* *2. Quantification of cholesterol from egg yolk by Zak's method.*	

Learning Resources	1. *Biochemistry Practical Manual - 2023.* 2. *Varley's Practical Clinical Biochemistry by Gowenlock A.H., 6th Edition, 2022 (8th Reprint), ISBN: 9788123904276, CBS Publishers & Distributors.*	3. *Principles and Techniques of Practical Biochemistry (5th Ed.).Wilson, K., Walker, J. (eds.); Cambridge University Press, Cambridge, 2000, 784 pp., ISBN 0-521-65873-X.* 4. *An Introduction to practical biochemistry (2nd edition): By David T. Plummer. Pp 362 McGraw-Hill Book Company (U.K.) Ltd., London 1978. https://doi.org/10.1016/0307-4412(78)90089-4*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)						Summative Final Examination (0% weightage)	
		CLA-1 Average of first cycle experiments (30%)		CLA-2 Average of second cycle experiments (30%)		Practical Examination (40% weightage)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	-	*15%*	-	*15%*	-	*15%*	-	-
Level 2	*Understand*	-	*20%*	-	*20%*	-	*20%*	-	-
Level 3	*Apply*	-	*25%*	-	*25%*	-	*25%*	-	-
Level 4	*Analyze*	-	*25%*	-	*25%*	-	*25%*	-	-
Level 5	*Evaluate*	-	*10%*	-	*10%*	-	*10%*	-	-
Level 6	*Create*	-	*5%*	-	*5%*	-	*5%*	-	-
	Total	*100 %*		*100 %*		*100 %*		-	

Course Designers

Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***
1. *Dr. G. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com*	1. *Prof. K Subramaniam, IITM, Chennai, suubu@iitm.ac.in*	1. *Dr. Pachiappan, SRMIST*
2. *Dr. Karthik Periyasamy, Scientist, Biocon, karthik.periyasamy@biocon.com*	2. *Prof. R. B. Narayanan, Anna University, Chennai arbeen09@gmail.com*	2. *Dr. S Subashini, SRMIST*

Course Code	21BTC202T	Course Name	MICROBIOLOGY	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biotechnology*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*introduce the concept of Microbiology and Microorganisms*
CLR-2:	*understand the growth, metabolism and adaptation of bacteria*
CLR-3:	*illustrate the structure and life cycle of eukaryotes*
CLR-4:	*illustrate the structure and life cycle of viruses*
CLR-5:	*analyze the applications of Microbiology in various fields*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*illustrate the structure of prokaryotes*	*2*	*2*	*2*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*2*	*-*	*-*
CO-2:	*understanding the growth of prokaryotes*	*2*	*2*	*2*	*-*	*2*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*2*	*-*	*-*
CO-3:	*explain the growth and life cycle of microbial eukaryotes*	*3*	*2*	*2*	*2*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*3*	*-*	*-*
CO-4:	*discuss the life cycle and pathogenicity of viruses*	*3*	*2*	*3*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*3*	*-*	*-*
CO-5:	*discuss the role of microbes and microbial products in various fields*	*3*	*2*	*2*	*-*	*3*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*3*	*-*	*-*

Unit-1 - Microscopy and Structure of Prokaryotes	***9 Hour***
Introduction to Microbiology. Characterization, Classification and Identification of microbes. Microscopy - Light, Electron and Advanced Microscopy. Structure of prokaryotes - Bacteria, Mycoplasma. Morphology, Structure, Cultivation, Reproduction and Pathogenicity of Actinomycetes	
Unit-2 - Metabolism and Adaptation of Prokaryotes	***9 Hour***
Metabolism of Prokaryotes: Bacteria - Growth curve and kinetics. Quantification of bacterial growth. Microbial metabolism: Non-biosynthetic and biosynthetic pathway. Adaptation mechanism of Halophiles, Alkaliphiles, Psychrophiles, Piezophiles, Xerophiles. Bacterial Recombination: Transformation, Transduction, Conjugation	
Unit-3 - Eukaryotes Structure and Methods of Microbial Control	***9 Hour***
Structure of eukaryotes: Fungi, Algae and Protozoa - Characteristics, Morphology, Reproduction, Physiology and Pathogenicity. Control of Microorganisms: Physical Control and Chemical Control. Antibiotics	
Unit-4 - Structure of Virus	***9 Hour***
Virus: Morphology, Structure, Classification and Pathogenicity. Bacteriophages: Lytic and Lysogenic life cycle of bacteriophages. Animal viruses, Plant viruses and Oncoviruses. Plaque assay.	
Unit-5 - Applications of Microbiology	***9 Hour***
Applications of Microbiology: Soil Microbiology - Microbial Interactions, Biogeochemical roles of Microbes.Aquatic Microbiology - Waste water treatment.Agricultural Microbiology - Biofertilizers. Environmental Microbiology - Bioremediation, Bioplastics, Biopolymers. Industrial Microbiology - Microbial metabolites. Medical Microbiology - Antibiotics and Vaccines	

Learning Resources	1. Pelczar MJ, Chan ECS and Krein NR: Microbiology, Mc Graw Hill, 10 th Edition, 2016. 2. Michael T. Madigan, Kelly S. Bender, Daniel H. Buckley, W. Matthew Sattley and David A. Stahl: Brock Biology of Microorganisms, Pearson. 15 th Edition, 2017.	3. Joanne M. Willey, Linda M. Sherwood, Christopher J. Woolverton: Prescott, Harley and Klein's Microbiology, Mc Graw Hill, International Edition, 10 th Edition, 2016. 4. Jawetz, MA Brooks, GF Butel JS and Morse SA: Medical Microbiology, Mc Graw Hill, 26 th Edition, 2012.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	15%	-	15%	-	15%	-
Level 2	Understand	25%	-	20%	-	25%	-
Level 3	Apply	30%	-	25%	-	30%	-
Level 4	Analyze	30%	-	25%	-	30%	-
Level 5	Evaluate	-	-	10%	-	-	-
Level 6	Create	-	-	5%	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. G. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	1. Prof. K Subramaniam, IITM, Chennai, suubu@iitm.ac.in	1. Dr. J. Lavanya, SRMIST.
2. Dr. Karthik Periyasamy, Scientist, Biocon, karthik.periyasamy@biocon.com	2. Prof. R. B. Narayanan, Anna University, Chennai arbeen09@gmail.com	2. Dr. R. Muthukumar, SRMIST.

Course Code	21BTC203L	Course Name	CELL AND MICROBIOLOGY LABORATORY	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							0	0	4	2

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biotechnology*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*provide basic differences between prokaryotic and eukaryotic organisms*
CLR-2:	*understand the different strategies of organization of cellular structures*
CLR-3:	*provide hands on training in isolation of cells and cell organelles*
CLR-4:	*focus on the cellular response to stimulus*
CLR-5:	*comprehend the mechanism of bacterial pathogenesis*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*distinguish between prokaryotic and eukaryotic cells using microscopic analysis*	-	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-
CO-2:	*gain proficiency in identifying the cellular structures*	-	-	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*3*
CO-3:	*acquire skills to isolate cells and cell organelles and relate with cell division*	-	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-
CO-4:	*critique the cell's response to stimuli thereby correlating cell signaling*	-	-	*3*	*3*	-	-	-	-	-	-	-	-	-	*3*	-
CO-5:	*integrate cell biology & microbiology to understand the bacterial pathogenesis in host*	-	-	-	*3*	-	-	-	-	-	-	-	-	-	-	*3*

Unit-1 - Distinguish Between Prokaryotic and Eukaryotic Cells — ***12 Hour***

Practice:

1. Microscopic observation of cells: Simple staining & Cross section of plant & animal tissues
2. Biochemical characterization of bacteria - IMVIC tests
3. Specific enzyme assays and substrate hydrolysis for bacterial identification

Unit-2 - Visualization of Cellular Structures Using Differential Staining — ***12 Hour***

Practice:

1. Cell wall staining – Gram staining/ Lactophenol cotton blue staining of fungi
2. Nuclear staining of cells using Giemsa
3. Bacterial Spore staining.

Unit-3 - Isolation of Cells/Cell Organelles and Cell Division — ***12 Hour***

Practice:

1. Isolation of bacteria by pour plate/spread plate and culturing techniques (Streak, Slant & Deep).
2. Isolation of Chloroplast from leaves and determination of chlorophyll content
3. Mitosis cell division in vegetative cells

Unit-4 - Response of Cell to Stimuli	***12 Hour***
Practice: *1. Stomatal movement in response to stimulus* *2. Bacterial motility using hanging drop technique* *3. Determination of cell viability using tryphan blue*	
Unit-5 - Understand the Mechanism of Bacterial Pathogenesis	***12 Hour***
Practice: *1. Bacterial Growth curve* *2. Antibiotic sensitivity tests using Kirby Bauer assay* *3. Adherence of Enteropathogenic E.coli on host cells.*	

Learning Resources	*1. Lab manual* *2. Chaitanya, k. V. Cell and molecular biology: A Lab Manual. India, PHI Learning, 2013.*	*3. Lorrence H. Green, Emanuel Goldman. Practical Handbook of Microbiology: Fourth Edition, CRC Press. Taylor and Francis; 2021.* *4. Julio E.Cellis. Cell Biology: A Laboratory Handbook. (2008). United Kingdom: Academic Press*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*						*Summative Final Examination (0% weightage)*	
		CLA-1 Average of first cycle experiments (30%)		*CLA-2 Average of second cycle experiments (30%)*		*Practical Examination (40% weightage)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	-	*15%*	-	*15%*	-	*15%*	-	-
Level 2	*Understand*	-	*20%*	-	*20%*	-	*20%*	-	-
Level 3	*Apply*	-	*25%*	-	*25%*	-	*25%*	-	-
Level 4	*Analyze*	-	*25%*	-	*25%*	-	*25%*	-	-
Level 5	*Evaluate*	-	*10%*	-	*10%*	-	*10%*	-	-
Level 6	*Create*	-	*5%*	-	*5%*	-	*5%*	-	-
	Total	*100 %*		*100 %*		*100 %*		-	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr. G. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	*1. Prof. K Subramaniam, IITM, Chennai, suubu@iitm.ac.in*	*1. Dr.S.Sujatha, SRMIST*
2. Dr. Karthik Periyasamy, Scientist, Biocon, karthik.periyasamy@biocon.com	*2. Prof. R. B. Narayanan, Anna University, Chennai arbeen09@gmail.com*	*2. Dr.J.Lavanya, SRMIST*

Course Code	21BTC204T	Course Name	BIOPROCESS PRINCIPLES	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biotechnology*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*describe the basics of the fermentation process*
CLR-2:	*explain the process of media formulation and sterilization kinetics*
CLR-3:	*study the basics of reactor design and its control systems*
CLR-4:	*analyze the metabolic stoichiometry and energetics of the biochemical process*
CLR-5:	*illuminate the various types of reactors for suspension and immobilized cell systems*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*understand the basics of the fermentation process*	*1*	-	*2*	-	-	-	-	-	-	-	-	-	*2*	*2*	*2*
CO-2:	*comprehend the process of media formulation and sterilization kinetics*	*2*	*2*	*2*	*2*	*2*	-	-	-	-	-	-	-	-	*2*	*1*
CO-3:	*acquire the basics of reactor design and its control systems*	*2*	-	*2*	*1*	*2*	-	-	-	-	-	-	-	*2*	*2*	*1*
CO-4:	*evaluate the metabolic stoichiometry and energetics of the biochemical process*	*2*	*3*	*1*	*2*	-	-	-	-	-	-	-	-	*2*	-	-
CO-5:	*explore the various types of reactors for suspension and immobilized cell systems*	*3*	-	*2*	*2*	-	-	-	-	-	-	-	-	*2*	*2*	*2*

Unit-1 - Microbial Cell Factories ***9 Hour***

Cellular systems as molecular factories and its industrial importance, Isolation and improvement of industrially important organisms, Types of fermentation, Upstream and downstream bioprocess, Process flow sheets of primary and secondary metabolites production- eg. ethanol, lactic acid, lysine, poly-L-lactic acid, lipase, rhamnolipid, streptomycin, insulin, Interferon, monoclonal antibody, tumour necrosis factor inhibitor, Pneumococcal conjugate vaccine.

Unit-2 - Design and Preparation of Media for Bioprocess ***9 Hour***

Bioreaction theory, Kinetics of biological systems, Growth patterns and kinetics of cells, Quantifying cell growth kinetic parameters, Optimization of cell growth environment, Types of media and classes of medium components. Media formulation and optimization of medium for the industrially important cultures - Microbial, plant and animal cells, Sterilization, Types of sterilization - batch, continuous and air sterilization

Unit-3 - Bioprocess Design - Instrumentation and Control Systems ***9 Hour***

Fermentation facility, equipment and space requirements - Fermenter design and its configuration, Body construction, Agitators, Stirrer glands and bearings, Spargers and valves, Aseptic operation and containment, Bioinstrumentation and its control - Methods of measuring process variables, Online analysis of chemical factors, Control systems, Combination of methods of the controller, Troubleshooting in a fermentation plant.

Unit-4 - Fundamentals of Biological Engineering ***9 Hour***

Material and energy balances for reactive and non-reactive systems; Stoichiometry of growth and product formation; Degree of reduction, electron balance and theoretical oxygen demand, Determination of stoichiometric coefficients, Theoretical prediction of yield coefficients, Conductive and convective heat transfer; Overall heat transfer coefficient, Bio-thermodynamics.

Unit-5 - Bioreactors for Suspension and Immobilized Cultures ***9 Hour***

Strategies for choosing a bioreactor, Microbial and immobilized cell system, Active and passive immobilization of Cells, novel reactors - Airlift Bioreactor, Fluidized Bed Bioreactor, Membrane Bioreactor, Photobioreactor, Biofilm reactor, Single-use bioreactors, Various modes of operation in Bioreactors, Performance equation of a batch, fed-batch and continuous reactors, Stability analysis of bioreactor.

Learning Resources	1. *Pauline M. Doran "Bioprocess Engineering Principles", 2nd Edition, Academic Press, 2012.* 2. *Michael L. Shuler, Fikret Kargi, Matthew DeLisa "Bioprocess Engineering: Basic Concepts", 3rd Edition, Prentice-Hall, 2017.*	3. *Hall, Stephen J., Stanbury, Peter F., Whitaker, Allan, "Principles of Fermentation Technology", 3rd Edition, Butterworth– Heinemann, 2017.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. S. Sam Gunasekar, Orchid Chemicals and Pharmaceuticals Ltd., Chennai., sam@orchidpharma.com*	1. *Prof. K Subramaniam, IITM, Chennai, suubu@iitm.ac.in*	1. *Dr. V. Vinoth Kumar, SRMIST*
2. *Dr. G. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com*	2. *Prof. R. B. Narayanan, Anna University, Chennai arbeen09@gmail.com*	2. *Dr. P. Radha, SRMIST*

Course Code	21BTC205L	Course Name	BIOPROCESS PRINCIPLES LABORATORY	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							0	0	4	2

Pre-requisite Courses	*Nil*	Co- requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	*Biotechnology*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*describe the basics of the fermentation process*
CLR-2:	*explain the process of media formulation and sterilization kinetics*
CLR-3:	*study the basics of reactor design and its control systems*
CLR-4:	*analyze the metabolic stoichiometry and energetics of the biochemical process*
CLR-5:	*illuminate the various types of reactors for suspension and immobilized cell systems*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*understand the basics of the fermentation process*	*1*	-	*2*	-	-	-	-	-	-	-	-	-	*2*	*2*	*2*
CO-2:	*comprehend the process of media formulation and sterilization kinetics*	*2*	*2*	*2*	*2*	*2*	-	-	-	-	-	-	-	-	*2*	*1*
CO-3:	*acquire the basics of reactor design and its control systems*	*2*	-	*2*	*1*	*2*	-	-	-	-	-	-	-	*2*	*2*	*1*
CO-4:	*evaluate the metabolic stoichiometry and energetics of the biochemical process*	*3*	*3*	*1*	*2*	-	-	-	-	-	-	-	-	*2*	-	-
CO-5:	*explore the various types of reactors for suspension and immobilized cell systems*	*3*	-	*2*	*2*	*3*	-	-	-	-	-	-	-	*2*	*2*	*2*

Unit-1 - Microbial Cell Factories — ***12 Hour***

Practice:

1. Estimation of glucose by DNS assay method
2. Production of enzymes by solid state fermentation
3. Production of enzymes by submerged fermentation
4. Effect of pH and temperature on enzyme activity

Unit-2 - Design and Preparation of Media for Bioprocess — ***12 Hour***

Practice:

1. Batch sterilization kinetics
2. Measurements of Cell Biomass Concentration
3. Medium optimization by Plackett - Burman design

Unit-3 - Bioprocess Design - Instrumentation and Control Systems — ***12 Hour***

Practice:

1. Fermenter operation – Demonstration/Explanation
2. Methods of measuring process variables during yeast fermentation in fermenter

Unit-4 - Fundamentals of Biological Engineering	***12 Hour***
Practice: *1. Microbial growth kinetics to determine the doubling time* *2. Microbial growth kinetics to determine the yield coefficient* *3. Enzyme kinetics – Michaelis Menten Kinetics and Lineweaver Burk – Plot*	
Unit-5 - Bioreactors for Suspension and Immobilized Cultures	***12 Hour***
Practice: *1. Preparation of immobilized cells/ enzyme* *2. Enzyme immobilization kinetics* *3. Production of ethanol by yeast*	

Learning Resources	*1. Debabrata Das, Debayan Das," Biochemical Engineering- A Laboratory Manual" Jenny Stanford Publishing, 2021.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*						*Summative Final Examination (0% weightage)*	
		CLA-1 Average of first cycle experiments (30%)		*CLA-2 Average of second cycle experiments (30%)*		*Practical Examination (40% weightage)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	-	*15%*	-	*15%*	-	*15%*	-	-
Level 2	*Understand*	-	*20%*	-	*20%*	-	*20%*	-	-
Level 3	*Apply*	-	*25%*	-	*25%*	-	*25%*	-	-
Level 4	*Analyze*	-	*25%*	-	*25%*	-	*25%*	-	-
Level 5	*Evaluate*	-	*10%*	-	*10%*	-	*10%*	-	-
Level 6	*Create*	-	*5%*	-	*5%*	-	*5%*	-	-
	Total	*100 %*		*100 %*		*100 %*		-	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr. S. Sam Gunasekar,Orchid Chemicals and Pharmaceuticals Ltd., Chennai.sam@orchidpharma.com	*1. Prof. K Subramaniam, IITM, Chennai, suubu@iitm.ac.in*	*1. Dr.M.Venkatesh Prabhu, SRMIST*
2. Dr. G. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	*2. Prof. R. B. Narayanan, Anna University, Chennai arbeen09@gmail.com*	*2. Dr. Vinoth kumar, SRMIST*

Course Code	21BTC206T	Course Name	GENETICS AND CYTOGENETICS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	*Biotechnology*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*describe the fundamental Laws of Genetics and interaction of genes*
CLR-2:	*explain the concepts and experiments in the preparation of linkage map*
CLR-3:	*describe the elements of Genetic Counseling*
CLR-4:	*analyze gene transfer and its role in mapping in bacteria*
CLR-5:	*differentiate factors that lead to genetic variation in a population*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1 Engineering Knowledge	2 Problem Analysis	3 Design/development of solutions	4 Conduct investigations of complex problems	5 Modern Tool Usage	6 The engineer and society	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*analyze the pattern of inheritance of genes and its interaction*	*2*	*2*	*2*	*2*	-	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*construct linkage maps from inheritance pattern of different genes*	*3*	*3*	*3*	*2*	-	-	-	-	-	-	-	-	*3*	-	-
CO-3:	*illustrate the role of Genetic Counselor and techniques in genetic testing*	*3*	*2*	*2*	*3*	-	-	-	-	-	-	-	-	*3*	-	-
CO-4:	*illustrate gene mapping based on the type of recombination in Bacteria*	*3*	*3*	*3*	*2*	-	-	-	-	-	-	-	-	*2*	-	-
CO-5:	*analyze genetic variations in a population*	*2*	*2*	-	*2*	-	-	-	-	-	-	-	-	*2*	-	-

Unit-1 - Pattern of Inheritance and Gene Interaction	***9 Hour***
Mendel's Experiments - Law of segregation, Law of independent assortment - Problems in Mendelian inheritance; Allelic interaction -Lethal genes, Non-allelic interaction – Epistasis, Duplicate genes, Complementary and inhibitory genes; Multiple allelism –ABO, Rh factor in Humans; Cytoplasmic inheritance; Mechanisms of sex determination and sex linked inheritance; Epigenetics - histone modification, methylation - x-inactivation, dosage compensation, Lyon hypothesis	
Unit-2 - Linkage and Chromosome Mapping	***9 Hour***
Chromosome structure, Chromosome organization, Giant chromosomes - polytene chromosome, Lampbrush chromosome; Linkage - Arrangement and types of linkage; Crossing over - Frequency of recombination, Cytological basis of crossing over - Stern's experiment; Chromosome mapping - Mapping by two factor cross, Mapping by three factor cross, Interference and Coincidence, Solving Problems, Combining of map segments, Preparation of linkage map; Somatic cell hybridization - HAT selection procedure	
Unit-3 - Basic Human Genetics	***9 Hour***
Mutation - classification, structural chromosomal aberration - deletion, duplication-tandem and dispersed repeats, inversion, translocation; Numerical aberration; Genetic counseling – History and pedigree construction – Autosomal and X-linked, Diagnosis - Human karyotype preparation, FACS, FISH, Counseling, Follow-up - Prenatal diagnosis – amniocentesis, chorionic villus sampling; Multifactorial inheritance – congenital malformation, diabetes, comparative genome hybridization	
Unit-4 - Bacterial Genetics	***9 Hour***
Bacterial genetics, Mechanisms of recombination, Transformation in bacteria - Mapping by transformation, Recombination by generalized transduction - Mapping by generalized transduction, Specialized transduction by lambda phage - Mapping by specialized transduction; Recombination by conjugation - Mapping by Interrupted mating analysis, Preparation of linkage map in bacteria, Fine structure mapping by Merozygote analysis	

Unit-5 - Population Genetics	***9 Hour***
Population genetics, Allele frequency - Calculation of allele frequency in a population, Calculation of genotype frequency - Hardy-Weinberg equilibrium, Applications of Hardy Weinberg equilibrium; Changes in allele frequency - Changes in allele frequency by mutation, changes in allele frequency by migration - migration dynamics, changes in allele frequency by selection - selection dynamics, Random genetic drift - Loss of heterozygotes, Genetic equilibrium	

Learning Resources	1. *Gardner, Simmons, Sunstad, "Principles of Genetics," 8 th edition – John Wiley and Sons, Inc., 2006.*	2. *Monroe W. Strickberger, "Genetics," 3 rd edition – Phi Learning, 2015* 3. *Peter Sunstad and Michael Simmons "Principles of Genetics" 7th edition, Wiley, 2015*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. C. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com*	1. *Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in*	1. *Dr. S. Barathi, SRMIST*
2. *Dr. Karthik Periyasamy, Scientist, Biocon, karthik.periyasamy@biocon.com*	2. *Prof. R. B. Narayanan, Anna University, Chennai arbeen09@gmail.com*	2. *Dr. K.T. Ramya Devi, SRMIST*

Course Code	21BTC207T	Course Name	MOLECULAR BIOLOGY	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	*Biotechnology*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*know the structures of nucleic acids and their role as hereditary materials*
CLR-2:	*adopt the structure of nucleic acids for their expression and regulation*
CLR-3:	*explain the basis and mechanism of protein synthesis and activity*
CLR-4:	*understand the regulatory role of nucleic acids in cell functioning*
CLR-5:	*scrutinize the controlling events of gene expression under anabolic and catabolic conditions*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*reminisce the structure of nucleic acids at the DNA and RNA levels*	-	*3*	-	-	-	-	-	-	-	-	-	-	-	*2*	*3*
CO-2:	*comprehend the analysis of functioning of nucleic acids*	-	*2*	*2*	-	-	-	-	-	-	-	-	-	-	*2*	*2*
CO-3:	*relate the expression of DNA at the different levels*	*3*	-	*1*	-	-	-	-	-	-	-	-	-	-	*3*	*3*
CO-4:	*assess the mechanisms of protein synthesis with the genetic code*	*3*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	*3*
CO-5:	*invoke the various regulatory elements and mechanisms controlling gene expression*	*3*	*2*	*2*	*1*	-	-	-	-	-	-	-	-	-	*3*	*3*

Unit-1 - Structure and Composition of Nucleic Acids	***9 Hour***
Genetic information and its perpetuation; Development of molecular biology; History of nucleic acids; Landmark experiments of DNA as the genetic material; Modes of DNA replication; DNA constituents; DNA structure and its stability; DNA models; A-, B- and Z-DNA forms; Central dogma; DNA topology	
Unit-2 - Replication and Repair of DNA	***9 Hour***
Basic rules for replication; Chemistry of DNA synthesis; Types and the mechanisms of DNA replication; Replication enzymes; DNA polymerases in prokaryotic and eukaryotic replications; Proof reading activity of DNA polymerase; Topoisomerases; Events in the replication fork; Models of DNA replication; DNA repair mechanism	
Unit-3 - Transcription and Post Transcription	***9 Hour***
Basic features of RNA synthesis; RNA polymerases; Types and function of RNA polymerases; DNA promoters- structure and function; Epigenetics Fundamentals; RNA transcription; Transcription of mRNA, rRNA, and tRNA genes; RNA processing; Posttranscriptional modifications of mRNAs; RNA editing-RNAi and miRNAs	
Unit-4 - Translation and Post Translation	***9 Hour***
Coding of genetic information; Outline of translation; Translation in prokaryotes and eukaryotes; Polyribosome; Posttranslational modifications; Protein folding and sorting; Protein targeting into mitochondria and nucleus;	
Unit-5 - Gene Regulation	***9 hour***
General aspects of Regulation; Gene regulators; Silencers and Enhancers; Operons; Positive and negative gene regulations; The operon models; Lac, Trp, Ara and Gal operons and their regulations	

Learning Resources	1. *Robert Weaver, Molecular Biology, McGraw-Hill, 2011*	2. *James D Watson, Molecular Biology of Gene, Pearson Publisher, 2017*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. S. Sam Gunasekar, Orchid Chemicals and Pharmaceuticals Ltd., sam@orchidpharma.com*	1. *Dr. Aravind Rengan, Indian Institute of Technology Hyderabad. aravind@bme.iith.ac.in*	1. *Dr. N. Selvamurugan, SRMIST*
2. *Dr. D. Gunaseelan, BIOCON Ltd., guna.sachin@gmail.com*	2. *Dr. K. Subramanian, Indian Institute of Technology Madras. subbu@iitm.ac.in*	2. *Dr. S. Barathi, SRMIST*

Course Code	21BTC208L	Course Name	MOLECULAR BIOLOGY LABORATORY	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							0	0	4	2

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biotechnology*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the genetic material as DNA in prokaryotes*
CLR-2:	*evaluation of the DNA in prokaryotes*
CLR-3:	*understand the extrachromosomal element and gene transcripts in prokaryotes*
CLR-4:	*dissection of extrachromosomal element and gene transcripts*
CLR-5:	*know DNA damage in prokaryotes*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*reminisce genetic materials in unicellular organisms*	-	*3*	-	-	-	-	-	-	-	-	-	-	-	*2*	*3*
CO-2:	*comprehend the isolation and characterization of genetic materials*	*3*	*2*	*2*	-	-	-	-	-	-	-	-	-	-	*2*	*2*
CO-3:	*retrospect the genetic materials at different levels*	*3*	-	*1*	-	-	-	-	-	-	-	-	-	-	*3*	*3*
CO-4:	*relate the co-existence of these materials*	*3*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	*3*
CO-5:	*invoke the genetic defect causing cell death*	*3*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	*3*

Unit-1 - Genomic DNA Isolation and Analysis — ***12 Hour***

Practice:

1. Isolation of Genomic DNA from E.coli
2. Quantitative Analysis of Genomic DNA
3. Qualitative Analysis Genomic DNA

Unit-2 - Plasmid DNA Isolation and Analysis — ***12 Hour***

Practice:

1. Isolation of Plasmid DNA from E.coli
2. Quantitative Analysis of Plasmid DNA
3. Qualitative Analysis of Plasmid DNA

Unit-3 - Total RNA Isolation and Analysis — ***12 Hour***

Practice:

1. Isolation of Total RNA from E.coli
2. Quantitative Analysis of Total RNA
3. Qualitative Analysis of Total RNA

Unit-4 - DNA Cloning Enzymes	***12 Hour***
Practice: *1. Restriction Enzyme Digestion of DNA* *2. Ligation of DNA Fragment into Plasmid* *3. E.coli Transformation*	
Unit-5 - DNA Damage	***12 Hour***
Practice: *1. Effect of UV radiation on Bacterial Growth*	

Learning Resources	*1. Molecular Cloning, A Laboratory Manual by M. R. Green and J. Sambrook, 2012, Cold Spring Harbor Laboratory Press*	*2. Molecular Biology Techniques, A Classroom Laboratory Manual, 2019, Elsevier Press*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)						Final Examination (0% weightage)	
		CLA-1 Average of first cycle experiments (30%)		CLA-2 Average of second cycle experiments (30%)		Practical Examination (40% weightage)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	-	*15%*	-	*15%*	-	*15%*	-	-
Level 2	*Understand*	-	*20%*	-	*20%*	-	*20%*	-	-
Level 3	*Apply*	-	*25%*	-	*25%*	-	*25%*	-	-
Level 4	*Analyze*	-	*25%*	-	*25%*	-	*25%*	-	-
Level 5	*Evaluate*	-	*10%*	-	*10%*	-	*10%*	-	-
Level 6	*Create*	-	*5%*	-	*5%*	-	*5%*	-	-
	Total	*100 %*		*100 %*		*100 %*		-	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. S. Sam Gunasekar, Orchid Chemicals and Pharmaceuticals Ltd., sam@orchidpharma.com	*1. Dr. K. Subramanian, Indian Institute of Technology Madras. subbu@iitm.ac.in*	*1. Dr. N. Selvamurugan, SRMIST*
2. Dr. D. Gunaseelan, BIOCON Ltd., guna.sachin@gmail.com	*2. Dr. Sudha Warrier, Professor and Dean, Manipal University, sudha.warrier@mannipal.edu*	*2. Dr. S. Barathi, SRMIST*

Course Code	21BTC209T	Course Name	BIOPROCESS ENGINEERING	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biotechnology*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*enumerate the Ideal and Non- Ideal Reactors*
CLR-2:	*discuss the fluid flow and its mixing in the reactor*
CLR-3:	*explain the mass and heat transfer in the reactor, and scale up in Bioreactor*
CLR-4:	*describe the structured and unstructured models of microbial system*
CLR-5:	*discuss modern tools in Bioprocess Engineering*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*understand the ideal and non-ideal systems in bioprocess engineering*	*3*	*3*	*3*	-		-	-	-	-	-	-	-	*1*	-	-
CO-2:	*gain knowledge on fluid flow and its mixing property*	*3*	*2*	*1*	*2*	-	-	-	-	-	-	-	-	*2*	*2*	-
CO-3:	*acquire knowledge in transport phenomena and scale up studies*	*3*	*2*	*1*	*1*	-	-	-	-	-	-	-	-	*2*	*2*	*2*
CO-4:	*understand structured and Unstructured models*	*2*	*1*	*3*	*1*	-	-	-	-	-	-	-	-	*2*	-	-
CO-5:	*apply modern tools in modelling of bioprocess system*	*1*	*1*	*3*	*3*	*3*	-	-	-	-	-	-	-	*2*	*2*	-

Unit-1 - Ideal and Non- Ideal Bioreactors — ***9 Hour***

Ideal Batch, Fed-Batch, Continuous, Enzymatic catalyzed reaction in CSTR, CSTR with Recycle, Ideal Plug flow reactor. Reactors with Nonideal mixing-mixing times in RTD, Models for Non-ideal reactors-Tanks in Series Model- Dispersion models.

Unit-2 - Fluid Flow and Mixing in Bioreactors — ***9 Hour***

Classification in fluids, Reynolds Number, Viscosity, Momentum Transfer, Non-Newtonian fluid, Rheological Properties of Fermentation Broths, Factors Affecting Broth Viscosity, Mixing- Power Requirements for Mixing- Scale-Up of Mixing Systems- Improving Mixing in Fermenters- Effect of Rheological Properties on Mixing- Role of Shear in Stirred Fermenters

Unit-3 - Transport Phenomena and Scaleup in Bioreactors — ***9 Hour***

Gas liquid mass transfer in cellular systems, Determination of Oxygen Transfer Rates, Forced Convection mass transfer, Correlation for Mass Transfer Coefficients, and Interfacial areas. Heat Transfer correlations. Scale up concerns in Microbial, Mammalian and plant cell Process-Scale up criteria-Selection of scaleup criteria-scaleup of genetically engineered cell culture fermentation.

Unit-4 - Models in Bioprocess — ***9 Hour***

Model classification- Model Formulation- Unstructured Models- Phases of batch growth cycles-Monod Models-Multiple substrate models and model Inhibition, Models of growth and non-growth product inhibition, Models for the growth of fungi, Plant cell and Animal cells, Structured models- Models of metabolites and growth-compartmental Models-Models of product formation.

Unit-5 - Modelling and Simulation in Bioprocessing — ***9 Hour***

Introduction to modelling and Simulation. Modelling and simulation of Batch, Fed-Batch and Continuous system using MATLAB. Artificial Intelligence and Machine Learning in bioprocessing. Introduction of object-oriented modelling in bioprocess using Python.

Learning Resources	1. *James E.Bailey, David F.Ollis "Biochemical Engineering Fundamentals", 2nd Edition, Mc Graw Hill, 1986.* 2. *Pauline M. Doran "Bioprocess Engineering Principles", 2nd Edition, Academic press, 2012.*	3. *S.N.Mukhopadhyay "Process Biotechnology Fundamentals", 2nd Edition, 2004.* 4. *Michael L. Shuler, Fikret Kargi, Matthew De Lisa "Bioprocess Engineering: Basic Concepts", 3rd Edition, Prentice-Hall, 2017.* 5. *Ravindra Pogaku,"Horizons in Bioprocess Engineering"Springer,2019*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Dr. S. Sam Gunasekar,Orchid Chemicals and Pharmaceuticals Ltd., Chennai,sam@orchidpharma.com*	1. *Dr.S.Senthil Kumar, IITG*	1. *Dr.M.Venkatesh Prabhu, SRMIST*
2. *Dr. G. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com*	2. *Dr.N.Selvaraj, IITG*	2. *Dr.P.Radha, SRMIST*

Course Code	21BTC210L	Course Name	BIOPROCESS ENGINEERING LABORATORY	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							0	0	4	2

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biotechnology*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*explain the Residence Time Distribution in Stirred tank and Plug flow reactor*
CLR-2:	*describe the rheological and mixing behavior of fermented fluid*
CLR-3:	*analyze the oxygen mass transfer coefficient and deactivation kinetics*
CLR-4:	*evaluate the model parameters in microbial growth*
CLR-5:	*discuss the modern tool of programming microbial cultures*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*explore the Residence Time Distribution studies in Stirred tank and Plug flow reactor*	*3*	*3*	*2*	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-2:	*understand the rheological and mixing behavior of fermented fluid*	*3*	*3*	*1*	-	-	-	-	-	-	-	-	-	*2*	*2*	-
CO-3:	*measure the oxygen mass transfer coefficient and deactivation kinetics parameters*	*3*	*3*	*2*	-	-	-	-	-	-	-	-	-	*2*	*2*	-
CO-4:	*estimate the model parameters in microbial growth*	*3*	*3*	*1*	-	-	-	-	-	-	-	-	-	*2*	*2*	-
CO-5:	*learn the modern tool for programming the microbial cultures*	*1*	*2*	*3*	-	*3*	-	-	-	-	-	-	-	*2*	*2*	-

Unit-1 - Non-Ideal Reactors	***12 Hour***
Practice: *1. RTD studies in Stirred tank reactor* *2. RTD studies in Plug flow reactor*	
Unit-2 - Fluid Flow and Mixing in Bioreactors	***12 Hour***
Practice: *1. Rheological study of fermented fluids* *2. Regime analysis of a stirred tank reactor* *3. Determination of mixing time in a stirred tank reactor*	
Unit-3 - Transport Phenomena and Scale-up in Bioreactors	***12 Hour***
Practice: *1. Determination of KLa by power correlation method* *2. Determination of KLa by dynamic gassing out method* *3. Deactivation kinetics of enzymatic reaction* *4. Deactivation kinetics of microbial growth*	

Unit-4 - Models in Bioprocess	***12 Hour***
Practice: *1. Estimation of unstructured model parameters of bacterial culture* *2. Estimation of unstructured model parameters of yeast culture*	
Unit-5 - Modelling and Simulation in Bioprocessing	***12 Hour***
Practice: *1. Modelling and simulation of Batch culture using MATLAB* *2. Modelling and simulation of continuous culture using MATLAB* *3. Modelling and simulation of Fed culture using MATLAB* *4. Modelling of batch reactor using Python*	

Learning Resources	*1. Hans-Peter Schmauder,"Methods in Biotechnology" Taylor and Francis Ltd, 2003.* *2. Arvind Kumar Bhatt,"Basic Biotechniques for Bioprocess and Bioentrepreneurship"Academic Press, Elsevier ,2023*	*3. Shijie Liu,"Bioprocess Engineering Kinetics, Sustainability, and Reactor Design"Elsevier, 2020.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)						Final Examination (0% weightage)	
		CLA-1 Average of first cycle experiments (30%)		CLA-2 Average of second cycle experiments (30%)		Practical Examination (40% weightage)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	-	15%	-	15%	-	15%	-	-
Level 2	Understand	-	20%	-	20%	-	20%	-	-
Level 3	Apply	-	25%	-	25%	-	25%	-	-
Level 4	Analyze	-	25%	-	25%	-	25%	-	-
Level 5	Evaluate	-	10%	-	10%	-	10%	-	-
Level 6	Create	-	5%	-	5%	-	5%	-	-
	Total	100 %		100 %		100 %		-	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. S. Sam Gunasekar,Orchid Chemicals and Pharmaceuticals Ltd., Chennai.sam@orchidpharma.com	1. Dr.S.Senthil Kumar, IITG, senthilkumar@iitg.ac.in	1. Dr.M.Venkatesh Prabhu, SRMIST
2. Dr. G. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	2. Dr.N.Selvaraj, IITG, selva@iitg.ac.in	2. Dr.P.Radha, SRMIST

Course Code	21BTC301J	Course Name	GENE MANIPULATION AND GENOMICS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biotechnology*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*assess the basic concepts and principles of utilization of different expression vectors for cloning from the perspective of engineers*
CLR-2:	*demonstrate the different strategies of gene cloning and construction of genomic and cDNA libraries*
CLR-3:	*analyze the concepts of structural and functional genomics with advanced cutting-edge technologies*
CLR-4:	*assess the applications of recombinant DNA technology in animals, plants, and microbial organisms*
CLR-5:	*develop and apply the strategies on altering gene expression in vitro and in vivo*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*describe the foundations of modern biotechnology*	-	-	*3*	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-2:	*design and conduct experiments involving genetic manipulation*	-	-	*2*	-	-	*2*	-	-	-	-	-	-	-	-	*3*
CO-3:	*illustrate the steps involved in the production of biopharmaceuticals in microbial and mammalian cell systems*	*2*	-	-	-	-	-	-	*2*	-	-	-	-	-	-	*3*
CO-4:	*apply modern biotechnology in the different areas like medicine, microbes, environment, and agriculture*	*3*	-	-	-	-	*3*	-	-	-	-	-	-	-	-	*3*
CO-5:	*discuss the cutting-edge techniques and their applications such as plant transformation, protein expression and genomic DNA library construction etc.*	*3*	-	*2*	-	-	-	-	*2*	-	-	-	-	-	-	*3*

Unit-1 - Overview of Cloning and Vectors ***15 Hour***

Introduction to genomics and gene regulation; Fundamental requirement for DNA cloning; Prokaryotic and eukaryotic vectors; Phage vectors; Strategies for gene cloning; Enzymes in genetic engineering

Practice*: 1. Genomic DNA isolation*
2. Double digestion of Genomic DNA

Unit-2 - Preparation and Screening of DNA library ***15 Hour***

DNA Library; Preparation of DNA Libraries; Genomic DNA library; Overlapping and non-overlapping DNA fragments; Choice of vectors; Evaluation of genomic DNA library; cDNA library; Purification and separation of mRNA; cDNA synthesis; cDNA library construction; Evaluation of cDNA library; Screening libraries; Polymerase chain reaction (PCR) and its applications

Practice*: 1. Double digestion of Vector*
2. Preparation of recombinant vector
3. E. coli Transformation

Unit-3 - DNA Sequencing and Genomics ***15 Hour***

DNA sequencing strategies; Principles of DNA sequencing; Sanger's Dideoxy sequencing method; Automated DNA sequencing; Next generation sequencing; Genome sequencing; Next generation sequencing and its applications; Methods of nucleic acid detection; Random priming; Nick translation and End labeling; RNA labeling; Non-isotopic labeling; Structural genomics; comparative genomics; Microarray

Practice*: 1. Colony PCR*
2. Functional Assay

Unit-4 - Analysis and Manipulation of Gene Expression and Function	***15 Hour***
Regulation of gene expression at different levels; Factors influencing gene expression; Epigenetic regulation; Protein expression in prokaryotic and eukaryotic cells; Alteration of gene expression by mutagenesis; Methods for site directed mutagenesis ***Practice**: 1. RNA isolation* *2. cDNA synthesis* *3. Semi-quantitative PCR*	
Unit-5 - Applications of Cloning	***15 Hour***
Medical applications; Human and genetic diseases; DNA vaccines; Gene therapy; Study of gene function in vivo; Embryonic stem cells; Applications in Embryonic stem cells; Transgenics; Methods of producing transgenic mice; Over-expression; Gene knock-in; Gene knock-out; Conditional knock-out; Genome editing; CRISPER-Cas9; Guide RNA; Gene inactivation ***Practice**: 1. Quantitative PCR* *2. Fold and Relative Gene Expression*	

Learning Resources	1. *Jeremy W. Dale and Malcolm von Schantz, "From Genes to Genomes," John Willey and Sons Publications, 2002* 2. *Old. R.W and Primrose. S.B, "Principles of Gene Manipulation, An Introduction to Genetic Engineering," Blackwell Scientific Publications, 2014*	3. *S. B. Primrose and R. M. Twyman, "Principles of Gene Manipulation and Genomics"7th Edition,Wiley-Blackwell, 2006* 4. *T A Brown Gene Cloning and DNA Analysis: An Introduction 8th Edition, Wiley Blackwell Publisher 2020*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*CLA-2-Practice (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	-	*15%*	*15%*	-
Level 2	*Understand*	*25%*	-	-	*20%*	*25%*	-
Level 3	*Apply*	*30%*	-	-	*25%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*25%*	*30%*	-
Level 5	*Evaluate*	-	-	-	*10%*	-	-
Level 6	*Create*	-	-	-	*5%*	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. C. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com*	1. *Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in*	1. *Dr. N. Selvamurugan, SRMIST*
2. *Dr. Karthik Periyasamy, Scientist, Biocon, karthik.periyasamy@biocon.com*	2. *Prof. R. B. Narayanan, Anna University, Chennai arbeen09@gmail.com*	2. *Dr. S. Barathi, SRMIST*

Course Code	21BTC302J	Course Name	IMMUNOLOGY	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biotechnology*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*introduce the science of immunology and a detailed study of various types of immune cells*
CLR-2:	*provide knowledge about immune systems produced molecules and their classification, structure, and function*
CLR-3:	*provide students with experience in methods used in immunology, particularly the use of specific antibody in biomolecular applications*
CLR-4:	*provide knowledge about major histocompatibility complex and acquired immune system, their cells and its interaction and how they fight against infectious diseases*
CLR-5:	*provide knowledge about dysregulation of immune system functioning, ways to strengthen immune system and how human body is designed and protected to fight against various pathogens*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*describe the immune system, their structure, classification and function*	-	-	*2*	-	-	-	-	-	-	-	-	-	*1*	-	*1*
CO-2:	*summarize genetic control of antibody diversity, monoclonal antibodies and cellular immunology*	-	-	*2*	*2*	*2*	-	-	-	-	-	-	-	*1*	-	*2*
CO-3:	*determine various methods to assess immune function, their application and interpretation of the results*	-	-	-	*2*	*3*	-	-	-	-	-	-	-	*3*	-	*3*
CO-4:	*outline major histocompatibility complex, types, function and the role of acquired immune cells signalling and its function*	-	-	*2*	*3*	-	-	-	-	-	-	-	-	*2*	-	*2*
CO-5:	*categorize hypersensitive immune reaction, autoimmunity, vaccination and cancer immunology and Illustrate the processes function to protect human body against infective agents*	-	-	-	*3*	-	*1*	-	-	-	-	-	-	*1*	-	*2*

Unit-1 - Immune System for Health ***15 Hour***

Overview of the immune system; Development and differentiation of the hematopoietic stem cells, Myeloid and Lymphoid lineage; Lymphatic system; Lymphoid organs – types; Innate lymphoid cells; Rhesus group types; incompatible blood transfusion and hemolytic disease; Receptors of Innate Immune system; Types of Immune cells, Innate Immunity; Anatomical and Physiological barriers; Acquired Immunity, Clonal selection theory; Comparative immunity - Plant Immune system, Vertebrate and Invertebrate Immune system; Immunogens, Antigens and Haptens; Requirements for immunogenicity; major classes of antigens; antigen recognition by T and B lymphocytes

Practice : *1: Laboratory safety principles and Blood grouping; Agglutination principle, blood group types, 2: Total Leukocyte count; Types of blood cells - Leukocyte counting, 3: Differential Leukocyte count*

Unit-2 - Immunity of Secretory Proteins ***15 Hour***

Immunoglobulin structure, types and function; Antibodies biological and functional properties - Proteolytic digestion of antibodies; Monoclonal antibodies production and applications; B Cell differentiation -B cell receptor structure and B cell signal transduction; Antibody diversity - Light chain synthesis; Heavy chain synthesis;; Cytokine types and function; Cytokine receptor structure; Role of cytokines in diseases; Complement system - Regulation of complement pathway; Role of complement proteins in diseases

Practice: *1. Antigen – Antibody reaction I – Widal test- slide method, 2. Antigen – Antibody reaction II -rapid plasma reagin (RPR) test, 3. Single radial immunodiffusion (SRID) - titer value, zone of equivalence*

Unit-3 - Methods to Assess Immune Status	***15 Hour***
Isolation of immune cells from Human and animals; Antigen- antibody interaction; antibody affinity and avidity; Hemaagglutination reaction - Coombs test – direct and indirect; precipitation reaction;; Quantitative Immuno assays; passive Immunodiffusion; Precipitation reaction; Active Immunodiffusion – Rocket immunoelectrophoresis, SDS-PAGE and Western blot; Quantitative Immuno assays - Radio-immunoassay, Immunoprecipitation; Immunofluorescence – Direct and indirect; Immunohistochemistry; flow cytometry, ELISA and types; Cell culture and experimental models, analysis of gene expression	
Practice: *1. Ouchterlony gel diffusion - Antigen-Antibody specificity, 2. Active Immunodiffusion I - Rocket Immunoelectrophoresis, 3. Active immunodiffusion – II – Counter Current Immunoelectrophoresis*	
Unit-4 - T Cell Signalling and Major Histocompatibility Complex	***15 Hour***
Major histo-compatibility Complex(MHC) – types and function; antigen processing and presentations – Endogenous and Exogenous; Diversity of MHC molecules;; Antigen – Antibody interaction Standard and test antigen; Rocket Immunoelectrophoresis; Biology of T lymphocyte - T cell receptors and interaction with MHC; T-cell maturation - T-cell activation and differentiation; Thymic selection – Positive and negative selection; T-cell activation and cytokine secretion; Cytokine control of TH1 and TH2 CD4+; Function of CD8+ T cells, T Regulatory cells; T-cell and B-cell cooperation, Pathways of Activation	
Practice: *1. Enzyme linked Immunosorbent assay (ELISA) – Qualitative, 2. Enzyme linked Immunosorbent assay (ELISA) – Quantitative, 3. Immunoprecipitation*	
Unit-5 - Immunity of Infection, Autoimmune Disorder and Cancer	***15 Hour***
Hypersensitive reactions - Type I, Type II, Type III and Type IV reaction; Immune responses to infectious diseases introduction; Viral disease-HIV infection; Bacterial disease-Tuberculosis; Parasitic disease - Malaria; Evading Mechanisms of pathogens; Vaccine history and principle; Active and passive Immunization; DNA vaccine, Edible vaccine and Adjuvants; Cancer Immunology introduction; Evidence for cancer Immunity; cancer Immuno therapy; Autoimmunity introduction; Genetic Basis of Autoimmunity; Classification of auto-immunity	
Practice: *1. SDS-PAGE, 2. Western blotting – Demo, 3. Flow cytometry - Demo*	

Learning Resources	*1. Sudha Gangal, Shubhangi Sontakke, Textbook of basic and clinical immunology, Universities Press, 2013*	*2. Jenni Punt, Sharon Stranford, Patricia Jones, Judith A Owen, Kuby Immunology, 8th ed., W. H. Freeman and Company, 2018*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (45%)		CLA-2-Practice (15%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	15%	-	-	15%	15%	-
Level 2	Understand	25%	-	-	20%	25%	-
Level 3	Apply	30%	-	-	25%	30%	-
Level 4	Analyze	30%	-	-	25%	30%	-
Level 5	Evaluate	-	-	-	10%	-	-
Level 6	Create	-	-	-	5%	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. C. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	*1. Dr. Joe Varghese, CMC Vellore, joevarghese@cmcvellore.ac.in*	*1. Dr.S.Nageswaran, SRMIST*
2. Dr. Karthik Periyasamy, Scientist, Biocon, karthik.periyasamy@biocon.com	*2. Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in*	*2. Dr.S.Rupachandra, SRMIST*

Course Code	21BTC303T	Course Name	PROTEIN ENGINEERING	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biotechnology*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*distinguish the organizational levels of protein structure*
CLR-2:	*appraise the structure-function correlation in selected proteins*
CLR-3:	*understand Mutagenesis based protein design*
CLR-4:	*construct 3D structure of protein from amino acid sequence*
CLR-5:	*discuss on the experimental techniques available for protein structure characterization*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*outline proteins and its properties at the elemental, molecular and structural levels*	-	*2*	-	-	-	-	-	-	-	-	-	-	-	*3*	-
CO-2:	*group the proteins based on super secondary structure of protein with its function*	-	*2*	-	-	*3*	-	-	-	-	-	-	-	-	*3*	-
CO-3:	*integrate protein biochemistry to design efficient protein structures*	-	*2*	-	-	*3*	-	-	-	-	-	-	-	-	*3*	-
CO-4:	*scoring and validating the methods of obtain protein structural data*	-	-	-	*2*	*3*	-	-	-	-	-	-	-	-	-	*3*
CO-5:	*mutagenesis experiments to test protein stability and/or function*	*2*	-	-	*2*	*3*	-	-	-	-	-	-	-	-	-	*3*

Unit-1 - Characteristics of Proteins — ***9 Hour***

Structure of amino acids- Properties of amino acids- Role of Glycine and Proline in structure determination- Ramachandran plot and its significance- Interactions that stabilize secondary -Structures, Structural features of alpha helix- Types of alpha helices- Parallel beta-strand structure-Anti-parallel beta-strand structure- Beta turns- loops and other secondary structures- Super- Secondary structures- Difference between motifs & domains- Types of motifs, Types of domains, Monomeric and polymeric proteins- hydrophobic collapse & theories of folding- Levinthal paradox- Role of chaperones- and heat shock proteins

Unit-2 - Structural features of Different Classes of Proteins — ***9 Hour***

Role of Transcription factors in gene - Nature of interaction between p53 and DNA- effect of mutations in the DNA binding domain of p53- Effects of mutations in the oligomerization and Nuclear localization region-Structural elucidation of leucine zipper- Interaction of leucine zipper and DNA- - Structural elucidation of GPCR- Types of GPCR- Mechanism of activation of GPCR- Structural features of serine proteases

Unit-3 - Experimental Protein Structure and Functional Analysis — ***9 Hour***

Methods of generating crystals- (ITC) Principle- Instrumentation of ITC- Determination enthalpy- entropy and free energy- Prediction of binding energy and multiple binding sites by ITC- Prediction of 3D structure from amino acid sequence, Homology modelling and threading

Unit-4 - Increasing Efficacy of Proteins — ***9 Hour***

Protein Engineering in Basic and Applied Biotechnology- engineering new protein function- Engineering enzymes- Specificity- stability- antibodies- Denovo designs Fusion proteins- Protein engineering in Vaccine development- Protein engineering in biosensors- Case Study: Enhancing binding affinity of T4 lysozyme- Enhancing stability in T4 lysozyme

Unit-5 - Protein Expression Purification and Characterization — ***9 Hour***

The isolation and characterization of proteins, Recombinant DNA technology and protein expression- Protein Digestion Techniques- Chemical and Enzymatic- Mass spectrometry - Tandem LC MS-/MS- Tools for mass spectrum analysis

Learning Resources	1. *Whitford, David. Proteins: Structure and Function. Wiley, 2013.* 2. *Tooze, John, and Branden, Carl Ivar. Introduction to Protein Structure. United States, CRC Press, 2012.* 3. *Ben-Tal, Nir. Kessel, Amit. Introduction to Proteins: Structure, Function, and Motion. United Kingdom: CRC Press, Taylor & Francis Group, 2018.*	4. *Buxbaum, Engelbert. Fundamentals of Protein Structure and Function. Germany: Springer International Publishing, 2015* 5. *Lilia Alberghina, Protein Engineering For Industrial Biotechnology, Taylor & Francis, 2003.* 6. *Chatwal. G. R, "Instrumental methods of Chemical Analysis", Himalaya Publishing House, 5th Edition, 2011.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. C. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com*	1. *Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in*	1. *Dr. Priya Swaminathan, SRMIST*
2. *Dr. Karthik Periyasamy, Scientist, Biocon, karthik.periyasamy@biocon.com*	2. *Prof. R. B. Narayanan, Anna University, Chennai arbeen09@gmail.com*	2. *Dr. Vasantharekha R, SRMIST*

Course Code	21BTC304T	Course Name	ANIMAL BIOTECHNOLOGY	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biotechnology*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*provide a basic understanding of animal breeding and animal health*
CLR-2:	*develop an understanding on raising animals using assisted reproductive techniques*
CLR-3:	*inculcate the understanding of cell culture technique and production of valuable products from them*
CLR-4:	*provide an understanding of alteration of animal body biological system*
CLR-5:	*give emphasis to transgenesis thereby improving livestock production*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*familiarize the students about breeding, biological markers for genetic diseases and managing animal health using vaccines*	-	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	*3*
CO-2:	*impart an understanding about Embryo transfer, fertilization methods and animal production*	-	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	*3*
CO-3:	*provide knowledge about different culture techniques, Characterization of cell lines and in vitro testing of drugs*	-	*3*	*2*	-	-	-	-	-	-	-	-	-	*3*	*3*	-
CO-4:	*provide knowledge about improvement of animals to increase the yield and quality of animal products*	*3*	-	-	*3*	-	-	-	-	-	-	-	-	*3*	*3*	-
CO-5:	*familiarize the students about livestock improvement using molecular pharming*	*3*	-	-	*2*	-	-	-	-	-	-	-	-	-	*3*	*3*

Unit-1 - Animal Improvement for Desired Traits and Animal Health	***9 Hour***
Breeding, different types of breeding; Marker assisted Selection - Gene mapping and identification of genes of economic importance in farm animals; Animal Health: Common viral, bacterial and parasitic diseases affecting animals; Vaccines for animal health; Developing diagnostic kits for animal diseases	
Unit-2 - Embryo Transfer and Animal Propagation	***9 Hour***
Assisted reproductive techniques in animals: Artificial insemination; In vitro fertilization- Superovulation, MOET,Embryo transfer,– Pregnancy diagnosis – Sexing of embryos, Embryo splitting; Cryopreservation of embryo; Cloning for conservation of endangered species; Stem cell technology & its applications	
Unit-3 - Animal Cell Culture	***9 Hour***
Principles of sterile techniques and cell propagation – Primary cell culture, secondary cell culture, continuous cell lines, suspension cultures; Chemically defined and serum free media for cell culture; Preservation and characterization of animal cells; Scaling up of animal cell culture; organ culture; 3D printing; Application of animal cell culture in vitro testing of drugs; Cell culture as source of therapeutic protein production	
Unit-4 - Biotechnology in Livestock Production	***9 Hour***
Manipulation of Growth hormone – somatotropic hormone – Thyroid hormone; Probiotics as growth promoters, Mode of action & uses of probiotics ; Manipulation of lactation – Lactogenesis – galactopoiesis ; Manipulation of rumen microbial digestive system; Manipulation of wool growth	
Unit-5 - Transgenesis and Molecular Pharming	***9 Hour***
Trangenesis, Gene editing using CRISPR Cas9, Transgenic animals, Methods of producing transgenic animals, knockin, knock out, mutation models; Transgenic animals as models for human diseases; Transgenic animals in livestock improvement- Therapeutic protein expression using transgenic animals, Animal as bioreactors; Ethical issues in animal biotechnology, 3R's and alternative for animal models - In vitro testing & insilico modeling	

Learning Resources	1. *Animal Biotechnology: Recent concepts and developments - P.Ramadas, MJP Publications, 2015.* 2. *Animal Breeding and Genetics; Aggrey, S.E.; Rekaya, R. Spangler, M.L., Ed.; Springer: New York, NY, USA, 2022.*	3. *Animal Biotechnology – M.M.Ranga, 3rd edition, 2007.* 4. *Culture of Animal cells; a manual of basic technique - R.Ian Freshney, 4th edition, Wiley publications, 2006.* 5. *Textbook of Animal Biotechnology – P.Ramadas & S.Meerarani, 2nd edition, 2002.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	*-*	*15%*	*-*	*15%*	*-*
Level 2	*Understand*	*25%*	*-*	*20%*	*-*	*25%*	*-*
Level 3	*Apply*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*10%*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*5%*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. G. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com*	1. *Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in*	1. *Dr.S.Sujatha, SRMIST*
2. *Dr. Karthik Periyasamy, Scientist, Biocon, karthik.periyasamy@biocon.com*	2. *Prof. R. B. Narayanan, Anna University, Chennai arbeen09@gmail.com*	2. *Dr.K.Venkatesan, SRMIST*

Course Code	21BTC305L	Course Name	ANIMAL BIOTECHNOLOGY LABORATORY	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							0	0	4	2

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biotechnology*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*provide the basics of cell culture media and primary cell culture*
CLR-2:	*understand the rationale of sub culturing of cells and maintaining it*
CLR-3:	*analyzing the cellular content using specific staining methods*
CLR-4:	*distinguish between cell viability and cell cytotoxicity*
CLR-5:	*comprehend the applications of animal cell culture*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1 Engineering Knowledge	2 Problem Analysis	3 Design/development of solutions	4 Conduct investigations of complex problems	5 Modern Tool Usage	6 The engineer and society	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*develop hands on training in primary cell culture techniques*	-	*2*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-
CO-2:	*gain proficiency in culturing and maintaining cell lines*	-	-	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*3*
CO-3:	*acquire skills to perform fluorescent staining procedures to visualize cellular content*	-	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-
CO-4:	*critique the toxicity of drugs invitro*	-	-	*3*	*3*	-	-	-	-	-	-	-	-	*2*	*3*	-
CO-5:	*utilize cell culture techniques in emerging fields of animal biotechnology*	-	-	-	*3*	*2*	-	-	-	-	-	-	-	-	-	*3*

Unit-1 - Media Preparation and Primary Cell Culture — ***12 Hour***

Practice:

1. Preparation & Sterilization of media for animal cell culture
2. Isolation of Hepatocytes and checking its viability
3. Isolation and culturing fibroblasts from chick embryo

Unit-2 - Cell Culture and Maintenance — ***12 Hour***

Practice:

1. Cell passaging
2. Cryopreservation of cells
3. Revival of Cryopreserved cells.

Unit-3 - Rapid Staining Procedures for Analysis of Cellular Content using Specific Fluorochromes — ***12 Hour***

Practice:

1. Mitochondrial & Nuclear staining using fluorochromes
2. Detection of apoptosis using Annexin V
3. Detection of mycoplasmal contamination by Hoechst staining

Unit-4 - Cell Viability and Cell Cytotoxicity Assays	***12 Hour***
Practice: *1. Determination of Cell viability by MTT assay* *2. Assessment of Cytotoxicity by LDH assay* *3. Clonogenic assay*	
Unit-5 - Applications of Cell Culture	***12 Hour***
Practice: *1. Determination of glucose uptake by the cells using 2NBDG method* *2. Demonstration on sorting of cells by flow cytometry* *3. Mammalian cell transfection using lipofectamine*	

Learning Resources	*1. Capes-Davis & Ian Freshney " Freshney's Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications", 8th Edition, ISBN: 978-1-119-51304-9, 2021 Wiley-Blackwell*	*2. ATCC Animal Cell culture guide*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)						Final Examination (0% weightage)	
		CLA-1 Average of first cycle experiments (30%)		CLA-2 Average of second cycle experiments (30%)		Practical Examination (40% weightage)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	-	15%	-	15%	-	15%	-	-
Level 2	Understand	-	20%	-	20%	-	20%	-	-
Level 3	Apply	-	25%	-	25%	-	25%	-	-
Level 4	Analyze	-	25%	-	25%	-	25%	-	-
Level 5	Evaluate	-	10%	-	10%	-	10%	-	-
Level 6	Create	-	5%	-	5%	-	5%	-	-
	Total	100 %		100 %		100 %		-	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. G. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	*1. Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in*	*1. Dr.S.Sujatha, SRMIST*
2. Dr. Karthik Periyasamy, Scientist, Biocon, karthik.periyasamy@biocon.com	*2. Prof. R. B. Narayanan, Anna University, Chennai arbeen09@gmail.com*	*2. Dr.K.Venkatesan, SRMIST*

Course Code	21BTC306T	Course Name	PLANT BIOTECHNOLOGY	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biotechnology*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the genome organization and gene expression in plants*
CLR-2:	*exercise the plants as production systems by altering the plant hormones for growth and development*
CLR-3:	*employ different methods for the development of transgenic plants*
CLR-4:	*interpret the mechanisms for the plant to cope with biotic and abiotic stresses*
CLR-5:	*apply the classical and modern plant breeding techniques for crop improvements*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*discuss the structure, organization of plant genomes and gene regulation*	*3*	-	*3*	-	-	-	*3*	-	-	-	-	-	-	*2*	-
CO-2:	*demonstrate the mechanism and role of plant tissue culture for mass multiplications*	*3*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-
CO-3:	*establish the various methods of genetic manipulation in plants*	*3*	*2*	-		*3*	-	-	-	-	-	-	-	-	*3*	-
CO-4:	*discuss the molecular aspects of plant adaptability to various stresses*	*3*	-	*2*	-	-	-	*3*	-	-	-	-	-	-	-	*3*
CO-5:	*apply the significance of plant breeding and genetic manipulations of plants for economic importance*	*3*	-	-	-	*3*	-	*3*	-	-	-	-	-	-	*3*	-

Unit-1 - Plant Genomes: the Organization and Expression of Genes — ***9 Hour***

Plant DNA, chromatin, chromosome structure. Nuclear genome, genome size, and organization. Chloroplast and mitochondrial - Genome structure, evolution, expression, and gene regulations. Eukaryotic gene expressions and its regulation - Transcription and translation levels: Organellar self-splicing, introns, and horizontal DNA transfer, RNA modification, post-transcriptional gene silencing (PTGS), Micro RNA - Production and interfering with the gene for silencing, DNA instability, Transposable elements in plants.

Unit-2 -Techniques for in Vitro Propagation of Plants — ***9 Hour***

Introduction to plant tissue culture. Plasticity and totipotency of plant cells. The culture environment - physical and chemical factors. Plant growth hormones - classes and their roles. Stages of plant tissue culture. Culture types. Cybrids production, haploid production. Production of secondary metabolites.

Unit-3 - Tools and Techniques for Transgenic Plant Development — ***9 Hour***

Introduction to Agrobacterium-mediated gene transfer and Biology. Ti-plasmid-process of T-DNA transfer and integration, transformation in the plant.Direct gene transfer methods - advantages and disadvantages. Basic features of vectors, optimization, and binary vectors. Alternative markers and reporter genes. The genetic manipulation of pest resistance crop plants, and Clean gene technology.

Unit-4 - Biotic and Abiotic Stresses of Plants — ***9 Hour***

Plant stresses - Biotic stress: Plant–pathogen interactions, prokaryotes, fungi, and viruses. Disease resistance, natural disease resistance in plants. Biotechnological approach - Overexpression of PR-proteins. Herbs as biotic stress factors. Abiotic stresses: Natural and plant responses - The nature of water deficit stress. Various approaches for tolerance - salt, cold, and heat stress - Molecular mechanisms.

Unit-5 - Genetic Improvements in Agriculture — ***9 Hour***

Introduction to crop improvement, crop plant domestication, and beyond. Breeding technologies: Advances in breeding technologies - Modern molecular plant breeding - Transgenic plants. Emerging technologies circumvent some concerns about transgenics. Applications of breeding. The second green revolution. Metabolic engineering: Molecular farming of carbohydrates, lipids, and protein. Producing fine chemicals, Plant-derived compounds as drugs. Current demand - the plants as alternative fuels

Learning Resources	1. *Slater. A, Scott.N.W and Fowler,M.R, "Plant Biotechnology - The genetic manipulation of plants", Oxford University Press 2008* 2. *Agnès Ricroch, Surinder Chopra, Marcel Kuntz. - Plant Biotechnology (2021). Springer Nature Switzerland AG 2021 Publisher. ISBN: 978-3-030-68344-3. Published: 31 August 2021. https://doi.org/10.1007/978-3-030-68345-0. 2nd Edition.*	3. *C Neil Stewart Jr. "Plant Biotechnology and Genetics: Principles, Techniques, and Applications (2016)"- John Wiley & Sons, Inc., New Jersey ISBN: 978-1-118-82012. 2nd Edition.* 4. *Malik Zainul Abdin, Usha Kiran, Kamaluddin, Athar Ali. - Plant Biotechnology: Principles and Applications (2017). Springer Publisher, Singapore. ISBN: 978-981-10-2959-2 Published: 17 March 2017. https://doi.org/10.1007/978-981-10-2961-5.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life Long Learning CLA-2 – (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	*-*	*15%*	*-*	*15%*	*-*
Level 2	*Understand*	*25%*	*-*	*20%*	*-*	*25%*	*-*
Level 3	*Apply*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*10%*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*5%*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. G. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com*	1. *Prof. K Subramaniam, IITM, Chennai, suubu@iitm.ac.in*	1. *R. Pachaiappan, SRMIST*
2. *Dr. Karthik Periyasamy, Scientist, Biocon, karthik.periyasamy@biocon.com*	2. *Prof. R. B. Narayanan, Anna University, Chennai arbeen09@gmail.com*	2. *S. Rupachandra, SRMIST*

Course Code	21BTC401L	Course Name	PLANT BIOTECHNOLOGY LABORATORY	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							0	0	4	2

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biotechnology*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*relate the growth and development of natural and in vitro growth of plants for production systems*
CLR-2:	*comprehend the methods of nucleic acids isolation from plants*
CLR-3:	*apply various gene transfer methods in plants*
CLR-4:	*employ different steps for the production of plant secondary metabolites*
CLR-5:	*apply the classical techniques for crop improvement*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*develop in vitro plants for mass multiplication*	*3*	*2*	*3*	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*contrast the different techniques for the isolation of nucleic acids for cloning and quantification of gene expression*	*2*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*3*	-
CO-3:	*demonstrate the different steps for gene transfer methods and verify the transgene in plants*	*3*	-	-	*3*	*2*	-	-	-	-	-	-	-	*3*	-	-
CO-4:	*establish the cells for the production of bioactive plant secondary metabolites and methods for isolation and detection*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*2*	*3*	-
CO-5:	*design the methods for the production of best traits and apply the plant pathology for crime investigation*	*3*	*2*	-	*3*	-	-	-	-	-	-	-	-	-	*3*	-

Unit-1 - Techniques for in Vitro Propagation of Plants	***12 Hour***
Practice:	
1. Preparation of plant tissue culture media - Murashige and Skoog's (MS) medium	
2. Plant tissue culture - Direct and Indirect Organogenesis	
Unit-2 - Plant Genomic DNA and RNA Isolation Techniques	***12 Hour***
Practice:	
1. Isolation of plant genomic DNA - Salk line & CTAB methods - Qualitative and quantitative analysis of DNA	
2. Extraction of total RNA from plant tissues using Trizol reagent - Qualitative and quantitative analysis of RNA	
Unit-3 - Techniques for Transgenic Plant Development	***12 Hour***
Practice:	
1. Transform the binary vector (pCAMBIA 1301) to Agrobacterium tumefaciens	
2. Screening of Agrobacterium colonies for confirming transformation of pCAMBIA 1301 by colony PCR and Agrobacterium - Mediated gene transformation by Co-cultivation of plant leaf discs	
3. Screening of transgenic plant tissues - GUS Reporter assay	

Unit-4 - Plant Secondary Metabolites - Production, Isolation and Detection	***12 Hour***
Practice: *1. Development of Cell suspension culture for the production of secondary metabolites* *2. Extraction and detection of plant secondary metabolites extract - Flavonoid - quercetin from onion dried peels and alkaloid - caffeine from Camellia sinensis - Tea / Detection by TLC and HPLC*	
Unit-5 - Applications of in Vitro Propagation & Plant Pathology	***12 Hour***
Practice: *1. Cybrids production through protoplast fusion* *2. Somatic embryogenesis through endosperm culture* *3. Crime scene investigation*	

Learning Resources	1. *Plant Biotechnology Practical Manual - 2023.* 2. *C Neil Stewart Jr. "Plant Biotechnology and Genetics: Principles, Techniques, and Applications (2016)"- John Wiley & Sons, Inc., New Jersey ISBN: 978-1-118-82012. 2nd Edition* 3. *Maheshwari, S.C. (1990). Tissue Culture, Molecular Biology and Plant Biotechnology — A Historical Overview. In: Sangwan, R.S., Sangwan-Norreel, B.S. (eds) The Impact of Biotechnology on Agriculture..Current Plant Science and Biotechnology in Agriculture, vol 8. Springer, Dordrecht. https://doi.org/10.1007/978-94-009-0587-0_1*	4. *Çelik, Ö. (2018). Introductory Chapter: New Age Molecular Techniques in Plant Science. In (Ed.), New Visions in Plant Science. IntechOpen. https://doi.org/10.5772/intechopen.79360.* 5. *Methods in Plant Molecular Biology and Biotechnology by Bernard R. Glick. Published November 29, 2017, by CRC Press. ISBN 9780367412128*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)						Final Examination (0% weightage)	
		CLA-1 Average of first cycle experiments (30%)		CLA-2 Average of second cycle experiments (30%)		Practical Examination (40% weightage)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	-	*15%*	-	*15%*	-	*15%*	-	-
Level 2	*Understand*	-	*20%*	-	*20%*	-	*20%*	-	-
Level 3	*Apply*	-	*25%*	-	*25%*	-	*25%*	-	-
Level 4	*Analyze*	-	*25%*	-	*25%*	-	*25%*	-	-
Level 5	*Evaluate*	-	*10%*	-	*10%*	-	*10%*	-	-
Level 6	*Create*	-	*5%*	-	*5%*	-	*5%*	-	-
	Total	*100 %*		*100 %*		*100 %*		-	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Dr. G. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com*	1. *Prof. K Subramaniam, IITM, Chennai, suubu@iitm.ac.in*	1. *R. Pachaiappan, SRMIST*
2. *Dr. Karthik Periyasamy, Scientist, Biocon, karthik.periyasamy@biocon.com*	2. *Prof. R. B. Narayanan, Anna University, Chennai arbeen09@gmail.com*	2. *S. Rupachandra, SRMIST*

Course Code	21BTC402J	Course Name	BIO SEPARATION TECHNOLOGY	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biotechnology*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*know the importance of bio separation and its recovery economically*
CLR-2:	*learn the separation of product from solid –liquid phase*
CLR-3:	*know the techniques of isolation of bio-products*
CLR-4:	*learn the methods of purification of products*
CLR-5:	*learn the methods of polishing and formulation of products for packaging*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*categories the products into various sectors*	*1*	*2*	*1*	-	-	-	-	-	-	-	-	-	*1*	*2*	*1*
CO-2:	*identify the unit operation for separation*	*2*	*3*	*1*	-	-	-	-	-	-	-	-	-	*2*	*2*	*1*
CO-3:	*adapt the best methods of isolation of products*	*2*	*2*	*2*	-	-	-	-	-	-	-	-	-	*2*	*2*	*1*
CO-4:	*identify the sophisticated equipment for purification*	*2*	*3*	*2*	-	-	-	-	-	-	-	-	-	*2*	*2*	*2*
CO-5:	*know the polishing and formulation of the products*	*2*	*2*	*2*	-	-	-	-	-	-	-	-	-	*2*	*2*	*2*

Unit-1 - Bioproducts Classification and Disruption Techniques ***15 Hour***

Classification of Bioproducts, Engineering Analysis, Analytical methods, Cell disruption Methods- Physical, Chemical, Mechanical and Biological methods.

Practice:

Cell disruption Techniques

1. Cell disruption by Sonication, 2. Cell disruption by High Pressure Homogenisation, 3. Chemical and Enzymatic method of cell disruption

Unit-2 - Separation of Insolubles ***15 Hour***

Electrical Double layers, Schulze–Hardy Rule, Flocculation Rate, Polymeric Flocculants, Sedimentation-Principles, Methods and Coefficients, Filtration Principles and Theory, Conventional Filtration- Filtration Equipments and Media, Scaleup and Design of Filtration Systems ,Cross flow filtration- Microfiltration, Centrifuges, Scaleup of Centrifugations.

Practice:

Recovery Methods

1. Cell separation by Flocculation, 2. Cell separation by Batch filtration, 3. Cell separation by Microfiltration, 4. Cell separation by Centrifugation

Unit-3 - Concentration of Solubles ***15 Hour***

Extraction-Batch,Staged,Differential Extraction,Aqueous two phase Extraction, Supercritical Extraction, Batch Adsorption, Adsorption in CSTR and Fixed Bed, Precipitation-Different methods of precipitation, Ultrafiltration, Dialysis and Electrodialysis.

Practice:

Protein Concentration Methods

1. Protein concentration by Precipitation methods, 2. Protein concentration by Ultrafiltration, 3. Protein Concentration by Aqueous two-phase extraction

Unit-4 - Protein Purification	***15 Hour***
Chromatography Column Dynamics, Plate Models, Chromatography Column Mass Balance with Negligible Dispersion, Dispersion Effects in Chromatography, Gradients and Modifiers, Adsorbent Types, Particle Size and Pressure Drop in Fixed Beds, Equipment, Scaleup. ***Practice:*** *Purification of Protein* *1. Protein purification by gel column chromatography* *2. Protein purification by ion exchange chromatography*	
Unit-5 - Polishing	***15 Hour***
Crystallization Principles, Batch Crystallizers, Process Crystallization of Proteins, Crystallizer Scaleup and Design, Drying Principles, Dryer Description and Operation, Scaleup and Design of Drying Systems, Case studies. ***Practice:*** *Polishing of Biomaterial* *1. Crystallization Techniques* *2. Freeze drying of biomaterials*	

Learning Resources	1. *Harrison. R.G., Todd. P., Rudge S.R, Petrides. D.P, "Bioseparation Science and Engineering" Oxford University press, 2003.* 2. *Belter. P.A., Cussler, E., "Bioseparations", Wiley, 1985.*	3. *Nooralabettu Krishna Prasad, "Downstream Process Technology: A New Horizon In Biotechnology", PHI Learning Private Limited 2013* 4. *Mihir K Purkait; Randeep Sing,"Membrane Technology in separation science, CRC Press Taylor & Francis Group, 2018*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*CLA-2-Practice (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	-	*15%*	*15%*	-
Level 2	*Understand*	*25%*	-	-	*20%*	*25%*	-
Level 3	*Apply*	*30%*	-	-	*25%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*25%*	*30%*	-
Level 5	*Evaluate*	-	-	-	*10%*	-	-
Level 6	*Create*	-	-	-	*5%*	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. G. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com*	1. *Dr.S.Senthil Kumar, IITG, senthilkumar@iitg.ac.in*	1. *Dr.M.Venkatesh Prabhu, SRMIST*
2. *Dr. Karthik Periyasamy, Scientist, Biocon, karthik.periyasamy@biocon.com*	2. *Dr.N.Selvaraj, IITG, selva@iitg.ac.in*	2. *Dr.P.Radha, SRMIST*

ACADEMIC CURRICULA

Non-Credit Course

Regulations 2021

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21BTM191T	Course Name	BIOETHICS AND IPR	Course Category	M	NON CREDIT	L	T	P	C
							1	0	0	0

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biotechnology*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*realize the need for ethical values in Biotechnology Research*
CLR-2:	*understand the risks associated with biotechnology Research*
CLR-3:	*know the type and extent of damage that could be caused to the environment*
CLR-4:	*understand the ethical and moral values to be inculcated in ethical decision making*
CLR-5:	*know the requirements for containment of risk group organisms*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*define Principles of Bioethics and aspects related to IP protection*	-	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*elaborate the ethical issues and safety precautions in biotechnology research*	-	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*explain concepts pertaining to exercising personal and environmental safety*	-	*2*	-	-	*3*	-	-	-	-	-	-	-	-	-	-
CO-4:	*examine case studies and ethical decisions in healthcare research*	-	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*discriminate different biosafety levels and different forms of IP*	-	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-

Unit-1 - Basic Principles of Bioethics	***3 Hour***
Ethics and Bioethics, Ethical Theories, Use of animals in research and Ethical issues in Clinical Trials, Ethical issues in Stem Cell Research, Ethical Issues in In vitro Fertilization	
Unit-2 - Global Health Ethics	***3 Hour***
Health Systems and Institutions, Synaptogenesis and development of sensory-motor system, Ethical issues in Organ transplantation, Biobanking, Ethical issues in Regenerative Medicine, Religious and Cultural Perspectives in Bioethics	
Unit-3 - Biosafety Regulations	***3 Hour***
Transgenic Research and Field Trials, Roles of various regulatory bodies, Biosafety Rules for GMOs, Biodiversity and Environment conservation, CBD and Cartagena Protocol	
Unit-4 - Forms of IPR	***3 Hour***
Designs, Copyrights and Geographical indications, Novelty and Utility, Patentable subjects and protection in biotechnology, Biodiversity	
Unit-5 - Patens	***3 Hour***
Basic principles and general requirements of patent law Patents and methods of application of patents-Legal implications, Objectives of the patent system, TRIPs-GATT-International conventions, Patent Cooperation Treaty, Plant variety protection and farmer rights, other forms of IP	

Learning Resources	1. *Singer and Viens (Eds.) Bioethics – Cambridge University Press, Cambridge,2008*	2. *The Indian Patent Act and Rules, 2015, GoI, India.*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100%*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. G. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com*	1. *Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in*	1. *Dr. DVL Saradha, SRMIST*
2. *Dr. Karthik Periyasamy, Scientist, Biocon, karthik.periyasamy@biocon.com*	2. *Prof. R. B Narayanan Anna University, Chennai,arbeen09@gmail.com*	2. *Dr Lilly M Saleena. SRMIST*

ACADEMIC CURRICULA

UNDERGRADUATE/ INTEGRATED POST GRADUATE DEGREE PROGRAMMES

(With exit option of Diploma)

(Choice Based Flexible Credit System)

Regulations 2021

Volume – 8B
(Syllabi for Biotechnology w/s Regenarative Medicine Programme Courses)

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

ACADEMIC CURRICULA

Professional Elective Courses

Regulations 2021

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21BTE206T	Course Name	MOLECULAR CELL BIOLOGY	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biotechnology*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*provide basic knowledge of stem cell specific gene expression in lineage-based tissues from the perspective of engineers*
CLR-2:	*identify the role of epigenetic regulation in stem cell proliferation and differentiation*
CLR-3:	*deliver the knowledge on signaling molecules and molecular mechanisms that regulate the stem cell proliferation and differentiation*
CLR-4:	*create insights on genome reprogramming*
CLR-5:	*utilize the strategies for novel gene editing techniques for tissue engineering*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*identify gene regulation in stem cells*	*2*	*2*	*2*	*2*	-	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*analyze gene expression in stem cells and artificial generation of pluripotency*	*3*	*2*	*2*	*3*	-	-	-	-	-	-	-	-	*3*	-	-
CO-3:	*identify the applications of growth factor signaling and their receptor molecules*	*3*	*2*	*2*	*2*	-	-	-	-	-	-	-	-	*3*	-	-
CO-4:	*analyze the regulation of molecules involved in self-renewal of stem cells*	*3*	*3*	*3*	*3*	-	-	-	-	-	-	-	-	*2*	-	-
CO-5:	*discuss stem cell death and survival mechanisms*	*3*	*2*	-	*2*	-	-	-	-	-	-	-	-	*2*	-	-

Unit-1 - Molecular Biology of life ***9 Hour***

The Molecules of Life- Genomes, Cell Architecture, and Cell Function- Chemical Foundations-Covalent Bonds and Noncovalent Interactions -Chemical Building Blocks of Cells -Nucleic acids, genetic material- Primary and secondary structure of DNA - Watson & Crick model -Hogsteen base pairing, Triple helix, Quadruple helix -DNA super-coiling- Linking number- satellite DNA replication - Meselson & Stahl experiment bi– directional DNA replication- Proteomics of DNA replication - Overview of differences in prokaryotic and eukaryotic DNA replication -Role of telomerase in aging and cancer- Mutagens, DNA mutations and their mechanism- Telomere replication in eukaryotes DNA Repair- DNA mismatch, Base-excision- Nucleotide-excision and direct repair DNA recombination- Homologous, site-specific and DNA transposition- Gene regulation and operon.

Unit-2 - Gene Regulation and Transcription ***9 Hour***

Overview of Central dogma- Characteristics promoter and enhancer sequences - Transcriptional bubble - prokaryotic and eukaryotic RNA polymerase -RNA synthesis- Fidelity of RNA synthesis. Inhibitors of transcription -Differences in prokaryotic and eukaryotic transcription -Regulatory elements- Mechanism of transcription regulation - Transcription of Protein-Coding Genes and Formation of Functional mRNA- Splicing - nuclear export of mRNA - mRNA stability-Role of gene expression in microRNA -LncRNA, snoRNA, piRNA- srRNA, siRNA and shRNA -Genetic code: Elucidation of genetic code- Codon degeneracy, Wobble hypothesis and its importance- Prokaryotic and eukaryotic ribosomes- Chromosomal Organization of Genes and Noncoding DNA- Molecular Mechanisms of Transcription Repression and Activation

Unit-3 - Protein Functions ***9 Hour***

Membrane Proteins: Structure and Basic Functions- cytoskeletal proteins Extra cellular matrix- cell-cell junctions, various types of transport across cell membrane - Protein sorting and trafficking, cargo proteins- Growth factor signaling, cell-cell communication - Mechanism of action of different class of hormones- Cell cycle –Molecules controlling cell cycle- Carcinogens and Caretaker Genes in Cancer- Recombination to Repair Double-Strand Breaks in DNA-Cell culture and immortalization of cells and its applications- Restriction Enzymes, Cloning and Libraries- DNA Cloning and Characterization - Molecular Analysis Using Cloned Sequences

Unit-4 - Molecular Biology Techniques	***9 Hour***
Molecular Genetic Techniques- Inactivating the Function of Specific Genes in Eukaryotes - Cloning a Human Gene - Locating and Identifying Human Disease Genes - Inactivating the Function of Specific Genes in Eukaryotes- Molecular basis of Organ culture- Molecular Basis of Pluripotency- Induced pluripotency- Lineage tracing experiments in stem cells- Characterization and maintenance of murine and human embryonic stem cells- Differentiation of embryonic Stem Cells- Embryonic stem cell cloning- Therapeutic cloning of stem cells- Genomic Reprogramming.	
Unit-5 - Molecular Diagnosis and Cell Therapy	***9 Hour***
Proteomics, Metabolomics, Microbiomics and Systems Biology -Newborn screening: Neonatal PKU- Cystic fibrosis and sweat tests- Prenatal diagnosis of diseases, amniotic fluid- Fetal blood examination- Karyotyping, Chromosomal abnormalities by cytogenetics- Restriction fragment length polymorphism (RFLP)- Nuclear injection- stem cell transplantations for sickle-cell anemia, hemophilia- Stem cell transplantation for cancer (leukemia and myeloma- Muscular dystrophy and stem cell therapy- Stem cell therapy, Neurodegenerative disease- and human embryonic stem cells, Stem cell transplantation- Dementia- Neurodegenerative disease- CRIPSR/Cas9 system-gene editing- Applications of CRISPR/Click chemistry techniques.	

Learning Resources	1. *Harvey Lodish, Arnolg Berk "Molecular Cell Biology," 9 th edition – Mcmillan - 2021; ISBN:9781319208523* 2. *Gerald Karp, "Karp's Cell and Molecular Biology," 9th edition – Wiley, 2019, ISBN: 978-1-119-59816-9*	3. *Lewin's Genes. Joycelyn E. Krebs, Elliott S. Goldstein, Stephen T. Kilpatrick. 12th Edition, Jones and Bartiett Publishers Inc. ISBN: 978-1284104493*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Dr.Ramesh Babu Boga, BogaR Laboratories, Hyderabad, brameshb@msn.com*	1. *Prof. N. Gopalan, Central University Tamil Nadu, email: gopalan@cutn.ac.in*	1. *Dr.Kanagaraj Palaniyandi, SRMIST*
2. *Dr. Archana Khosa Kakkar, IDRS Labs Private Limited, Bangalore, archgana.kk@idrslabs.com*	2. *Dr. Ajaikumar B. Kannumakkara , IITG, kunnumakkara@iitg.ernet.in*	2. *Dr. N. Selvamurugan, SRMIST*

Course Code	21BTE311T	Course Name	CELL COMMUNICATION AND SIGNALING	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biotechnology*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*provide basic concepts of gene expression patterns from the perspective of engineers*
CLR-2:	*identify the role of epigenetic regulation in adult stem cells*
CLR-3:	*identify the external and internal signaling molecules that regulate the stem cell proliferation and differentiation*
CLR-4:	*analyze the self-renewal and cell death mechanisms in stem cells*
CLR-5:	*analyze the molecular mechanism of stemness- signaling pathways and transcription factors and diseases*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*apply the basic understanding of gene regulation in stem cells*	*2*	*2*	*2*	*2*	-	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*manipulate the gene expression in stem cells and artificial generation of pluripotency*	*3*	*2*	*2*	*3*	-	-	-	-	-	-	-	-	*3*	-	-
CO-3:	*identify the applications of growth factor signaling and their receptor molecules*	*3*	*2*	*2*	*2*	-	-	-	-	-	-	-	-	*3*	-	-
CO-4:	*apply the regulation of molecules involved in self-renewal of stem cells*	*3*	*3*	*3*	*3*	-	-	-	-	-	-	-	-	*2*	-	-
CO-5:	*discuss the stem cell death and survival mechanisms*	*3*	*2*	-	*2*	-	-	-	-	-	-	-	-	*2*	-	-

Unit-1 - Cell-Cell Communication ***9 Hour***

Heterotypic and homotypic cell-cell contacts and how these contacts mediate intracellular communication-Cell-matrix communication including mechanisms of cell motility -Pluripotency associated transcription factors-Tissue specific multi potency-Stem cells with no tissue specificity-Transcriptional network controlling pluripotency in ES cells-Alternative splicing in embryonic stem cells- Niche required for inducing stem cell control-Homeostasis and Feed-back regulation in niche- Cytokines and growth factors maintenance of stemness-Modeling for stem cell asymmetry- Pluripotency genes, expression and regulation

Unit-2 - Receptor Mediated Cell Signaling ***9 Hour***

Cell surface receptor mediated signal transduction-Growth factor and receptors-tyrosine kinases Mediated signaling (RasRaf-MAP-MEK)-Wnt -signaling-Notch signaling pathways-Hedgehog singling-Hippo signaling-JAK-STAT- nuclear signaling-NF-κB signaling pathways-TGFβ -activation/nodal BMP-signaling-FGF signaling pathways-Hemotopoiesis and signaling molecules-Progenitor cell differentiation factors-Colony stimulating factor and its receptor signaling pathways. Glycoprotein and proteoglycan structure and biology including molecular gradients and their involvement in embryology and disease.

Unit-3 - Aging and Senescence Signaling ***9 Hour***

Stem cell aging and apoptosis-Regulation and significance apoptosis in stem cells-Stem cell necrosis-Intrinsic – extrinsic pathways of apoptosis-Death ligands, cytokines and tumor necrosis factor-Role of apoptosis in hematopoiesis-Apoptosis resistance in stem cells-Anti-apoptotic molecules expression in stem cells-Caspase mediated apoptosis-Apoptosis transcription factors and regulators-Heat shock proteins- The role of ubiquitination in signal transduction and protein degradation-The role of reactive oxygen species as secondary messengers-How cells respond to stress signals in homeostasis and disease (e.g. autophagy and ER stress).

Unit-4 - Neural Cell Differentiation and Signaling ***9 Hour***

Neural stem cells-Neural progenitors-The heterogeneity of adult neural stem cells-Emerging complexity of neural niche-Neural stem cell signaling-Neural stem cell homeostasis-Galecitin-1 in neural stem cells- -Neurotransmitter-induced stem cell differentiation-cholinergic-dopaminergic signals-Nerve cell growth factor-Induced regeneration of neuronal cells-Neurosphere culture-Astrocyte, oligodendrocyte differentiation-Glial cell differentiation-Pathophysiology of neuronal stem cell signaling-Multiple sclerosis, Parkinson's and Alzhimer's -How microRNA/lncRNA regulate cell signaling.

Unit-5 - Methods in Cell Signaling	***9 Hour***
How different techniques are used to study cell signaling-Regeneration, Stem Cells, and the Evolution of Tumor Suppression- Smads - Polycomb genes- Cellular signaling of Akt/PKB - β-catenin- Induced pluripotency (iPSc)- Epithelial-mesenchymal transition (EMT)- EMT markers- Growth factor induced differentiation of stem cells- Pancreatic stem cells- Beta cell differentiation factors and transplantation- Stem cell therapy for obesity- Leukemia, lymphoma and Myeloma- Bone marrow transplantation- Cytokine and chemokine therapies- Cancer stem cell - cell survival and tumor maintenance- Mechanism of cancer stem cell resistance- Targeting cancer stem cells- Selective killing of cancer stem cells- Nano carrier mediated drug delivery	

Learning Resources	*1 Hancock John T "Cell signaling," Oxford University Press- 2016; ISBN: 9780199658480*	*2 Handbook of Cell signaling, Edward A Dennis and Ralph A Bradshaw. Elsevier, 2003 ISBN: 9780121245467*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	*-*	*15%*	*-*	*15%*	*-*
Level 2	*Understand*	*25%*	*-*	*20%*	*-*	*25%*	*-*
Level 3	*Apply*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*10%*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*5%*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr.Ramesh Babu Boga, BogaR Laboratories, Hyderabad, brameshb@msn.com	*1. Dr. Ravisankar B, University of Madras, email: bravisankar68@gmail.com*	*1. Dr.Kanagaraj Palaniyandi, SRMIST*
2. Mr.J.B. Vijayakumar BioArtis Life Sciences Pvt. Ltd. email: contact@bioartis.in	*2. Dr. Ajaikumar B. Kannumakkara , IITG, kunnumakkara@iitg.ernet.in*	*2. Dr. R. Satish, SRMIST*

Course Code	21BTE312T	Course Name	STEM CELL TECHNOLOGY	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biotechnology*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*provide basic knowledge on embryogenesis from the perspective of engineers*
CLR-2:	*create an interest to know about the different types of embryonic stem cells, its isolation, and cloning*
CLR-3:	*illustrate awareness about adult and cancer stem cells, IPSCs and importance of stem cell niches*
CLR-4:	*initiate interest on signaling pathways, epigenetics control of stem cells*
CLR-5:	*generate interest on applications and uses of stem cells and to develop strategies for tissue engineering and create awareness on ethics and regulations of stem cell research*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*recall knowledge about embryogenesis, stem cells and its characteristics*	-	-	-	*2*	-	-	-	*3*	-	-	-	-	-	-	*2*
CO-2:	*interpret knowledge on different types of stem cells isolation of ESCs and cloning*	-	-	-	*2*	-	-	-	*3*	-	-	-	-	-	-	*2*
CO-3:	*interpret about adult and cancer stem cells, IPSCs and stem cell niches*	-	-	-	*2*	-	-	-	*3*	-	-	-	-	-	-	*3*
CO-4:	*analyze the role of signaling pathways, epigenetics control of stem cells*	-	-	-	*3*	-	-	-	*3*	-	-	-	-	-	-	*2*
CO-5:	*evaluate the application of stem cells for different diseases and reconstruct knowledge on tissue engineering for regenerative medicine*	-	-	-	*3*	-	-	-	*3*	-	-	-	-	-	*3*	-

Unit-1 - Stem Cells-Characteristics and Types	***9 Hour***
Overview of Stem cells - "Stemness": Definitions, Criteria - Embryonic and adult stem cells - Types and classification of stem cells based on potency - Types of stem cells –Embryonic stem cells (ESCs), Adult stem cells (ASCs) - Differences between ESCs and ASCs- Similarities between ESCs and ASCs- Identification and characterization of ESCs and ASCs at cellular level and molecular level	
Unit-2 - Embryonic Stem Cells- Isolation and Cloning	***9 Hour***
ESCs –IVF, Primate and Mouse ES cells, Markers - Nuclear transfer technology in ES cells - Human ESCs -Isolation and culturing of hESC's - Differentiation of stem cells - Enzymatic and Mechanical isolation – Immunosurgical Isolation - Stem Cells derived from early mouse embryos-ES, EC, EG, TS cells - Primed Cells - Naïve Cells - Epiblast Stem Cells - ESC markers- Therapeutic cloning using ESCs - Reproductive cloning using ESCs	
Unit-3 - Adult Stem Cells - Sources, Types and Niches	***9 Hour***
Adult stem cells (ASC)-advantages and disadvantages - Sources of ASCs and its properties and its role as specialised cells in differentiation - Transdifferentiation- -Fusion experiments -Experiments on transdifferentiation - Induced pluripotent stem cells (iPSCs)-Methodology, Applications - Cancer stem cells- Isolation Characterization, Properties, origin, theories - CSCs and Metastasis -Stem Cell Niche – Drosophila testis and ovary nich - Human intestinal epithelia niche	
Unit-4 - Signaling Pathways and Epigenetics in Stem Cells	***9 Hour***
ESC pluripotency and signaling- JAK-STAT pathway -Activin/Nodal/TGFβ Signaling Pathway - FGF Signaling Pathway - Wnt signaling and Insulin-like growth factors - HSC signaling pathways- Notch,Wnt, TGF,, SMAD signalling-Epigenetic control of stem cells- Effect of TSA on stem cell differentiation - Effects of histone demethylases - Epigenetic control in pluripotent stem cells, somatic cells, germ cells -Epigenetics in iPSCs	

Unit-5 - Application of Stem Cells and Ethics in Stem Cell Research	***9 Hour***
Stem Cells in Tissue Engineering - Therapeutic Applications - Parkinson's disease - Bone defects - Stem Cells for Spinal Cord Injury- Common strategies toward regeneration of the damaged spinal cord- Stem Cell treatment for diabetes- Cardiac tissue engineering using stem cells-Stem cell treatment for burns Transplantable matrices - Ethics of Stem Cell Research- The Ethics of Using Human Embryonic Stem Cells in Research - Regulations governing Stem Cell research-ICMR, Drugs and Cosmetic Act	

Learning Resources	1. *Robert Lanza, Edited by: Robert Lanza and Anthony Atala , "Essentials of Stem Cell Biology"3rd Edition, Academic Press,Copyright © 2014 Elsevier Inc. 4.* 2. *Huang G, Ye S, Zhou X, Liu D, Ying QL. Molecular basis of embryonic stem cell self-renewal: from signaling pathways to pluripotency network. Cell Mol Life Sci. 2015, May; 72(9):1741-57.*	3. *The Science of Stem Cells by Jonathan M W Slack, John Wiley & Sons, 16-Jan-2018 - Science - 272 pages.* 4. *Stem Cells - Biology and Application by Mary Clarke, Jonathan Frampton · 2020 CRC Press.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. B.R.Desikachari, Medical Director, Westminster Health Care, Chennai, brdesikachari@hotmail.com*	1. *Prof .Halagowder D, Univ. of Madras, hdrajum@yahoo.com*	1. *Dr. Devi.A, SRMIST*
2. *Dr. A. Premkumar, Ph.D., GVK Biosciences, Hyderabad aprem70@yahoo.com*	2. *Dr.Sudha Warrier, Associate Professor, Manipal University, sudha.warrier@mannipal.edu*	2. *Dr. N.Selvamurugan, SRMIST*

Course Code	21BTE313T	Course Name	BIOMATERIALS IN TISSUE ENGINEERING	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biotechnology*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*demonstrate the basic knowledge on biomaterials from the perspective of engineers*
CLR-2:	*analyze biological tissue engineering problems with biomaterials*
CLR-3:	*demonstrate basic concepts regarding design of drug delivery system using different biomaterials*
CLR-4:	*analyze the design of artificial tissues and their medical applications*
CLR-5:	*analyze the regulatory strategies and commercialization of biomaterials*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1 Engineering Knowledge	2 Problem Analysis	3 Design/development of solutions	4 Conduct investigations of complex problems	5 Modern Tool Usage	6 The engineer and society	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*appraise the fundamental concepts of biomaterials and their impact with biological response*	-	-	2	-	-	-	-	2	-	-	-	-	2	3	-
CO-2:	*comprehend various biomaterials compatibility and their interaction with tissue growth*	-	-	2	2	-	-	-	2	-	-	-	-	2	3	-
CO-3:	*assessment of bio mimetics and drug delivery system applications*	-	-	2	2	-	-	-	3	-	-	-	-	2	3	-
CO-4:	*dissect the biological problems in tissue engineering that require engineering expertise to solve them*	2	-	2	2	-	3	-	3	-	-	-	-	2	3	-
CO-5:	*translate biomaterials as scaffolds for various clinical applications and assess regulatory controls in global marketing*	-	-	2	2	-	3	-	3	-	-	-	-	-	3	-

Unit-1 - Introduction to Biomaterials ***9 Hour***

Properties of biomaterials (chemical, physical, mechanical and thermal), Elements of Biomaterials, preparation and characterization of biomaterials (metal, bio ceramic polymeric materials), Evaluation of biomaterials and biological responses

Unit-2 - Basic Concepts in Tissue Engineering ***9 Hour***

Fundamentals of tissue engineering, Tissues, Organization of tissues in vertebrate body, Cell sources, Stem cells, Cell lineages, Cell-biomaterial interactions, Cell-biomaterial response, Assessment of biocompatibility of biomaterials, cell viability assays, MTT and cytotoxicity assays, Antibacterial assessment of biomaterials, In vitro and In vivo evaluation of biomaterials

Unit-3 - Bioactive Molecules and Their Delivery in Tissue Engineering ***9 Hour***

Stimuli responsive in biomaterials, Bio mimetics, Dental and bone, Designing nanoparticles for drug delivery, Targeted delivery, Proteins, peptides, DNA, RNAs, oligos in drug delivery, Surface modifications, Applications in drug delivery, Advantages and limitations of biomaterials in drug delivery

Unit-4 - Biomaterials in Biomedical Applications ***9 Hour***

Tissue engineering, wound care and suture materials, vascular implants and bio-inspired materials, Biomimetic devices, Organ transplant, Tissue Construction, Bio artificial tissues, Connective tissues, Regeneration of connective tissues, Targeting ligands in drug delivery, Targeting ligands in cancer treatment, Cell growth and repair, Drug discovery, Impact of drug discovery and development

Unit-5 -Biomaterials and Their Marketing in Medicine ***9 Hour***

Technical considerations of biomaterials, Commercialization of biomaterials, Regulatory strategies for biomaterials, Clinical development with biomaterials, Clinical evaluation of biomaterials, Approval threshold of biomaterials, Supply chain of biomaterials, Strategies of global marketing, Regulatory controls in global marketing, Global authorization of biomaterials, Post-market surveillance approaches for biomaterials, Good manufacturing practice for biomaterials

Learning Resources	1. *Hench L. Larry, and Jones J., (Editors), Biomaterials, Artificial organs and Tissue Engineering, Woodhead Publishing Limited, 2005* 2. *Ulrich Meyer, Thomas Meyer, Jörg Handschel, Hans Peter Wiesmann (2009): Fundamentals of Tissue Engineering and Regenerative Medicine, Springer*	3. *Regenerative Medicine and Tissue Engineering, Edited by Jose A. Andrades, ISBN 978-953-51-1108-5, Publisher: InTech,2013* 4. *S. Amato and B. Ezzell, (Editors), Regulatory Affairs for Biomaterials and Medical Devices, Woodhead Publisher, 2015*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	*-*	*15%*	*-*	*15%*	*-*
Level 2	*Understand*	*25%*	*-*	*20%*	*-*	*25%*	*-*
Level 3	*Apply*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*10%*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*5%*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1 *Dr. Giridharan, Life Cell, giridharan.a@lifecell.in*	1 *R. Jayakumar, Ph. D, Amrita Medical Center, Kochi jayakumar77@yahool.com*	1 *Dr. N. Selvamurugan, SRMIST*
2 *Dr. Gokuladhas Krishnan , Director, Laboratory, World Stem Cell Clinic, Chennai, care@worldstemcellclinic.com*	2 *N. Srinivasan, Ph. D., Chettinad Health City, Chennai, srinivasanibms@gmail.com*	2 *Dr. K. Venkatesan, SRMIST*

Course Code	21BTE314T	Course Name	NANOTECHNOLOGY IN REGENERATIVE MEDICINE	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biotechnology*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understanding the basic concepts of nanomedicine*
CLR-2:	*exploring various types of nanomaterials and their applications*
CLR-3:	*demonstrate the cutting-edge nanomedicine technologies for diagnosis and therapeutic applications*
CLR-4:	*apply the knowledge for utilizing nanotechnology to achieve innovation in healthcare*
CLR-5:	*understanding the issues related to toxicity and environmental impact of nanomaterials*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1 Engineering Knowledge	2 Problem Analysis	3 Design/development of solutions	4 Conduct investigations of complex problems	5 Modern Tool Usage	6 The engineer and society	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*recall the basics of nanobiotechnology*	*3*	-	-	*2*	-	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*classify the nanomaterials as vehicles for drug delivery*	-	*2*	*3*	*2*	-	-	-	-	-	-	-	-	*3*	-	-
CO-3:	*organize various types of nanomedical devices and their applications*	*3*	-	*3*	*3*	-	-	-	-	-	-	-	-	*3*	-	-
CO-4:	*infer the efficient methods in the development of nanobiosensors and their applications*	-	-	*3*	*2*	-	-	-	-	-	-	-	-	*2*	-	-
CO-5:	*interpret the toxicity of nanomaterials and its remediation*	-	*3*	-	*2*	-	-	-	-	-	-	-	-	*2*	-	-

Unit-1 - Basics of Nanobiotechnology in Relation to Nanomedicine ***9 Hour***

Scientific principles of nanomedicine, Nanotools – types & various techniques of detection, Scanning Tunneling microscope, Atomic Force Microscope, Functional biological nanomaterials, nanoengines, Nanomaterials and their Production, Various synthesis methods of Nanomaterials, Nanodevices-Quantum Computing, Spintronic Materials and Devices, Impact of nanotechnology - Scientific and technical Impacts, Environmental Impacts, Grand challenges of nanomedicine, Ethical, Legal, and Social Issues, Government Promotion of Advancements in nanomedicine, Government Evaluation, Policy and Regulation of Nanotechnology.

Unit-2 - Nano Based Drug Delivery Systems ***9 Hour***

Nanomaterials as vehicles for drug delivery , Types of Nanomaterials, criteria and selection of Nanomaterials, Sources of Nanomaterials, Drug loading and release, biodegradation, Nanopatterning, Electrospinning Technology, nanopolymers, Classification of biopolymers, magnetic nanoparticles – preparation and properties, Applications of Magnetic Nanoparticles, Properties and applications of Nanotubes, Nano immunotherapy, Nanomaterials for vaccine delivery- Types of nanomaterials as vaccine adjuvants, Nanotechnology and Diagnostic Imaging, Nanomaterials as contrast agents in clinical use

Unit-3 - Nanotechnology and its Applications in Medicine ***9 Hour***

Nanorobots in medicine, nanorobots in nanosurgery, Nanocameras and its applications, Recombinamers, nanochips, nanoimplants, nanomaterials for bone and cartilage applications, nanomaterials for vascular applications and skin disorders, Nanomaterials in 3D Bioprinting, nanoparticle-based therapy for genetic diseases, Cell Delivery of Therapeutic Nanoparticles, nanomaterials for delivery in cells- nerve cell repair, Applications of Nanofibers in Tissue Engineering, nanomaterials for stem cells growth, Stem Cell Tracking with Nanoparticles, Nanomaterials for Stem Cell Imaging, Nanotechnology in the regulation of stem cell behavior

Unit-4 - Nano Biosensors: Properties and Applications ***9 Hour***

Introduction- nanobiosensors, Biosensing Techniques, unique properties of nanobiosensors, Preparation of nanobiosensors- immobilization strategies, covalent conjugation technique, Self-assembled monolayer nanomaterial, Nano biosensors for protein and DNA detection, Detection methods – optical detection and electronic detection, In vivo Biosensors, Nanowire Biosensors, Cantilever Biosensors, Applications – DNA nanobiosensor, Protein biosensor, whole cell biosensor applications, Nanobiosensor in diagnostics, Biosensors in forensic sciences

Unit-5 - Nanotoxicology	***9 Hour***
Overview of Nanotoxicology in Humans and the Environment, Physico-chemical characteristics dependent toxicity, Potential Adverse Effects of Engineered Nanomaterial Exposure, Respiratory Response to Pulmonary Exposure, Oral Exposure, Dermal Exposure, Handling, storage and disposal of nanomaterials, Remediation in case of nanomaterials spills, In vitro and in vivo toxicity assessment of nanoparticles, Embryonic Toxicity of Nanoparticles, Mapping Exposure onto Nanoscale, Toxicity Measures, Factors Affecting Nanoparticle Dose–Exposure and Cell Response, Green Synthesis of Nanoparticles – mechanism and Applications, Nanoparticles: Environmental Problems, nanotoxicity regulations, nanomaterials intellectual property perspective	

Learning Resources	1 *Melba Navarro and Josep A. Planell. Nanotechnology in Regenerative Medicine (2012), Humana Press* 2 *Jamie R. Lead, Shareen H. Doak and Martin J. D. Clift, Nanotoxicology in Humans and the Environment (2021), Springer Press*	3 *Haiyan Xu and Ning Gu, Nanotechnology in Regenerative Medicine and Drug Delivery Therapy (2020), Springer Press*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1 *Dr. S Natarajan, Advisor / Sr. Vice President - R & D; Sami Labs Limited,Bangalore. mail@samilabs.com*	1 *Prof. Sundara Ramaprabhu, Department of Physics IIT-Madras. ramp@iitm.ac.in; ramp@physics.iitm.ac.in*	1 *Dr. Ramkumar K M, SRMIST*
2 *Dr. Gokuladhas Krishnan, Director, Laboratory, World Stem Cell Clinic, Chennai,care@worldstemcellclinic.com*	2 *Prof. Ashok M. Raichur, Department of Materials Engineering, IISc, Bangalore. amr@materials.iisc.ernet.in*	2 *Dr. N. Selvamururgan, SRMIST*

Course Code	21BTE416T	Course Name	TISSUE ENGINEERING FOR REGENERATIVE MEDICINE	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biotechnology*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*from the viewpoint of engineers, explain the foundations of tissue engineering and tissue restoration*
CLR-2:	*describe understanding of tissue engineering's clinical applications*
CLR-3:	*describe understanding of tissue engineering's clinical applications*
CLR-4:	*state engineering students to think more on artificially generated tissues for their tissue engineering applications*
CLR-5:	*talk about the technology of 3D-bioprinting and Explain the methods for cutting-edge bioactive tissue engineering research*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*examine the elements that make up the tissue architecture*	*3*	*2*	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-2:	*show the traits of stem cells and their importance in medicine*	*3*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	*2*
CO-3:	*describe knowledge of biomaterials' characteristics and wide range of applications*	*1*	*1*	-	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-4:	*analyze the role of tissue engineering and stem cell therapy in organogenesis*	*3*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*2*	*2*
CO-5:	*create novel biomaterials and emerging techniques for creating effective tissue and organ replacements and examine the in vivo and in vitro testing of biomaterials*	*3*	*3*	*2*	*2*	-	-	-	-	-	-	-	-	-	*3*	*3*

Unit-1 - Basics of Tissue Engineering ***9 Hour***

Cellular Basis of Regeneration-Molecular Basis of Regeneration; Overview of tissue engineering-Simple terms used in tissue engineering-Present possibility of development in tissue engineering -Therapeutic application of tissue engineering; Components used in tissue engineering-Primary cells, cell lines and immortalization of cells; Evaluation of tissue characteristics, appearance, cellular component -Cell differentiation, cell migration, and processes determining a cell's fate; Extracellular matrix (ECM) constituent and their regulation of cell behavior-Mechanical measurements of the ECM component-Physical properties of the ECM component-Cell-ECM interactions –Modifying the ECM-Faults in ECM signaling

Unit-2 - Interactions and Culture of Cells and Tissue ***9 Hour***

Tissue kinds-Tissue constituents -Tissue healing-Engineering wound healing-Sequence of events of wound healing; Three-Dimensional Cell Culture-Organ Culture- Organotypic Culture; Basic Wound Healing Overview-The use of growth factors: Function of VEGF/angiogenesis-Various methods of angiogenesis and its significance-Fundamental characteristics of growth factors, Cell-Matrix Interactions-Cell-Cell Interactions; Telomeres and Self-renewal

Unit-3 - Biomaterials and Their Implementations ***9 Hour***

Basics of the science of biomaterials; Idea of biocompatibility; Categories of biomaterials-Fundamental traits of biomaterials-Disinfection and sterilization of biomaterials; Biomaterials' physico-chemical characteristics: Mechanical (elasticity, yield stress, ductility, toughness, strength, fatigue, hardness, wear resistance)- Tribological (friction, wear, lubricity)-Morphological and texture, Physical (electrical, optical, magnetic, thermal)-Chemical and biological characteristics; Rudiments in contact with the surface of a biomaterial: blood composition, plasma proteins, cells, tissues; Scaffolds' function in tissue engineering-Biopolymers; Modifications of Biomaterials-In vitro testing of biomaterials-In vivo testing of biomaterials

Unit-4 - Stem Cells and Their Applications in Tissue Engineering	***9 Hour***
Overview of Stem Cells-Various kinds of Stem cells-Hematopoietic differentiation pathway of stem cells-Potency of stem cells-Plasticity of stem cells-Sources of embryonic stem cells-Sources of hematopoietic and mesenchymal stem cells; Stem Cell markers, FACS analysis; Types & sources of stem cell with characteristics: Embryonic stem cells and Adult stem cells-Comparison between- embryonic and adult stem cells; Bone marrow, primordial germ cells; Cancer stem cells; Induced pleuripotent stem cells	
Unit-5 -Therapeutic Aspects of Tissue Engineering	***9 Hour***
Discussion on Stem cell therapy- Therapies for spinal cord injury, muscular dystrophy-Orthopedic applications-Stem cells and Gene therapy; Tissue engineering of bones-Tissue engineering of cartilage-Neural tissue engineering-Skin tissue engineering-Cardiovascular tissue Engineering-Therapeutic applications; Overview on the basic principles for Biofabrication and 3D printing-Methods and materials-Applications of Biofabrication and 3D printing: Lab-on-chip, Organ-on-chip; Innovative bioactive research; Regenerative medicine	

Learning Resources	1 *Clemens Van Blitterswijk, Jan De Boer, "Tissue Engineering", 2nd Edition - Academic Press, 2014.* 2 *Robert Lanza, Robert Langer, Joseph Vacanti,"Principles of Tissue Engineering", 4th Edition - Academic Press, 2013.* 3 *John P. Fisher, Antonios G. Mikos, Joseph D. Bronzino, Donald R. Peterson, "Tissue Engineering: Principles and Practices", 1st Edition - CRC Press, 2017*	4 *Buddy D. Ratener, Allan S. Hoffman, Frederick J. Schoen, Jack E. Lemons, "Biomaterial Science: An Introduction to Material in Medicine", 3rd edition – Academic Press, 2013.* 5 *Lijie Grace Zhang, John Fisher, Kam Leong, "3D Bioprinting and Nanotechnology in Tissue Engineering and Regenerative Medicine", 1st Edition - Academic Press, 2015.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	20%	-	15%	-	15%	-
Level 2	Understand	20%	-	20%	-	25%	-
Level 3	Apply	30%	-	25%	-	30%	-
Level 4	Analyze	30%	-	25%	-	30%	-
Level 5	Evaluate	-	-	10%	-	-	-
Level 6	Create	-	-	5%	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1 *Dr. Harikrishna Varma, SCTIMST, Thiruvananthapuram, India; head-bmtw@sctimst.ac.in*	1 *Dr. Sourabh Ghosh, IIT Delhi, India, sghosh08@textile.iitd.ac.in*	1 *Dr. Koustav Sarkar, SRMIST*
2 *Dr. Dipak Datta, CDRI, Lucknow, India; dipak.datta@cdri.res.in*	2 *Dr. Rathindranath Baral, CNCI, Kolkata., India, baralrathin@hotmail.com*	2 *Dr. N. Selvamurugan, SRMIST*

Course Code	21BTE417T	Course Name	BIOREACTORS IN TISSUE ENGINEERING	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biotechnology*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*provide the basic concepts of tissue engineering and bioreactors from the perspective of engineers*
CLR-2:	*identify the 3D- culture of stem cells and organogenesis*
CLR-3:	*identify the role of stem cells in clinical applications of different disease conditions*
CLR-4:	*identify the safety and efficacy of bioreactors*
CLR-5:	*create the strategies for designing clinically relevant bioreactors*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*apply the basic understanding of large-scale production stem cells in bioreactors*	*2*	*2*	*2*	*2*	-	-	-	-	-	-	-	*2*	*3*	-	-
CO-2:	*discuss the 3D- culture systems and artificial organs*	*3*	*2*	*2*	*3*	-	-	-	-	-	-	-	*2*	*3*	-	-
CO-3:	*identify the bioreactor-based strategies to generate organoids*	*3*	*2*	*2*	*2*	-	-	-	-	-	-	-	*2*	*3*	-	-
CO-4:	*understand the role of bioreactors in the development of drug development and therapy*	*3*	*3*	*3*	*3*	-	-	-	-	-	-	-	*2*	*2*	-	-
CO-5:	*explain the large scale production of stem cells*	*3*	*2*	-	*2*	-	-	-	-	-	-	-	-	*2*	-	-

Unit-1 - Tissue Organization and Bioreactors ***9 Hour***

Complexity and organization of the organ system-Measurement of tissue characteristics, appearance, tissue types-Types of Bioreactors- Cells for tissue engineering– Perfusion Bioreactors for 3D cultures, Spinner Flask Bioreactor-Rotating Wall Bioreactor, Compression Bioreactor, Strain Bioreactor-static culture, stem cell cultivation in scaffold Bioreactor systems -Hydrostatic pressure Bioreactor, Flow Perfusion Bioreactor, Combined Bioreactor- Clinic grade production of mesenchymal stem cells.

Unit-2 - Scaffold and Functionalized Tissue Engineering ***9 Hour***

Functional tissue engineering and role of Biomechanics in a 3D environment –Controlled release strategies in tissue engineering -Tissue fabrication technology, microfabrication -Bioreactors role in tissue engineering of Cartilage-Cardiovascular tissue, Vascular tissue, musculoskeletal tissue and Skin –Bone-microfluidic devices and microbioreactors for stem cell micro environment – Perfusion bioreactors for granulocyte progenitor cell growth; Bioreactor stimulation-Mechanics and Controlled Parameters of Bioreactors –Engineering stem cell niches in bioreactors- Oxygen tension, Scaffold/substrate cues-Decellularized ECMs, Mechanical forces, Electrical stimulation, Flow shear rate, and paracrine and autocrine factors.

Unit-3 - Applications of Bioreactors ***9 Hour***

Novel approaches in bioreactor systems for stem cell seeding of vascularized bioscaffolds-Bioreactor-based strategies with reconstructive applications- Stem cell cultivation in scaffold-bioreactor systems; Physiological biomimicry-Understanding Mechanical forces on organs and functional aspects-Control and Feedback Control in Mechatronics for mechanical stimulation; Scaffolds and Constructs for Bioreactor Systems – Organoids and organ-on-chip-Boprinting- Applications of growth factors-Role of VEGF. Angiogenesis, Basic properties, Cell-Matrix, Cell-Cell Interactions, Control of cell migration in tissue engineering.

Unit-4 - Biomaterial and Tissue Engineering ***9 Hour***

Biomaterials: Properties of Biomaterials, Surface, bulk, mechanical and biological properties-Scaffolds & tissue engineering, Types of Biomaterials, biological and synthetic materials-Biopolymers, Applications of biomaterials, Sensing and Automation in bioreactor systems-Bioreactors in drug discovery and implant testing; Bioreactors in clinics-Stem cell cultivation in scaffold-bioreactor systems-Large-scale bioreactor cultivation of pluripotent stem cells-Engineering of functional bone tissue from human stem cells-Miniature bioreactors for precise, systematic studies of stem cell environments.

Unit-5 - Clinical Applications of Bioreactors	***9 Hour***
Clinical applications - Stem cell therapy, Molecular Therapy-In vitro organogenesis, Neurodegenrative diseases-spinal cord injury, heart disease, diabetes, burns and skin ulcers-muscular dystrophy, orthopedic applications-Stem cells and Gene Therapy-Physiological models, tissue engineering therapies, product characterization-components, safety, efficacy. Preservation –Product and process design toward industrial tissue engineering manufacturing - Patent protection and regulation of tissue engineered products, ethical issues in tissue engineering.	

Learning Resources	*1 Bioreactors: Design operation and Novel Applications, 2016, Chaudri, Wiley pulications; ISBN: 9783527683369*	*2 Tissue engineering and Regeneration, 2022, Heinz Redl, Springer Publications, ISSN: 2731-0558*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	*-*	*15%*	*-*	*15%*	*-*
Level 2	*Understand*	*25%*	*-*	*20%*	*-*	*25%*	*-*
Level 3	*Apply*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*10%*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*5%*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1 Dr.Ramesh Babu Boga, BogaR Laboratories, Hyderabad, brameshb@msn.com	*1 Dr. Ajaikumar B. Kannumakkara , IITG, kunnumakkara@iitg.ernet.in*	*1 Dr. Kanagaraj Palaniyandi, SRMIST*
2 Mr.J.B. Vijayakumar BioArtis Life Sciences Pvt. Ltd. email: contact@bioartis.in	*2 Dr. Suttur S Malini, University of Mysore, drssmalini@gmail.com*	*2 Dr. R. Satish, SRMIST*

Course Code	21BTE418T	Course Name	DEVELOPMENTAL BIOLOGY IN TISSUE ENGINEERING	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biotechnology*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*describe cell-cell interactions from the context of tissue engineering*
CLR-2:	*illustrate the types of cell specification and germ layers*
CLR-3:	*provide information on neurulation and types of mesoderm tissues*
CLR-4:	*summarize on heart and gut tube development*
CLR-5:	*appraise on ageing and types of regeneration*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*interpret on the basics of signaling mechanisms*	-	-	-	2	-	-	-	3	-	-	-	-	-	-	2
CO-2:	*recall the concepts in cell commitment and morphogen gradients*	-	-	-	2	-	-	-	3	-	-	-	-	-	-	2
CO-3:	*describe the genetics of neural tube and kidney development*	-	-	-	2	-	-	-	3	-	-	-	-	-	-	3
CO-4:	*analyze the development of heart and the digestive organs*	-	-	-	3	-	-	-	3	-	-	-	-	-	-	2
CO-5:	*understand the processes of germ cell migration and types of tissue regeneration*	-	-	-	3	-	-	-	3	-	-	-	-	-	3	-

Unit-1 - Cell Communication in Development	***9 Hour***
Differential cell affinity – Cadherins and cell adhesion – Cell migration – Cell induction – Cell competence – Paracrine factors – Signal transduction cascades – RTK pathway – Jak-STAT pathway – Juxtracrine signaling – Notch pathway – Developmental signals from ECM – Epithelial-to-mesenchymal transition	
Unit-2 - Cell Specification and Germ Layers	***9 Hour***
Cell commitment – Cell determination - Cell specification – Autonomous, Conditional and Syncytial specifications - Morphogen gradients – Cell fate – Cell lineage – Stem cells in development – Stem cell niches – Regulatory microenvironments – Germ layers – Ectoderm, mesoderm and endoderm	
Unit-3 - Neurulation, Somitogenesis and Kidney Development	***9 Hour***
Neurulation – Primary and secondary neurulation - Neural tube formation – DV axis of the neural tube – Brain organization – Ectodermal placodes – Types of mesoderm – Somite formation –Specification of intermediate mesoderm – Development of mammalian kidney	
Unit-4 - Formation of Heart, Gut Tube and Respiratory Tube	***9 Hour***
Specification of lateral plate mesoderm – Cardiac precursor cells – Determination of cardiac domains – Formation of heart chambers – Specification of gut tissue – Development of liver and pancreas – Origin and development of respiratory tube	
Unit-5 - Concepts on Tissue Regeneration	***9 Hour***
Genetic causes of ageing –Germplasm -Specification of primordial germ cells - Germ cell migration – Regeneration – Epimorphic regeneration –Morphallactic regeneration - Regeneration in mammalian liver	

Learning Resources	1 *Developmental Biology (2020): Scott F. Gilbert and Michael J.F. Barresi, Twelfth Edition, Oxford University Press, Inc.* 2 *Essential Developmental Biology (2012): J.M.W. Slack, Third Edition, Wiley-Blackwell Publishers*	3 *Principles of Development (2015): Lewis Wolpert, Cheryll Tickle and Alfonso Arias, Fifth Edition, Oxford Publishers, Inc.* 4 *Principles of Developmental Genetics (2014) S.A. Moody (Ed.) Second Edition, Academic Press*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	*-*	*15%*	*-*	*15%*	*-*
Level 2	*Understand*	*25%*	*-*	*20%*	*-*	*25%*	*-*
Level 3	*Apply*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*10%*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*5%*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1 *Dr. B.R.Desikachari, Medical Director, Westminster Health Care, Chennai, brdesikachari@hotmail.com*	1 *Dr. K. Subramaniam,Indian Institute of Technology Madras, Chennai,subbu@iitm.ac.in*	1 *Dr. S. Kirankumar, SRMIST*
2 *Dr. V.L.Ramprasad, MedGenome Labs Ltd, Bengaluru ramprasadv@medgenome.com*	2 *Dr.Sudha Warrier, Associate Professor, Manipal University sudha.warrier@mannipal.edu*	2 *Dr. N. Selvamurugan, SRMIST*

Course Code	21BTE419T	Course Name	ADVANCED IMMUNOLOGY AND VASCULAR ENGINEERING	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Biotechnology*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*provide the most recent advancement in the field of immunology from the perspective of bioengineers*
CLR-2:	*enrich with knowledge on immunobiology and immune responses related to regeneration and transplants*
CLR-3:	*recognizing the issue of shortage of organ donors as the major limitations in the transplantation and finding solution for the same*
CLR-4:	*learning of various treating methods for injury and the significance of vascular engineering*
CLR-5:	*train and develop skills among the students to explore strategies for Immunotherapy and Stem cell therapy*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*acquire knowledge on the latest tools for diagnosis of diseases*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-	*2*
CO-2:	*gain knowledge in molecular and immunological basis of diagnosis*	*2*	*2*	-	*2*	-	-	-	-	-	-	-	-	-	*2*	*2*
CO-3:	*able to appreciate the relevance of clinical immunology*	*2*	*3*	-	*2*	*2*	-	-	-	-	-	-	-	-	*3*	*2*
CO-4:	*acquire knowledge on vascular biology and vascular tissue engineering*	*3*	*3*	-	*2*	*2*	-	-	-	-	-	-	-	-	*3*	*2*
CO-5:	*acquire knowledge on host vs Graft rejection, neovascularization and the significance of immune system in these processes*	*2*	*3*	-	*2*	-	-	-	-	-	-	-	-	*2*	*3*	*2*

Unit-1 - Basics of Immunology	***9 Hour***
Components of innate and acquired immunity: Phagocytosis; Complement and Inflammatory responses; Haematopoesis; Organs and cells of the immune system – primary and secondary lymphoid organs; Lymphatic system; Lymphocyte circulation; Lymphocyte homing; Mucosal and Cutaneous associated Lymphoid tissue. (MALT & CALT); Mucosal Immunity; Antigens – immunogens, haptens; Major Histocompatibility Complex – MHC genes, MHC and immune responsiveness and disease susceptibility, HLA typing ; Immunological considerations for stem cell banking (self-study)	
Unit-2 - Antigen and Antibodies	***9 Hour***
Immunoglobulins-basic structure, classes & subclasses of immunoglobulins, antigenic determinants; Mutagenic organization of immunolobulin genes; B-cell receptor; Immunoglobulin superfamily; Principles of cell signaling; Basis of self – non-self-discrimination; Kinetics of immune response, memory; B cell maturation, activation and differentiation; Generation of antibody diversity; T-cell maturation activation and differentiation and T-cell receptors; Functional T Cell Subsets; Cell-mediated immune responses, ADCC; Cytokines-properties, receptors and therapeutic uses; Antigen processing and presentation – endogenous antigens, exogenous antigens, non-peptide bacterial antigens and super-antigens; Cell-cell co-operation, Hapten-carrier system; Current status of Immunotherapy (self-study)	
Unit-3 -Transplantation	***9 Hour***
Immunologic targeting of cancer stem cell population- tumor- initiating cells and their immuno targeting; CML of Haematopoietic stem cells-allogenic transplantation of HSC- Graft versus leukemia effect, T-cells, B-cells and NK cells as mediators of graft versus leukemia –Malignant progenitors targeting by graft- versus-leukemia; Cells and factors involved in transplant acceptance and rejection; (self-study); Recent advances in transplantation	

Unit-4 - Tissue Regeneration	***9 Hour***
Stem cells in Regenerative Biology, Stem cell therapy for treatment of ulcers, skin burns, neurodegenerative diseases, Immunological considerations and the potential barriers for stem cell therapy; Immuno-suppressive therapies (self-study)- Immunological Aspects of Allogeneic and Autologous Mesenchymal Stem Cell Therapies	
Unit-5 - Grafts and Vascularization	***9 Hour***
Significance of acellular grafts in regeneration; tissue injury and immune responses; potential barriers to engraftment of human pluripotent stem cells; Transplantation – Immunological basis of graft rejection (self-study); mast cells in allograft rejection Mouse models of graft-versus-host disease; Clinical transplantation and immunosuppressive therapy; Importance of vascularization in Tissue Engineering, Signaling pathways of angiogenesis, Vascular Remodeling; Stem cells and scaffolds for vascular regeneration.	

Learning Resources	1 *Vascularization: Regenerative Medicine and Tissue Engineering, edited by Eric M. Brey, CRC Press 2017* 2 *Stem Cell Transplantation, edited by Carlos López-Larrea, Antonio López Vázquez, and Beatriz Suárez Álvarez. Springer 2016*	3 *The Immunological Barriers to Regenerative Medicine. Editors-Paul J. Fairchild, Humana Press 2013* 4 *Immunotherapy in Bioregenerative Medicine, by Dmytro Klokol, Dato Sri Mike K. S. Chan, Roni Lara Moya · 2022*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1 *Dr. Vani, Jeevan Stem Cell Foundation, Chennai, stemcell@jeevan.org*	1 *Dr. S. Sittadjody, Research Fellow, Institute for Regenerative Medicine, Winston-Salem, USA. ssdjody@gmail.com*	1 *Dr. N. Selvamururgan, SRMIST*
2 *Dr. Satheesh K. Sainathan, Study Director, Phenotypic Services, Eurofins Discovery, St Charles, Missouri, United States*	2 *Dr. Yuvaraj Sambandam, Assistant Professor, Surgery, Transplant Surgery Division, North western University, USA*	2 *Dr. R. Satish, SRMIST*

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

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