ACADEMIC CURRICULA

UNDERGRADUATE DEGREE PROGRAMMES

Bachelor of Technology
Biotechnology

(B.Tech. - Four Years)

(Choice Based Flexible Credit System)

Regulations 2021

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

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

Kattankulathur, Kancheepuram District 603203, Tamil Nadu, India

B.Tech. in Biotechnology

1. (a) Mission of the Department

Mission Stmt - 1	*To adopt effective teaching methods to improve the learning process and impart knowledge of biology and technology.*
Mission Stmt - 2	*To provide hands-on training and technical skills to transform students into technocrats and facilitate research and higher education in the fields of biotechnology.*
Mission Stmt - 3	*To pursue and promote cutting-edge research in selected fields of biotechnology*

1. (b) Program Educational Objectives (PEO)

PEO - 1	To develop graduates with enhanced technical acumen, aptitude, and professional skills in Biotechnology
PEO - 2	To develop the ability amongst the students to apply modern bioengineering techniques in industry and research.
PEO - 3	To prepare students for a successful career in research and development in Biotechnology

1. (c) Mission of the Department to Program Educational Objectives (PEO) Mapping

	Mission Stmt. - 1	Mission Stmt. - 2	Mission Stmt. - 3
PEO - 1	*H*	*H*	*H*
PEO - 2	*M*	*H*	*H*
PEO - 3	*H*	*H*	*H*

H – High Correlation, M – Medium Correlation, L – Low Correlation

1. (d) Mapping Program Educational Objectives (PEO) to Program Outcomes (PO)

	Program Outcomes (PO)												Program Specific Outcomes (PSO)		
	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
PEO - 1	*H*	*H*	*M*	*H*	*M*	*M*	*M*	*M*	*H*	*M*	*M*	*M*	*H*	*H*	*H*
PEO - 2	*H*	*H*	*H*	*H*	*H*	*M*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*H*
PEO - 3	*H*	*H*	*H*	*H*	*H*	*M*	*M*	*M*	*H*	*M*	*H*	*H*	*H*	*H*	*H*

H – High Correlation, M – Medium Correlation, L – Low Correlation

PSO – Program Specific Outcomes (PSO)

PSO - 1	*Apply basic knowledge of biological processes to solve problems in the applied fields of biotechnology.*
PSO - 2	*Apply biotechnological skills to provide cost-effective and sustainable solutions in Industries*
PSO - 3	*Ability to integrate biological knowledge and concepts with the entrepreneurial perspectives of biotechnology.*

1. (e) Program Structure: B.Tech. in Biotechnology

Humanities & Social Sciences including Management Courses (H)

Course Code	Course Title	Hours/ Week L	T	P	C
21LEH101T	Communicative English	2	1	0	3
21LEH102T	Chinese	2	1	0	3
21LEH103T	French				
21LEH104T	German				
21LEH105T	Japanese				
21LEH106T	Korean				
21LEH107T	Spanish				
21GNH101J	Philosophy of Engineering	1	0	2	2
21PDH201T	Social Engineering	2	0	0	2
21GNH401T	Behavioral Psychology	2	1	0	3
	Total Learning Credits				**13**

Engineering Science Courses (S)

Course Code	Course Title	Hours/ Week L	T	P	C
21CSS101J	Programming for Problem Solving	3	0	2	4
21MES101L	Basic Civil and Mechanical Workshop	0	0	4	2
21MES102L	Engineering Graphics and Design	0	0	4	2
21EES101T	Electrical and Electronics Engineering	3	1	0	4
21DCS201P	Design Thinking and Methodology	1	2	0	3
21CHS251T	Basic Chemical Engineering	3	0	0	3
21CHS252J	Chemical Engineering Principles	3	0	2	4
21CSS303T	Data Science	1	1	0	2
	Total Learning Credits				**24**

Professional Elective Courses (E)
(Any 5 Courses)

Course Code	Course Title	Hours/ Week L	T	P	C
	Sub-stream: Medical Biotechnology				
21BTE201T	Developmental Biology	3	0	0	3
21BTE301T	Diseases Models and Mechanism	3	0	0	3
21BTE302T	Metabolic Disorders	3	0	0	3
21BTE401T	Cellular & Molecular Neuroscience	3	0	0	3
21BTE402T	Cancer Biology and Therapeutics	3	0	0	3
21BTE403T	Physiology of Stress and its Management	3	0	0	3
	Sub-stream: Pharmaceutical Biotechnology				
21BTE202T	Pharmaceutical Biotechnology	3	0	0	3
21BTE303T	Computational Molecular Biology	3	0	0	3
21BTE304T	Computer aided Drug Designing	3	0	0	3
21BTE404T	Marine Biotechnology	3	0	0	3
21BTE405T	Vaccine Biotechnology	3	0	0	3
21BTE406T	Molecular Basis of Drug action	3	0	0	3
	Sub-stream: Plant and Food Biotechnology				
21BTE203T	Plant Hormones and Signaling	3	0	0	3
21BTE305T	Epigenetics in Plants	3	0	0	3
21BTE306T	Pathogenesis-Related Proteins In Plants	3	0	0	3
21BTE407T	Food Science and Nutrition	3	0	0	3
21BTE408T	Therapeutic Compounds from Plants	3	0	0	3
21BTE409T	Food safety and quality Management	3	0	0	3
	Sub-stream: Bioprocess Technology				
21BTE204T	Enzyme Engineering and Technology	3	0	0	3
21BTE307T	Membrane Separation Technology	3	0	0	3
21BTE308T	Industrial Fermentation Engineering	3	0	0	3
21BTE410T	Bioreactor Design	3	0	0	3
21BTE411T	Bioprocess Modelling and Simulation	3	0	0	3
21BTE412T	Bioprocess Plant Design	3	0	0	3
	Sub-stream: Environmental Biotechnology				
21BTE205T	Environmental Biotechnology	3	0	0	3
21BTE309T	Industrial Waste Management	3	0	0	3
21BTE310T	Bioenergy	3	0	0	3
21BTE413T	Metabolic Engineering of Microorganism for Environment and Energy	3	0	0	3
21BTE414T	Microbial degradation and Bioremediation Technology	3	0	0	3
21BTE415T	Environmental Biosensors	3	0	0	3
	Total Learning Credits				15

Basic Science Courses (B)

Course Code	Course Title	Hours/ Week L	T	P	C
21PYB101J	Physics: Electromagnetic Theory, Quantum Mechanics & Waves Optics	3	1	2	5
21CYB101J	Chemistry	3	1	2	5
21MAB101T	Calculus and Linear Algebra	3	1	0	4
21MAB102T	Advanced Calculus and Complex Analysis	3	1	0	4
21MAB303T	Bio-Statistics for Biotechnologists	3	1	0	4
21BTB105T	Cell Biology	2	0	0	2
	Total Learning Credits				**24**

Professional Core Courses (C)

Course Code	Course Title	Hours/ Week L	T	P	C
21BTC101T	Biochemistry	3	0	0	3
21BTC201L	Biochemistry Laboratory	0	0	4	2
21BTC202T	Microbiology	3	0	0	3
21BTC203L	Cell and Microbiology Laboratory	0	0	4	2
21BTC204T	Bioprocess Principles	3	0	0	3
21BTC205L	Bioprocess Principles Laboratory	0	0	4	2
21BTC206T	Genetics and Cytogenetics	3	0	0	3
21BTC207T	Molecular Biology	3	0	0	3
21BTC208L	Molecular Biology Laboratory	0	0	4	2
21BTC209T	Bioprocess Engineering	3	0	0	3
21BTC210L	Bioprocess Engineering Laboratory	0	0	4	2
21CSC206T	Artificial Intelligence	3	0	0	3
21BTC301J	Gene Manipulation and Genomics	3	0	2	4
21BTC302J	Immunology	3	0	2	4
21BTC303T	Protein Engineering	3	0	0	3
21BTC304T	Animal Biotechnology	3	0	0	3
21BTC305L	Animal Biotechnology Laboratory	0	0	4	2
21BTC306T	Plant Biotechnology	3	0	0	3
21BTC401L	Plant Biotechnology Laboratory	0	0	4	2
21BTC402J	Bio Separation Technology	3	0	2	4
	Total Learning Credits				**56**

Open Elective Courses (O)
(Any 3 Courses)

Code	Course Title	L	T	P	C
21BTO101T	Human Health and Diseases	3	0	0	3
21BTO 105T	Animal Models for Research	3	0	0	3
21BTO106T	Waste to Wealth to Wheels	3	0	0	3
21BTO107T	Fundamental Neurobiology	3	0	0	3
	Total Learning Credits				9

Project Work, Seminar, Internship In Industry/ Higher Technical Institutions (P)

Code	Course Title	L	T	P	C
21GNP301L	Community Connect	0	0	2	1
21BTP302L	Project	0	0	6	3
21BTP303T	MOOC	3	0	0	
21BTP401L	Major Project	0	0	20	15
21BTP402L	Industrial Project				
	Total Learning Credits				**19**

Mandatory Courses (M)

Code	Course Title	L	T	P	C
21PDM101L	Professional Skills and Practices	0	0	2	0
21PDM102L	General Aptitude	0	0	2	0
21PDM201L	Verbal Reasoning	0	0	2	0
21PDM202L	Critical and Creative Thinking Skills	0	0	2	0
21PDM301L	Analytical and Logical Thinking Skills	0	0	2	0
21PDM302L	Employability Skill and Practices	0	0	2	0
21CYM101T	Environmental Science	1	0	0	0
21LEM101T	Constitution of India	1	0	0	0
21LEM201T	Professional Ethics	1	0	0	0
21LEM202T	Universal Human Values	1	0	0	0
21LEM301T	Indian Art Form	1	0	0	0
21LEM302T	Indian Traditional Knowledge	1	0	0	0
21GNM101L	Physical and Mental health using Yoga	0	0	2	0
21GNM102L	NSS				
21GNM103L	NCC				
21GNM104L	NSO				
21BTM191T	Bioethics and IPR	1	0	0	0
	Total Learning Credits				**0**

1. (f) Program Articulation: B.Tech. in Biotechnology

Course Code	Course Name	Program Outcome (PO)												PSO		
		Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
21BTB105T	Cell Biology	2	3	3	3	2	-	-	-	-	-	-	-	-	2.67	3
21BTC101T	Biochemistry	3	2	-	3	-	-	-	-	-	-	-	-	3	2	-
21BTC201L	Biochemistry Laboratory	3	2	-	3	-	-	-	-	-	-	-	-	3	2	-
21BTC202T	Microbiology	2.5	2	2.25	2.67	3	-	2	2	-	-	-	-	1.83	-	2
21BTC203L	Cell and Molecular Biology Laboratory	2.5	2	2.25	2.67	3	-	2	2	-	-	-	-	1.83	-	2
21BTC204T	Bioprocess Principles	2.5	2.67	2.25	2	2	-	-	-	-	-	-	-	2.67	1.75	-
21BTC205L	Bioprocess Principles Laboratory	2.5	2.67	2.25	2	2	-	-	-	-	-	-	-	2.67	1.75	-
21BTC206T	Genetics and Cytogenetics	2.67	2.5	2.2	2	-	-	-	-	-	-	-	-	-	2.5	2.5
21BTC207T	Molecular Biology	3	2.75	2.4	-	-	-	-	-	-	-	-	-	-	2.67	2.83
21BTC208L	Molecular Biology Laboratory	3	2.75	2.4	-	-	-	-	-	-	-	-	-	-	2.67	2.83
21BTC209T	Bioprocess Engineering	-	3	1.75	2.25	2	-	-	-	-	-	-	-	2	2	1
21BTC210L	Bioprocess Engineering Laboratory	-	3	1.75	2.25	2	-	-	-	-	-	-	-	2	2	1
21BTC301J	Gene manipulation and Genomics	2.67	2.67	2.5	2.33	2.75	-	-	2	-	-	-	-	-	2.83	2.83
21BTC302J	Immunology	-	-	2	2.6	2.33	1	-	-	-	-	-	-	1.67	-	2
21BTC303T	Protein engineering	1.5	2	3	2	3	-	-	-	-	-	-	-	-	3	3
21BTC304T	Animal Biotechnology	3	3	3	3	-	-	-	-	-	-	-	-	-	3	3
21BTC305L	Animal biotechnology Laboratory	3	3	3	3	-	-	-	-	-	-	-	-	-	3	3
21BTC306T	Plant Biotechnology	3	2.6	3	3	3	-	-	-	-	-	-	-	2.5	2	2.75
21BTC401L	Plant Biotechnology Laboratory	3	2.6	3	3	3	-	-	-	-	-	-	-	2.5	2	2.75
21BTC402J	Bio separation Technology	3	2.33	2.5	1	-	-	-	-	-	-	-	-	-	2.5	2.67
21BTM191T	Bioethics and IPR	1.83	2.33	-	-	-	-	2.67	3	-	-	-	-	2.67	-	3
21BTE201T	Developmental Biology	3	2.5	2	2.5	2.5	-	-	-	-	-	-	-	-	2.83	2.83
21BTE301T	Diseases Models and Mechanism	-	2.83	2.75	2.67	1.5	-	-	-	-	-	-	-	-	2	3
21BTE302T	Metabolic Disorders	1.3	2.5	3	2	3	3	-	-	-	-	-	-	-	3	3
21BTE401T	Cellular & Molecular Neuroscience	2.83	2.5	2.4	2	-	-	-	-	-	-	-	-	-	2.5	2.5
21BTE402T	Cancer Biology and Therapeutics	-	1.8	1.5	2.5	1.5	-	-	-	-	-	-	-	-	2	2
21BTE403T	Physiology of Stress and its Management	2	2.67	2.67	-	-	-	-	-	-	-	-	-	-	2.4	2.83
21BTE202T	Pharmaceutical Biotechnology	3	3	2.5	2.83	-	-	-	-	-	-	-	-	3	3	-
21BTE303T	Computational Molecular Biology	2.17	2.25	-	-	3	-	-	-	-	-	-	-	-	2	3
21BTE304T	Computer aided Drug Designing	3	3	3	2	3	-	-	-	-	-	-	-	-	2	2.83
21BTE404T	Marine Biotechnology	1.83	2	2	2.8	2	-	-	-	-	-	-	-	-	2.25	3
21BTE405T	Vaccine Biotechnology	3	2.5	2.67	3	-	-	-	-	-	-	-	-	2	2.8	2.75
21BTE406T	Molecular Basis of Drug action	2	2.75	2.8	3	3	-	-	-	-	-	-	-	-	2.83	2.83
21BTE203T	Plant Hormones and Signaling	2.83	-	2.83	2.83	-	-	-	-	-	-	-	-	-	2.83	2
21BTE305T	Epigenetics in Plants	3	2.33	2.5	-	2	-	-	-	-	-	-	-	-	2.5	2
21BTE306T	Pathogenesis-Related Proteins In Plants	3	3	2.33	2	-	-	-	-	-	-	-	-	-	3	3
21BTE407T	Food Science and Nutrition	-	3	3	3	3		-	2	-	-	-	-	-	3	3
21BTE408T	Therapeutic Compounds from Plants	2.83	-	2.83	-	2.83	-	-	-	-	-	-	-	-	2.83	-
21BTE409T	Food safety and quality Management	2	3	3	2.33	3	3	2	-	-	-	-	-	3	3	-
21BTE204T	Enzyme Engineering and Technology	1.8	1.8	2.33	2.67	-	-	-	-	-	-	-	-	2.6	1.83	-
21BTE307T	Membrane Separation Technology	3	3	3	3	1	-	-	-	-	-	-	-	2.5	3	-
21BTE308T	Industrial Fermentation Engineering	2	1.25	2.67	2.83	-	--	-	-	-	-	-	-	2.6	2.4	-
21BTE410T	Bioreactor Design	2.75	2.5	3	3	1	-	-	-	-	-	-	-	2.5	3	-
21BTE411T	Bioprocess Modelling and Simulation	2.33	2	2	-	2.6	-	-	-	-	-	-	-	2.5	3	-
21BTE412T	Bioprocess Plant Design	3	1.75	2.25	-	-	-	-	-	-	-	-	-	2	2	1
21BTE205T	Environmental Biotechnology	2	2.83	2.33	2.67	2	-	2.8	-	-	-	-	-	1.6	3	2.83
21BTE309T	Industrial Waste Management	2	2.6	2.75	2.67	2	-	3	2	-	-	-	-	2.75	3	2..67
21BTE310T	Bioenergy	3	2	2.6	2.67	-	-	3	-	-	-	-	-	1.6	3	3
21BTE413T	Metabolic Engineering of Microorganism for Environment and Energy	2.25	2.8	2.67	2.33	2	-	1.75	-	-	-	-	-	-	2.83	2.83
21BTE414T	Microbial degradation and Bioremediation Technology	2	3	2.67	3	2.5	-	3	-	-	-	-	-	3	3	3
21BTE415T	Environmental Biosensors	2	2	2.2	2.17	2	-	2.5	-	-	-	-	-	1.8	3	-
21GNP301L	Community Connect	3	2	2	-	-	-	-	-	-	2	-	2	2	2	-
21BTP302L	MOOC	3	2	2	-	-	-	-	-	-	2	-	2	2	2	-
21BTP303L	Project	3	3	3	3	3	2	2	3	3	3	3	3	3	3	3
21BTP401L	Major Project	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
21BTP402L	Industrial Projects	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	Program Average	2.62	2.50	2.54	2.59	2.44	2.20	2.45	2.54	3.00	2.80	3.00	2.30	2.46	2.62	2.60

1. (g) Implementation Plan: B. Tech.in Biotechnology

Semester - I

Code	Course Title	Hours/ Week L	T	P	C
21LEH101T	Communicative English	2	1	0	3
21MAB101T	Calculus and Linear Algebra	3	1	0	4
21PYB101J	Physics: Electromagnetic Theory, Quantum Mechanics, Waves and Optics	3	1	2	5
21MES102L	Engineering Graphics and Design	0	0	4	2
21EES101T	Electrical and Electronics Engineering	3	1	0	4
21CYM101T	Environmental Science	1	0	0	0
21PDM101L	Professional Skills and Practices	0	0	2	0
21LEM101T	Constitution of India	1	0	0	0
	Total Learning Credits				**18**

Semester - II

Code	Course Title	Hours/ Week L	T	P	C
21LEH102T	Chinese	2	1	0	3
21LEH103T	French				
21LEH104T	German				
21LEH105T	Japanese				
21LEH106T	Korean				
21LEH107T	Spanish				
21GNH101J	Philosophy of Engineering	1	0	2	2
21MAB102T	Advanced Calculus and Complex Analysis	3	1	0	4
21CYB101J	Chemistry	3	1	2	5
21BTB105T	Cell Biology	2	0	0	2
21CSS101J	Programming for Problem Solving	3	0	2	4
21MES101L	Basic Civil and Mechanical Workshop	0	0	4	2
21BTC101T	Biochemistry	3	0	0	3
21PDM102L	General Aptitude	0	0	2	0
21GNM101L	Physical and Mental health using Yoga	0	0	2	0
21GNM102L	NSS				
21GNM103L	NCC				
21GNM104L	NSO				
	Total Learning Credits				**25**

Semester - III

Code	Course Title	Hours/ Week L	T	P	C
21CHS251T	Basic Chemical Engineering	3	0	0	3
21DCS201P	Design Thinking and Methodology	1	0	4	3
21BTC201L	Biochemistry Laboratory	0	0	4	2
21BTC202T	Microbiology	3	0	0	3
21BTC203L	Cell and Microbiology Laboratory	0	0	4	2
21BTC204T	Bioprocess Principles	3	0	0	3
21BTC205L	Bioprocess Principles Laboratory	0	0	4	2
21BTC206T	Genetics and Cytogenetics	3	0	0	3
21LEM201T	Professional Ethics	1	0	0	0
21PDM201L	Verbal Reasoning	0	0	2	0
	Total Learning Credits				**21**

Semester - IV

Code	Course Title	Hours/ Week L	T	P	C
21CHS252J	Chemical Engineering Principles	3	0	2	4
21CSC206T	Artificial Intelligence	3	0	0	3
21BTC207T	Molecular Biology	3	0	0	3
21BTC208L	Molecular Biology Laboratory	0	0	4	2
21BTC209T	Bioprocess Engineering	3	0	0	3
21BTC210L	Bioprocess Engineering Laboratory	0	0	4	2
E	Professional Elective - I	3	0	0	3
21PDH201T	Social Engineering	2	0	0	2
21PDM202L	Critical and Creative Thinking Skills	0	0	2	0
21LEM202T	Universal Human Values	1	0	0	0
	Total Learning Credits				**22**

Semester - V

Code	Course Title	Hours/ Week L	T	P	C
21MAB303T	Bio-Statistics for Biotechnologists	3	1	0	4
21BTC301J	Gene Manipulation and Genomics	3	0	2	4
21BTC302J	Immunology	3	0	2	4
21BTC303T	Protein Engineering	3	0	0	3
E	Professional Elective – 2	3	0	0	3
O	Open Elective – 1	3	0	0	3
21GNP301L	Community Connect	0	0	2	1
21PDM301L	Analytical and Logical Thinking Skills	0	0	2	0
21LEM301T	Indian Art Form	1	0	0	0
	Total Learning Credits				**22**

Semester - VI

Code	Course Title	Hours/ Week L	T	P	C
21CSS303T	Data Science	1	1	0	2
21BTC304T	Animal Biotechnology	3	0	0	3
21BTC305L	Animal Biotechnology Laboratory	0	0	4	2
21BTC306T	Plant Biotechnology	3	0	0	3
E	Professional Elective – 3	3	0	0	3
O	Open Elective – 2	3	0	0	3
21BTP302L	Project	0	0	6	3
21BTP303T	MOOCS	3	0	0	
21LEM302T	Indian Traditional Knowledge	1	0	0	0
21PDM302L	Employability Skills and Practices	0	0	2	0
	Total Learning Credits				**19**

Semester - VII

Code	Course Title	Hours/ Week L	T	P	C
21BTC401L	Plant Biotechnology Laboratory	0	0	4	2
21BTC402J	Bio Separation Technology	3	0	2	4
E	Professional Elective – 4	3	0	0	3
E	Professional Elective – 5	3	0	0	3
O	Open Elective – 3	3	0	0	3
21GNH401T	Behavioral Psychology	2	1	0	3
21BTM191T	Bioethics and IPR	1	0	0	0
	Total Learning Credits				**18**

Semester - VIII

Code	Course Title	Hours/ Week L	T	P	C
21BTP401L	Major Project	0	0	20	15
21BTP402L	Industrial project				
	Total Learning Credits				**15**

B.Tech. in Biotechnology with Specialization in Regenerative Medicine

1. (a) Mission of the Department

Mission Stmt - 1	*To adopt effective teaching methods to improve the learning process and impart knowledge of biology and technology.*
Mission Stmt - 2	*To provide hands-on training and technical skills to transform students into technocrats and facilitate research and higher education in the fields of biotechnology.*
Mission Stmt - 3	*To pursue and promote cutting-edge research in selected fields of biotechnology*

1. (b) Program Educational Objectives (PEO)

PEO - 1	*To develop graduates with enhanced technical and professional skills in Tissue Engineering*
PEO - 2	*To develop the ability amongst the students to apply modern bioengineering techniques in solve complex engineering solutions in Regenerative Medicine*
PEO - 3	*To prepare students to demonstrate the applications of biotechnological principles through research related to regeneration and transplants for societal and industrial importance*

1. (c) Mission of the Department to Program Educational Objectives (PEO) Mapping

	Mission Stmt. - 1	Mission Stmt. - 2	Mission Stmt. - 3
PEO - 1	*H*	*H*	*H*
PEO - 2	*H*	*H*	*H*
PEO - 3	*H*	*H*	*H*

H – High Correlation, M – Medium Correlation, L – Low Correlation

1. (d) Mapping Program Educational Objectives (PEO) to Program Outcomes (PO)

	Program Outcomes (PO)												Program Specific Outcomes (PSO)		
	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
PEO - 1	*H*	*H*	*M*	*H*	*M*	*M*	*M*	*M*	*H*	*M*	*M*	*M*	*H*	*H*	*H*
PEO - 2	*H*	*H*	*H*	*H*	*H*	*M*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*H*
PEO - 3	*H*	*H*	*H*	*H*	*H*	*M*	*M*	*M*	*H*	*M*	*H*	*H*	*H*	*H*	*H*

H – High Correlation, M – Medium Correlation, L – Low Correlation

PSO – Program Specific Outcomes (PSO)

PSO - 1	*Integrate engineering principles for pursuing excellence in applied fields of Tissue Engineering*
PSO - 2	*Acquire knowledge and problem-solving skills in tissue engineering and stem cell research, critical in sustaining life processes for better health.*
PSO - 3	*Ability to apply biological knowledge from the perspective of engineers for development of industrial products in tissue regeneration*

1. (e) Program Structure: B.Tech. in Biotechnology with Specialization in Regenerative Medicine

Humanities & Social Sciences including Management Courses (H)					
Course Code	Course Title	Hours/ Week L	T	P	C
21LEH101T	Communicative English	2	1	0	3
21LEH102T	Chinese	2	1	0	3
21LEH103T	French				
21LEH104T	German				
21LEH105T	Japanese				
21LEH106T	Korean				
21LEH107T	Spanish				
21GNH101J	Philosophy of Engineering	1	0	2	2
21PDH201T	Social Engineering	2	0	0	2
21GNH401T	Behavioral psychology	2	1	0	3
Total Learning Credits					**13**

Engineering Science Courses (S)					
Course Code	Course Title	Hours/ Week L	T	P	C
21CSS101J	Programming for Problem Solving	3	0	2	4
21MES101L	Basic Civil and Mechanical Workshop	0	0	4	2
21MES102L	Engineering Graphics and Design	0	0	4	2
21EES101T	Electrical and Electronics Engineering	3	1	0	4
21DCS201P	Design Thinking and Methodology	1	0	4	3
21CHS251T	Basic Chemical Engineering	3	0	0	3
21CHS252J	Chemical Engineering Principles	3	0	2	4
21CSS303T	Data Science	1	1	0	2
Total Learning Credits					**24**

Professional Elective Courses (E) (Any 5 Courses)					
Course Code	Course Title	Hours/ Week L	T	P	C
21BTE206T	Molecular Cell Biology	3	0	0	3
21BTE311T	Cell Communication and Signaling	3	0	0	3
21BTE312T	Stem Cell Technology	3	0	0	3
21BTE313T	Biomaterials in Tissue Engineering	3	0	0	3
21BTE314T	Nanotechnology in Regenerative Medicine	3	0	0	3
21BTE416T	Tissue Engineering for Regenerative Medicine	3	0	0	3
21BTE417T	Bioreactors in Tissue Engineering	3	0	0	3
21BTE418T	Developmental Biology in Tissue Engineering	3	0	0	3
21BTE419T	Advanced Immunology and Vascular Tissue Engineering	3	0	0	3
Total Learning Credits					15

Basic Science Courses (B)					
Course Code	Course Title	Hours/ Week L	T	P	C
21PYB101J	Physics: Electromagnetic Theory, Quantum Mechanics & Waves Optics	3	1	2	5
21CYB101J	Chemistry	3	1	2	5
21MAB101T	Calculus and Linear Algebra	3	1	0	4
21MAB102T	Advanced Calculus and Complex Analysis	3	1	0	4
21MAB303T	Bio-Statistics for Biotechnologists	3	1	0	4
21BTB105T	Cell Biology	2	0	0	2
Total Learning Credits					**24**

Professional Core Courses (C)					
Course Code	Course Title	Hours/ Week L	T	P	C
21BTC101T	Biochemistry	3	0	0	3
21BTC201L	Biochemistry Laboratory	0	0	4	2
21BTC202T	Microbiology	3	0	0	3
21BTC203L	Cell and Microbiology Laboratory	0	0	4	2
21BTC204T	Bioprocess Principles	3	0	0	3
21BTC205L	Bioprocess Principles Laboratory	0	0	4	2
21BTC206T	Genetics and Cytogenetics	3	0	0	3
21BTC207T	Molecular Biology	3	0	0	3
21BTC208L	Molecular Biology Laboratory	0	0	4	2
21BTC209T	Bioprocess Engineering	3	0	0	3
21BTC210L	Bioprocess Engineering Laboratory	0	0	4	2
21CSC206T	Artificial Intelligence	3	0	0	3
21BTC301J	Gene Manipulation and Genomics	3	0	2	4
21BTC302J	Immunology	3	0	2	4
21BTC303T	Protein Engineering	3	0	0	3
21BTC304T	Animal Biotechnology	3	0	0	3
21BTC305L	Animal Biotechnology Laboratory	0	0	4	2
21BTC306T	Plant Biotechnology	3	0	0	3
21BTC401L	Plant Biotechnology Laboratory	0	0	4	2
21BTC402J	Bio Separation Technology	3	0	2	4
Total Learning Credits					**56**

Open Elective Courses (O) (Any 3 Courses)					
Code	Course Title	L	T	P	C
21BTO101T	Human Health and Diseases	3	0	0	3
21BTO 105T	Animal Models for Research	3	0	0	3
21BTO106T	Waste to Wealth to Wheels	3	0	0	3
21BTO107T	Fundamental Neurobiology	3	0	0	3
Total Learning Credits					9

Project Work, Seminar, Internship In Industry/ Higher Technical Institutions (P)					
Code	Course Title	L	T	P	C
21GNP301L	Community Connect	0	0	2	1
21BTP302L	Project	0	0	6	3
21BTP303T	MOOC	3	0	0	
21BTP401L	Major Project	0	0	20	15
21BTP402L	Industrial Project				
Total Learning Credits					**19**

Mandatory Courses (M)					
Code	Course Title	L	T	P	C
21PDM101L	Professional Skills and Practices	0	0	2	0
21PDM102L	General Aptitude	0	0	2	0
21PDM201L	Verbal Reasoning	0	0	2	0
21PDM202L	Critical and Creative Thinking Skills	0	0	2	0
21PDM301L	Analytical and logical Thinking Skills	0	0	2	0
21PDM302L	Employability Skill and Practices	0	0	2	0
21CYM101T	Environmental Science	1	0	0	0
21LEM101T	Constitution of India	1	0	0	0
21LEM201T	Professional Ethics	1	0	0	0
21LEM202T	Universal Human Values	1	0	0	0
21LEM301T	Indian Art Form	1	0	0	0
21LEM302T	Indian Traditional Knowledge	1	0	0	0
21GNM101L	Physical and Mental health using Yoga	0	0	2	0
21GNM102L	NSS				
21GNM103L	NCC				
21GNM104L	NSO				
21BTM191T	Bioethics and IPR	1	0	0	0
Total Learning Credits					**0**

1. (f) Program Articulation: B.Tech. in Biotechnology with Specialization in Regenerative Medicine

		Program Outcome (PO)												PSO		
Course Code	Course Name	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
21BTB105T	Cell Biology	2	3	3	3	2	-	-	-	-	-	-	-	-	2.67	3
21BTC101T	Biochemistry	3	2	-	3	-	-	-	-	-	-	-	-	3	2	-
21BTC201L	Biochemistry Laboratory	3	2	-	3	-	-	-	-	-	-	-	-	3	2	-
21BTC202T	Microbiology	2.5	2	2.25	2.67	3	-	2	2	-	-	-	-	1.83	-	2
21BTC203L	Cell and Molecular Biology Laboratory	2.5	2	2.25	2.67	3	-	2	2	-	-	-	-	1.83	-	2
21BTC204T	Bioprocess Principles	2.5	2.67	2.25	2	2	-	-	-	-	-	-	-	2.67	1.75	-
21BTC205L	Bioprocess Principles Laboratory	2.5	2.67	2.25	2	2	-	-	-	-	-	-	-	2.67	1.75	-
21BTC206T	Genetics and Cytogenetics	2.67	2.5	2.2	2	-	-	-	-	-	-	-	-	-	2.5	2.5
21BTC207T	Molecular Biology	3	2.75	2.4	-	-	-	-	-	-	-	-	-	-	2.67	2.83
21BTC208L	Molecular Biology Laboratory	3	2.75	2.4	-	-	-	-	-	-	-	-	-	-	2.67	2.83
21BTC209T	Bioprocess Engineering	-	3	1.75	2.25	2	-	-	-	-	-	-	-	2	2	1
21BTC210L	Bioprocess Engineering Laboratory	-	3	1.75	2.25	2	-	-	-	-	-	-	-	2	2	1
21BTC301J	Gene manipulation and Genomics	2.67	2.67	2.5	2.33	2.75	-	-	2	-	-	-	-	-	2.83	2.83
21BTC302J	Immunology	-	-	2	2.6	2.33	1	-	-	-	-	-	-	1.67	-	2
21BTC303T	Protein engineering	1.5	2	3	2	3	-	-	-	-	-	-	-	-	3	3
21BTC304T	Animal Biotechnology	3	3	3	3	-	-	-	-	-	-	-	-	-	3	3
21BTC305L	Animal biotechnology Laboratory	3	3	3	3	-	-	-	-	-	-	-	-	-	3	3
21BTC306T	Plant Biotechnology	3	2.6	3	3	3	-	-	-	-	-	-	-	2.5	2	2.75
21BTC401L	Plant Biotechnology Laboratory	3	2.6	3	3	3	-	-	-	-	-	-	-	2.5	2	2.75
21BTC402J	Bio separation Technology	3	2.33	2.5	1	-	-	-	-	-	-	-	-	-	2.5	2.67
21BTM191T	Bioethics and IPR	1.83	2.33	-	-	-	-	2.67	3	-	-	-	-	2.67	-	3
21BTE201T	Molecular Cell Biology	1.83	1.8	1.67	2	1	2.5	-	-	-	-	-	-	-	2	2
21BTE301T	Cell Communication and Signaling	-	-	1.8	-	-	-	--		-	-	-	-	-	2	2
21BTE302T	Stem Cell Technology	-	-	-	2.2	3	-	-	3	-	-	-	-	2.5	3	3
21BTE401T	Biomaterials in Tissue Engineering	-	-	2	2	-	-	-	3	-	-	-	-	2	2	-
21BTE402T	Nanotechnology in Regenerative Medicine	3	2.5	2.75	2.2	1	-	-	-	-	-	-	-	-	3	3
21BTE403T	Tissue Engineering for Regenerative Medicine	2.67	2.5	2.2	2	-	-	-	-	-	-	-	-		2.5	2.5
21BTE202T	Bioreactors in Tissue Engineering	-	-	2	2	2	-	-	-	-	-	-	-	2	2	
21BTE303T	Developmental Biology in Tissue Engineering	-	3	2.5	2.25	-	-	-	-	-	-	-	-	2	2.75	2.5
21BTE304T	Advanced Immunology and Vascular Tissue Engineering	3	3	2	2.5	3	-	-	3	-	-	-	-	2.5	2	2.5
21GNP301L	Community Connect	3	2	2	-	-	-	-	-	-	2	-	2	2	2	-
21BTP302L	MOOC	3	2	2	-	-	-	-	-	-	2	-	2	2	2	-
21BTP303L	Project	3	3	3	3	3	2	2	3	3	3	3	3	3	3	3
21BTP401L	Major Project	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
21BTP402L	Industrial Projects	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	Program Average	2.62	2.50	2.54	2.59	2.44	2.20	2.45	2.54	3.00	2.80	3.00	2.30	2.46	2.62	2.60

1. (g) Implementation Plan: B.Tech. in Biotechnology with Specialization in Regenerative Medicine

Semester - I

Code	Course Title	Hours/ Week L	T	P	C
21LEH101T	Communicative English	2	1	0	3
21MAB101T	Calculus and Linear Algebra	3	1	0	4
21PYB101J	Physics: Electromagnetic Theory, Quantum Mechanics, Waves and Optics	3	1	2	5
21MES102L	Engineering Graphics and Design	0	0	4	2
21EES101T	Electrical and Electronics Engineering	3	1	0	4
21CYM101T	Environmental Science	1	0	0	0
21PDM101L	Professional Skills and Practices	0	0	2	0
21LEM101T	Constitution of India	1	0	0	0
	Total Learning Credits				**18**

Semester - II

Code	Course Title	Hours/ Week L	T	P	C
21LEH102T	Chinese	2	1	0	3
21LEH103T	French				
21LEH104T	German				
21LEH105T	Japanese				
21LEH106T	Korean				
21LEH107T	Spanish				
21GNH101J	Philosophy of Engineering	1	0	2	2
21MAB102T	Advanced Calculus and Complex Analysis	3	1	0	4
21CYB101J	Chemistry	3	1	2	5
21BTB105T	Cell Biology	2	0	0	2
21CSS101J	Programming for Problem Solving	3	0	2	4
21MES101L	Basic Civil and Mechanical Workshop	0	0	4	2
21BTC101T	Biochemistry	3	0	0	3
21PDM102L	General Aptitude	0	0	2	0
21GNM101L	Physical and Mental health using Yoga	0	0	2	0
21GNM102L	NSS				
21GNM103L	NCC				
21GNM104L	NSO				
	Total Learning Credits				**25**

Semester - III

Code	Course Title	Hours/ Week L	T	P	C
21CHS251T	Basic Chemical Engineering	3	0	0	3
21DCS201P	Design Thinking and Methodology	1	0	4	3
21BTC201L	Biochemistry Laboratory	0	0	4	2
21BTC202T	Microbiology	3	0	0	3
21BTC203L	Cell and Microbiology Laboratory	0	0	4	2
21BTC204T	Bioprocess Principles	3	0	0	3
21BTC205L	Bioprocess Principles Laboratory	0	0	4	2
21BTC206T	Genetics and Cytogenetics	3	0	0	3
21LEM201T	Professional Ethics	1	0	0	0
21PDM201L	Verbal Reasoning	0	0	2	0
	Total Learning Credits				**21**

Semester - IV

Code	Course Title	Hours/ Week L	T	P	C
21CHS252J	Chemical Engineering Principles	3	0	2	4
21CSC206T	Artificial Intelligence	3	0	0	3
21BTC207T	Molecular Biology	3	0	0	3
21BTC208L	Molecular Biology Laboratory	0	0	4	2
21BTC209T	Bioprocess Engineering	3	0	0	3
21BTC210L	Bioprocess Engineering Laboratory	0	0	4	2
E	Professional Elective - I	3	0	0	3
21PDH201T	Social Engineering	2	0	0	2
21PDM202L	Critical and Creative Thinking Skills	0	0	2	0
21LEM202T	Universal Human Values	1	0	0	0
	Total Learning Credits				**22**

Semester - V

Code	Course Title	Hours/ Week L	T	P	C
21MAB303T	Bio-Statistics for Biotechnologists	3	1	0	4
21BTC301J	Gene Manipulation and Genomics	3	0	2	4
21BTC302J	Immunology	3	0	2	4
21BTC303T	Protein Engineering	3	0	0	3
E	Professional Elective – 2	3	0	0	3
O	Open Elective – 1	3	0	0	3
21GNP301L	Community Connect	0	0	2	1
21PDM301L	Analytical and Logical Thinking Skills	0	0	2	0
21LEM301T	Indian Art Form	1	0	0	0
	Total Learning Credits				**22**

Semester - VI

Code	Course Title	Hours/ Week L	T	P	C
21CSS303T	Data Science	1	1	0	2
21BTC304T	Animal Biotechnology	3	0	0	3
21BTC305L	Animal Biotechnology Laboratory	0	0	4	2
21BTC306T	Plant Biotechnology	3	0	0	3
E	Professional Elective – 3	3	0	0	3
O	Open Elective – 2	3	0	0	3
21BTP302L	Project	0	0	6	3
21BTP303T	MOOCS	3	0	0	
21LEM302T	Indian Traditional Knowledge	1	0	0	0
21PDM302L	Employability Skills and Practices	0	0	2	0
	Total Learning Credits				**19**

Semester - VII

Code	Course Title	Hours/ Week L	T	P	C
21BTC401L	Plant Biotechnology Laboratory	0	0	4	2
21BTC402J	Bio Separation Technology	3	0	2	4
E	Professional Elective – 4	3	0	0	3
E	Professional Elective – 5	3	0	0	3
O	Open Elective – 3	3	0	0	3
21GNH401T	Behavioral Psychology	2	1	0	3
21BTM191T	Bioethics and IPR	1	0	0	0
	Total Learning Credits				**18**

Semester - VIII

Code	Course Title	Hours/ Week L	T	P	C
21BTP401L	Major Project	0	0	20	15
21BTP402L	Industrial project				
	Total Learning Credits				**15**

B.Tech. in Biotechnology with Specialization in Genetic Engineering

1. (a) Mission of the Department

Mission Stmt - 1	*To adopt effective teaching methods to improve the learning process and impart knowledge of biology and technology.*
Mission Stmt - 2	*To provide hands-on training and technical skills to transform students into technocrats and facilitate research and higher education in the fields of biotechnology.*
Mission Stmt - 3	*To pursue and promote cutting-edge research in selected fields of biotechnology*

1. (b)Program Educational Objectives (PEO)

PEO - 1	*To acquire adequate knowledge and expertise in genetic engineering for higher education and research*
PEO - 2	*To identify, analyze, and learn strategies to solve genetic engineering problems*
PEO - 3	*To advance professionally as genetic engineers, who can contribute to betterment of society and be involved in life-long learning*

1. (c)Mission of the Department to Program Educational Objectives (PEO) Mapping

	Mission Stmt. - 1	Mission Stmt. - 2	Mission Stmt. - 3
PEO - 1	*H*	*H*	*H*
PEO - 2	*M*	*H*	*H*
PEO - 3	*H*	*H*	*H*

H – High Correlation, M – Medium Correlation, L – Low Correlation

1. (d)Mapping Program Educational Objectives (PEO) to Program Outcomes (PO)

	Program Outcomes (PLO)												Program Specific Outcomes (PSO)		
	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
PEO - 1	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
PEO - 2	*H*	*H*	*H*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
PEO - 3	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*

H – High Correlation, M – Medium Correlation, L – Low Correlation

PSO – Program Specific Outcomes (PSO)

PSO - 1	*Gain knowledge on different approaches utilized in genetic engineering*
PSO - 2	*Ability to solve clinical, industrial and agricultural problems in genetic Engineering*
PSO - 3	*Emerge as professionals who can develop new strategies in the genetic engineering research for the benefit of society*

1. (e) Program Structure: B.Tech. in Biotechnology with Specialization in Genetic Engineering

Humanities & Social Sciences including Management Courses (H)

Course Code	Course Title	Hours/ Week L	T	P	C
21LEH101T	Communicative English	2	1	0	3
21LEH102T	Chinese	2	1	0	3
21LEH103T	French				
21LEH104T	German				
21LEH105T	Japanese				
21LEH106T	Korean				
21LEH107T	Spanish				
21GNH101J	Philosophy of Engineering	1	0	2	2
21PDH201T	Social Engineering	2	0	0	2
21GNH401T	Behavioral psychology	2	1	0	3
Total Learning Credits					**13**

Engineering Science Courses (S)

Course Code	Course Title	Hours/ Week L	T	P	C
21CSS101J	Programming for Problem Solving	3	0	2	4
21MES101L	Basic Civil and Mechanical Workshop	0	0	4	2
21MES102L	Engineering Graphics and Design	0	0	4	2
21EES101T	Electrical and Electronics Engineering	3	1	0	4
21DCS201P	Design Thinking and Methodology	1	0	4	3
21CHS251T	Basic Chemical Engineering	3	0	0	3
21CHS252J	Chemical Engineering Principles	3	0	2	4
21CSS303T	Data Science	1	1	0	2
Total Learning Credits					**24**

Professional Elective Courses (E)
(Any 5 Courses)

Course Code	Course Title	Hours/ Week L	T	P	C
21BTE207T	Human Genetics	3	0	0	3
21BTE315T	Metabolic Engineering of microbes	3	0	0	3
21BTE316T	Genetic Engineering for Crop Improvement	3	0	0	3
21BTE317T	Molecular Biology of Infectious diseases	3	0	0	3
21BTE318T	Molecular Diagnostics	3	0	0	3
21BTE420T	Gene therapy	3	0	0	3
21BTE421T	Functional genomics	3	0	0	3
21BTE422T	Genome editing	3	0	0	3
21BTE423T	Genes & Animal Development	3	0	0	3
21BTE424T	Genetics of Cancer	3	0	0	3
Total Learning Credits					15

Basic Science Courses (B)

Course Code	Course Title	Hours/ Week L	T	P	C
21PYB101J	Physics: Electromagnetic Theory, Quantum Mechanics & Waves Optics	3	1	2	5
21CYB101J	Chemistry	3	1	2	5
21MAB101T	Calculus and Linear Algebra	3	1	0	4
21MAB102T	Advanced Calculus and Complex Analysis	3	1	0	4
21MAB303T	Bio-Statistics for Biotechnologists	3	1	0	4
21BTB105T	Cell Biology	2	0	0	2
Total Learning Credits					**24**

Professional Core Courses (C)

Course Code	Course Title	Hours/ Week L	T	P	C
21BTC101T	Biochemistry	3	0	0	3
21BTC201L	Biochemistry Laboratory	0	0	4	2
21BTC202T	Microbiology	3	0	0	3
21BTC203L	Cell and Microbiology Laboratory	0	0	4	2
21BTC204T	Bioprocess Principles	3	0	0	3
21BTC205L	Bioprocess Principles Laboratory	0	0	4	2
21BTC206T	Genetics and Cytogenetics	3	0	0	3
21BTC207T	Molecular Biology	3	0	0	3
21BTC208L	Molecular Biology Laboratory	0	0	4	2
21BTC209T	Bioprocess Engineering	3	0	0	3
21BTC210L	Bioprocess Engineering Laboratory	0	0	4	2
21CSC206T	Artificial Intelligence	3	0	0	3
21BTC301J	Gene Manipulation and Genomics	3	0	2	4
21BTC302J	Immunology	3	0	2	4
21BTC303T	Protein Engineering				
21BTC304T	Animal Biotechnology	3	0	0	3
21BTC305L	Animal Biotechnology Laboratory	0	0	4	2
21BTC306T	Plant Biotechnology	3	0	0	3
21BTC401L	Plant Biotechnology Laboratory	0	0	4	2
21BTC402J	Bio Separation Technology	3	0	2	4
Total Learning Credits					**53**

Open Elective Courses (O)
(Any 3 Courses)

Code	Course Title	L	T	P	C
21BTO101T	Human Health and Diseases	3	0	0	3
21BTO 105T	Animal Models for Research	3	0	0	3
21BTO106T	Waste to Wealth to Wheels	3	0	0	3
21BTO107T	Fundamental Neurobiology	3	0	0	3
Total Learning Credits					9

Project Work, Seminar, Internship In Industry/ Higher Technical Institutions (P)

Code	Course Title	L	T	P	C
21GNP301L	Community Connect	0	0	2	1
21BTP302L	Project	0	0	6	3
21BTP303T	MOOC	3	0	0	
21BTP401L	Major Project	0	0	20	15
21BTP402L	Industrial Project				
Total Learning Credits					**19**

Mandatory Courses (M)

Code	Course Title	L	T	P	C
21PDM101L	Professional Skills and Practices	0	0	2	0
21PDM102L	General Aptitude	0	0	2	0
21PDM201L	Verbal Reasoning	0	0	2	0
21PDM202L	Critical and Creative Thinking Skills	0	0	2	0
21PDM301L	Analytical and Logical Thinking Skills	0	0	2	0
21PDM302L	Employability Skill and Practices	0	0	2	0
21CYM101T	Environmental Science	1	0	0	0
21LEM101T	Constitution of India	1	0	0	0
21LEM201T	Professional Ethics	1	0	0	0
21LEM202T	Universal Human Values	1	0	0	0
21LEM301T	Indian Art Form	1	0	0	0
21LEM302T	Indian Traditional Knowledge	1	0	0	0
21GNM101L	Physical and Mental health using Yoga	0	0	2	0
21GNM102L	NSS				
21GNM103L	NCC				
21GNM104L	NSO				
21BTM191T	Bioethics and IPR	1	0	0	0
Total Learning Credits					**0**

1. (f) Program Articulation : B.Tech. in Biotechnology with Specialization in Genetic Engineering

		Program Outcome (PO)												PSO		
Course Code	Course Name	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
21BTB105T	Cell Biology	2	3	3	3	2	-	-	-	-	-	-	-	-	2.67	3
21BTC101T	Biochemistry	3	2	-	3	-	-	-	-	-	-	-	-	3	2	-
21BTC201L	Biochemistry Laboratory	3	2	-	3	-	-	-	-	-	-	-	-	3	2	-
21BTC202T	Microbiology	2.5	2	2.25	2.67	3	-	2	2	-	-	-	-	1.83	-	2
21BTC203L	Cell and Molecular Biology Laboratory	2.5	2	2.25	2.67	3	-	2	2	-	-	-	-	1.83	-	2
21BTC204T	Bioprocess Principles	2.5	2.67	2.25	2	2	-	-	-	-	-	-	-	2.67	1.75	-
21BTC205L	Bioprocess Principles Laboratory	2.5	2.67	2.25	2	2	-	-	-	-	-	-	-	2.67	1.75	-
21BTC206T	Genetics and Cytogenetics	2.67	2.5	2.2	2	-	-	-	-	-	-	-	-	-	2.5	2.5
21BTC207T	Molecular Biology	3	2.75	2.4	-	-	-	-	-	-	-	-	-	-	2.67	2.83
21BTC208L	Molecular Biology Laboratory	3	2.75	2.4	-	-	-	-	-	-	-	-	-	-	2.67	2.83
21BTC209T	Bioprocess Engineering	-	3	1.75	2.25	2	-	-	-	-	-	-	-	2	2	1
21BTC210L	Bioprocess Engineering Laboratory	-	3	1.75	2.25	2	-	-	-	-	-	-	-	2	2	1
21BTC301J	Gene manipulation and Genomics	2.67	2.67	2.5	2.33	2.75	-	-	2	-	-	-	-	-	2.83	2.83
21BTC302J	Immunology	-	-	2	2.6	2.33	1	-	-	-	-	-	-	1.67	-	2
21BTC303T	Protein engineering	1.5	2	3	2	3	-	-	-	-	-	-	-	-	3	3
21BTC304T	Animal Biotechnology	3	3	3	3	-	-	-	-	-	-	-	-	-	3	3
21BTC305L	Animal biotechnology Laboratory	3	3	3	3	-	-	-	-	-	-	-	-	-	3	3
21BTC306T	Plant Biotechnology	3	2.6	3	3	3	-	-	-	-	-	-	-	2.5	2	2.75
21BTC401L	Plant Biotechnology Laboratory	3	2.6	3	3	3	-	-	-	-	-	-	-	2.5	2	2.75
21BTC402J	Bio separation Technology	3	2.33	2.5	1	-	-	-	-	-	-	-	-	-	2.5	2.67
21BTM191T	Bioethics and IPR	1.83	2.33	-	-	-	-	2.67	3	-	-	-	-	2.67	-	3
21BTE207T	Human Genetics	2	-	2.67	2.75	2	-	-	-	-	-	-	-	1.75	3	1.66
21BTE315T	Metabolic Engineering of microbes	-	2	2.4	-	2	-	-	-	-	-	-	-	1.5	2.5	-
21BTE316T	Genetic Engineering for Crop Improvement	2.33	-	3	3	3	-	-	-	-	-	-	-	2	3	-
21BTE317T	Molecular biology of Infectious diseases	3	2	2.5	2.5	3	-	-	-	-	-	-	-	-	3	2
21BTE318T	Molecular Diagnostics	2	2.67	-	2.33	3	-	-	-	-	-	-	-	2.67	2.67	-
21BTE420T	Gene therapy	2.5	-	2	1.5	2	-	-	2.16	-	-	-	-	2.5	3	2
21BTE421T	Functional genomics	2.33	2.33	3	3	2	-	-	-	-	-	-	-	3	2.75	2
21BTE422T	Genome Editing	2.5	2.5	1.33	1.33	-	-	-	-	-	-	-	-	1	1.5	2
21BTE423T	Genes and Animal Development	2.33	2.33	3	3	2	-	-	-	-	-	-	-	3	2.75	2
21BTE424T	Genetics of Cancer	2.5	2.5	1.33	1.33	-	-	-	-	-	-	-	-	1	1.5	2
21GNP301L	Community Connect	3	2	2	-	-	-	-	-	-	2	-	2	2	2	-
21BTP302L	MOOC	3	2	2	-	-	-	-	-	-	2	-	2	2	2	-
21BTP303L	Project	3	3	3	3	3	2	2	3	3	3	3	3	3	3	3
21BTP401L	Major Project	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
21BTP402L	Industrial Projects	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	Program Average	2.62	2.50	2.54	2.59	2.44	2.20	2.45	2.54	3.00	2.80	3.00	2.30	2.46	2.62	2.60

1. (g) Implementation Plan: B.Tech. in Biotechnology with Specialization in Genetic Engineering

Semester - I

Code	Course Title	Hours/ Week L	T	P	C
21LEH101T	Communicative English	2	1	0	3
21MAB101T	Calculus and Linear Algebra	3	1	0	4
21PYB101J	Physics: Electromagnetic Theory, Quantum Mechanics, Waves and Optics	3	1	2	5
21MES102L	Engineering Graphics and Design	0	0	4	2
21EES101T	Electrical and Electronics Engineering	3	1	0	4
21CYM101T	Environmental Science	1	0	0	0
21PDM101L	Professional Skills and Practices	0	0	2	0
21LEM101T	Constitution of India	1	0	0	0
	Total Learning Credits				**18**

Semester - II

Code	Course Title	Hours/ Week L	T	P	C
21LEH102T	Chinese	2	1	0	3
21LEH103T	French				
21LEH104T	German				
21LEH105T	Japanese				
21LEH106T	Korean				
21LEH107T	Spanish				
21GNH101J	Philosophy of Engineering	1	0	2	2
21MAB102T	Advanced Calculus and Complex Analysis	3	1	0	4
21CYB101J	Chemistry	3	1	2	5
21BTB105T	Cell Biology	2	0	0	2
21CSS101J	Programming for Problem Solving	3	0	2	4
21MES101L	Basic Civil and Mechanical Workshop	0	0	4	2
21BTC101T	Biochemistry	3	0	0	3
21PDM102L	General Aptitude	0	0	2	0
21GNM101L	Physical and Mental health using Yoga	0	0	2	0
21GNM102L	NSS				
21GNM103L	NCC				
21GNM104L	NSO				
	Total Learning Credits				**25**

Semester - III

Code	Course Title	Hours/ Week L	T	P	C
21CHS251T	Basic Chemical Engineering	3	0	0	3
21DCS201P	Design Thinking and Methodology	1	0	4	3
21BTC201L	Biochemistry Laboratory	0	0	4	2
21BTC202T	Microbiology	3	0	0	3
21BTC203L	Cell and Microbiology Laboratory	0	0	4	2
21BTC204T	Bioprocess Principles	3	0	0	3
21BTC205L	Bioprocess Principles Laboratory	0	0	4	2
21BTC206T	Genetics and Cytogenetics	3	0	0	3
21LEM201T	Professional Ethics	1	0	0	0
21PDM201L	Verbal Reasoning	0	0	2	0
	Total Learning Credits				**21**

Semester - IV

Code	Course Title	Hours/ Week L	T	P	C
21CHS252J	Chemical Engineering Principles	3	0	2	4
21CSC206T	Artificial Intelligence	3	0	0	3
21BTC207T	Molecular Biology	3	0	0	3
21BTC208L	Molecular Biology Laboratory	0	0	4	2
21BTC209T	Bioprocess Engineering	3	0	0	3
21BTC210L	Bioprocess Engineering Laboratory	0	0	4	2
E	Professional Elective - I	3	0	0	3
21PDH201T	Social Engineering	2	0	0	2
21PDM202L	Critical and Creative Thinking Skills	0	0	2	0
21LEM202T	Universal Human Values	1	0	0	0
	Total Learning Credits				**22**

Semester - V

Code	Course Title	Hours/ Week L	T	P	C
21MAB303T	Bio-Statistics for Biotechnologists	3	1	0	4
21BTC301J	Gene Manipulation and Genomics	3	0	2	4
21BTC302J	Immunology	3	0	2	4
21BTC303T	Protein Engineering	3	0	0	3
E	Professional Elective – 2	3	0	0	3
O	Open Elective – 1	3	0	0	3
21GNP301L	Community Connect	0	0	2	1
21PDM301L	Analytical and Logical Thinking Skills	0	0	2	0
21LEM301T	Indian Art Form	1	0	0	0
	Total Learning Credits				**22**

Semester - VI

Code	Course Title	Hours/ Week L	T	P	C
21CSS303T	Data Science	1	1	0	2
21BTC304T	Animal Biotechnology	3	0	0	3
21BTC305L	Animal Biotechnology Laboratory	0	0	4	2
21BTC306T	Plant Biotechnology	3	0	0	3
E	Professional Elective – 3	3	0	0	3
O	Open Elective – 2	3	0	0	3
21BTP302L	Project	0	0	6	3
21BTP303T	MOOCS	3	0	0	
21LEM302T	Indian Traditional Knowledge	1	0	0	0
21PDM302L	Employability Skills and Practices	0	0	2	0
	Total Learning Credits				**19**

Semester - VII

Code	Course Title	Hours/ Week L	T	P	C
21BTC401L	Plant Biotechnology Laboratory	0	0	4	2
21BTC402J	Bio Separation Technology	3	0	2	4
E	Professional Elective – 4	3	0	0	3
E	Professional Elective – 5	3	0	0	3
O	Open Elective – 3	3	0	0	3
21GNH401T	Behavioral Psychology	2	1	0	3
21BTM191T	Bioethics and IPR	1	0	0	0
	Total Learning Credits				**18**

Semester - VIII

Code	Course Title	Hours/ Week L	T	P	C
21BTP401L	Major Project	0	0	20	15
21BTP402L	Industrial project				
	Total Learning Credits				**15**

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, Kancheepuram, Tamil Nadu, India

Course Code	21BTC201L	Course Name	BIOCHEMISTRY LABORATORY	Course Category		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 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:	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
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
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
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
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
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)*	
		Formative CLA-1 Average of unit test (30%)		*Life Long Learning CLA-2 – (30%)*		*Summative (40%)*			
		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
Dr. G. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	Prof. K Subramaniam, IITM, Chennai, suubu@iitm.ac.in	Dr. Pachiappan, SRMIST
Dr. Karthik Periyasamy, Scientist, Biocon, karthik.periyasamy@biocon.com	Prof. R. B. Narayanan, Anna University, Chennai arbeen09@gmail.com	Dr. S Subashini, SRMIST

Course Code	21BTC202T	Course Name	MICROBIOLOGY	Course Category		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	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
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
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
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
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
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
Dr. G. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	Prof. K Subramaniam, IITM, Chennai, suubu@iitm.ac.in	Dr. J. Lavanya, SRMIST.
Dr. Karthik Periyasamy, Scientist, Biocon, karthik.periyasamy@biocon.com	Prof. R. B. Narayanan, Anna University, Chennai arbeen09@gmail.com	Dr. R. Muthukumar, SRMIST.

Course Code	21BTC203L	Course Name	CELL AND MICROBIOLOGY LABORATORY	Course Category		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	Environment &	Ethics	Individual & Team	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
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
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
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
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

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)*	
		Formative CLA-1 Average of unit test (30%)		*Life Long Learning CLA-2 – (30%)*		*Summative (40%)*			
		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
Dr. G. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	Prof. K Subramaniam, IITM, Chennai, suubu@iitm.ac.in	Dr.S.Sujatha, SRMIST
Dr. Karthik Periyasamy, Scientist, Biocon, karthik.periyasamy@biocon.com	Prof. R. B. Narayanan, Anna University, Chennai arbeen09@gmail.com	Dr.J.Lavanya, SRMIST

Course Code	21BTC204T	Course Name	BIOPROCESS PRINCIPLES	Course Category		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	Environment &	Ethics	Individual & Team	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
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
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
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
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 cultures9	9
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.
	1. Michael L. Shuler, Fikret Kargi, Matthew DeLisa "Bioprocess Engineering: Basic Concepts", 3rd Edition, Prentice-Hall, 2017.
	2. 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
Dr. S. Sam Gunasekar, Orchid Chemicals and Pharmaceuticals Ltd., Chennai., sam@orchidpharma.com	Prof. K Subramaniam, IITM, Chennai, suubu@iitm.ac.in	Dr. V. Vinoth Kumar, SRMIST
Dr. G. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	Prof. R. B. Narayanan, Anna University, Chennai arbeen09@gmail.com	Dr. P. Radha, SRMIST

Course Code	21BTC205L	Course Name	BIOPROCESS PRINCIPLES LABORATORY	Course Category		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	Environment &	Ethics	Individual & Team	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
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
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
Practice: 1. Fermenter operation – Demonstration/Explanation 2. Methods of measuring process variables during yeast fermentation in fermenter	
Unit-4 : Fundamentals of Biological Engineering	12
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

Practice: 1. Preparation of immobilized cells/ enzyme 2. Enzyme immobilization kinetics 3. Production of ethanol by yeast

Learning Resources	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)*	
		Formative CLA-1 Average of unit test (30%)		*Life Long Learning CLA-2 – (30%)*		*Summative (40%)*			
		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
Dr. S. Sam Gunasekar,Orchid Chemicals and Pharmaceuticals Ltd., Chennai.sam@orchidpharma.com	Prof. K Subramaniam, IITM, Chennai, suubu@iitm.ac.in	Dr.M.Venkatesh Prabhu, SRMIST
Dr. G. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	Prof. R. B. Narayanan, Anna University, Chennai arbeen09@gmail.com	Dr. Vinoth kumar, SRMIST

Course Code	21BTC206T	Course Name	GENETICS AND CYTOGENETICS	Course Category		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	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	Environment &	Ethics	Individual & Team	Communication	Project Mgt. & Finance	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
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
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
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
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
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
Dr. C. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in	Dr. S. Barathi, SRMIST
Dr. Karthik Periyasamy, Scientist, Biocon, karthik.periyasamy@biocon.com	Prof. R. B. Narayanan, Anna University, Chennai arbeen09@gmail.com	Dr. K.T. Ramya Devi, SRMIST

Course Code	21BTC207T	Course Name	MOLECUALR BIOLOGY	Course Category		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	Environment &	Ethics	Individual & Team	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
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
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
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
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
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
Dr. S. Sam Gunasekar, Orchid Chemicals and Pharmaceuticals Ltd., sam@orchidpharma.com	Dr. Aravind Rengan, Indian Institute of Technology Hyderabad. aravind@bme.iith.ac.in	Dr. N. Selvamurugan, SRMIST
Dr. D. Gunaseelan, BIOCON Ltd., guna.sachin@gmail.com	Dr. K. Subramanian, Indian Institute of Technology Madras. subbu@iitm.ac.in	Dr. S. Barathi, SRMIST

Course Code	21BTC208L	Course Name	MOLECUALR BIOLOGY LABORATORY	Course Category		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	Modem Tool Usage	The engineer and	Environment &	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
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
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
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
Practice: 1. Restriction Enzyme Digestion of DNA 2. Ligation of DNA Fragment into Plasmid 3. E.coli Transformation	
Unit-5: DNA Damage	12

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)*						*Summative Final Examination (0% weightage)*	
		Formative CLA-1 Average of unit test (30%)		*Life Long Learning CLA-2 – (30%)*		*Summative (40%)*			
		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
Dr. S. Sam Gunasekar, Orchid Chemicals and Pharmaceuticals Ltd., sam@orchidpharma.com	Dr. K. Subramanian, Indian Institute of Technology Madras. subbu@iitm.ac.in	Dr. N. Selvamurugan, SRMIST
Dr. D. Gunaseelan, BIOCON Ltd., guna.sachin@gmail.com	Dr. Sudha Warrier, Professor and Dean, Manipal University, sudha.warrier@mannipal.edu	Dr. S. Barathi, SRMIST

Course Code	21BTC209T	Course Name	BIOPROCESS ENGINEERING	Course Category		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 scaleup 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	Environment &	Ethics	Individual & Team	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
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
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
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
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
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
Dr. S. Sam Gunasekar Orchid Chemicals and Pharmaceuticals Ltd., Chennai. sam@orchidpharma.com	Dr.S.Senthil Kumar, IITG	Dr.M.Venkatesh Prabhu, SRMIST
Dr. G. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	Dr.N.Selvaraj, IITG	Dr.P.Radha, SRMIST

Course Code	21BTC210L	Course Name	BIOPROCESS ENGINEERING LABORATORY	Course Category		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	Environment &	Ethics	Individual & Team	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
Practice: 1. RTD studies in Stirred tank reactor 2. RTD studies in Plug flow reactor	
Unit-2 : Fluid flow and mixing in Bioreactors	12
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
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
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
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	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)*						*Summative Final Examination (0% weightage)*	
		Formative CLA-1 Average of unit test (30%)		*Life Long Learning CLA-2 – (30%)*		*Summative (40%)*			
		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
Dr. S. Sam Gunasekar Orchid Chemicals and Pharmaceuticals Ltd., Chennai. sam@orchidpharma.com	Dr.S.Senthil Kumar, IITG	Dr.M.Venkatesh Prabhu, SRMIST
Dr. G. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	Dr.N.Selvaraj, IITG	Dr.P.Radha, SRMIST

Course Code	21BTC301J	Course Name	GENE MANIPULATION AND GENOMICS	Course Category		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	Environment &	Ethics	Individual & Team	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

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

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

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

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
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%)		*Life Long Learning CLA-2 – (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
Dr. C. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in	Dr. N. Selvamurugan, SRMIST
Dr. Karthik Periyasamy, Scientist, Biocon, karthik.periyasamy@biocon.com	Prof. R. B. Narayanan, Anna University, Chennai arbeen09@gmail.com	Dr. S. Barathi, SRMIST

Course Code	21BTC302J	Course Name	IMMUNOLOGY	Course Category		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	PSO-1	PSO-2	PSO-3
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment &	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning			
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

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

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

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
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
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%)		*Life Long Learning CLA-2 – (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
Dr. C. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	Dr. Joe Varghese, CMC Vellore, joevarghese@cmcvellore.ac.in	Dr.S.Nageswaran, SRMIST
Dr. Karthik Periyasamy, Scientist, Biocon, karthik.periyasamy@biocon.com	Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in	Dr.S.Rupachandra, SRMIST

Course Code	21BTC303T	Course Name	PROTEIN ENGINEERING	Course Category		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	Environment &	Ethics	Individual & Team	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
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
Role of Transcription factors in gene 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- 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
Methods of generating crystals- 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 (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
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
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
Dr. C. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in	Dr. Priya Swaminathan, SRMIST
Dr. Karthik Periyasamy, Scientist, Biocon, karthik.periyasamy@biocon.com	Prof. R. B. Narayanan, Anna University, Chennai arbeen09@gmail.com	Dr. Vasantharekha R, SRMIST

Course Code	21BTC304T	Course Name	ANIMAL BIOTECHNOLOGY	Course Category		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 :	To 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 :	To 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	PSO-1	PSO-2	PSO-3
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and	Environment &	Ethics	Individual & Team	Communication	Project Mgt. & Finance	Life Long Learning			
CO-1:	To familiarize the students about breeding, biological markers for genetic diseases and managing animal health using vaccines	-	3	3	-	-	-	-	-	-	-	-	-	-	3	3
CO-2:	To impart an understanding about Embryo transfer, fertilization methods and animal production	-	3	3	-	-	-	-	-	-	-	-	-	-	3	3
CO-3:	To provide knowledge about different culture techniques, Characterization of cell lines and in vitro testing of drugs	-	3	2	-	-	-	-	-	-	-	-	-	3	3	-
CO-4:	To provide knowledge about improvement of animals to increase the yield and quality of animal products	3	-	-	3	-	-	-	-	-	-	-	-	3	3	-
CO-5:	To familiarize the students about livestock improvement using molecular pharming	3	-	-	2	-	-	-	-	-	-	-	-	-	3	3

Unit-1 : ANIMAL IMPROVEMENT FOR DESIRED TRAITS & ANIMAL HEALTH	9
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 & ANIMAL PROPAGATION	9
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
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
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 & MOLECULAR PHARMING	9
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
Dr. G. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	Prof.. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in	Dr.S.Sujatha, SRMIST
Dr. Karthik Periyasamy, Scientist, Biocon, karthik.periyasamy@biocon.com	Prof. R. B. Narayanan, Anna University, Chennai arbeen09@gmail.com	Dr.K.Venkatesan, SRMIST

Course Code	21BTC305L	Course Name	ANIMAL BIOTECHNOLOGY LABORATORY	Course Category		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	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	Environment &	Ethics	Individual & Team	Communication	Project Mgt. & Finance	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 & Primary cell culture	12
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 & Maintenance	12
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
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 & Cell cytotoxicity assays	12
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
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)*						*Summative Final Examination (0% weightage)*	
		Formative CLA-1 Average of unit test (30%)		*Life Long Learning CLA-2 – (30%)*		*Summative (40%)*			
		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
Dr. G. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	Prof.. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in	Dr.S.Sujatha, SRMIST
Dr. Karthik Periyasamy, Scientist, Biocon, karthik.periyasamy@biocon.com	Prof. R. B. Narayanan, Anna University, Chennai arbeen09@gmail.com	Dr.K.Venkatesan, SRMIST

Course Code	21BTC306T	Course Name	PLANT BIOTECHNOLOGY	Course Category		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	Environment &	Ethics	Individual & Team	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

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

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

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

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

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

Course Code	21BTC401L	Course Name	PLANT BIOTECHNOLOGY LABORATORY	Course Category		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	Environment &	Ethics	Individual & Team	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
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
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
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
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
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.	3. 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)*						*Summative Final Examination (0% weightage)*	
		Formative CLA-1 Average of unit test (30%)		*Life Long Learning CLA-2 – (30%)*		*Summative (40%)*			
		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
Dr. G. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	Prof. K Subramaniam, IITM, Chennai, suubu@iitm.ac.in	R. Pachaiappan, SRMIST
Dr. Karthik Periyasamy, Scientist, Biocon, karthik.periyasamy@biocon.com	Prof. R. B. Narayanan, Anna University, Chennai arbeen09@gmail.com	S. Rupachandra, SRMIST

Course Code	21BTC402J	Course Name	BIO SEPARATION TECHNOLOGY	Course Category		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	Environment &	Ethics	Individual & Team	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

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

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

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
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
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	

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%)		*Life Long Learning CLA-2 – (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
Dr. G. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	Dr.S.Senthil Kumar, IITG	Dr.M.Venkatesh Prabhu, SRMIST
Dr. Karthik Periyasamy, Scientist, Biocon, karthik.periyasamy@biocon.com	Dr.N.Selvaraj, IITG	Dr.P.Radha, SRMIST

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, Kancheepuram, Tamil Nadu, India

Course Code	21BTE201T	Course Name	DEVELOPMENTAL BIOLOGY	Course Category		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 :	Discuss the basic concepts of developmental patterning and organization
CLR-2 :	Compare the early embryonic development events across species
CLR-3 :	Demonstrate the metamorphosis and organogenesis
CLR-4 :	Describe the influence of external environment on developmental process
CLR-5 :	Study various developmental defects

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	PSO-1	PSO-2	PSO-3
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and	Environment &	Ethics	Individual & Team	Communication	Project Mgt. & Finance	Life Long Learning			
CO-1:	Understand the key aspects of developmental biology	2	2	-	-	-	-	-	-	-	-	-	-	2	-	2
CO-2:	Develop the concepts and experiments in the early development, cleavage and axis formation	-	2	3	-	-	-	-	-	-	-	-	-	3	-	2
CO-3:	Illustrate the roles of signaling pathways during the organogenesis	-	3	3	-	-	-	-	-	-	-	-	-	3	-	2
CO-4:	Illustrate the fertilization and developmental events in plants	-	3	3	-	-	-	-	-	-	-	-	-	3	-	3
CO-5:	Integrate modern biotechnology in the developmental process	-	3	3	-	-	-	-	-	-	-	-	-	3	-	3

Unit-1 : Principles of Developmental Biology	9
Introduction to Developmental Biology, Life cycles and the evolution of developmental patterns, Principles of experimental embryology, Genes and development: Techniques and ethical issues, Differential gene expression, Cell-cell communication in development	
Unit-2 : Early embryonic development	9
Fertilization, Early development in selected invertebrates, The genetics of axis specification in Drosophila, Early development and axis formation in amphibians, The early development of vertebrates: Fish, birds, and mammals	
Unit-3: Later embryonic development	9
The central nervous system and the epidermis, Neural crest cells and axonal specificity, Paraxial and intermediate mesoderm, Lateral plate mesoderm and endoderm, Development of the tetrapod limb, Sex determination, Metamorphosis, regeneration, and aging, Germ cell	
Unit-4 : Ramifications of developmental biology	9
Development of Plants, Environmental regulation of animal development, Developmental mechanisms of evolutionary change	
Unit-5: Developmental Defects	9
Birth defects associated with Pharyngeal arches, Neural tube, Nervous system, Cardiovascular system, Skeletal system, Immune-system, Limbs, Respiratory system, Circulatory system and Excretory system	

Learning Resources	1. Scott F. Gilbert, Michael J. F. Barresi. Developmental Biology, Sinauer Associates-Oxford University Press; 12 edition, 2020 2. JMW Slack Essentials of Developmental Biology 3rd Edition Wiley-Blackwell;. 2013	3. Before we are born. Essentials of Embryology and Birth Defects; Keith L. Moore, T.V.N. Persaud, Mark G. Torcha; 10th Edition; 2019; Philadelphia, Elsevier

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
Dr. G. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	Prof.. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in	Dr. Harinarayana Ankamreddy, SRMIST
Dr. Karthik Periyasamy, Scientist, Biocon, karthik.periyasamy@biocon.com	Prof. R. B Narayanan Anna University, Chennai,arbeen09@gmail.com	Dr.R.Vasantharekha, SRMIST

Course Code	21BTE301T	Course Name	DISEASES MODELS AND MECHANISM	Course Category		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 :	To gain fundamental knowledge about the existing diseases and their pathologies.
CLR-2 :	Understanding the molecular mechanism of varied metabolic and cardiovascular diseases.
CLR-3 :	Mechanistic insights into various neurological disorders, and pathways associated with it
CLR-4 :	Understand the commonly used model systems and their pros and cons.
CLR-5 :	To gain more information on advanced disease model systems and their advantages and disadvantages.

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	Environment &	Ethics	Individual & Team	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	Relate various diseases and pathologies.	-	2	2	-	-	-	-	-	-	-	-	-	2	-	3
CO-2:	Demonstrates multiple metabolic and cardiovascular diseases.	2	2	3	-	-	-	-	-	-	-	-	-	2	-	3
CO-3:	Discuss the varied neurological diseases and their mechanism.	2	3	3	3	-	-	-	-	-	-	-	-	3	-	3
CO-4:	Analyze the widely studied disease model systems.	3	3	3	3	-	-	-	-	-	-	-	-	3	-	3
CO-5:	Explain the modern engineered disease model systems.	3	3	3	3	-	-	-	-	-	-	-	-	3	-	3

Unit-1 : Introduction to Pathology and Disease	9
General pathophysiology: Pathophysiological mechanisms of acute and chronic injury, necrosis/apoptosis & tissue repair (the healing process). Overview of physical diseases, mental diseases, infectious diseases, non-infectious diseases, inherited diseases, degenerative diseases, social diseases, and self-inflicted diseases. Categories of infectious agents, mechanisms, and pathogenesis of infectious diseases, viz tuberculosis, malaria, influenza, and HIV/AIDS.	
Unit-2 : Metabolic and Cardiovascular Disease	9
The origin of metabolic diseases, Disorders of Amino acid metabolism, Carbohydrate metabolism, Lipid metabolism, Mitochondrial disorders, Lysosomal storage disorders, Peroxisomal disorders, Purine and Pyrimidine disorders, and Porphyrias. Hyperlipidemia, Atherosclerosis, Coronary artery disease, Hypertension, Heart failure, Thromboses, and stroke. Compare and contrast Diabetes vs Atherosclerosis	
Unit-3: Neurological diseases and their mechanism	9
Alzheimer's, Parkinson's, Amyotrophic Lateral Sclerosis, Huntington, Creutzfeldt Jakob Disease, Spinal muscular atrophy, Multiple Sclerosis, Epilepsy, and Seizures. Diseases of the peripheral nervous system. Compare and contrast peripheral to central nervous system disorders (Charcot Marie Tooth vs Alzheimer's).	
Unit-4 : : Widely studied disease model systems	9
2D Cell Culture, Yeast, C. elegans, D. melanogaster, Zebrafish, Xenopus mouse, and Primate model systems for various diseases.	
Unit-5: Advanced disease model systems	9
3D Primary Cell Cultures, the evolution of organoids, cerebral organoids, Intestinal organoids, organoids in cancer research, Somatic cell-derived organoids, other applications of organoids in designing personalized medicine, and Organs on a chip.	

Learning Resources	
1. The Nature of Disease-Pathology for the Health Professions, Author: McConnell, Publisher: Lippincott Williams & Wilkins, second edition, 2014 ISBN-10 : 9781609133696 ISBN-13 : 978-1609133696	3. Lippincott's Illustrated Reviews: Microbiology, Second 2014 Edition. Richard A Harvey Ph.D., Cynthia N Cornelissen Ph.D. ISBN/ISSN: 9781608317332
2. Robbins & Cotran Pathologic Basis of Disease (Robbins Pathology) ninth edition 2014,	4. Park's Textbook of Preventive and Social Medicine, Banarsidas Bhanot Publishers Edition: 2021 ISBN: 9789382219163

	Kumar MBBS MD FRCPath, Abbas MBBS, Aster MD Ph.D., Jon C. ISBN-13: 978-1455726134 / ISBN-10: 1455726133	

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
Dr. Giridharan Appaswamy, Lifecell International (P) Limited, Chennai, giridharan.a@lifecell.in	Prof. Karunagaran D, IITM, Chennai, karuna@iitm.ac.in	Dr.Bibin SRMIST
Dr. Karthik Periyasamy, Scientist, Biocon, karthik.periyasamy@biocon.com	Dr. Sib Sankar Roy, CSIR-IICB, Kolkatta, sibsankar@iicb.res.in	Dr. K.M Ramkumar SRMIST

Course Code	21BTE302T	Course Name	METABOLIC DISORDERS	Course Category		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 :	Discuss the basic principles of metabolic regulation
CLR-2 :	Demonstrate the importance of genetics in medicine and in metabolic diseases.
CLR-3 :	Analyse the influence of regulatory enzymes in various metabolic disorders
CLR-4 :	Understand the common genetic diseases in our society and the reason for it
CLR-5 :	Know how to prevent and treat metabolic disorders

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	Environment &	Ethics	Individual & Team	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	Explain the basic principles of metabolic disorders	-	2	2	-	-	-	-	-	-	-	-	-	3	-	3
CO-2:	Examine and solve the metabolic problems of specific nutrients	-	3	3	-	-	-	-	-	-	-	-	-	3	-	3
CO-3:	Dissect the knowledge in metabolic control	-	2	2	3	-	-	-	-	-	-	-	-	3	-	3
CO-4:	Comprehend the importance of genetics in medicine and in metabolic diseases	-	3	-	2	-	-	-	-	-	-	-	-	2	-	3
CO-5:	Evaluate how genetic diseases are common in our society and the reason for it.	-	2	-	2	-	-	-	-	-	-	-	-	2	-	3

Unit-1 : Introduction to metabolic disorders	9
Principles of metabolic regulation- Garrod's hypothesis, Regulation of enzyme activity Covalent modifications and reversible modifications, phosphorylation, dephosphorylation, adenylation and disulphide reduction, Overview of inherited metabolic disorders	
Unit-2 : Disorders of carbohydrate metabolism	9
Pathways of carbohydrate metabolism and their physiological significance, Regulation of carbohydrate metabolism, Allosteric and hormonal mechanisms, Metabolic interrelationships among various tissues, Congenital disorders of Glycosylation, Galactosaemia, Fructosaemia, Lactose intolerance, Glycogen storage diseases, glucose homeostasis and diabetes mellitus	
Unit-3: Disorders of Nitrogen metabolism	9
Disorders of amino acids metabolism- Phenylketonuria, tyrosinemia, homocystinuria, maple syrup urine disease, Argininemia, Tyrosinemia, Alkaptonuria, Albinism, Amino acid transport disorders: Cystinuria, Dicarboxylic aminoaciduria, Hartnup disease, Inborn error of purine metabolism, Adenylosuccinate lyase deficiency, adenosine monophosphate deaminase deficiency, Nucleotide salvage - Lesch-Nyhan syndrome, Adenine phosphoribosyl transferase deficiency, Xanthinuria – Pyrimidine metabolism, Inborn error of pyrimidine metabolism: Oroticaciduria, Miller syndrome, Dihydropyrimidine dehydrogenase deficiency	
Unit-4 : Disorders of Lipid and Lipoprotein Metabolism	9
Inborn error of lipid metabolism, Hyperlipidemia, Hypercholesterolemia and its associated disorders, Hypolipoproteinemia, Tangier disease, Lipodystrophy, Lipid storage disorders: Fatty-acid metabolism disorders, biotinidase deficiency, malonicaciduria, Sjögren–Larsson syndrome	
Unit-5: Micronutrients and Metabolic Diseases	9
Disorders of vitamins, Disorders of coenzymes, Disorders of cofactors, Biotinidase deficiency, Holocarboxylase synthetase deficiency, Pantothenate kinase-associated neurodegeneration, Methylmalonic academia, Glutaric aciduria, Al Aqeel-Sewairi syndrome – multicentric osteolysis, nodulosis, arthropathy (MONA) – MMP-2 deficiency	

Learning Resources	1. John Fernandes, Jean-Marie Saudubray, Georges van den Berghe John H. Walter. Inborn Metabolic Diseases: Diagnosis and Treatment. Fourth, Revised Edition, Springer press, 2006	2. Enid Gilbert-Barness, Lewis A. Barness, Philip M. Farrell." Metabolic Diseases: Foundations of Clinical Management, Genetics, and Pathology", IOS Press BV, Netherlands, Second Edition, 2017

	2. Robert K. Murray, Darryl K. Granner, Peter A. Mayes, Harper's Illustrated Biochemistry 30th Edition, 2003	

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
Dr. Giridharan Appaswamy, Lifecell International (P) Limited, Chennai, giridharan.a@lifecell.in	Prof. Karunagaran D, IITM, Chennai, karuna@iitm.ac.in	Dr. K.M. Ramkumar, SRMIST
Dr. Karthik Periyasamy, Scientist, Biocon, karthik.periyasamy@biocon.com	Dr. Sib Sankar Roy, CSIR-IICB, Kolkatta, sibsankar@iicb.res.in	Dr. Koustav Sarkar, SRMIST

Course Code	21BTE401T	Course Name	CELLULAR AND MOLECULAR NEUROSCIENCE	Course Category		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 :	Recall the brain function from its organization
CLR-2 :	Discuss the genetic variations in brain development and behavior
CLR-3 :	Recall the synaptic dysfunctions and drug treatment
CLR-4 :	Explain different methods for studying neuro-immune functions
CLR-5 :	Describe the cortical structures pertaining to behavior

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	PSO-1	PSO-2	PSO-3
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and	Environment &	Ethics	Individual & Team	Communication	Project Mgt. & Finance	Life Long Learning			
CO-1:	Explain the fundamental organization of the brain and its functions	*2*	3	3	-	-	-	-	-	-	-	-	-	3	-	2
CO-2:	Describe the role of genes in brain development and functions	*2*	3	2	-	-	-	-	-	-	-	-	-	3	-	2
CO-3:	Enhances the knowledge about the neuropathological disorders and treatment options	*3*	2	-	-	3	-	-	-	-	-	-	-	3	-	3
CO-4:	Evaluate the different methods in the neuroendocrine and immune interactions	*3*	2	3	-	-	-	-	-	-	-	-	-	3	-	3
CO-5:	Outline the anatomical relation with behavior	*3*	2	-	-	-	-	-	-	-	-	-	-	3	-	3

Unit-1 : Organization of nervous system	9
Development of the nervous system- Molecular basis of neural induction- Initial differentiation of neurons and glia- Cellular Components of the Nervous system- Neurons and Glia- Organization of nerves- Presynaptic terminals- Neural Circuits- Myotactic reflex- Organization of the Nervous system- Divisions of nervous system- Central nervous system- Peripheral nervous system- Structural and Functional analysis of the Nervous system- Cellular diversity of nervous system- Model organisms in neuroscience	
Unit-2 : Neurotransmission and synaptic plasticity	**9**
Electrical signals- Long-distance transmission of Electrical signals- The ionic basis of resting membrane potential- Voltage-dependent membrane permeability- Ion channels and transporters- Diversity of ion channels- Synaptic transmission-Neurotransmitters and their receptors- Chemical and electrical synapses- Molecular signaling in neurons- Activation of signaling pathways- Second messengers- Nuclear signaling- Synaptic plasticity- Short and long-term synaptic plasticity- Properties of neurotransmitters- Receptors of neurotransmitters- Unconventional neurotransmitters	
Unit-3: Synaptogenesis and development of sensory-motor systeml	*9*
Synaptogenesis- Molecular mechanisms involved in synapse formation- Construction and modification of neural circuits- Genetic influence and control on animal behavior- Motor neuron circuits-Motor neuron control by the CNS- Motor units- Motor neurons and functions- Reward and motivation- Visual and Vestibular pathways- Retinal circuitry- Phototransduction- Potential treatment for vision loss- The Corticospinal and Corticobulbar Tracts- Repair and Regeneration in nervous system- Axon Growth after Brain Injury- Rodent brain functional anatomy and behavior- Goat brain dissection	
Unit-4 : Cognition, pharmacology and neuro-immunology	*9*
Overview of cortical structures- Emotions-Memory- Early theories of emotional brain- Kluver-Bucy syndrome- Brain reward circuitry- Cognition- Learning, Memory consolidation and Priming- Dementia- Anti-psychotic drugs and Neurotoxicity- Neuropharmacology in treating social impairments related to autism- Hypothalamus and endocrine system- Hormones of endocrine system and its regulation- Interactions between neuroendocrine system and immune system- Neural-Immune interactions in the periphery- Nervous-immune system role in health and disease	
Unit-5: Neuropathology and therapeutics	*9*
Diseases and injuries of the nervous system- Autism Spectrum Disorders- Alzheimer's disease- Parkinson's disease- Spinal Cord Injury- Traumatic Brain Injury (TBI)- chronic traumatic encephalopathy- Blood Supply to Brain- Stroke and Transient Ischemic Attack- Acute stroke treatment- Prevention of stroke- Hypoxia/Ischemia in mammalian brain- Therpeutics in Neurodevelopmental disorders-GPCR signaling- Novel therapeutic drugs in Alzheimer's disease- Prevention and treatment- Synaptic perspective in neuronal health and disease	

Learning Resources	1.Dale Purves, George J. Augustine, David Fitzpatrick, William C. Hall, Anthony-Samuel LaMantia, Leonard E. White, "Neuroscience," Sinauer Associates, Inc., 6th Edition, 2017.	2. Eric R. Kandel, James H. Schwartz, Thomas M. Jessell, "Principles of Neural Science," McGraw-Hill, 5th 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
Dr. G. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in	Dr. Anil Annamneedi, SRMIST
Dr. Karthik Periyasamy, Scientist, Biocon, karthik.periyasamy@biocon.com	Prof. R. B Narayanan Anna University, Chennai,arbeen09@gmail.com	Dr. R . Vasantherekha, SRMIST

Course Code	21BTE402T	Course Name	CANCER BIOLOGY AND THERAPEUTICS	Course Category		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 protooncogene and oncogenes, risk factors in tumor progression
CLR-2 :	Discuss epigenetics, DNA damage and repair in cancer
CLR-3 :	Recall the molecular signaling mechanisms in cancer
CLR-4 :	Describe the role of stem cells in cancer treatment and metastasis
CLR-5 :	Analyze the role of advanced cancer therapeutics and alkaloids in cancer treatment

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	Modem Tool Usage	The engineer and	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	Describe the role of diet in different forms of cancer	-	-	-	-	-	-	3	2	-	-	-	-	-	2	2
CO-2:	Determine the fundamental assays in hazard identification	-	2	2	3	-	-	-	-	-	-	-	-	-	2	2
CO-3:	Explain the role of signaling pathway mediated cancer initiation	-	2	-	-	2	-	-	-	-	-	-	-	-	2	-
CO-4:	Explain the role of cancer stem cell signaling pathway and angiogenesis	-	2	-	-	2	-	-	-	-	-	-	-	-	-	2
CO-5:	Determine the concepts of cancer detection and therapy	-	-	2	-	2	-	-	-	-	-	-	-	-	-	2

Unit-1 : Concept of cancer Biology	9
Basic concepts of cancer - Oncogenes and tumor suppressor genes; Risk factors, Pathogenesis, treatment and future prospects; The cell cycle - cyclin and cyclin dependent kinases; Mechanisms of CdK regulation; Tumor suppressor genes - Knudson's two-hit hypothesis; P53 and pRb control of cell cycle; Molecular pathways of p53; Role of myc oncoprotein in regulating pRb; pRb's role in cancer; Different forms of cancer; Diet and cancer	
Unit-2 : DNA damage and epigenetics of cancer	**9**
DNA structure and stability -Spontaneous DNA damage; DNA repair pathways - Clinical applications of DNA repair biomarkers; Epigenetics and its implication on cancer; Carcinogenesis -Types and mechanism of carcinogens - Carcinogen metabolism; Biotransformation and cancer risk Cancer prevention and hazard identification assays	
Unit-3: Molecular signaling of cancer and cell death	*9*
Signal transduction -Growth factors and receptors; EGF growth factor receptor signaling - Ras activation; Activation of MAPK pathways; NF-KB signaling pathway, JAK/STAT signaling and cancer immuno oncology - Immune system; Effector mechanisms in cancer immunity, Wnt signaling and its Implications in cancer therapy; Apoptosis - Intrinsic and Extrinsic pathways; cell death and cancer	
Unit-4 : Cancer stem cells and Angiogenesis	*9*
Stem cells and cancer - Self- renewal and its molecular mechanisms; Hedgehog signaling pathway; polycomb group proteins; tumor micro environment in cancer; Invasion and metastasis - Cell adhesion molecules; Angiogenesis -Tumor angiogenesis and neovasculature - VEGF signal transduction; Angiogenic inhibitors -Vascular targets	
Unit-5: Basic therapeutics and screening of cancer	*9*
Cancer therapy and detection; Modalities of treatment; Nuclear medicine; Chemotherapeutic agents – Types of chemotherapeutic agent; plant based cancer therapeutics; Immunotherapy; cancer prevention and early detection - Screening techniques and diagnostic tests Imaging and cancer - X-Ray CT, MRI, radio imaging and optical imaging; contrast agents in cancer molecular imaging	

Learning Resources	1. Lauren Pecorino, Molecular Biology of Cancer: Mechanisms, Targets, and Therapeutics, Oxford University Press; 4th edition, 2016	2. John Mendelsohn, Peter M. Howley, Mark A. Israel, Joe W. Gray, Craig B. Thompson. The Molecular Basis of Cancer, Saunders; 4 edition, 2014

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
Dr. G. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	Prof.. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in	Dr.S.Nageswaran, SRMIST
Dr. Karthik Periyasamy, Scientist, Biocon, karthik.periyasamy@biocon.com	Prof. Natarajan Bhaskaran, Sri Ramachandra Institute of Higher Education and Research, Chennai, natarajanbhaskaran@sriramachandra.edu.in	Dr.Koustav Sarkar, SRMIST

Course Code	21BTE402T	Course Name	PHYSIOLOGY OF STRESS AND ITS MANAGEMENT	Course Category		Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	Describe the homeostasis, control systems and role of biogenic amines in stress
CLR-2 :	Explain the concepts of epigenetics and hormones in stress response
CLR-3 :	Describe the behavioral response and impact of environmental factors on stress
CLR-4 :	Explain the disorders of stress and the role of occupation hazards in stress
CLR-5 :	Analyze the role of education, caregivers, exercises and meditation in control of stress

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	Environment & Sustainability	Ethics	Individual & Team	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	Analyze the role of neuroendocrine and immune system in stress condition	2	2	2	2	-	-	-	-	-	-	-	-	3	-	3
CO-2:	Summarize the role of central nervous system and neurotransmitters in stress	3	3	3	2	-	-	-	-	-	-	-	-	3	-	3
CO-3:	Discuss the interactions of behavioral and physiological components in stress	3	2	2	3	-	-	-	-	-	-	-	-	3	-	3
CO-4:	Compare the various disorders of stress and the neuropsychological tests for stress	3	3	3	2	-	-	-	-	-	-	-	-	2	-	2
CO-5:	Explain the concepts of diet, exercise and lifestyle in managing stress	2	2	-	2	-	-	-	-	-	-	-	-	2	-	2

Unit-1 : Homeostasis and control system	9
Homeostasis and control systems-HPA Axis and endocrine system; Nervous system and stress disorder-Hippocampus and depression. Parasympathetic system-Flight/fight responses; rest/digest responses. Noradrenergic control of stress-Norepinephrine in stress.;	
Unit-2 : Neuroendocrinology of Stress	9
Corticotrophin releasing hormone, CRF- family with role in HPA axis, intracellular signaling of stress, external signals of stress, Catecholamines; Neural circuitry of stress, fear and anxiety. Serotonergic systems modulate anxiety. Stress-Hippocampal neurogenesis.	
Unit-3: Psychological and Environmental stressors	9
Behavioral response to stress, Impairment of response inhibition, lack of motivation, physiological components of stress response, environmental factors- impact of environmental factors on stress, differential exposure and vulnerability of environmental stressors. Physiological stressors, cognition and stress, consequence of stress on cognitive functions	
Unit-4 : Disorders of stress	9
Anxiety disorders, panic disorder, post traumatic syndromes. Psychological concomitants of distress. Chronic stress and fear. Emotional stress, acute and chronic stress models, aging and psychological stress, occupational hazards of stress. Non stress, distress and neuropsychological tests questionnaire for stress analysis.	
Unit-5: Stress Management	9
Awareness about stress management; Value of education in stress condition, relaxation, effective communication. Intervention of caregivers and Institutional care. Meditation model, physical and mental exercises. Eating behavior for healthy lifestyle. Mechanism of stress in abnormal eating behavior. Physical and mental well-being and general principles of stress prevention	

Learning Resources	George Fink. Stress: concepts, cognition, emotion and behavior. Handbook in stress. Academic press. First edition. 2016	George Fink: Stress: Neuroendocrinology and neurobiology, Academic press. First edition.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
Dr. C. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in	Dr. R.Vasantharekha, SRMIST
Dr. Karthik Periyasamy, Scientist, Biocon, karthik.periyasamy@biocon.com	Prof. R. B Narayanan Anna University, Chennai,arbeen09@gmail.com	Dr. MK. Jaganathan, SRMIST

Course Code	21BTE202T	Course Name	PHARMACEUTICAL BIOTECHNOLOGY	Course Category		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 :	Understand the general principles of drug action.
CLR-2 :	Demonstrate the parameters that affect the action of drug in human system
CLR-3 :	Relate the different type of adverse drug reactions and drug abuse
CLR-4 :	Explain the mechanism of action, and uses of antibiotics and Oligonucleotide therapeutics
CLR-5 :	Describe the regulation of drugs in Indian Government and its initiatives in promoting Indian System of medicine

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	Environment &	Ethics	Individual & Team	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	Select appropriate target, drug-like candidates based on desired pharmacokinetic and pharmacodynamics parameters	-		*3*	2	*2*	-	-	-	-	-	-	-	2	2	-
CO-2:	Explain the logical usage of drugs and suggest appropriate treatment	-	*3*	3	2	-	-	-	-	-	-	-	-	2	2	-
CO-3:	Evaluate the dose of drug to be administered for individuals	-	*3*	3	2	-	-	-	-	-	-	-	-	2	2	-
CO-4:	Explains the mechanism and improve their use of antibiotics and oligonucleotides as tools or potential therapeutics.	-	-	*3*	2	*3*	-	-	-	-	-	-	-	2	2	2
CO-5:	Explain the significance of laws pertaining to manufacturing, distribution and sale of drugs in India	-	-	-	-	-	-	2	2	-	-	-	-	-	1	2

Unit-1 : Pharmacokinetics	9
Routes of drug administration, Absorption of Drugs - Passsive transport and facilitated transport, Influence of pH on transport of molecules across membranes, Bioavailability. Distribution and Redistribution of drugs - Tissue storage, placental & brain transport. Biotransformation of drugs and types, Inhibition of drug metabolism, Induction of microsomal enzymes Routes of excretion of drugs - Rate of Clearance and Plasma half-life,	
Unit-2 : Pharmacodynamics	9
Principles of drug action - Mechanism of drug action on receptors, enzymes, ion channels and transporters.Transducer mechanism. Dose-Response Relationship, Therapeutic efficiency, Factors modifying drug action. Pharmacovigilance - Casualty assessment, Side, secondary and toxic effects of drugs, Accidental overdose of drugs and the treatment, Drug Intolerance and Drug allergy, Drug abuse and Treatment	
Unit-3: Biotechnological drugs obtained by microbial synthesis.	9
Classification of anti-microbial agents based on chemical structue. Structure, classification, Mechanism of action and uses of beta-lactam, Tetracycline, aminoglycosides and Macrolide antibiotics	
Unit-4 : Oligonucleotide therapeutics	9
Introduction of oligonucleotide therapeutics and types of oligonucleotide therapeutics, Mechanism, application and limitations of Messenger RNA (mRNA), RNAi, Antisense therapeutics, DNAzymes, Oligonucleotide aptamers. Preparations in advanced phases of clinical trials. Other therapeutic and diagnostic potential of synthetic nucleic acids (drug delivery, aptasensors, etc.)	
Unit-5: Drug Regulatory System	9
Drug Regulatory body - CDSCO, Hierarchy at CDSCO, Functions of CDSCO, Functions of Central Drug-Inspectors, Functions of State Drug-Inspectors. Ayurvedic Formulary of India - Ayurvedic Dosage Forms, Ayurvedic Pharmacopoeia of India, Ayurvedic, Unani, Siddha drugs undertaken by British commission, Indian Government Initiatives to promote Ayurvedic products, Indian Government Initiatives to promote Unani and Siddha products	

Learning Resources	1.Laurence Brunton, Bjorn Knollmann, Randa Hilal-Dandan, "Goodman and Gilman's - The Pharmacological Basis of Therapeutics", McGraw-Hill Education, 13th Edition 2018, ISBN: 978-1-25-958473-2,	3. SK Gupta, Sushma Srivastava, "Textbook of Pharmacovigilance- Ensuring the Safe Use of Medicines", Jaypee Brothers Medical Publisher, 2st Edition 2018 4. https://cdsco.gov.in/opencms/opencms/en/Home/

	2.Nicolay Ferrari, Rosanne Seguin, "Oligonucleotide-Based Drugs and Therapeutics Preclinical and Clinical Considerations for Development" John Wiley & Sons, 1st 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*	*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
Dr. S. Sam Gunasekar, Orchid Chemicals and Pharmaceuticals Ltd., sam@orchidpharma.com	Prof. K Subramaniyam, IITM, Chennai, suubu@iitm.ac.in	Dr. M.K. Jaganathan, SRMIST
Dr. Karthik Periyasamy, Scientist, Biocon, karthik.periyasamy@biocon.com	Dr. R. B Narayanan Anna University, Chennai,arbeen09@gmail.com	Dr. Y. Ravichandran,SRMIST

Course Code	21BTE303T	Course Name	COMPUTATIONAL MOLECUALR BIOLOGY	Course Category		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 :	Analyze the databases in bioinformatics
CLR-2 :	Use sequence alignment to find similar sequences
CLR-3 :	Use alignment to build hierarchical lineages
CLR-4 :	Apply principles of bioinformatics to build tertiary structures of proteins
CLR-5 :	Analyze uses of Python programming in Bioinformatics applications

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	Environment &	Ethics	Individual & Team	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	Describe the applications of bioinformatics to build databases for universal usage	2	-	-	-	3	-	-	-	-	-	-	-	-	-	3
CO-2:	Explain the concepts and tools to build alignment between similar sequences of DNA or Protein	2	-	-	-	3	-	-	-	-	-	-	-	-	-	3
CO-3:	Illustrate the pattern of lineages and evolution	2	2	-	-	3	-	-	-	-	-	-	-		-	3
CO-4:	Examine the different methods in the construction of protein structure	3	2	-	2	3	-	-	-	-	-	-	-	-	2	3
CO-5:	Evaluate the principles of Programming in Python for bioinformatics	2	2	-	2	3	-	-	-	-	-	-	-	-	2	3

Unit-1 : Molecular biology data storage	9
Bioinformatics significance- Applications of bioinformatics- Internet Protocols. HTML script- Webpage creation- Human genome project-Uses of human genome project- The NCBI data model: Introduction - SEQ-Ids- BIOSEQs and BIOSEQ-SETs- SEQ-ANNOT and SEQ-DESCR- Genbank database- Genbank Flat file- Sequence submission to Genbank- Online and offline tools- Entrez - INSDC- Other databases in NCBI	
Unit-2 : Database resources in molecular biology	9
Introduction on databases & biological databases- Uses of biological databases- Primary sequence databases- Nucleotide- Protein sequence database- Primary structure databases- PDB file format- FASTA , GCG,VFF etc- High Throughput sequencing databases- Secondary databases- secondary sequence databases- Secondary structure databases- SCOP- CATH- Composite protein databases- Metabolic databases- SNP -databases- Whole genome - mendelian disease databases- chemical structure databases- bibliographic databases	
Unit-3: Sequence analysis	9
Sequence alignment- Global Pairwise Alignment Algorithm- Solving problems- Local Pairwise Alignment Algorithm- Database searching- BLAST- FASTA- Multiple Sequence Alignmen:- Progressive and Iterative Alignment- Tools for pairwise alignment- tools for multiple sequence alignment- Application of Multiple Sequence Alignment- Databases Of Multiple Alignment- Molecular Phylogeny- Methods of phylogeny- types of trees - Tools for phylogeny- PAM and BLOSUM	
Unit-4 : Protein Structure analysis	9
Motifs and Patterns prediction, Databases for motif prediction, Databases for patterns and blocks, Secondary Database Searching, Secondary structure prediction, , Tools for secondary , structure prediction, , Specialized secondary structure prediction, Tertiary structure prediction, Comparative modelling, Abinitio modelling, Validation of tertiary structure, tools for homology , modeling , tools for structure validation, Structure visualization tools, Pymol, Chemical structure building tools, file formats for small molecules, file format conversion tools	
Unit-5: Python coding in molecular analysis	9
Introduction of Python and text editors, String datatype, Tuples datatype, Lists datatype, Flow control: If else, For loop, While loop, Reading and Writing files, Modules in Python, Functions, Regular expressions: Syntax, Regex , examples, Biopython, Advantages of python in bioinformatics, Components of biopython: Alphabet, Seq, Seq object, SeqUtils, Align and clustalw with Biopython, BLAST Running and Processing with Biopython	

Learning Resources	1.Pevsner, Jonathan. Bioinformatics and Functional Genomics. United Kingdom, Wiley, 2015. 2.Andreas D Baxevanis & B F Francis, "Bioinformatics- A practical guide to analysis of Genes & Proteins", John Wiley, 2002 3.T K Attwood, D J Parry-Smith," Introduction to Bioinformatics", Pearson Education, 1st Edition, 11th Reprint 2005.	4.Jin Xiong , " Essential Bioinformatics", Cambridge University Press, 2006 5.Sebastian Bassi, " Python for Bioinformatics", 2nd Edition CRC Press, 2017 6..Ramalho, Luciano. Fluent Python: Clear, Concise, and Effective Programming. United States, O'Reilly Media, 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
Dr. C. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in	Dr. Priya Swaminathan, SRMIST
Dr. Karthik Periyasamy, Scientist, Biocon, karthik.periyasamy@biocon.com	Prof. R. B. Narayanan, Anna University, Chennai, arbeen09@gmail.com	Dr. MK Jaganathan, SRMIST

Course Code	21BTE304T	Course Name	COMPUTER AIDED DRUG DESIGNING	Course Category		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 :	Gain knowledge on basic concepts of drug discovery and drug design processes
CLR-2 :	Explain about the various computational tools in drug discovery
CLR-3 :	Gain knowledge on physicochemical Properties and the techniques involved in QSAR
CLR-4 :	Discuss about the pharmacophore Model
CLR-5 :	Discuss about the quantum mechanics in drug design and De novo ligand synthesis.

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	Environment &	Ethics	Individual & Team	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	Demonstrate an understanding of the steps involved in the drug discovery and design process.	-	3	3	-	3	2	-	-	-	-	-	-	-	3	3
CO-2:	Compare the different computational tools for drug designing and the computer software used in the drug designing.	-	3	-	1	3	-	-	-	-	-	-	-	-	3	3
CO-3:	Demonstrate the ability to use evidence-based approaches to guide decision making during the drug discovery and development process.	-	3	3	3	3	-	-	-	-	-	-	-		3	2
CO-4:	Explain the various methods used in structure-based drug design.	-	3	3	3	3	-	-	-	-	-	-	-	-	3	2
CO-5:	Describe the methods in molecular and quantum mechanics, and De nova ligand synthesis.	-	3	3	3	3	-	-	-	-	-	-	-	-	3	3

Unit-1 : The drug discovery process	9
The sequence of research activities in the development of new drug, Terminology related to drug testing: "hits," "leads," "drug candidates," "drugs,",Criteria that may be necessary to move a compound series onto the lead development stage, Compound Testing, Phases in clinical trials, Effect of Molecular Structure on Activity ,Effect of Molecular Structure on Bioavailability, Drug Side Effects and Toxicity, The Lipinski rule of fives, Exceptions to the Rules Examples of successful drugs that do not obey the "rules.	
Unit-2 : Rational Drug Design	9
Target Identification: Primary Sequence and Metabolic Pathway, Crystallography and 2D NMR, Homology Models and Protein Folding in target identification, Analysis of Target Mechanism: Kinetics and Crystallography, Automated Crevice Detection, ,Introduction to Molecular Dynamics Simulations, Molecular dynamics in target characterization,, The Structure-Based Design Process,The Drug Design Process for a Known Protein Target: Initial Hits and Compound Refinement, Drug Resistance ,Mechanisms of resistance to the drug, The Drug Design Process for an Unknown Target: The Ligand-Based Design Process, Targets inside cells, Targets within the central nervous system	
Unit-3: Force field and molecular mechanics	9
Introduction to computational tools in drug discovery, Introduction to Homology Model Building, Importance of sequence similarity in homology modeling, Steps for Building a Homology Model, Homology Model creation ,Homology Model validation, Molecular Mechanics: ,How molecular mechanics are utilized in drug design. Force Fields for Drug, Introduction to Molecular Docking ,Search Algorithms in Molecular Docking, The Docking Process: Preparation of Protein and Ligand, Analysis of docking Results, Docking softwares/tools	
Unit-4 : Pharmacophore Models and QSAR equations	9
Components of a Pharmacophore Model,, Creating a Pharmacophore Model from the Active Compounds ,Advantages of pharmacophore searching, Creating a Structure based pharmacophore, Searching Compound Databases Reliability of search Results, QSAR Conventional QSAR versus 3D-QSAR,The QSAR Process Descriptors, Automated QSAR Programs ,QSAR versus Other Fitting Methods, The 3D-QSAR Process, Criteria are used to construct conformers,3D-QSAR Software Packages, Advantage and disadvantages of 3D-QSAR Software	
Unit-5: Application oriented examples of Drug Design	9
Structure-based De novo Ligand synthesis, Example of De novo Ligand synthesis, Future Developments in Drug Design: Individual Patient Genome Sequencing, Analysis of the Entire Proteome, Drugs Customized for Ethnic Group or Individual Patient, Application of Genetic Manipulation in drug designing, Cloning and Stem Cells in drug design	

Learning Resources	1.Young, "Computational Drug Design: a Guide for Computational and Medicinal Chemists", Wiley, 2009 2. Kristian Stromgaard, Povl Krogsgaard-Larsen, Ulf Madsen,"Textbook of Drug Design and Discovery. . CRC Press, 2022 3.Andrew Leach, "Molecular Modeling: Principles and applications," 2nd edition, Pearson Education, 1996.	4.Rick NG, "Drugs: From Discovery to Approval," John Wiley & Sons, 2004. 5.Paul S Charifson, "Practical Application of Computer-Aided Drug Design," Informa Health Care, 1997 6.Dev Bukhsh Singh, Computer-Aided Drug Design.: Springer Singapore, 2020.

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
Dr. C. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in	Dr. M K Jaganathan, SRMIST
Dr. Karthik Periyasamy, Scientist, Biocon, karthik.periyasamy@biocon.com	Prof. R. B. Narayanan, Anna University, Chennai, arbeen09@gmail.com	Dr. Priya Swaminathan, SRMIST

Course Code	21BTE404T	Course Name	MARINE BIOTECHNOLOGY	Course Category		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 :	Learn the knowledge of the living and non-living resources.
CLR-2 :	Analyze the pharmacological potency of toxins.
CLR-3 :	Apply the biopolymers from various sources.
CLR-4 :	Control measures of various marine pollution.
CLR-5 :	Understand the commercialization of marine and aquaculture resources.

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	Environment &	Ethics	Individual & Team	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	Describe the economically important marine resources and their wealth.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	Explain the natural toxins and its pharmacological potency.	-	2	2	3	-	-	-	-	-	-	-	-	2	2	2
CO-3:	Distinguish the availability of bioactive compounds.	-	2	2	3	2	-	-	-	-	-	-	-	2	2	2
CO-4:	Value the degradation process for discharged wastes.	-	2	2	3	2	-	-	-	-	-	-	-	-	-	-
CO-5:	Integrate the diseases of cultivable animals and its controlling measures.	-	-	2	2	2	-	-	-	-	-	-	-	2	-	-

Unit-1 : Living and non-living resources	9
Zonation of the sea; motion of the ocean; Living resources - Corals, seaweeds and mangroves. Non-living resources -Oil, gas and salts. Economically important animals - Finfishes, shrimps, crabs, edible oysters and pearl oysters.	
Unit-2 : Natural toxins and its potential pharmacological uses	9
Marie toxins from animals; sources of toxins; pharmacological potential of toxins- tetrodotoxin, conotoxin and ciguateratoxin.	
Unit-3:Potential bioactive compounds	9
Biopolymers - collagen, gelatin, heparin, chitosan, antioxidants. Polyunsaturated fatty acids - omega 3-fatty acids. Sources of carotenoids.	
Unit-4 :Marine pollution	9
Oil spillage - fate of spilled oil, methods of degradation. Harmful blooms- blue-green algal blooms, red tides. Pesticide pollution - degradation. Heavy metal pollution - minamata disease. Solid waste pollution - plastic waste and degradation, factors affecting degradation.	
Unit-5:Finfish and shellfish diseases and aquaculture	9
Finfish diseases; shrimp diseases associated with culture and management; antibiotics used in culture, immunostimulants, diagnostic kits. Watre quality management in hatcheries and grow-out ponds.	

Learning Resources	Se-Kwon Kim (Ed.) "Springer Handbook of Marine Biotechnology", (Series) Springer Berlin, Heidelberg, 2015. Milton Fingerman and Rachakonda Nagabhushanam, "Recent Advances in Marine Biotechnology (Series) Biomaterials and Bioprocessing", Science Publishers, 2009. Proksch and Werner E.G.Muller, "Frontiers in Marine Biotechnology", Horizon Bioscience, 2006.	Le Gal, Y., Ulber, R, "Marine Biotechnology I: Advances in Biochemical Engineering/Biotechnology", (Series editor: T. Scheper) Springer-Verlag Berlin Heidelberg. Vol. 96, 2005. Le Gal, Y., Ulber, R "Marine Biotechnology II: Advances in Biochemical engineering/Biotechnology", (Series editor: T. Scheper) Springer-Verlag Berlin Heidelberg. Vol. 97, 2005.

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
Dr. G. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in	Dr.R.A.Nazeer, SRMIST
Dr. S. Sam Gunasekar, Orchid Chemicals and Pharmaceutical Ltd., Chennai	Prof. R. B. Narayanan, Ann University, Chennai, arbeen09@gmail.com	Dr.R.Jaiganesh, SRMIST

Course Code	21BTE405T	Course Name	VACCINE BIOTECHNOLOGY	Course Category		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 :	Understand the conventional strategies in vaccine production
CLR-2 :	Develop an understanding in the vaccine production techniques
CLR-3 :	Categorise the types of vaccine
CLR-4 :	Analyze different methods of vaccine delivery
CLR-5 :	Comprehend the guidelines for vaccine management

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	Environment &	Ethics	Individual & Team	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	Acquire theoretical knowledge on conventional strategies in vaccine production	-	3	-	-	-	-	-	-	-	-	-	2	-	3	-
CO-2:	Exemplify the students with vaccine production techniques	-	3	3	-	-	-	-	-	-	-	-	-	3	-	3
CO-3:	Distinguish various types of vaccine	-	3	-	3	-	-	-	-	-	-	-	-	-	3	-
CO-4:	Devise various methods for vaccine delivery	3	-	-	3	-	-	-	-	-	-	-	-	-	3	3
CO-5:	Explicate the guidelines for vaccine production and delivery	-	-	3	-	-	-	-	2	-	-	-	-	-	3	3

Unit-1 : CONVENTIONAL STRATEGY & CURRENT DEVELOPMENTS IN VACCINE	9
History of vaccine development -Conventional strategies for vaccine improvement; Live, attenuated, subunit, peptide and killed vaccines; Types of adjuvants; Current development in vaccines- Next-generation vaccines: Human Immunome project; Human antibodies as vaccines	
Unit-2 : VACCINE DESIGN & DEVELOPMENT	9
Steps involved in vaccine production; Production techniques-Strain selection, growing the microorganisms in maximum titre; Technology related to monitoring -temperature, sterilization, environment, quality assurance, vaccine efficacy and lot release; Preservation techniques-cryopreservation and freeze drying	
Unit-3: TYPES, METHODS & APPLICATIONS	9
Types of vaccines- Inactivated toxins, Inactivated whole bacteria or viruses, Live attenuated bacteria or viruses, Subunit vaccines, Polysaccharide vaccines, Conjugate vaccines, Genetic approaches in vaccine development- Recombinant DNA vaccines, Edible vaccines; Recent developments in vaccine - Virus like particles, Nanoparticles in vaccine delivery, Induction of immune responses by nanoparticle based vaccine	
Unit-4 :VACCINE DELIVERY	9
Immunomodulators-Innovative methods of delivering immunogens ; liposomes-role of liposomes in delivering vaccines-Mechanism of liposome formation; Microspheres-Types of microspheres, Preparation methods; ISCOMS-Properties of ISCOM based vaccines, Types, components of ISCOM	
Unit-5: GUIDELINES FOR VACCINE MANAGEMENT	9
Regulatory issues- Regulatory bodies, Environmental effects of recombinant vaccines; Disease security and biosecurity principles; OIE guidelines for vaccine seed lot management; OIE guidelines for the method of vaccine production, OIE guidelines for production facility; In process control and batch control-organization and responsibilities, documentation and evaluation of data; Test on final products-Overview, General manufacturing recommendations, Final product release tests	

Learning Resources	1. Ronald W. Ellis, "New Vaccine Technologies", Landes Bioscience, 2001. 2. Noel Mowat, "Vaccine manual: The production and quality control of veterinary vaccines for use in developing countries", Daya books, 1999.	3. Cheryl Barton, "Advances in Vaccine Technology and Delivery", Espicom Business Intelligence, 2009. 4. Vaccines: Stanley A. Plotkin, Walter A. Orenstein, Paul A. Offit(Elsevier), 6th edition, 2008 5. Ibrahim M Shnawa ,"Vaccine Technology at A Glance", Boffin Access Limited, UK, 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
Dr. S. Sam Gunasekar, Orchid Chemicals and Pharmaceuticals Ltd., sam@orchidpharma.com	Prof. K Subramaniyam, IITM, Chennai, suubu@iitm.ac.i	Dr.S.Sujatha, SRMIST
Dr. Karthik Periyasamy, Scientist, Biocon, karthik.periyasamy@biocon.com	Dr. R. B Narayanan Anna University, Chennai,arbeen09@gmail.com	Dr.Koustav Sarkar, SRMIST

Course Code	21BTE406T	Course Name	MOLECUALR BASIS OF DRUG ACTION	Course Category		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 :	Impart knowledge of drug targets and methods used in molecular cloning of drug targets
CLR-2 :	Increase the understanding of how drugs work.
CLR-3 :	Impart knowledge about the molecular aspects of drug targets and their signaling mechanisms.
CLR-4 :	Impart knowledge about the structure of different drug targets.
CLR-5 :	Explain how an individual's genetic makeup influences their response to therapeutic drugs.

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	Environment &	Ethics	Individual & Team	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	Gain knowledge about drug targets and molecular biology techniques used in pharmacology.	-	-	2	2	3	-	-	-	-	-	-	-	2	2	-
CO-2:	Discuss the molecular pharmacology of receptors, channels, and enzymes.	-	2	2	2	-	-	-	-	-	-	-	-	2	2	-
CO-3:	Classify the different types of receptors, ion channels, and transporters.	-	2	-	2	2	-	-	-	-	-	-	-	2	-	-
CO-4:	Identify the receptors, ion channels, and transporter based on structure.	-	-	2	2	2	-	-	-	-	-	-	-	2	2	-
CO-5:	Investigate how an individual's genetic makeup influences their response to therapeutic drugs.	-	-	2	2	2	-	-	-	-	-	-	-	2	2	-

Unit-1 : Drug Targets and Molecular Cloning of Drug Targets	9
Outline of molecular pharmacology based approaches used to interrogate drug targets, Molecular pharmacology vs traditional pharmacology, Nature of the Drug targets, Future drug targets .Molecular Cloning – from DNA to drug discovery, The relevance of recombinant DNA technology to pharmacology/drug discovery. The 'Cloning' of drug targets: Cloning using peptide sequence(s), construction and screening of a DNA library, Cloning using a specific antibody, a functional assay and Polymerase chain reaction. Reverse pharmacology: Reverse pharmacology illustrated on orphan GPCRs	
Unit-2 : G-Protein Coupled receptor	9
Classification and molecular structure of G-Protein Coupled receptor (GPCR), Mechanism of Activation and Signal transduction pathways - phospholipase C and adenylyl cyclase, Measurement of phospholipase C and adenylyl cyclase activation, Desensitization and down-regulation of GPCR signaling and Role of GPCR phosphorylation in desensitization, Constitutive GPCR activity, Agonist-directed signaling and Allosteric modulators of GPCR function. Pharmacological chaperones for GPCRs , GPCR dimerization- Methods to study GPCR dimerization,	
Unit-3: Ion channels	9
Classification of ion channels .Voltage-gated ion channels -Structure of Voltage-gated Ca2+ channels, Na+ channels, K+ channels. Voltage-gated ion channels in health and disease and their role in neurotransmission and muscle contraction, Effect of toxin on the Voltage-gated ion channels. Ligand-gated ion channels - Pentameric ligand-gated ion channel family, Nicotinic acetylcholine receptors, 5-HT3 receptor channels and GABAA receptors.	
Unit-4 : Transporters	9
Classification of Transporter proteins- Transporter families of pharmacological interest-The major facilitator superfamily (MFS), The neurotransmitter: sodium symporter (NSS) - Structure of Glutamate transporters (Gltph) and Leucine Transporter (LeuTAa), NhaA Na+:H+ antiporter (NhaA) family. The cell penetrating peptides (CPP), ATPase transporters Structure and role in human health and disease, Role of transporters in drug pharmacokinetics and cellular homeostasis	
Unit-5: Pharmacogenomics	9
Types of genetic variation, Methods for detecting genetic polymorphisms-PCR-RFLP analysis and Large-scale SNP analysis. Polymorphisms affecting drug metabolism- Different Scenario how the polymorphisms affecting drug metabolism. Genetic variation in drug transporters. Genetic variation in G protein coupled receptors-Genetic variation within the adrenergic receptor family and role of adrenergic receptor SNP in asthma and cardiovascular function.	

Learning Resources	1. Michael Palmer, Alice Chan, Thorsten Dieckmann, John Honek, "Biochemical Pharmacology", Wiley, 2012. 2. Chris Lloyd Mills, Fiona Freeman, Christian Thode, Shiva Sivasubramaniam, John Dickenson, "Molecular pharmacology : from DNA to drug discovery ",Wiley-Blackwell, 2012	3. Terry Kenakin, "Pharmacology in drug discovery: understanding drug response", Mica Haley, 2016. 4. Rang and Dale, " Pharmacology", Churchill Livingstone, 2007.

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
Dr. G. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in	Dr. M. K. Jaganathan, SRMIST
Dr. Karthik Periyasamy, Scientist, Biocon, karthik.periyasamy@biocon.com	Dr. R. B Narayanan Anna University, Chennai,arbeen09@gmail.com	Dr. Y. Ravichandran,SRM IST

Course Code	21BTE203T	Course Name	PLANT HORMONES AND SIGNALING	Course Category		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 :	Exemplify how plant hormones contribute to their growth, development, reproduction and stress responses.
CLR-2 :	Understand the fundamental properties, tropic movement, and mechanism of action of auxin.
CLR-3 :	Interpret the effects of cytokinin, its receptor perception & signaling.
CLR-4 :	Study the gibberllins and ethylene receptors and regulation of physiological functions.
CLR-5 :	Illustrate the interactions of core signaling for controlling the functions of abscisic acid in plants.

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 &	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	Discuss the major plant hormones and their roles in a plant's life.	3	3	3	-	-	-	-	-	-	-	-	-	-	3	-
CO-2:	Describe the history, synthesis, transport, and functions of auxin.	3	2	3	-	-	-	-	-	-	-	-	-	-	3	-
CO-3:	Understand the cytokinin biosynthetic pathway and protein kinase cascade for signaling.	3	3	-	3	-	-	-	-	-	-	-	-	-	3	-
CO-4:	Interpret the different physiological responses to the environment by hormones gibberellins and ethylene.	3	*3*	2	-	-	-	-	-	-	-	-	-	-	-	3
CO-5:	Explain the ways that ABA affects the development of roots, fruits, and seeds during stresses	3	3	-	*3*	-	-	-	-	-	-	-	-	-	3	-

Unit-1 : Introduction to Phytohormones	9
Types of phytohormones. Overview of hormone action and signaling. Hormones and vegetative developments in plants: Auxin, cytokinin, strigolactones, gibberellins & brassinosteroids. Hormonal control of reproductive development - Transition to flowering, development of flowers and fruits: Ethylene & abscisic acid. Hormonal responses to abiotic stress: Abscisic acid. Hormonal responses to biotic stress: Jasmonates & Salicylates. Hormonal crosstalk, and in defense.	
Unit-2 : Auxin	9
Overview of auxin studies, signaling pathways. Biosynthesis and homeostasis, transport. Polar auxin transport, chemiosmotic model. Auxin moves through efflux and influx carrier proteins, types of carrier proteins - AUX1 / LAX, ABCB family & PIN family, perception – receptors, ABP1, TIR1 and AFP protein family of F-box proteins, signaling - Aux/IAA proteins, auxin-responsive transcription factors. Physiological actions.	
Unit-3: Cytokinins (CK)	9
The discovery of cytokinins - overview, homeostasis, and structure of major CKs. The Agrobacterium tmr gene is a CK biosynthesis gene CYP735A. Formation of active CKs, LONELY GUY overexpression, CK inactivation by conjugation or degradation, cytokinin oxidase, CK acts as a paracrine and a long-distance signal PUP and ENT. CK perception and signaling, a two-component-like system. Downstream of the receptors - Histidine phosphotransfer proteins (HPTs) and response regulators (RRs). CK action in whole-plant processes, Abiotic and biotic stress responses.	
Unit-4 : Gibberellins & Ethylene	9
Gibberellins - History and overview. Inhibitor of an inhibitor, synthesis and homeostasis, deactivation & transport, perception and signaling, GID1 encodes a GA receptor, GA-regulated growth repressors, DELLA proteins, GA's roles in whole-plant physiology, Response to salt stress, seed germination, and flowering. Ethylene - A gaseous hormone, triple response, ethylene synthesis, and homeostasis. Burg and Thimann's studies, The Yang cycle. Ethylene response, receptors, and downstream signaling. Ethylene's roles in whole-plant processes.	
Unit-5: Abscisic Acid (ABA)	9
Abscisic acid - Plant processes, biosynthesis and homeostasis - Zeaxanthin epoxidase, NCED, VP14 & CYP707A. Transport - ABA movement perception and signaling - PYR/ RCAR, ABI1 encodes a PP2C protein phosphatase, PP2C binds ABA + receptor & SnRK kinase similarly, calcium-dependent protein kinases, ABA's roles in the control of guard cell	

turgor, ABA in whole-plant processes - drought stress, surviving extreme desiccation, systemic stress responses.

Learning Resources	1.Lecture Notes. 2023. The Plant Cell, American Society of Plant Biologist, Oxford University Press. 2. Jiayang Li, Chuanyou Li, Steven M. Smith. "Hormone Metabolism and Signaling in Plants" Academic Press, ISBN - 978-0-12-811562-6. (2017). 3.Davies, P. J., "Plant Hormones -Biosynthesis, Signal Transduction, Action", Third Edition, Springer 2011.	4. S. L. Kochhar and Sukhbir Kaur Gujral "Plant Physiology Theory and Applications", pp. 468 – 525. DOI: https://doi.org/10.1017/9781108486392.019. Cambridge University Press, (2020). 5. Lincoln Taiz and Eduardo Zeiger, "Plant Physiology", Third edition. Panima Publishing Corporation, 2003.

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
Dr. C. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	Prof. K Subramaniyam, IITM, Chennai, suubu@iitm.ac.in	Dr. R. Pachaiappan, SRMIST
Dr. Karthik Periyasamy, Scientist, Biocon, karthik.periyasamy@biocon.com	Prof. R. B Narayanan Anna University, Chennai,arbeen09@gmail.com	Dr. DVL. Sarada, SRMIST

Course Code	21BTE305T	Course Name	EPIGENETICS IN PLANTS	Course Category		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 :	Illustrate the epigenetic modifications of DNA and chromatin that affect the activity of genes
CLR-2 :	Understand the post-transcriptional gene silencing and transcriptional gene silencing by small RNAs
CLR-3 :	Interpret the regulation of small RNAs in the plant developmental process through gene expression
CLR-4 :	Understand the mechanism of epigenetic modification through small RNAs
CLR-5 :	Illustrate the methods of studying epigenetic modification in plants

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	Environment &	Ethics	Individual & Team	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	Discuss the genome organization complexity and controlled expression of the genes	3	3	-	3	-	-	-	-	-	-	-	-	-	3	-
CO-2:	Demonstrate the various levels of checkpoints for gene expressions by small RNAs	3	3	3	-	-	-	-	-	-	-	-	-	3	-	-
CO-3:	Understand the small RNA contribution to plant developmental patterning	3	3	-	3	-	-	-	-	-	-	-	-	-	3	-
CO-4:	Interpret the different small RNAs to control the gene expressions by regulating different factors	3	3	-	3	-	-	-	-	-	-	-	-	-	-	3
CO-5:	Explain the various techniques for epigenetic modification studies	3	3	-	-	3	-	-	-	-	-	-	-	-	-	3

Unit-1 : Genome structure, gene, expression and controls	9
Introduction to the structural organization of the genome in plants, genes structure, and expression in prokaryotic and eukaryotic systems. Transcriptional and post-transcriptional regulations. Epigenetic markers - transcriptional silencing, chromatin remodeling, DNA methylation. The structure of histones, interactions between DNA and histone methylation functions, RNA-independent chromatin modification.	
Unit-2 : Overviews of RNAs	9
Types and roles of RNAs, General roles - transgene silencing, and viral resistance. Comparative studies of small RNAs in C. elegans. Types of small RNAs, and RNA polymerases in plants. Biogenesis of small RNAs in plants, regulations of small RNAs.	
Unit-3: Epigenetic regulation in whole-plant processes.	9
Epigenetic control of transposon, repetitive elements. Epigenetic control of flowering time. Plant Developmental Programs - PRC2-mediated H3K27me3 deposition. Vegetative propagated plant regulations. Epigenetic response to stress - Drought stress - H3K4Me3, heat-induced activation - ONSEN transposon. Epigenetic control of imprinted genes. Epigenome reprogramming. Natural epigenetic variations.	
Unit-4 : Epigenetic modification by small RNA.	9
Functions of small RNAs - mobility and non-cell-autonomous functions, trans-generational transposon silencing with mobile siRNAs. Gametes and zygotes, miRNA regulation of developmental patterning. Functions of phasiRNAs and tasiRNAs. Small RNAs in biotic interactions and defense. AC/DS elements regulations in maize. Applications of small RNAs in crop improvement.	
Unit-5: Methods to study Epigenetics)	9
Chromatin immunoprecipitation binding analyses in Arabidopsis. Capture-based analysis of nuclear architecture. Analysis of DNA methylation in plants. Combined Bisulfite Restriction Analysis (COBRA) assay. Cytosine-extension assay and in situ analysis of DNA methylation. Analysis of DNA hydroxymethylation. Colorimetric assay. Analysis of small RNA populations. Profiling transposable elements.	

Learning Resources	**1.** Rajewsky, Nikolaus & Jurga, Stefan & Barciszewski, Jan. (2017). Plant Epigenetics. 10.1007/978-3-319-55520-1. 2. Williams, M.E. (April 2, 2013). Epigenetics.Teaching Tools in Plant Biology:Lecture Notes. The Plant Cell (online), doi/10.1105/tpc.110.tt0110. 3. Williams, M.E. (May 3, 2013). The Small RNA World. Teaching Tools in Plant Biology:	4. Kovalchuk, Igor. (2017). Plant Epigenetics: Methods and Protocols. 10.1007/978-1-4899-7708-3. 5. Spillane, Charles & McKeown, Peter. (2014). Plant Epigenetics and Epigenomics: Methods and Protocols. 10.1007/978-1-62703-773-0. 6. Kovalchuk, Igor & Zemp, Franz. (2010). Plant Epigenetics: Methods and Protocols. 10.1007/978-1-60761-646-7.

	Lecture Notes. The Plant Cell (online), doi/10.1105/tpc.110.tt10210	

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
Dr. C. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in	Dr. R. Pachaiappan, SRMIST
Dr. Karthik Periyasamy, Scientist, Biocon, karthik.periyasamy@biocon.com	Prof. R. B. Narayanan, Anna university, Chennai, arbeen09@gmail.com	Dr. DVL. Sarada, SRMIST

Course Code	21BTE306T	Course Name	PATHOGENESIS RELATED PROTEINS IN PLANTS	Course Category		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 :	Highlight the different types of interactions between plants and pathogens
CLR-2 :	Realize inducibility of microbial resistance
CLR-3 :	Delineate various functions of different classes of PR proteins
CLR-4 :	Introduce concepts related to pest resistance
CLR-5 :	Apprise the applications of PR Proteins 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	Environment &	Ethics	Individual & Team	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	Expalin the molecular mechanisms underlying plant pathogen interactions	2	2	2	2	-	-	-	-	-	-	-	-	3	-	3
CO-2:	Analyze the induction of PR proteins for host defense	3	3	3	2	-	-	-	-	-	-	-	-	3	-	2
CO-3:	Categorize the functions of different classes of PR proteins to host resistance	3	2	2	3	-	-	-	-	-	-	-	-	3	-	-
CO-4:	Infer the differences between pathogen resistance and pest resistance	3	3	3	2	-	-	-	-	-	-	-	-	2	-	3
CO-5:	Evaluate the applications of PR Proteins for crop improvement	2	2	-	2	-	-	-	-	-	-	-	-	2	-	2

Unit-1 : Plant Pathogen Interactions	9
Plant Pathology – Basics – Major Classes of Pathogens - Fungi, viruses, bacteria, oomycetes and nematodes – Pathogen -Host- Environment Interactions - The Disease Triangle - Strategies of pathogenicity - biotrophy, necrotrophy, and hemi-biotrophy - Host Responses - Pathogen-triggered & Effector-triggered immunity - Pathogen-recognition receptors – Induction of phytoalexin, reactive oxygen and callose production- Recognition and response to effectors through paired R proteins	
Unit-2 : Classes I and II	9
PRs, and PR like proteins PR - proteins from other organisms & Functions Occurrence, Properties and Functions - PR- 1 Proteins Characterization -Induction - Pathogens /wounds, Salicylic acid, Ethylene and Other hormones, UV light and Developmental Stimuli - PR-1 promoter analysis - PR-2 Proteins – β-1,3-Glucanases Structural classes - Biological Functions of β-1,3-Glucanases – Reproduction and Defense – Induction by Developmental, Hormonal and Biotic stimuli	
Unit-3: Chitinases and Osmotins	9
Structure of PR- 3, 4, 8, 11 Proteins - Other Related Proteins - Catalytic Mechanisms and Specificities - Structure and Regulation of the Genes - Antifungal Activities and other Physiological Properties - PR-5 - Thaumatin-like proteins - Occurrence, Physico- chemical properties - Biological properties - Taste - Antifungal Activity - Anti-Freeze Properties - TLP Expression - Microbial Infection Osmotic Stress, Abscisic Acid, Ethylene, Salicylate, Methyl Jasmonate other Elicitors -Wounding	
Unit-4 : Proteinase Inhibitors, Defensins and Ribosome Inactivating Proteins	9
Proteinases and Proteinase Inhibitors- Occurrence and Structure- Plant–Microbe and Plant Insect Interactions – Defensins – Structure – Significance of Disulphide Residues- Structure – Activity Relationships-Mechanism of Antimicrobial Action - Ribosome inactivating proteins and – Structure, Function and Engineering	
Unit-5: Molecular Basis of Disease Resistance and Application	9
Signals and Putative Receptors that Activate PR Gene Expression – Activation of PR Genes by Different Stimuli - Reactive oxygen species (ROS), salicylic acid (SA), ethylene, and jasmonates Leucine-rich repeat receptor kinases , LysM receptor proteins - Transcriptional Regulation of PR Gene Expression - W-box, GCC box, MRE-like sequence & G-box - SA-inducible promoter - GCC box-binding proteins - EREBP-1, EREBP-2, EREBP-3, and EREBP-4 – Transgenics – Expression of PR Proteins – Examples in Rice.	

Learning Resources	1 Agrios, G.N. (2005). Plant Pathology. (Burlington, MA: Elsevier Academic Press). 2. Schumann, G.L., andand D'Arcy, C.J. (2010). Essential Plant Pathology. (St. Paul, MN: The American Phytopathological Society).	3. Swapan K. Datta and Muthukrishnan, "Pathogenesis –Related Proteins in plants", CRC Press, 1999. 4. John A. Lucas "Plant pathology and Plant Pathogens" Fourth Edition Wiley- Blackwell 2020

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
Dr. C. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in	Dr. Sarada, DVL, SRMIST
Dr. Karthik Periyasamy, Scientist, Biocon, karthik.periyasamy@biocon.com	Prof. R. B. Narayanan, Anna university, Chennai, arbeen09@gmail.com	Dr. R. Pachaiappan, SRMIST

Course Code	21BTE407T	Course Name	FOOD SCIENCE AND NUTRITION	Course Category		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 :	Identify the need for greater and more efficient utilization of the existing food sources
CLR-2 :	Demonstrate nutritional quality and nutritional requirement
CLR-3 :	Solve calculate energy requirements of the body
CLR-4 :	Describe about new trends in nutrition
CLR-5 :	Identify antinutritional factors in food

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	Environment &	Ethics	Individual & Team	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	Demonstrate nutritional quality and nutritional requirement	-	3	-	-	-	-	-	-	-	-	-	-	2	-	-
CO-2:	Explain about carbohydrate nutrition	-	2	-	-	-	-	-	-	-	-	-	-	2	-	-
CO-3:	Describe about protein and fat	3	-	-	-	-	-	-	-	-	-	-	-	2	-	-
CO-4:	Identify vitamins minerals and antinutritional factors in food	3	-	-	-	-	-	-	-	-	-	-	-	-	2	-
CO-5:	Describe about new trends in nutrition	3	-	3	-	-	-	-	-	-	-	-	-	3	-	-

Unit-1 : Nutritional requirements and dietary standards 9

Food as a source of energy, Essential nutrients, The food pyramid, Food Group System, Balanced diet, malnutrion, obesity and health implications; calorific value of nutrients, calculating energy values from food, Instrumental methods to calculate caloric value of food, Proximate analysis of foods,; BMR and BMI calculation, RDA- Recommended dietary allowances for Indians fixed by ICMR comparison with that of FAO/WHO standards ; Digestion, Absorption and Metabolism of fat , Carbohydrate and protein ; Functions of protein, fat and carbohydrates and their dietary requirements,

Unit-2 : Carbohydrates **9**

Sources of Carbohydrates, Classification of Carbohydrates, Polysaccharides –Starch and dietary fibers. Role of dietary fibers in food, Carbohydrate rich food- Cereal and tuber crops, Nutritional significance of carbohydrates,non-glycemic and Glycemic carbohydrates, recommended carbohydrate intake, lactose intolerance; blood glucose regulation, diabetics and nutrition; Artificial sweeteners, Sugar alcohols and its adverse effect on health t

Unit-3: Protein and Lipid *9*

Protein- dietary requirements, functions, and deficiency in diet; Sources of Protein and its composition- pulses, meat , milk and egg; single cell protein, Antinutritional factors in pulses, gluten-free diet; Classification of lipids , Plant Sources of fat/oil, Marine and animal sources of fat/oil ,Nutritional significance of lipids-essential fatty acids and omega 3 fatty acids, Diabetes mellitus – Cardiovascular disease- HDL & LDL cholesterol and triglycerides in blood and diet; Trans fatty acids and health effects,

Unit-4 : Water, Vitamins, minerals and antinutritional factors *9*

Function and daily intake of water, Sources of vitamins in food, Vitamin deficiency disease, Fat soluble vitamins –A,D,E, and K, Water soluble Vitamins-B-complex vitamins, Anemia –preventing vitamins and Vitamin-C; toxicity due to vitamins, bioavailability of vitamins, reasons for losses of vitamins in foods; Sources of mineral in food, Classification of minerals, Naturally occurring food toxicants in foods- Carcinogens produced during food processing and storage

Unit-5: Diet planning, Therapeutic diet and New trends in nutrition *9*

Diet planning principles, dietary guidelines, dietary recommendations using the nutritional assessment of individuals and populations, therapeutic die; Estimation of energy requirements for different age group and women at different life stages,- Therapeutic diets – Diabetes mellitus – Cardiovascular disease – Hypertension – Cancer – Obesity and underweight; Nutritional value and health implications of fast food and junk food; Probiotics an prebiotics, Antioxidants , Nutraceuticals, Functional food

Learning Resources	1. Sunetra Roday. "Food science and nutrition". 2016, Oxford university Press.. 2. Swaminathan, M. (5th Edition). "Hand Book of food and Nutrition", 2015. The Bangalore Printing and Publishing co. Ltd. Bangalore 3.Srilakshmi B 2018 (7th Edition). Food Science. New age International Publishers.	4. .Spark, Arlene. "Nutrition in Public Health : Principles, Policies, and Practice". CRC Press, 2007. 5. Mann, Jim and Stewart Truswell "Essentials of Human Nutrition". 3rd Edition. Oxford University Press, 2007 6.Ahuja, K.J, Nath Prem and K.R.M Swamy Food and Nutrition, 2010. Studium Press Pvt. Ltd., New Delhi.,

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
Dr. C. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in	Dr.R.Preetha, SRMIST
Dr. Karthik Periyasamy, Scientist, Biocon, karthik.periyasamy@biocon.com	Prof. R. B. Narayanan, Anna university, Chennai, arbeen09@gmail.com	Dr. S. Subhashini, SRMIST

Course Code	21BTE408T	Course Name	THERAPEUTIC COMPOUNDS FROM PLANTS	Course Category		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 :	Outline the importance of natural compounds of plant origin in health and disease
CLR-2 :	Differentiate between the properties of different classes of phytoconstituents
CLR-3 :	Demonstrate the methods of production of phytoconstituents in vitro
CLR-4 :	Appraise the therapeutic applications of phytoconstituents
CLR-5 :	Outline the concepts of metabolic engineering for production of plants with improved phytoconstituents

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	Environment &	Ethics	Individual & Team	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	Recall natural products originating from plants and outline their importance in health and disease	2	2	2	2	2	-	-	-	-	-	-	-	3	3	-
CO-2:	Analyze the differences between structure and function of different classes of phytoconstituents	3	3	3	3	3	-	-	-	-	-	-	-	3	3-	-
CO-3:	Make use of in vitro culture techniques for production of phytoconstituents	3	3	3	3	3	-	-	-	-	-	-	-	3	3	-
CO-4:	Infer the role of phytoconstituents in development of medicines for therapeutic applications	3	3	3	3	3	-	-	-	-	-	-	-	3	3	-
CO-5:	Appraise the application of metabolic engineering for production of plants with improved content of phytoconstituent.	3	3	3	3	3	-	-	-	-	-	-	-	3	3-	-

Unit-1 : Plant Genome Structure and Organization	9
Plants vs Medicinal Plants, Taxonomy and validation of Herbal Medicine, Traditional Indian Medicine, Traditional knowledge ,Ethano botany. quality assurance of herbal medicine, over the counter herbal medicines, plant extracts vs purified compounds, quest for active compounds, modern approaches, screening plants for drugs, plant families associated with drug production, drug discovery by relatedness, phytoconstituents , alkaloids , flavonoids , terpenoids	
Unit-2 : Analytical Techniques	9
Overview of extraction and purification of phytoconstituents extraction techniques , different types , advantages and limitations of extraction techniques analytical techniques – spectrometry , purification, Analytical Techniques – Chromatography , Bioassay Guided Fractionation , Identification , Analytical Techniques –Mass Spectrometry , Standardization , Clinical validation	
Unit-3: Secondary Metabolism	9
Primary vs Secondary Metabolism, Examples of Major Secondary Metabolic Pathways , The Mevalonate Pathway , Examples , The shikmate pathway , Examples , The phenyl propanoid and the polyketide pathway, Examples , Biosynthesis of alkaloids , Tissue Cultures for production of metabolites , Examples , Organ Cultures for production of metabolites , Examples Hairy Root Cultures as a means for enhanced metabolite production , Manipulation of hairy roots for metabolite production , Production of Gingsenolides , In vitro production – Role of Endophytes , Production of Taxol.	
Unit-4 : Therapeutic Applications of Phytoconstituents	9
Potential drugs available in the market , Mechanism of action , Analgesic action of alkaloid (Morphine), Antihyperglycemic action of alkaloids (Piperene) , Anti cancer activity of alkaloids (Berberine) , Anticancer activity of Vinca alkaloids , Antibacterial action of alkaloids (ciproflaxicin) , Neurostimulatory effects of alkaloids , Neuroprotective effects of alkaloids , Antiinflammatory mechanism of action of flavonoids , Antimalarial action of Terpenoids (Quinine) , Antimalarial action of Terpenoids (Artemesin) , Terpenoids against Trypaonosomes , Terpenoids against Leishmanias , Ephedra- Use and Misuse , Ginseng – The Panacea	
Unit-5: Metabolic engineerinf for improvement of Phyto constituents	9
In vitro Synthesis – Advantages and dis advantages Omics, Systems and Semi synthetic methods Metabolic Engineering - High throughput methods to identify genes intermediates and pathways Strategies Host Selection and Pathway reconstitution - Metabolic Engineering for Phytoconstituents production in Yeast- Metabolic Engineering in Plants and Plant Cell Cultures	

Learning Resources	1. Trease and Evans Pharmacognosy, William Evans, Sixteenth Edition Elsivier 2009 Phytochemical Methods – A guide to Modern Techniques in Plant Analysis, Harborne Springer 1998	2. Fundamentals of Pharmacognosy and Phytotherapy Second Edition Michael Heinrich, Joanne Barnes, Simon Gibbons and Elizabeth M. Williamson, Elsivier 2012 3. Textbook of Medicinal and Aromatic Plants, Amritpal Singh Saroya Indian Council of Agricultural Research 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*	*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
Dr. C. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in	Dr. Sarada, D.V.L., SRMIST
Dr. Karthik Periyasamy, Scientist, Biocon, karthik.periyasamy@biocon.com	Prof. R. B. Narayanan, Anna university, Chennai, arbeen09@gmail.com	Dr. R. Pachaiappan, SRMIST

Course Code	21BTE409T	Course Name	FOOD SAFETY AND QUALITY MANAGEMENT	Course Category		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 and analyze Food contaminates and adulterants
CLR-2 :	Describe safety limits of food additives and risk assessment
CLR-3 :	Prepare HACCP program to any food industry
CLR-4 :	Employ Food Quality control and Risk analysis tools
CLR-5 :	Apply certification methods for the food industries

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	Environment &	Ethics	Individual & Team	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	Identify the issues of food safety and quality	2	2	2	-	-	3	-	2	-	-	-	-	2	-	-
CO-2:	Enhance the knowledge on food additives and Identify safety limits of food additives	2	-	-	2	-	3	-	2	-	-	-	-	2	-	-
CO-3:	Analyze and practice HACCP and Quality Management Systems	-	3	3	3	-	2	-	2	-	-	-	-	-	2	-
CO-4:	Analyze Risk assessment and risk management.	-	3	-	2	-	2	-	-	-	-	-	-	-	2	-
CO-5:	Explain the concept on monitoring & implementing FSSAI regulations.	-	3	3	3	2	-	-	-	-	-	-	-	3	-	-

Unit-1 : Food contaminates and adulterants — 9

Food contaminants- pesticide residues, chemicals, mycotoxins and microbial contamination. Analytical tools and methods for identification and quantification of contaminant; identification of food borne pathogens; Food adulterants, testing methods for adulterants,

Unit-2 : Food additives, GMO and Food labeling — **9**

Food preservatives-natural , synthetic, FSSAI standards for synthetic preservatives; Synthetic Food colours and flavours, Artificial sweeteners; GM Foods- microbes, plants and animals; GM testing and analysis , Safety evaluation of GM foods and future of GM foods, Food safety regulation on additives and GMO in India; Food Labeling, Label claims, Allergen declaration,

Unit-3: HACCP and Quality Management Systems — *9*

HACCP- Principles, Implementation and maintenance, Hazard identification, HACCP case studies, ; CCP; Quality management system- Bar Chart, Pareto analysis, Fish bone model, Run charts; Scatter plots, Control charts,,

Unit-4 : Food Quality control and Risk analysis — *9*

Principles of food safety and quality; Methods for food quality analysis; methods and importance of sampling, Statistical Process and Quality Control; Risk-identification, classification, Food quality issues, Food recall

Unit-5: Food Safety and Certification — *9*

Food safety issues; Definition and terminology in QMS; Food Safety and standard Authority of India; Food Safety authority and responsibilities ; FSSAI standards; Indian Laws on food safety regulations; Food Safety licensing and registration; Procedure for FSSAI licensing; Registration, Inspection and enforcement; Food import clearance systems; Role of food testing laboratories; Food safety standards in India; GMP, GHP in food industries; Food safety certification bodies;

Learning Resources	1. Sunetra Roday, S. 2 nd edition Food Hygiene and Sanitation, 2017,Tata McGraw-Hill Education. 2.Virag Gupta,The Food Safety and Standards Act, 2006. 16 th edition 2022 Commercial Law Publishers (India) Pvt. Ltd. 3.Andres Vasconcellos J. 2 nd edition. Quality Assurance for the Food industry - A practical	4. Inteaz Alli. 1st edition, Food quality assurance - Principles & practices. 2004, CRC Press. New York. 5. Sara Mortimore and Carol Wallace. 3rd edition HACCP - A practical approach.2013, Chapman and Hall, London.

	approach. 2005, 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. Sankaran Jagadeesan, VP, Jasmine Concrete Exports, Chennai sankaran.jagadeesan@jasmineindia.com	Prof. S. *Shanmuga Sundaram, IIFPT,* Thanjavur - 613 005 sasu@iifpt.edu.in, sasu.iicpt@gov.in	Dr.R.Preetha, SRMIST
2Krishnamoorthy, Business Head, Food-India, Chennai	Prof. G. Sarathchandra, TANUVAS, Chennai 600007. *sarathchandra.g@tanuvas*.ac.in	Dr.P.Gurumoorthi, SRMIST

Course Code	21BTE204T	Course Name	ENZYME ENGINEERING AND TECHNOLOGY	Course Category		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 the basics of enzyme mechanism, classification and factors affecting enzyme activity
CLR-2 :	Explore the sequential process of the enzyme purification
CLR-3 :	Evaluate the kinetics of enzyme action, inhibition, and regulation
CLR-4 :	Analyze the various methods of enzyme immobilization and evaluate their kinetic efficiency
CLR-5 :	Deliberate the applications of enzymes in various industries

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	Environment &	Ethics	Individual & Team	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	Recognize the basic nature of enzyme, classification and their mechanism of working	2	-	2	-	2	-	-	-	-	-	-	-	2	-	-
CO-2:	Formulate the succession of enzyme purification and their characterization	2	2	2	-	2	-	-	-	-	-	-	-	2	2-	2
CO-3:	Explain various kinetic mechanisms and regulation of enzyme actions	3	3	2	2	2	-	-	-	-	-	-	-	2	-	-
CO-4:	Analyze the methods of enzyme immobilization and assess the effectiveness of immobilization	2	2	2	2	2	-	-	-	-	-	-	-	2	2-	-
CO-5:	Explore the extent of enzyme applications in various industries	2	-	2	2	-	-	-	-	-	-	-	-	-	2-	2

Unit-1 : Introduction to Enzymes — 9

Chemical nature of enzymes, Characteristics of enzymes, Enzymes and their actions, Mechanism of enzyme action, Structural components of enzymes, Active site of an enzyme, Cofactors and coenzymes, Enzyme commission classification of enzyme, Enzyme-substrate complex formation models - Lock and Key and Induced fit models, Mechanisms of enzyme catalysis, Factors affecting enzyme activity - pH, Temperature, Substrate, Enzyme and Inhibitor concentration, Thermodynamics and stability.

Unit-2 : Production and Purification of Enzymes — 9

Sources of industrial enzymes - natural and recombinant, Strategies of isolation and purification of new enzymes, large scale industrial enzyme production - technologies for enzyme production, Recovery and purification methods for enzymes, Monitoring of purification of enzymes, Determination of molecular weight of enzymes, Drying and packing, Modification of enzymes - Engineering tools for enzymes

Unit-3: Enzyme Kinetics — 9

Basics of enzyme kinetics - Michaelis Menten Kinetics, Significance of Michaelis-Menten kinetics, Evaluation of Michaelis-Menten kinetic parameters -Line weaver Burk plot, Hanes Woolf plot and Eadie Hofstee plot, Turn over number, Catalytic efficiency, Enzyme Inhibitors, Types of enzyme inhibition - Competitive inhibition, Uncompetitive inhibition, Noncompetitive inhibition, Substrate inhibition, Feedback inhibition, Enzyme deactivation model, Allosteric activation and inhibition.

Unit-4 : Enzyme Immobilization — 9

Enzyme immobilization - Advantages and disadvantages, Methods of enzyme immobilization - Physical and chemical, Carrier-based immobilization, Carrier-free immobilization, Immobilization by using porous support - Mass transfer effects and diffusion limitation, Immobilization by using non-porous support - Mass transfer effects and diffusion limitations, Stabilization of immobilized enzymes in an aqueous environment, Stabilization of immobilized enzymes in the non-aqueous environment, Analyzing the effectiveness factor of immobilized enzymes, Advantages and Limitations of immobilized enzyme systems, Types of immobilized enzyme bioreactors.

Unit-5: Industrial Applications of Enzymes — 9

Applications of enzymes - Food processing, Starch and sucrose industries, Dairy industries, Brewing industries, Beverage industries, Leather industries, Textile industries, Detergent industries, Pulp and paper industries, Chemical and Polymer industries. Analytical and Diagnostic applications of enzymes, Role of enzymes - Pharmaceuticals, Medicine, Agriculture, Environment protection and Biofuels development.

Learning Resources	1. Trevor Palmer and Philip L Bonner. "Enzymes: Biochemistry, Biotechnology, Clinical Chemistry," East-West Press, 2004.	2. Young Je Yoo · Yan Feng Yong Hwan Kim · Camila Flor J. Yagonia. "Fundamentals of Enzyme Engineering" Springer, 2017. 3. Syed Tanveer Ahmed Inamdar. "Biochemical Engineering: Principles and Concepts "Third Edition, PHI Learning Pvt. Ltd., 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
Dr. G. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in	Dr. V.Vinothkumar, SRMIST
Dr. Karthik Periyasamy, Scientist, Biocon, karthik.periyasamy@biocon.com	Prof. R. B. Narayanan, Anna university, Chennai, arbeen09@gmail.com	Dr. P. Radha, SRMIST

Course Code	21BTE307T	Course Name	MEMBRANE SEPARATION TECHNOLOGY	Course Category		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 :	Acquire knowledge on membrane and its types cum application
CLR-2 :	Understand the casting and characterization of membrane
CLR-3 :	Analyse the functions of reverse osmosis, Micro and ultra-filtration membranes
CLR-4 :	Discuss the functions of dialysis and electro dialysis membrane
CLR-5 :	Discuss the membranes as reactor and distillation of alcohol

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	Environment &	Ethics	Individual & Team	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	Apply membranes for bioprocess industries	3	3	3	2	-	-	-	-	-	-	-	-	2	-	-
CO-2:	Demonstrate methods of casting membrane	2	3	3	2	-	-	-	-	-	-	-	-	2	2	2
CO-3:	Utilize the selection of membranes for Micro and Macro molecules separation	3	3	3	2	-	-	-	-	-	-	-	-	2	2	2
CO-4:	Apply membrane for dialysis	3	3	3	3	-	-	-	-	-	-	-	-	3	3	3
CO-5:	Demonstrate membrane for distillation and production	3	3	3	3	-	-	-	-	-	-	-	-	2	2	2

Unit-1 : Membranes overview and its Industrial Application — 9

Basic principles of Membrane, Separation, Membrane developments, Golden age of membranes, Classification of membrane processes-Pressure driven, Concentration gradient, and Electrical potential, Advantages and disadvantages of membranes, Application in Biotechnology Industries, Micro and macromolecular separation, Chemical and Pharmaceutical Industry, Recovery of salt, acid and bases, Food and dairy Industries, Dairy, Animal Products, Fruits and Vegetables, Electrochemical industries, Effluent treatment plants.

Unit-2 : Membrane casting, Characterization and Modules — 9

Membrane Types, Materials, Preparation and Characterization Types of Synthetic Membranes- Micro porous Membranes, Asymmetric, thin film, Electrically Charged Inorganic Membrane, Membrane Modules-Plate and frame, Tubular, Spiral wound and Hollow fiber, Typical Flow pattern, Membrane Material

Pore Characterization, General Methods of Membrane Manufacture-Phase Inversion Method, Track–etching, Sol-gel Peptization Method, Interfacial Polymerization, Melt pressing, Film Stretching, Film Stretching, Ion Exchange Membrane Preparation

Unit-3: Reverse Osmosis, Ultra and Microfiltration — 9

Reverse Osmosis, Nano filtration, Ultra filtration, and Microfiltration, Concept of osmosis, Determination of osmotic pressure and thermodynamics of osmosis, Phenomena of Reverse osmosis, Models of Reverse osmosis, Design and operating parameters, Design of Reverse Osmosis module Principles, Transport Mechanism, Mass transfer and Industrial Application of Nano filtration Process Limitation Basic principles of Ultra filtration Types of Ultra filtration

Factors affecting Ultra filtration and membrane flux of ultra-filtration,Principles of Microfiltration, Microfiltration Membranes, Mechanism of Transport,Flow characterization, Fouling and applications in Microfiltration, Energy Consideration and Application, Flow characterization, Fouling and applications in Microfiltration, Energy Consideration and Application

Unit-4 : Dialysis and pervaporation — 9

Dialysis, pervaporation and electro dialysis, Principles of Dialysis, Dialysis membranes, Mass transfer in dialysis, Design of Dialysis membranes

Applications and its advantages. Principles, Operation of Pervaporation, Application of Pervaporation, Design of pervaporation modules, Factors affecting pervaporation, Applications. Principles of Electro dialysis, Ion Exchange Membranes Energy Requirements Current utilization and Efficiency, Dialysis, Application, Batch electro- dialysis, Continuous electro- dialysis,

Unit-5: Membrane distillation, Membrane reactors and Chromatography, — 9

Membrane distillation, Membrane bioreactors and industrial membranes, Membrane contactors, Principles Advantages and Disadvantages, Applications.

Membrane Distillation Mechanism, Membrane recycles bioreactors, Plug flow bioreactors, Perstraction- Flux and separation in Perstraction Membrane Chromatography Design and application, Membranes in Wastewater Treatment Design and Application, Membrane in Desalination, Membrane in in Fuel cells ,Biomedical application of membranes, Blood Oxygenator and Drug Delivery.

Learning Resources	1. Kaushik Nath," Membrane Separation Processes", PHI, publication, India, 2012. 2. William.K..Wang," Membrane Separations in Biotechnology", Marcel Dekker. INC, New York, 2001 3. Scott .K, "Hand Book of Industrial Membranes "Elsevier Publication, 1995.	4. Mihir K Purkait; Randeep Sing,"Membrane Technology in separation science, CRC Press Taylor & Francis Group, 2018 5. Katarzyna Staszak, Karolina Wieszczycka and Bartosz Tylkowski," Membrane Technologies from Academia to Industries, De Gruyter, 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
Dr. S. Sam Gunasekar, Orchid Chemicals and Pharmaceuticals Ltd., sam@orchidpharma.com	1Dr.G.Pugazhenthi, IITG, pugal@iitg.ac.in	Dr.M.Venkatesh Prabhu, SRM IST
Dr. Karthik Periyasamy, Scientist, Biocon, karthik.periyasamy@biocon.com	Dr.S.Senthil Kumar, IITG, senthilkumar@iitg.ac.in	Dr.S.Prabhakar SRMIST

Course Code	21BTE308T	Course Name	INDUSTRIAL FERMENTATION ENGINEERING	Course Category		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 :	Analyze the fundamental behind the need of aseptic strain development
CLR-2 :	Explore the importance of Isolation and Screening of Industrially Important Microorganisms
CLR-3 :	Decipher an understanding on the production of various primary metabolites from microbial fermentation
CLR-4 :	Comprehend the importance and production of secondary metabolites with commercial significance
CLR-5 :	Apprehend the biochemical transformation in the production of recombinant protein with medical importance

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	Environment &	Ethics	Individual & Team	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	Accomplish knowledge on improvement of strain development for primary and secondary metabolites	2	2	2	-		-	-	-	-	-	-	-	3	-	3
CO-2:	Explain the upstream and Downstream fermentation process of organic acids and amino acids	2	2	2		-	-	-	-	-	-	-	-	3	-	2
CO-3:	Describe the industrial scale methodologies for Antibiotic and microbial enzyme production	2	2	2		-	-	-	-	-	-	-	-	3	-	2
CO-4:	Understand the enzyme biotransformation biostratergies and recombinant protein production with commercial and medical importance	2	2	2		-	-	-	-	-	-	-	-	3	-	2
CO-5:	Apprehend the food fermentation process and its preservants used for improving the shelf period	2	2	2	-		-	-	-	-	-	-	-	3	-	3

Unit-1 : Industrial Fermentation technology	9
Industrial fermentations, Types of fermentation process, Microbial growth metabolism, maintenance, and preservation of microbial starter cultures , Microbial metabolites, Strain development, Aseptic inoculation of plant fermenters, Measuring process variables, Product development, Hazard Analysis and Critical Control Point (HACCP) Program – Good manufacturing Practices(GMP's) and microbiological standards.	
Unit-2 : Production of primary metabolites	9
Strategies and methods for production of organic acids fermentation: Citric acid, Lactic acid, Acetic acid, gluconic acid, Amino acids fermentation: L-glutamic acid, L-lysine, L-tryptophan, L-valine, Solvents fermentation: Acetone, Butanol, Ethanol, Vitamins production: Cyanaocobalamin, Riboflavin.	
Unit-3: Production of secondary metabolites	9
Strategies and methods for production of industrial enzyme production - Protease, Lipase, Cellulase, Biopolymers fermentation: Xanthan gum, Polyhydroxyalkanoates, Agrochemicals production –Siderophores, Bacillus thuringenesis Cry protein, Artemisinin, Antibiotic production – Avermectin, Streptomycin, Erythromycin, Nystatin.	
Unit-4 : Production of biologicals	9
Design and properties of different types of protein drugs, eg. antibodies, antibody analogues, hormone, Use of different engineering methods to design new / optimized variants. Strategies and methods for production of biologicals, eg. Insulin, Interferon, monoclonal antibody, tumor necrosis factor inhibitor, human granulocyte colony-stimulating factor, Pneumococcal conjugate vaccine.	
Unit-5: Food and alcohol fermentations	9
Probiotics, Fermenting with lactic acid bacteria: pickles, sauerkraut, yogurt, and fresh cheese, Soy-based fermented products, Food preservative fermentation: Nisin, bacteriocins, Food colorants fermentation: Monascus pigments, Carotenoid, Astaxanthin Production, Production of single cell protein, Beverages - Brewing process with microbial communities: Wine, Cider, beer, sourdough, kefir and kombucha	

Learning Resources	1. Cruger W., Cruger A., Aneja K.R., "Biotechnology: A Textbook of Industrial Microbiology", Medtech Publishing, 3rd edition, 2017. 2.Lee Y.K., "Microbial Biotechnology: Principles and Applications", World Scientific Publishing, 3rd edition, 2013. .	3. Waites M. J., Morgan N.L., Rockey J.S., Higton G., "Industrial Microbiology: An Introduction", Blackwell Science, 2013. 4. Saran S., Babu V., Chuabey A., "High Value Fermentation Products: Human Health", Scrivener Publishing, 2019

		4. Stanbury. P.F., Whitaker. A., Hall. S.J., "Principles of Fermentation Technology", 3rd Edition, Butterworth– Heinemann, 2016

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
Dr. S. Sam Gunasekar, Orchid Chemicals and Pharmaceuticals Ltd., sam@orchidpharma.com	Prof. K Subramaniyam, IITM, Chennai, suubu@iitm.ac.in	Dr. Vinoth Kumar, SRMIST
Dr. Karthik Periyasamy, Scientist, Biocon, karthik.periyasamy@biocon.com	Dr. R. B Narayanan Anna University, Chennai,arbeen09@gmail.com	Dr. Amala Reddy, SRMIST

Course Code	21BTE410T	Course Name	BIOREACTOR DESIGN	Course Category		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 :	Teach conservation of mass and energy in the bioreactor system
CLR-2 :	Explain the mechanical aspects of reactor design
CLR-3 :	Demonstrate the scale up in bioreactor
CLR-4 :	Explain the biochemical aspects of reactor design
CLR-5 :	Teach Modeling, CFD and design of novel reactors

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	Environment &	Ethics	Individual & Team	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	Practice conservation of mass and energy in the bioreactor system	2	2	2	-	-	-	-	-	-	-	-	-	2	2	-
CO-2:	Explain the mechanical aspects of reactor design	2	2	2	-	-	-	-	-	-	-	-	-	2	2	2
CO-3:	Discuss the scale up in bioreactor	2	2	2	-	-	-	-	-	-	-	-	-	2	2	2
CO-4:	Practice the biochemical aspects of reactor design	2	3	3	2	-	-	-	-	-	-	-	-	2	2	2
CO-5:	Demonstrate Modeling, CFD and design of novel reactors	2	3	3	2	-	-	-	-	-	-	-	-	2	2	2

Unit-1 : Mass and Energy Balance in Bioreactor	9
lements in Bioreactor Design, Rate Expression in Biological Systems, Basic Concept of Energy Transfer, Basic Concept of Mass Balance, Classification of Bioreactors, Bioreactors for Animal Cell Cultivation, Bioreactors for Plant Cell Culture, Bioreactors for Immobilized System	
Unit-2 : Mechanical Aspects of Bioreactor design	9
Requirements for Construction of a Bioreactor, Guidelines for Bioreactor Design, Bioreactor Vessels, Agitator Assembly	
Unit-3: Scaleup of Bioreactors and Operation	9
Criteria of Scale-Up, Similarity Criteria, Scale-Up Methods, Generalized Approaches to Scale-Up in Combination of Methods, Common Operations of Bioreactor, Selection, Identification of Other Common Factors Necessary for Smooth Operation of Bioreactors, Spectrum of Basic Bioreactor Operations, Reactor Operation for Immobilized Systems, Operation of Animal Cell Bioreactors, Operation of Bioreactors for Plant Cell Culture, Reactors for Waste Management	
Unit-4 : Biochemical aspects of Reactor Design	9
Batch Bioreactors, Continuous Flow Bioreactors, Plug Flow Tubular Reactor (PFTR), Recycle Bioreactors, Combination of Bioreactors, Semi-Continuous Bioreactors, Input to Kinetic Modeling of Enzyme Reactors	
Unit-5: Reactor Modeling	9
Modeling Principles, Fundamental Laws Used in Process Modeling, First-Order Systems, Second-Order Systems, Complexity of the Model, Case Studies-Design of Packed Bed Bioreactor, Airlift Bioreactors, Hollow Fiber Bioreactor (HFBR), Plant Cell Bioreactor, Design of Bioreactors for Solid State Fermentation (SSF), Mammalian Cell Bioreactor Design, CFD in Bioreactor Design-Modeling approaches, Dimensionality of simulation, Difference between Lagrangian and Eulerian approaches, Fluid Dynamic Modeling, Simulation	

Learning Resources	1. B.Atkinson.,"Biochemical Reactors",Pion limited,London,1974 2. Panda. T., "Bioreactors: Analysis and Design", McGraw Hill Education (India) Private Limited, 2011 .	3. Riet. K. V., Tramper. J., "Basic Bioreactor Design", 2nd ed., Marcel Dekker, Inc., New York, 1991 4. Shijie Liu,"Bioprocess Engineering Kinetics, Sustainability, and Reactor Design"Elsevier ,2020. 5. Enes Kadic, Theodore J. Heindel,"An Introduction to Bioreactor Hydrodynamics and gas -liquid mass transfer, John Wiley & Sons, 2014

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
Dr. S. Sam Gunasekar, Orchid Chemicals and Pharmaceuticals Ltd., sam@orchidpharma.com	Dr.S.Senthil Kumar, IITG, senthilkumar@iitg.ac.in	Dr.M.Venkatesh Prabhu,SRMIST
Dr. Karthik Periyasamy, Scientist, Biocon, karthik.periyasamy@biocon.com	Dr.N.Selvaraj, IITG, selva@iitg.ac.in	Dr.P.Radha,SRMIST

Course Code	21BTE411T	Course Name	BIOPROCESS MODELLING AND SIMULATION	Course Category		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 the importance of models, models for Mass and Energy Balance
CLR-2 :	Explain models of upstream and downstream process
CLR-3 :	Demonstrate the development of Process flow sheet using software
CLR-4 :	Explain MATLAB fundamentals, and application of Numerical Integration in MATLAB
CLR-5 :	Describe modelling and simulation in bioreactors using MATLAB and SIMULINK

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	Environment &	Ethics	Individual & Team	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	Discuss the importance of models, models for Mass and Energy Balance	2	2	2	-	-	-	-	-	-	-	-	-	3	2	-
CO-2:	Demonstrate models for upstream and downstream process	2	2	2	-	-	-	-	-	-	-	-	-	3	2	-
CO-3:	Develop process flowsheet using software	2	2	3	-	-	-	-	-	-	-	-	-	3	2	2
CO-4:	Explain MATLAB fundamentals	2	2	3	-	-	-	-	-	-	-	-	-	3	2	2
CO-5:	Develop programme for reactors using MATLAB	2	-	3	-	-	-	-	-	-	-	-	-	3	2	2

Unit-1 : Modelling Fundamentals and Models of Mass and Energy Balance	9
Models - Introduction, Basic modeling principles, Introduction of mathematical modeling, Uses of mathematical modeling, Classification of modeling techniques, Grouping of models into opposite pairs, Classification based on Mathematical complexity, Classification of models according to scale Fundamental laws – Expression, Energy equations - expression , Continuity equations, Transport equations -expression , Equations of motion, Chemical kinetics	
Unit-2 : Models of Upstream and Downstream process	9
Basic Mathematical Models, Setting up a model, Continuous flow tanks - enclosed vessel, Continuous flow tanks - mixing vessel, Steam jacketed vessel Steam jacketed vessel - open and closed, Batch distillation – basics, Batch distillation model, Bioprocess modeling, Modelling approaches for biomanufacturing, Operations, Types of bioprocess model, Mathematical models of microbial process, Applying mechanistic models in bioprocess development, Model formulation for aerobic cultivation of budding yeast, Parameter identifiable analysis ,Uncertainty analysis, Metabolic flux modelling (MFM),MFM as a tool to analyze the behavior of genetically modified yeast strain	
Unit-3: Process flow sheeting and Process Economics using intelligence software	9
Introduction to Superpro, Developing a Process Model, Process design, Process Modeling and Simulation, Process flow diagrams, Process flow diagram to produce human insulin, The -Galactosidase Process, The Industrial Wastewater Treatment Process, Procedures and Operations, Resources, Scheduling, Process Properties and Simulation, Economics, Material-Balance Calculations, Material-Balance , Energy-Balance Calculations, Energy-Balance	
Unit-4 : MATLAB and Numerical Integration	9
MATLAB - Introduction, MATLAB - basics, MATLAB - Data analysis, Curve fitting - Introduction, Curve fitting using MATLAB - Theory, Curve fitting using MATLAB – examples, Numerical Integration, Numerical Integration Techniques, Trapezoidal Rule, Trapezoidal Rule ,Simpson's Rule, Euler's Method, Runge-Kutta 4th Order Method, Programming with MATLAB, Program design and development	
Unit-5: MATLAB and SIMULINK in Bioreactors	9
Modeling of Batch Culture Using MATLAB – basics, Batch Culture – programme, Modeling of Fed-batch Culture Using MATLAB – basics, Fed-batch Culture – programme, ,Modeling of Continuous Culture Using MATLAB – basics, Continuous Culture – programme, ,Process Simulation, Simulink - Introduction, Simulink - basics, Simulation of gravity flow tank, Simulation of three isothermal CSTR, Simulation by Simulink in Batch Culture, Simulation by Simulink in fed-batch Culture, Simulation by Simulink in continuous Culture	

Learning Resources	1. Mandenius C., Titchener-Hooker N. J., “Measurement, Monitoring, Modelling and Control of Bioprocesses”, Springer Publishers, 2013. 2. Burstein L., “Matlab® in Bioscience and Biotechnology, Woodhead Publishing, 2011. 3. Luben. W.L., “Process Modelling Simulation and Control for Chemical Engineers”, McGrawHill, 1990. 4. Franks. R.G.E., “Mathematical Modeling in Chemical Engineering”, John Wiley and Sons, Inc., 2004.	5. Biquette. W.B., “Process Dynamics- Modeling analysis with simulation”, Prentice Hall; 1 edition, 1998. 6. Beers. K.J., “Numerical Methods for Chemical Engineering Applications in MATLAB®”,Massachusetts Institute of Technology, Cambridge University press. 2007. www.intelligen.com/ SuperPro Designer user guide. 7. Ashok Kumar Verma," Process Modelling and Simulation in Chemical, Biochemical and Environmental Engineering"CRC Press, 2015. 8. Joseph DiStefano," Dynamic Systems Biology Modeling and Simuation",Academic Press, 2013

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
Dr. S. Sam Gunasekar, Orchid Chemicals and Pharmaceuticals Ltd., sam@orchidpharma.com	Dr.S.Senthil Kumar, IITG, senthilkumar@iitg.ac.in	Dr.M.Venkatesh Prabhu,SRMIST
Dr. Karthik Periyasamy, Scientist, Biocon, karthik.periyasamy@biocon.com	Dr.N.Selvaraj, IITG, selva@iitg.ac.in	Dr.P.Radha,SRMIST

Course Code	21BTE412T	Course Name	BIOPROCESS PLANT DESIGN	Course Category		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 the Process Flow Sheeting
CLR-2 :	Explain the Material of Selection for Process design
CLR-3 :	Teach Economic Analysis of Process Industries
CLR-4 :	Describe Optimization of Process Variables
CLR-5 :	Explain the Design of Process equipment

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	Environment &	Ethics	Individual & Team	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	Execute the Process Flow Sheeting	2	3	2	2	-	-	-	-	-	-	-	-	2	-	2
CO-2:	Discuss the Material of Selection for Process Design	2	3	2	2	-	-	-	-	-	-	-	-	2	-	2
CO-3:	Evaluate the Cost involved in the Process Industries	2	3	3	2	-	-	-	-	-	-	-	-	2	2	-
CO-4:	Optimize the process variables	2	3	3	2	2	-	-	-	-	-	-	-	2	2	-
CO-5:	Execute the Design of Reactors	2	3	3	2	2	-	-	-	-	-	-	-	2	2	-

Unit-1 : Process Flowsheet development	9
Organization of a Bioprocess Engineering Project, Project Documentation, Codes and Standards, Design Factors, Product Design Flowsheet Presentation, Anatomy of a Manufacturing Process, Selection, Modification, and Improvement of Commercially-Proven Processes, Selection, Modification, and Improvement of Commercially-Proven Processes.	
Unit-2 : Materials of Construction	9
Material Properties, Mechanical Properties, Corrosion Resistance, Selection for Corrosion Resistance, Material Costs, Commonly Used Materials of Construction, Mechanical Design of Piping Systems, Pipe Size Selection	
Unit-3: Process Economics	9
Capital Cost Estimating, Estimating Revenues and Production Costs, Economic Evaluation of Projects	
Unit-4 : Optimization	9
Optimization in Design-The Design Objective, Optimization of a Single Decision Variable, Optimization of Two or More Decision Variables,	
Unit-5: Equipment design	9
Equipment Selection, Specification, and Design, The Design of Thin-Walled Vessels Under Internal Pressure, Reactor Design: General Procedure, Design of Bioreactors, Computer Simulation of Reactors	

Learning Resources		
	1. Towler G., Sinnott R., "Chemical Engineering Design - Principles, Practice and Economics of Plant and Process Design, Elsevier, 2007. 2. Subhabrata Ray; Gargi Das," Process Equipment and Plant Design",Elsevier, 2020. 3. Siddhartha Mukherjee," Process Engineering and Plant Design",CRC Press,2022.	4. Jacobs T., Signore A. A., "Good Design Practices for GMP Pharmaceutical Facilities", 2nd edition, Taylor, and Francis, 2017. 5. Peters M. S., Timmer Haus. K. D., "Plant Design and Economics for Chemical Engineers", 5th Edition, McGraw-Hill Book Co., 2003

Learning Assessment				
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*		*Summative Final Examination*
		Formative	*Life Long Learning*	

		CLA-1 Average of unit test (50%)		*CLA-2 – (10%)*		*(40% weightage)*	
		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
Dr. S. Sam Gunasekar, Orchid Chemicals and Pharmaceuticals Ltd., sam@orchidpharma.com	Dr.S.Senthil Kumar, IITG, senthilkumar@iitg.ac.in	Dr.M.Venkatesh Prabhu,SRMIST
Dr. Karthik Periyasamy, Scientist, Biocon, karthik.periyasamy@biocon.com	Dr.N.Selvaraj, IITG, selva@iitg.ac.in	Dr.P.Radha,SRMIST

Course Code	21BTE205T	Course Name	ENVIRONMENTAL BIOTECHNOLOGY	Course Category		Department Elective	L	T	P	C

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 :	Create awareness on environmental pollution and the need for advanced technologies for their mitigation
CLR-2 :	Provide the in-depth insights on recent advancements in biological approach for the conversion of various environmental pollutants
CLR-3 :	Understand the microbial degradation pathways and interventions of genetic engineering in emerging contaminates removal
CLR-4 :	Understand various biotechnological contributions to the industries to reduce the environmental pollution
CLR-5 :	Educate the relevant information about recovery of bio- and by-products from industrial wastes and Environmental policies

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 & [illegible]	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	Discuss the global impact of environmental pollutants and the current scenario of treatment	-	3	-	-	-	-	2	-	-	-	-	-	2	-	3
CO-2:	Demonstrate biotechnological solutions for the treatment of industrial wastes	2	-	3	2	-	-	3	-	-	-	-	-	-	2	3
CO-3:	Explain the bioconversion pathways for the degradation of various xenobiotic compounds	2	2	-	2	-	-	3	-	-	-	-	-	2	-	3
CO-4:	Evaluate the biotechnological interventions on emerging contaminates removal and application of computing technologies for environmental management	2	2	2	-	-	-	2	-	-	-	-	-	2	-	3
CO-5:	Choose from an array of options to turn waste into economic goods and learn environmental policies	-	2	2	-	-	-	3	-	-	-	-	-	2	-	3

Unit-1 : Current scenario of Environmental pollution and Physicochemical Technologies 9

Environmental pollution Current Scenario-water, air, soil; Perspectives of liquid and solid wastes; Design of wastewater treatment systems- Primary, secondary and tertiary treatments; Physicochemical technologies for the liquid waste management; Coagulation, Flocculation, Sedimentation, Filtration -mechanism-Membrane Technologies: Ultra filtration, Reverse Osmosis ; Adsorption processes-Activated Carbon, Ion Exchange; Advanced oxidation processes; Electrolysis; Desalination for wastewater-Membrane distillation, Forward Osmosis, Pressure Retarded Osmosis; Solid waste management-Effects- Secured Landfill, Bacterial and Vermi composting, incineration/pyrolysis; 4R Principle; Air pollution Management-CO2 sequestration, Odour Control;

Unit-2 : Recent Advances in Biological Treatment of Wastewater **9**

Recent trends in Biological wastewater treatment; Conversion processes of the carbonaceous and nitrogenous matters; Effluent standards; Aerobic Suspended-Growth Treatment: Biological Kinetics; ctivated sludge process and its process modifications, Process design considerations, Cyclic Activated Sludge process; Membrane Bioreactor; Sequencing batch reactor; Fluidized bed reactor. Modeling of Suspended Growth Treatment Processes-CSTR; Activated Sludge Principles; Key Process Control Parameters: Mean Cell Resident Time, Food-to-Microorganism (F/M) ratio, Anaerobic digestion process-Stages; Microbiology of anaerobic digester; Factors influencing anaerobic digestion; Anaerobic Biological treatment technologies: Completely mixed anaerobic digestion process; Upflow Anaerobic sludge blanket (UASB) reactor; Two phase AD process, Anaerobic filter; Tertiary treatment: Nutrients removal-N and P removal; Attached-Growth system: Trickling filters;Rotating biological contractors; Packed bed reactors; Integrated fixed film activated sludge process:

Unit-3: Emerging Environmental Pollutants and biodegradation pathways *9*

Xenobiotics and Recalcitrants; Environmental effects of Xenobiotics and recalcitrants; Biodegradation of xenobiotics; Mechanisms of Biodegradation of xenobiotics-Reductive/Oxidative/Hydrolytic; Biotransformation of Aliphatic, Aromatic, polyaromatic and polycyclic aromatic Hydrocarbons; Biotransformation of halogenated hydrocarbons; Case studies-Oil pollution and its effect on the environment; Microbial treatment of oil pollution; Microbial treatment of polychlorinated compounds; Radioactive waste and e-waste management-Recent biotechnological advances; Genetic Engineering in environmental pollution management

Unit-4 : Computing technologie application in Environmental management *9*

Biotechnological interventions in Industrial processing and effluent treatment; Environmental Biocatalysts and Biosurfactants in environmental and industrial applications and emerging contaminants removal; Advantages of immobilized cells and enzymes over free cells and enzymes; Microbial heavy metal removal-mechanisms; Role of biosurfactants, Extracellular polysaccharides, Metallothioniens and siderophores in heavy

metal removal; Challenges in lipid rich industrial effluents treatment-Application of immobilized lipase and biosurfactant; Biotechnology in Textile industry and dye removal; Bioelectrochemical technologies for wastewater treatment; Application of IOTs and AI in Environmental pollution monitoring and automization of ETPs and CETPs
Unit-5: Industrial wastes as resources for value-additions and Environmental policies *9*
Value additions from industrial wastes-Circular economy concepts-Leather industry wastes; Slaughterhouse industry; Plastics and microplastics; Bioplastics from industrial resources; Biomining-Microbial metal leaching-methods; Environmental laws and regulations; Environmental Impact Assessment; Role of State and Central Pollution Control Boards and Environmental protection Agency in pollution control; Indian Government schemes for the environmental cleanup- Swachh Bharat Abhiyan

Learning Resources	1. Bruce E.Rittmann and Perry L.McCarty, Environmental Biotechnology: Principles and Applications, McGraw Hill.2001. 2. Macros Von Sperling, Basic principles of wastewater treatment. IWA Publishing, 2007 3. Sergio et al. Sea water reverse osmosis desalination, IWA publishing, 2021 4.Bimal C Bhattacharyya, Environmental Biotechnology, Oxford University press, 2007. 5.Milton Wainwright, An Introduction to Environmental Biotechnology, Springer,1999. 6.P.Rajendran, P.Gunasekaran, Microbial Bioremediation, MJP Publishers, India,2006.	7. Ram Chandra, Advances in biodegradation and bioremediation of industrial wastes, CRC Press, Taylor&Francis, 2015. 8. Hanes Joachim Joardening, Environmental Biotechnology, Concepts and Applications,2017. 9. Navaneitha Krishnaraj and Sani, Biovalorization of wastes to renewable chemicals and biofuels, Elsevier, 2020 10. Rathinam and Sani, Next generation biomanufacturing Technologies, ACS Symposium series, ACS Publications, 2019 Online NPTEL Course: Environmental Biotechnology https://onlinecourses.nptel.ac.in/noc21_bt41/preview

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
Dr. S. Sam Gunasekar, Orchid Chemicals and Pharmaceuticals Ltd., sam@orchidpharma.com	Dr.G.Sekaran. CSIR-, Chennai, ganesansekaran@gmail.com	Dr. K.Ramani,SRMIST
Mr. D.K.Rana, Heubach Colour Pvt.Ltd.Gujarat, ankplant@heubach-india.com	Dr. Kurian Joseph., Anna University, Chennai, cccdm.au@gmail.com	Dr. W.Richard Thilagaraj, SRMIST

Course Code	21BTE309T	Course Name	INDUSTRIAL WASTE MANAGEMENT	Course Category		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 :	Identify the relevant information about industrial solid waste reduction and hazardous waste management
CLR-2 :	Demonstrate the state of the art in technology, organizational and legislative developments and practices
CLR-3 :	Adapt the concepts of environmental regulation and inculcate in newly developed treatment technologies
CLR-4 :	Create insights to the waste characterization aspects
CLR-5 :	Identify the applications of best possible conversion technology for industrial sustainability]

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	Environment &	Ethics	Individual & Team	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	Formulate an insight into the pollution from major industries including the sources and characteristics of pollutants and their impact on climate change	-	3	-	2	-	-	2	-	-	-	-	-	3	-	2
CO-2:	Apply the biotechnological solutions for the industrial waste management and resource generation	3	-	3	2	-	-	-	-	-	-	-	-	-	-	2
CO-3:	Analyze the impact of industrial wastes on the environmental compartments (land, water and air) and elucidate the mode of monitoring through recent technological innovations	3	2	2	-	2	-	-	-	-	-	-	-		2	3
CO-4:	Evaluate the waste and wastewater for its toxicity and design of the treatment plants to attain standard limits prescribed by pollution control board	-	-	3	2	2	-	2	-	-	-	-	-	2	-	2
CO-5:	Explain the stringent environmental regulations and legal aspects in generation, management, and processing of Industrial wastes	-	-	-	2	-	2	2	2	-	-	-	-	2	3	-

Unit-1 : Paradigm shifts in industrial development and its consequences	9
Evolution of Industries 20th Century to 21st Century for Economic Development - Raw materials from natural resources and synthetic precursors employed in industries - Process flow of industries that use hazardous chemicals and reagents - Xenobiotics and recalcitrants - Environmental impacts - Threat to biodiversity - Climate Change - Mitigation strategies for efficient waste management	
Unit-2 : Waste Circular Bioeconomy	9
Industrial Wastes as Resource Generation for Fuel, Chemicals and Value Products - Emphasis on major role of Manufacturing and Process Sectors-Paper and Pulp, Tannery, Poultry industry, Food and Agro-based industries - Hierarchy of Potential Implementation of waste management Strategies - 4R Principles - Landfill and leachate management strategies-Biorefinery concepts-for value additions from wastes-Desalination-Membrane processes (Reverse osmosis, Electrodialysis), Distillation processes (Single/multi stage flash distillation, vapour compression distillation), Low temperature thermal desalination process	
Unit-3: Waste Management 4.0	9
An adoption of Industry 4.0 concepts (AI, BigData and Blockchain on sustainable waste management and audits - Role of Environmental (Bio-)sensors in monitoring and assessment - Characteristics of industrial wastewater-COD, BOD and TOC - Solids analysis – TDS, TSS and VSS - Characteristics of industrial wastewater-, TKN, Ammonia, Chloride, Sulfide and Sulfate - Remote monitoring and Human-less/Robotic treatment plant operation	
Unit-4 : Management for Hazardous and Health Risk (Pandemic like) related Industrial Wastes and Wastewater	9
Hazardous waste management; Biomedical waste- Physio chemical treatment - Solidification and incineration – Zero discharge - Secure landfills - Removal of refractory organics-strategies -AOP processes- Primary, Secondary and Tertiary Treatment-Aerobic and Anaerobic Technologies-Role of microorganisms and enzymes - Application of nanotechnology for waste degradation - Bioelectricity production through Microbial fuel cells with hazardous leachate and wastewater	
Unit-5: Regulatory Affairs for Industrial Waste Management in Compliance to Global Scenario	9
Global and Indian Scenario Environmental Management System (EIA), Environmental Impact Assessment (EIA), ISO 14000 Environmental Auditing; Sustainable Development Goals (SDGs) for industrial sustainability, Life Cycle Assessment (LCA), International Organization for Standards (ISO), Green Tribunal Act (GTA) and Occupational Safety and Health Association (OSHA)]	

Learning Resources	1. Guide for Industrial Waste Management by Environment Protection Agency (EPA), 2022 2. Waste Management Practices Municipal, Hazardous, and Industrial, Second Edition By John Pichtel, CRC Press 3. Macros Von Sperling, Basic principles of wastewater treatment. IWA Publishing, 2007	4. Sergio et al. Sea water reverse osmosis desalination, IWA publishing, 2021 5. Sawyer et al. Chemistry for Environmental Engineering and Science, 5th Edition, McGraw-Hill Education Online Resources: https://www.udemy.com/course/waste-management-in-industry-4/]

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
Dr. S. Sam Gunasekar, Orchid Chemicals and Pharmaceuticals Ltd., sam@orchidpharma.com	Dr.G.Sekaran, CSIR, Chennai ganesanskaran@ygmail.com	Dr.K.Ramani, Associate Professor, SRMIST
Mrs. Aarathi Nandhakumar, Sustainability and Environment Management, JSW Steels, Vijayanagar, Karnataka.	Dr. Surajbhan Sevda, NIT Warangal, sevdasuraj@nitw.ac.in	Dr.B.Samuel Jacob, Assistant Professor, SRMIST

Course Code	21BTE310T	Course Name	BIOENERGY	Course Category		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 :	Classify the potent biomass resources based generations (1G-4G) for energy production]
CLR-2 :	Ascertain the applications of energy conversion technology]
CLR-3 :	Demonstrate the significance of environmental benefits of bioenergy]
CLR-4 :	Create insights to the concepts of sustainable and green technologies]
CLR-5 :	Analyze the important wastes to energy conversion]

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	Environment &	Ethics	Individual & Team	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	Formulate the appropriate biofuel production based on available feedstocks]	-	3	-	2	-	-	2	-	-	-	-	-	3	-	2
CO-2:	Apply the biotechnological solutions for waste to fuel conversion]	3	-	3	2	-	-	-	-	-	-	-	-	-	-	2
CO-3:	Employ synthetic routes for ease and fast biofuel production]	3	2	2	-	2	-	-	-	-	-	-	-		2	3
CO-4:	Evaluate the substituent possibility of biofuel for conventional use]	-	-	3	2	2	-	2	-	-	-	-	-	2	-	2
CO-5:	Create novel biofuel formulation to adapt to the National policy towards energy security]	-	-	-	2	-	2	2	-	-	-	-	-	2	3	-

Unit-1 : Energy in Past, Present and Future	9
Non-renewable Resources (Fossil fuel) - Oil-The Black Gold for Global Economic driver and factor of slow down-Alternate and renewable resources (Solar, wind and biomass based)- Consequences of Burning Fossil Fuel- Mitigation of Global Warming- Political Drivers for Biofuel Development- Potential Benefits of Replacing Fossil Fuels with Biofuel, Biomass and Biogas- Circular & Biobased Economy-Is E-vehicles a boon or bane?	
Unit-2 : [Renewable Carbon from Bioresources: An outlook on different generations generations	9
Transition of 'Bioenergy' from a mere term 'biomass' to microbial driven energy production-Basics of biomass conversion tecgnology (Resources and Technology perspective)-Factors to be considered as an energy crop- Food Vs Fuel vs. feed- Rationale of biomass power sustainable environment- First, Second, Third and Fourth Generation Biofuel feedstock	
Unit-3: Integrating Bioenergy with Industrial process with Circular Bioeconomy	9
Agro waste resources – Crop residues and by-products - Waste resources – Industrial (solid and liquid) and MSW - Cradle to grave approach of waste raw materials for bioenergy development- Cradle to grave approach of waste raw materials for bioenergy development- Carbon dioxide sequestration Approaches	
Unit-4 : Liquid and Gaseous Biofuels	9
Liquid - Bioethanol Enzymology for conversion of biomass to biofuels – Ligninolytic enzymes (MnP, LiP and laccase)- Hexose and Pentose sugar conversion to ethanol- Bioethanol plant design and its components- Bio refinery demonstration projects of Bioethanol-Biodiesel - Biodiesel from vegetable oils/ non-edible oils - Transesterification process-Oleaginous microorganisms-Algal Biofuel - Algal based technologies for biofuel and value added chemical preparation - Biobutanol - ABE Fermentation for Butanol production - Pyrolysis bio-oil/bio-char -Bio-alkanes and alkenes from waste biomass - Gaseous Biofuel - Bio-synthetic natural gas (SNG)- Biomethanation process- Microbiology of anaerobic digestion- Dimethyl ether (DME)-Biohydrogen- Biological Processes for Hydrogen Production- Dark fermentation and algal based technologies	
Unit-5: New and Alternative energy research Projects	9
Metabolic pathway engineering for fuel biosynthesis- NextGen development for biofuel in India through National Biofuel Policy- Rural participation in Renewable Energy Development- Integrated industrial waste-based energy recovery- Economic, Social and Ecological Impacts of Bioenergy	

Learning Resources	Anju Dahiya, Bioenergy: Biomass to Biofuels and Waste to Energy, Second Edition, Elsevier, 2020] [Abul Azad, Mohammad Khan, Bioenergy Resources and Technologies, 1st Edition, Elsevier, 2021]	Online resource: https://onlinecourses.nptel.ac.in/noc19_bt16/preview]

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
Mr.Kirti Singh, Camlin Fine Sciences Ltd., New Delhi	Dr. Rintu Banerjee, IIT Kharagpur, rb@agfe.iitkgp.ernet.in	Dr.B.Samuel Jacob, SRMIST
Dr. S. Sam Gunasekar, Orchid Chemicals and Pharmaceuticals Ltd., sam@orchidpharma.com	Dr. Vinod Kumar, Cranfield University, UK, vinod.kumar@cranfield.ac.uk	Dr.K.Ramani, SRMIST

Course Code	21BTE413T	Course Name	METABOLIC ENGINEERING OF MICROORGANISM FOR ENVIRONMENT AND ENERGY	Course Category		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 :	Understand the importance of advanced microbial technologies for the environmental and energy applications
CLR-2 :	Educate the metabolic Engineering of microorganisms and synthetic biology for environment and energy applications
CLR-3 :	Understand the metabolic Engineering of microorganisms for the improved yield of biocatalysts and effectiveness of biodegradation of emerging contaminants
CLR-4 :	Understand the application of Metabolic engineering for advanced biofuels synthesis
CLR-5 :	Educate the future prospects of metabolic engineering in environment and energy

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 &	8 Ethics	9 Individual & Team	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	Discuss various advanced microbial technologies for the environmental and energy applications	-	3	-	-	-	-	2	-	-	-	-	-	2	-	3
CO-2:	Acquire knowledge on metabolic Engineering of microorganisms and synthetic biology for environment and energy applications	2	-	3	2	-	-	3	-	-	-	-	-	-	2	3
CO-3:	Apply metabolic Engineering to redesign the pathway to improve the yield of biocatalysts and effectiveness of biodegradation of emerging contaminants	2	2	-	2	-	-	3	-	-	-	-	-	2	-	3
CO-4:	Gain knowledge on application of Metabolic engineering for advanced biofuels synthesis	2	2	2	-	-	-	2	-	-	-	-	-	2	-	3
CO-5:	Choose from an array of options to design the microbial pathway to degrade pollutants and produce biofuels	-	2	2	-	-	-	3	-	-	-	-	-	2	-	3

Unit-1 : Metabolic Engineering approach in-methods and types	9
Introduction to Metabolic Engineering, Basic concepts; Scopes and Applications; Metabolism overview _1 (Cellular Transport processes, Fueling Reactions); Regulation of Metabolic Pathways; Emerging technologies for engineering of metabolic pathways-Strategies and tools; Systems and Synthetic Biology-an overview; Metagenomic approach-Techniques for Culturable and Uncultivable microorganisms	
Unit-2 : Metabolic Engineering in Environmental and Energy applications	9
Reconstruction of Genome-scale metabolic network; Pathway manipulations by metabolic engineering for environmental applications : Improvements of Biodegradation, Ethanol production; Advanced molecular biological techniques in metabolic engineering of microbes, Analytical tools;	
Unit-3: Pathway Design for effective biodegradation of emerging environmental contaminats	9
Pathway Design- Pathway Design Workflow - Engineering of biodegradation pathways; Engineering of the synthetic metabolic pathway for biodegradation of 1,2,3 trichloropropane and Halogenated hydrocarbons; Biocatalysts engineering for polyethylene terephthalate plastic waste green recycling; Metabolic Engineering for radioactive and e-waste;	
Unit-4 : Metabolic engineering for advanced biofuels synthesis	9
Metabolic engineering for enhancing microbial biosynthesis of advanced biofuels; Genetic and metabolic engineering approaches for improving accessibilities of lignocellulsic biomass-Bioethanol, Biobutanol production; Metabolic engineering in increase of Bioydrogen, Biomethane and Biohythane production and improving of anaerobic digestion process; Metabolic engineering of algae for biodiesel synthesis; Whole crop biorefinery for biofuel and by-products production	
Unit-5: Case studies and Future prospects on metabolic Engineering	9
Futuristic avenues of metabolic engineering techniques in bioremediation; Case studies-application of systems and synthetic biology and metabolic engineering in environmental management and bioenergy production	

Learning Resources	1. G N Stephanopoulos, A A Aristidou, J Nielsen, Metabolic Engineering, Principles and Methodologies, 2001, Springer. 2. Metabolic Pathway design, A Practical Guide; P Carbonell	3. Arindam Kuila and Vinay Sarma, Genetic and metabolic Engineering for improved biofuel production from lignocellulosic biomass, 2020, Elsevier publication. 4. Vineet kumar et al., Metagenomics to bioremediation, 2023, Elsevier publication Online soyurces: NPTEL - Metabolic Engineering https://onlinecourses.nptel.ac.in/noc21_bt18/preview

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
Dr.Nagarajan, Srinivas Waste Management Services Pvt. Ltd., Chennai.	Dr.Susmita Dutta, NIT Warangal	Dr. K.Ramani SRM IST
Dr. S. Sam Gunasekar, Orchid Chemicals and Pharmaceuticals Ltd., sam@orchidpharma.com	Dr.T.Rajesh, NEERI, Chennai	Dr.B.Samuel Jacob, , SRMIST

Course Code	21BTE414T	Course Name	MICROBIAL DEGRADATION AND BIOREMEDIATION TECHNOLOGY	Course Category		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 :	Create the awareness on the microbial applications in the environmental pollution abatement]
CLR-2 :	Give an overview of indigenous microbes on environmental bioremediation]
CLR-3 :	Apply the metagenomic approach for the environmental microbial analysis]
CLR-4 :	Apply the biomolecules for the environmental applications and biomining processes]
CLR-5 :	Demonstrate the application of microbes in industrial emerging pollutants, radioactive wastes, and e-wastes]

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	Environment &	Ethics	Individual & Team	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	Explain the microbial interventions in bioremediation and the importance of bioremediation]	-	3	2	2	-	-	2	-	-	-	-	-	3	-	2
CO-2:	Demonstrate various types of bioremediation techniques and its field implementation strategies	3	-	3	2	-	-	-	-	-	-	-	-	-	-	2
CO-3:	Apply various bioremediation design in industrial effluents and contaminated sites treatment]	3	2	2	-	2	-	-	-	-	-	-	-		2	3
CO-4:	Analyze the metagenomics data to describe the taxonomic make-up and ecological processes of microbial communities from a range of environments.]	2	-	3	2	2	-	2	-	-	-	-	-	2	-	2
CO-5:	Evaluate various biomolecules based bioremediation technologies for the bioremediation of polluted environment]	-	-	3	2	-	2	2	-	-	-	-	-	2	3	-

Unit-1 : Anthropogenic interventions in Biogeochemical cycles	9
Pollutants from industries and accidents - Emerging Pollutants - Dyes and Detergents - PAH and Aliphatic hydrocarbons - Ocean oil spills and its consequences - Heavy metals leach in ground water - Antibiotics in wastewater -Volatile organic compounds (VOCs) - E wastes - Microplastics - Radioactive compounds - Classification based on toxicity - Toxicity assessment - Biodiversity impact analysis - Biomagnification - Bioaugumentation - Eutrophication - Acid rain	
Unit-2 : [Microbial metabolism of xenobiotics]	9
Bioremediation of contaminated environments: 'The Green Option'- Mineralisation and other biotransformation mechanisms - Aerobic and Anaerobic routes - Toxicity tests - Mixed cultures - Enzymes for toxic pollutant remediation - Environmental Factors Affecting Microbial Metabolism of Xenobiotics - Mycoremediation - Bioleaching - Biomining - Metagenomic approach for consolidated bioremediation of pollutants - Screening of candidate microbes through molecular approaches - Cell free bioremediation	
Unit-3: Phytoremediation and Bio-conjugated material science for remediation	9
Candidate plants for phytoremediation -Mechanism of phytoremediation - Phyto volatilization - phytodegradation - phytoaccumulation - hyper accumulation - Terrestrial and Aquatic plants for remediation - Constructed Wetlands - Hydroponic system based waster treatment for removal of organic solids - Nano material for metal recovery and treatment- Nano-sponges - Microbial enhanced oil recovery (MEOR) - Surfactant based pollutant remediation -	
Unit-4 : Enhanced Sustainable Remediation Technology for emerging pollutants	9
Biochar-Based Soil and Water Remediation- Biochar for Bioremediation of Toxic Metals - Biochar for Wastewater Treatment - Biosensors - Nanotechnology for micropollutants - Microplastic bioremediation through plastic active enzymes - Black Soldier Fly (a entomological) way to tackle organo-pollutants - Synthetic biology for microbial bioremediation of xenobiotic - Nuclear waste management by microbial interventions- Actinides pollutant removal strategies	
Unit-5: Bioremediation Techniques and Field Studies)	9
In situ and ex situ remediation technologies - Soil bioremediation - Bioremediation in sediments (sub-surface) - Bioremediation of aqueous environments contaminated with organic chemicals - Lake and lagoon ecosystems - Marine pollution - Industrial effluents - Environmental Impact Assesment (EIA), Environment Protection Agency (EPA) and Role of Pollution control boards (Central and State) in abatements]	

Learning Resources	Mirza Hasanuzzaman, Majeti Narasimha Vara Prasad, Handbook of Bioremediation Physiological, Molecular and Biotechnological Interventions 1st Edition, Elsevier, 2020] [Vineet Kumar, Muhammad Bilal, Sushil Kumar Shahi, Vinod Garg, Metagenomics to Bioremediation Applications, Cutting Edge Tools, and Future Outlook 1st Edition, Elsevier, 2022]	Online sources: NPTEL - Environemntal Biotechnology https://archive.nptel.ac.in/courses/102/105/102105088/ NPTEL - Environmental remediation of Contaminated soils https://archive.nptel.ac.in/courses/105/107/105107181/]

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
Dr.Nagarajan, Srinivas Waste Management Services Pvt. Ltd., Chennai.	Dr. Rintu Banerjee IIT Kharagpur, rb@agfe.iitkgp.ernet.in	Dr.B.Samuel Jacob, , SRMIST
Dr. S. Sam Gunasekar, Orchid Chemicals and Pharmaceuticals Ltd., sam@orchidpharma.com	Dr. Vinod Kumar, Cranfield University, UK, vinod.kumar@cranfield.ac.uk	Dr.K.Ramani, , SRMIST

Course Code	21BTE415T	Course Name	ENVIRONMENTAL BIOSENSORS	Course Category		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 :	Create awareness on biosensors and the need for biosensors in day today life
CLR-2 :	Provide overview of various biomolecules used in biosensors
CLR-3 :	Reflects on the importance of biosensors in healthcare industries
CLR-4 :	Understand on the importance of biosensors in environmental monitoring
CLR-5 :	Educate the advanced state of the art of technology in biosensors

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	Environment &	Ethics	Individual & Team	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	Explain the biosensors components and its applications	3]	-	2]	-	2]	-	3]	-	-	-	-	-	3]	-	2]
CO-2:	Acquire knowledge in biomolecules in biosensors	-	2]	2]	3]	-	-	-	-	-	-	-	-	-	-	1]
CO-3:	Evaluate the importance of biosensors in healthcare industries	-	3]	2]	-	2]	-	-	-	-	-	-	-	-	2]	3]
CO-4:	Discuss the importance of biosensors in environmental monitoring	3]	3]	-	2]	2]	-	3]	-	-	-	-	-	2	-	2]
CO-5:	Demonstrate in novel technologies in biosensors	3]	-	2]	-	2]	-	-	-	-	-	-	-	2]	3]	-

Unit-1 : Basic principle and instrumentation of biosensors	9
Introduction to biosensors; Various Types of Biosensors: electrochemical & opticals; acoustic & piezoelectric; Fluorescence & calorimetric; Materials for biosensors: Polymers; Metal Oxides; Photonic Crystals; Nano Materials.	
Unit-2 : Biomolecules in biosensors	9
Bioaffinity Based Sensor- DNA-Based Biosensors, Protein-Based Biosensors, Enzyme-Based Biosensors, Peptide-Based Biosensors, Antibody-Based Biosensors. Real time applications - Glucose; Cholestrol ; Urea ; Pregnancy Kit, Pathogens & Detections.	
Unit-3: Biosensors in Healthcare Sectors	9
Biosensors in Health Cares: Biosensors and diabetes management; Biosensors in Cancers management; Biosensor in HIV early diagnosis (ELISA); Biosensors for Influenza Viruses.	
Unit-4 : Biosensors in Environmental Monitoring:	9
Biosensors in Environmental Monitoring: Water Quality – DO, BOD& COD Sensors; Heavy Metals. Biosensors for AIR Pollutions - Indoor pollutants detection, Gas Leaks Detectors. Biosensors In Agriculture Science - Soil Nutrients and Moisture Detection.	
Unit-5: Microfluidic Devices	9
Bioinspired Molecular Machines; Microfluidic Devices and Analysis; Microfluidics for Disease Diagnosis.	

Learning Resources	1. Modern Techniques in Biosensors Detection Methods and Commercial Aspects, herausgegeben von: Ph.D. Gorachand Dutta, Dr. Arindam Biswas, Prof. Dr. Amlan Chakrabarti, 2021. 2. Emerging Biosensor Trends in Organ-on-a-Chip, Mario Rothbauer & Peter Ertl, 2020.	3. Smart Biosensor Technology, George Knopf, Amarjeet S. Bassi, 2019. 4. Advanced Biosensors for Health Care Applications, Inamuddin, Raju Khan, Ali Mohammad, Abdullah Asiri, 1st Edition - June 15, 2019. 5. Commercial Biosensors and Their Applications, Mustafa Kemal Sezgintürk, Clinical, Food, and Beyond, 1st Edition - June 12, 2020.

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
Dr. S. Sam Gunasekar Orchid Chemicals and Pharmaceuticals Ltd., Chennai	Dr. Dr. V V Raghavendra Sai IIT Madras, Chennai, vvrsai@iitm.ac.in	Dr. W. Richard Thilagaraj,SRMIST
Mr. D.K.Rana, Heubach Colour Pvt.Ltd.Gujarat, ankplant@heubach-india.com	Dr. Athi N. Naganathan IIT Madaras , Chennai, athi@iitm.ac.in	Dr. B.Samuel Jacob, SRMIST

ACADEMIC CURRICULA

B Tech in Biotechnology with Specilization In Regenerative medicine

Professional Elective Courses

Regulations - 2021

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

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

Kattankulathur, Kancheepuram, Tamil Nadu, India

Course Code	21BTE206T	Course Name	MOLECULAR CELL BIOLOGY	Course Category		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 &	Ethics	Individual & Team	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
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
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
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
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

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

Course Code	21BTE311T	Course Name	CELL COMMUNICATION AND SIGNALING	Course Category		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	Environment &	Ethics	Individual & Team	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
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 multipotency-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
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 -activing/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
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
. 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
. 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- Nanocarrier 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. Elsvier, 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
Dr.Ramesh Babu Boga, BogaR Laboratories, Hyderabad, brameshb@msn.com	Dr. Ravisankar B, University of Madras, email: bravisankar68@gmail.com	Dr.Kanagaraj Palaniyandi, SRMIST
Mr.J.B. Vijayakumar BioArtis Life Sciences Pvt. Ltd. email: contact@bioartis.in	Dr. Ajaikumar B. Kannumakkara , IITG, kunnumakkara@iitg.ernet.in	Dr. R. Satish, SRMIST

Course Code	21BTE312T	Course Name	STEM CELL TECHNOLOGY	Course Category		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 &	Ethics	Individual & Team	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
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
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
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
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
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
Dr. B.R.Desikachari, Medical Director, Westminster Health Care, Chennai, brdesikachari@hotmail.com	Prof .Halagowder D, Univ. of Madras, hdrajum@yahoo.com	Dr. Devi.A, SRMIST
Dr. A. Premkumar, Ph.D., GVK Biosciences, Hyderabad aprem70@yahoo.com	Dr.Sudha Warrier, Associate Professor, Manipal University, sudha.warrier@mannipal.edu	Dr. N.Selvamurugan, SRMIST

Course Code	21BTE313T	Course Name	BIOMATERIALS IN TISSUE ENGINEERING	Course Category		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	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	Environment &	Ethics	Individual & Team	Communication	Project Mgt. & Finance	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 biomimetics 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	-	-	-	-	2	3	-
CO-5:	Translate biomaterials as scaffolds for various clinical applications and assess regulatory controls in global marketing	-	-	2	2	-	-	-	3	-	-	-	-	-	3	-

Unit-1 : Introduction to biomaterials.	9
Properties of biomaterials (chemical, physical, mechanical and thermal), Elements of Biomaterials, preparation and characterization of biomaterials (metal, bioceramic polymeric materials), Evaluation of biomaterials and biological responses	
Unit-2 : Basic concepts in tissue engineering	9
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
Stimuli responsive in biomaterials, Biomimetics, 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
Tissue engineering, wound care and suture materials, vascular implants and bio-inspired materials, Biomimetic devices, Organ transplant, Tissue Construction, Bioartificial 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
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
Dr. Giridharan, Life Cell, giridharan.a@lifecell.in	R. Jayakumar, Ph. D, Amrita Medical Center, Kochi jayakumar77@yahool.com	Dr. N. Selvamururgan, SRMIST
Dr. Gokuladhas Krishnan , Director, Laboratory, World Stem Cell Clinic, Chennai, care@worldstemcellclinic.com	N. Srinivasan, Ph. D., Chettinad Health City, Chennai, srinivasanibms@gmail.com	Dr. K. Venkatesan, SRMIST

Course Code	21BTE314T	Course Name	NANOTECHNOLOGY IN REGENERATIVE MEDICINE	Course Category		Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co- requisite Courses	Nil	Progressive Courses	Ni
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	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	Environment &	Ethics	Individual & Team	Communication	Project Mgt. & Finance	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
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
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
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
Introduction- nanobiosensors, Biosensing Techniques, unique properties of nanobiosensors, Preparation of nanobiosensors- immobilsation 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
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
Dr. S Natarajan Advisor / Sr. Vice President - R & D; Sami Labs Limited Bangalore. mail@samilabs.com	Prof. Sundara Ramaprabhu, Department of Physics IIT-Madras. ramp@iitm.ac.in; ramp@physics.iitm.ac.in	Dr. Ramkumar K M, SRMIST
Dr. Gokuladhas Krishnan, Director, Laboratory, World Stem Cell Clinic, Chennai, care@worldstemcellclinic.com	Prof. Ashok M. Raichur, Department of Materials Engineering IISc, Bangalore. amr@materials.iisc.ernet.in	Dr. N. Selvamururgan, SRMIST

Course Code	21BTE416T	Course Name	TISSUE ENGINEERING FOR REGENERATIVE MEDICINE	Course Category		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 :	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 &	Ethics	Individual & Team	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
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
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
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
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
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
Dr. Harikrishna Varma, SCTIMST, Thiruvananthapuram, India; head-bmtw@sctimst.ac.in	Dr. Sourabh Ghosh, IIT Delhi, India, sghosh08@textile.iitd.ac.in	Dr. Koustav Sarkar, SRMIST
Dr. Dipak Datta, CDRI, Lucknow, India; dipak.datta@cdri.res.in	Dr. Rathindranath Baral, CNCI, Kolkata., India, baralrathin@hotmail.com	Dr. N. Selvamururgan, SRMIST

Course Code	21BTE417T	Course Name	BIOREACTORS IN TISSUE ENGINEERING	Course Category		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 [illegible]	Environment & [illegible]	Ethics	Individual & Team [illegible]	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	-	-	-	-	-	-	-	-	3	-	-
CO-2:	Discuss the 3D- culture systems and artificial organs	3	2	2	3	-	-	-	-	-	-	-	-	3	-	-
CO-3:	Identify the bioreactor-based strategies to generate organoids	3	2	2	2	-	-	-	-	-	-	-	-	3	-	-
CO-4:	Understand the role of bioreactors in the development of drug development and therapy	3	3	3	3	-	-	-	-	-	-	-	-	2	-	-
CO-5:	Explain the large scale production of stem cells	3	2	-	2	-	-	-	-	-	-	-	-	2	-	-

Unit-1 : Tissue organization and Bioreactors	9
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
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
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
. 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
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
Dr.Ramesh Babu Boga, BogaR Laboratories, Hyderabad, brameshb@msn.com	Dr. Ajaikumar B. Kannumakkara , IITG, kunnumakkara@iitg.ernet.in	Dr. Kanagaraj Palaniyandi, SRMIST
Mr.J.B. Vijayakumar BioArtis Life Sciences Pvt. Ltd. email: contact@bioartis.in	Dr. Suttur S Malini, University of Mysore, drssmalini@gmail.com	Dr. R. Satish, SRMIST

Course Code	21BTE418T	Course Name	DEVELOPMENTAL BIOLOGY IN TISSUE ENGINEERING	Course Category		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	Environment &	Ethics	Individual & Team	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 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 regneration	-	-	-	3	-	-	-	3	-	-	-	-	-	3-	-

***Unit-1* :** Cell communication in development	9
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
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
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
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
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
Dr. B.R.Desikachari, Medical Director, Westminster Health Care, Chennai, brdesikachari@hotmail.com	Dr. K. Subramaniam Indian Institute of Technology Madras, Chennai subbu@iitm.ac.in	Dr. S. Kirankumar, SRMIST
Dr. V.L.Ramprasad, MedGenome Labs Ltd, Bengaluru ramprasadv@medgenome.com	Dr.Sudha Warrier, Associate Professor, Manipal University sudha.warrier@mannipal.edu	Dr. N. Selvamurugan, SRMIST

Course Code	21BTE419T	Course Name	ADVANCED IMMUNOLOGY AND VASCULAR ENGINEERING	Course Category		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 &	Ethics	Individual & Team	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 Immunlogy	9
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
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
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
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
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, 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
Dr. Vani, Jeevan Stem Cell Foundation, Chennai, stemcell@jeevan.org	Dr. S. Sittadjody, Research Fellow, Institute for Regenerative Medicine, Winston-Salem, USA. ssdjody@gmail.com	Dr. N. Selvamururgan, SRMIST
Dr. Satheesh K. Sainathan, Study Director, Phenotypic Services, Eurofins Discovery, St Charles, Missouri, United States	Dr. Yuvaraj Sambandam, Assistant Professor, Surgery, Transplant Surgery Division, North western University, USA	Dr. R. Satish, SRMIST

ACADEMIC CURRICULA

Open Elective Courses

Regulations - 2021

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

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

Kattankulathur, Kancheepuram, Tamil Nadu, India

Course Code	21BTO101T	Course Name	HUMAN HEALTH AND DISEASES	Course Category		Open 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 :	Explain the basic structural organization of human health system
CLR-2 :	Summarize the etiology of human infectious diseases
CLR-3 :	Describe immune system and nervous system of human body and diseases related ot it
CLR-4 :	Impart knowledge on genetic diseases
CLR-5 :	Indicate the high risk diseases associated with modern society

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	7 Environment &	8 Ethics	9 Individual & Team	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	Explain the structural organization of human system and concepts in human diseases	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	Differentiate the disease-causing agents and explain the life style related diseases	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	Describe the immune and neural system and related diseases.	-	2	-	-	3	-	-	-	-	-	-	-	-	-	-
CO-4:	Integrate the genetical makeup with genetical disorders	-	2	-	-	3	-	-	-	-	-	-	-	-	-	-
CO-5:	Apply the knowledge of disease and their symptoms in developing monitors and diagnostic device	-	2	-	-	3	-	-	-	-	-	-	-	-	-	-

Unit-1 : **Human system and cell structure and function**	9
Introduction to human heath, Anatomy and Physiology, Respiratory system, Circulatory System, Digestive System, Excretory system, Reproductive system, Fertilization and Cell structure, Embryogenesis Tissue types, body gets energy, ATP Synthesis, Cell metabolism, Cell cycle, Checkpoints in cell division, Cell division -Mitosis and Meiosis, Growth factors- overview, Types and function	
Unit-2 : **Infections and life style diseases**	9
Infectious Diseases , Bacterial toxins, virulence of bacterial infection, Antibiotic resistance strains, An overview of replication cycle of virus, Effect of virus infection in the host cell, Epidemiology, Roots of spreading, Emerging and reemerging virus. Life style diseases: High risk disease of modern society, Obesity, Hypertension and diabetics, Neoplasm, Oncogenes and tumor suppressor genes, Types of cancer, Stages of cancer, Cancer in future, Life style and cancer risk	
Unit-3: **Immune disorders**	9
Immune system, Physical chemical and cellular barrier, Types of Immune cell, Humoral and cell mediated immunity, Cells Involved in inflammation, Inflammatory Process, Immune disorders, Abscesses, ulcer, cellulitis And Allergy, Autoimmunity, Immunodeficiency. Nervous system, Parkinson's, Alzheimer's disease	
Unit-4 : **Genetical Diseases**	9
Mendelian genetics, Genetics of simple and complex traits, Hereditary disease, Karyotype preparation and analysis Chromosome abnormality, Thalassemia, Cystic fibrosis, Duchene Muscular dystrophy, Sickle cell anemia, Indian genetic disease database, Human gene mutation database, Principle class of metabolic disorders, Inherited Metabolic disorders, Metabolic syndrome, Risk factors, Lysozyme storage disease: Molecular basis, List of proteins involved in LSD, Balanced nutrition and Malnutrition, Deficiency disease	
Unit-5: **Diseases diagnosis and treatment**	9
Disease Diagnosis, Treatment strategy, Biomedical Instruments, Biosensors, Sources of drug- plants and microbes, Drug Designing, Computer aided drug designing, Vaccines, Route of administration, Vaccines types, Recommendation by age, Vaccines – Recent advancement, Immunotherapy, Immunotherapeutic approaches currently in use, Stem cell therapy, Gene therapy	

Learning Resources	1. *Goodenough and McGuire, Biology of Humans: Concepts, Applications and issues, 4th ed., Benjamin Cummins/Pearson Publisher, 2011*	*2. Marianne Neighbors, Ruth Tannehil, Human Diseases, 4th ed.,Jones Cengage learning, 2015* *3.* Marianne Neighbors, and Ruth Tannehill-Jones Human Diseases , 5th *ed* Delmar Cengage Learning 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*	*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
Dr. C. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in	Dr. Lilly M saleena, SRMIST
Dr. Karthik Periyasamy, Scientist, Biocon, karthik.periyasamy@biocon.com	Prof. R. B. Narayanan, Anna University, Chennai arbeen09@gmail.com	Dr. Rpriya Swaminathan , SRMIST

Course Code	21BTO105T	Course Name	ANIMAL MODELS FOR BIOMEDICAL RESEARCH	Course Category		Open 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 :	Understand the basics animal Biology.
CLR-2 :	Describe the various animal models and their requirement in biomedical research
CLR-3 :	Learn the models available for various human diseases
CLR-4 :	Learn to do pilot experiments to evaluate their working/living environment
CLR-5 :	Learn different ethical and regulatory issues with animal models and design an alternative model to replace animal models

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 &	Ethics	Individual & Team	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	Define the fundamentals of animal experiments	-	2	1	2	-	-	-	-	-	-	-	-	-	-	-
CO-2:	Outline the various animal models available for biomedical research	-	2	2	2	-	-	-	-	-	-	-	-	-	-	-
CO-3:	Explain the similarities between animal models and humans	-	2	2	2	-	-	-	-	-	-	-	-	-	-	-
CO-4:	Design and evaluate pilot experiments to study their environment	-	-	3-	3	2	-	-	-	-	-	-	-	-	-	-
CO-5:	Prepare alternative models to replace animal models and comply with ethical issues	-	3	3	3	2	-	-	-	-	-	-	-	-	-	-

Unit-1 : Basics of Animal Biology	9
Introduction to biology of animals, Classification of Animals (Invertebrates and Vertebrates), Structure and organs, Human evolution, Darwinism theory, History of animals and research	
Unit-2 : Animal models in Biomedical Research	9
Animal models, Need for Animal models, Living and Non-living animal models for research, Selection of animal models, Non-Invertebrate animal models (Drosophila and C.elagans), Vertebrate animal models (Rats, mice, Primates, Cow, Dog and Sheep), Genetically engineered animals	
Unit-3: Animal models for Human Diseases	9
Animal models for cataracts and retinitis pigmentosa, Atherosclerosis and myocardial infarction, cardiac and cardiovascular disease, metabolic syndrome, diabetes and obesity, liver diseases, skin disorders and regeneration, Neurodegenerative disorders, Cancer	
Unit-4 : Animal models in preclinical studies	9
Drugs and compound administration, need for animal models to test new compounds prior clinical study, Oral administration, Nasal Dosage, Inhalation, Invasive administrations (intravenous, intraperitoneal, intraocular, intramuscular, subcutaneous), non-invasive drug administration, Skin adsorption, selecting appropriate drug administration route, understanding the route of exposure in toxicity cases, Human-animal equivalent dose calculations,	
Unit-5: Regulatory and Ethical issues in Animal and human Research	9
Animals in laboratory environment, Regulations and ethics in Animal research, Biohazards, Biosafety levels, and Radiation Safety, Breeding and animal husbandry, 3Rs for humane animal research, Alternative animal models (cell and tissue cultures, organoids), Limitations and ethical issues on human research, Ethical issues in using human samples and animal models, Application of computational models to replace animal models, Simulations and animal models	

Learning Resources	4. Hau J, Van Hoosier GL Jr, Handbook of Laboratory Animal Science, Volume I: Essential Principles and Practices" 2nd ed., CRC Press: Boca Raton, FL, 2003 5. Micheal Conn P, Animal Models for the Study of Human Disease,2nd ed., Academic Press, 2017 6. Jerome Y Yager, Animal Models of Neuro-developmental Disorders, Human Press, 2015	4. The Guide for Care and Use of Animals in Research, Eight 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
Dr. C. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in	Dr.R.A. Nazeer, SRMIST
Dr. Karthik Periyasamy, Scientist, Biocon, karthik.periyasamy@biocon.com	Prof. R. B. Narayanan, Anna University, Chennai arbeen09@gmail.com	Dr. Harinarayana Ankamreddy, SRMIST

Course Code	21BTO106T	Course Name	WASTE TO WEALTH TO WHEELS	Course Category		Open 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 :	Identify the applications of engineering concepts for sustainable waste management
CLR-2 :	Demonstrate of energy conversion technology for fuel application
CLR-3 :	Examine the significance of eco-friendly process in waste management
CLR-4 :	Prescribe the concepts of zero-waste process in industrial waste disposal methods
CLR-5 :	Analyze the important wastes to energy conversion

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	Environment &	Ethics	Individual & Team	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	Understand the waste and formulate methodology for waste segregation	-	3	-	2	-	-	2	-	-	-	-	-	-	-	-
CO-2:	Evaluate the National policy towards novel biofuel production and energy security	3	-	3	2	-	-	-	-	-	-	-	-	-	-	-
CO-3:	Compare and plan thermo-chemical conversion process for waste to energy conversion	3	2	2	-	2	-	-	-	-	-	-	-	-	-	-
CO-4:	Demonstrate bioprocessing techniques to convert waste to biofuel and value-added chemicals	-	-	3	2	2	-	2	-	-	-	-	-	-	-	-
CO-5:	Utilize novel recent technologies for efficient waste management to meet the mandates of Global and National policy	-	-	-	2	-	2	2	-	-	-	-	-	-	-	-

Unit-1 : Wastes: A boon or bane?	9
Waste generation sources - Classification of wastes - Waste Management pyramid - Characterization of wastes - 4R principle - Modern Waste collection tools -Environmental and climatic change issues - Rapid urbanization, depletion of fossil reserves, need for energy security - Impact of wastes on biodiversity	
Unit-2 : [Waste Bioeconomy	9
Transforming from fossil-based economy to a sustainable circular bio-economy - Global and Indian perspective - waste as the core element for the future economic models - drivers for the bioeconomy - futuristic needs, scope and opportunities envisaged in the business and economic realm	
Unit-3: Technologies/processes that can be applied for biogenic wastes valorization	9
Circular economy in a waste biorefinery model for the production of biobased products including bioenergy - Thermal processing of wastes: Combustion, Co-generation/co-firing - Pyrolysis and torrefaction - Hydrolysis and plasma treatment for waste to energy conversion - Catalytic conversion process - Syngas production- Bioenergy-Biochar energy cycle - Land fill and flue gas recovery for its commercial application	
Unit-4 : Insights into Bioenergy	9
Classification of Biofuels - Liquid, Gaseous and Solid - Bioethanol Hexose and Pentose sugar conversion to ethanol- Bioethanol plant design and its components- Bio refinery demonstration projects of Bioethanol- Biodiesel - Biodiesel from vegetable oils/ non-edible oils - Transesterification process-Oleaginous microorganisms-Algal Biofuel - Algal based technologies for biofuel and value added chemical preparation - Biobutanol - ABE Fermentation for Butanol production - Pyrolysis bio-oil/bio-char -Bio-alkanes and alkenes from waste biomass - Gaseous Biofuel - Bio-synthetic natural gas (SNG)- Biomethanation process- Microbiology of anaerobic digestion- Dimethyl ether (DME)-Biohydrogen- Biological Processes for Hydrogen Production- Dark fermentation and algal based technologies	
Unit-5: Technologies for Waste Management and Government Policies)	9
Smart Bins - Robotic hand for waste segregation using image acquisition and analysis - Unmanned Arial Vehicle (UAV) for landfill waste forecasting - AI and Sensor Technology for waste segregation - Robotic ocean waste collection and reutilization - Activities of Ministry of Energy, Government of India and International Energy Agency - Potential Benefits of Replacing Fossil Fuels with Biofuel, Biomass and Biogas	

Learning Resources	1.Peter Lacy , Jakob Rutqvist, Waste to Wealth,The Circular Economy Advantage, Springer, 2015 2.Reeta Rani Singhania, Rashmi Avinash Agarwal, R. Praveen Kumar, Rajeev K Sukumaran, Waste to Wealth, Springer, 2018 3. Online resources: https://onlinecourses.nptel.ac.in/noc21_ch09/preview]

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
Mr.Kirti Singh, Camlin Fine Sciences Ltd., New Delhi	Dr. Rintu Banerjee IIT Kharagpur, rb@agfe.iitkgp.ernet.in	Dr.B.Samuel Jacob, SRMIST
Dr.D.Gunaseelan, Alvotech Pvt., Ltd., Iceland	Dr. Vinod Kumar, Cranfield University, UK, vinod.kumar@cranfield.ac.uk	Dr.K.Ramani, SRMIST

Course Code	21BTO107T	Course Name	FUNDAMENTAL NEUROBIOLOGY	Course Category		Open 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 :	Recall the brain function from its organization
CLR-2 :	Discuss the synaptic structure and function
CLR-3 :	Understand different types of learning and memory, influence of sleep and ageing
CLR-4 :	Analyze genetic variations in brain development and behavior
CLR-5 :	Study the brain pathology

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	Environment &	Ethics	Individual & Team	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	Describe the fundamental organization of brain and its functions	*2*	2	-	-	-	-	-	-	-	-	-	-	2	-	2
CO-2:	Explain the synaptic composition and neurotransmitter release cycle	*2*	2	-	-	-	-	-	-	-	-	-	-	2	-	2
CO-3:	Analyze different domains of learning and synaptic protein maintenance	*2*	2	-	-	3	-	-	-	-	-	-	-	2	-	3
CO-4:	Summarize the role of genes in brain development and functions	*3*	2	-	-	3	-	-	-	-	-	-	-	3	-	3
CO-5:	Understand the neuropathological conditions across the age groups	*3*	2	-	-	3	-	-	-	-	-	-	-	3	-	3

Unit-1 : Introduction to brain and neuronal types	9
Basics of Neurobiology- Understanding brain function- Orientation of Central nervous system- Peripheral nervous system- Levels of Neural organization- Concept of functional units- Cellular basis of Neurobiology- Clinical issues in neurobiology- Neuron terminology- Cell biology of neurons and glia- Differentiation of axon and dendrite- Synaptic organization- Sensorimotor, autonomic and enteric divisions- Synapses and spines- Inhibitory interneurons and classification- Inhibitory projection neurons- Excitatory neurons- Neuroglia and glial sheaths	
Unit-2 : Transmission of nerve impulse	9
Membrane potential- Action potential- Resting potential- Electrochemical basis of nerve function- Electrical and Thermodynamic Forces in Passive Distribution of Ions- Hyperpolarization or Depolarization- Chemical basis for neuronal communication- Ion pumps and Ion gradients- Ion channels and transporters- Hyperpolarization- Activated Ionic Currents- Membrane excitability- Neurotransmitters- Receptors of neurotransmitters- Synthesis of neurotransmitters and neuropeptides- Synaptic vesicle cycle- Release and metabolism of neurotransmitters- Molecular mechanisms nerve terminal- Molecular signaling in neurons	
Unit-3: Functions of brain-Learning and memory	9
Brain energy metabolism at the cellular level- Sensory systems- Receptors to perceptions- Chemical and somatic senses- Molecular and neural basis of visual perception- Organization of autonomic nervous system and functions- Nature of motor system and its functions- Reflexes and fixed motor responses- Locomotion- Epigenetics of the brain- Epigenetics in brain disorders- Sleep, dreaming and wakefulness- Reward and motivation- Emotion and addiction- Aging and synaptic degradative pathways- Cognitive impairment- Learning and memory- Language, communication and consciousness	
Unit-4 : Circuits of neuroendocrinology, neuroimmunology and role of neurogenetics	9
Nature of central systems- Survey methods- Neuroendocrine circuits- Functions of neuroendocrine system- Neuroendocrine tumors- Global epidemiology of neuroendocrine tumors- Neuro-immune circuits- Neuro-immune functions- Neuroendocrine-immune interactions in neurological disorders- Neuroendocrine-immune interactions in autoimmune diseases- Developmental genetics of the brain- Genes for human brain development- Genes in neurological disorders- Genes and behavior- Drugs and the brain- Role of Environmental factors in neurodevelopment- Exposure of lead and methyl mercury in neurodevelopmental disorders- Neurotoxins-	
Unit-5: Diseases of brain	9
Disorders of the nervous system- Developmental disorder- Autism, Intellectual disability, Dyslexia, ADHD- Mental Disorder- Schizophrenia- Degenerative disorders- Alzheimer's disease- Parkinson's disease- Psychiatric disorder- Depression and anxiety- Stroke- Epilepsy- Implications of neuropharmacology- Novel therapeutic targets- Neural Plasticity, Goat Brain Dissection- Understanding brain by Artificial Intelligence- Neural network for analyzing brains network	

Learning Resources	1.Larry Squire, Darwin Berg,Floyd E. Bloom,Sascha du Lac,Anirvan Ghosh,Nicholas C. Spitzer, Fundamental Neuroscience, 4th ed., Academic Press, 2012 2. Michael Aschner, Lucio G. Costa,Environmental factors in Neurodevelopmentaland neurodegenerative disorders, 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*	*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
Dr. C. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in	Dr. Anil Annamneedi, SRMIST
Dr. Karthik Periyasamy, Scientist, Biocon, karthik.periyasamy@biocon.com	Prof. R. B. Narayanan, Anna University, Chennai arbeen09@gmail.com	Dr. R. Vasantharekha, SRMIST

ACADEMIC CURRICULA

Mandatory Courses

Regulations - 2021

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

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

Kattankulathur, Kancheepuram, Tamil Nadu, India

Course Code	21BTM191T	Course Name	BIOETHICS AND IPR	Course Category		Mandatory	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	Environment &	Ethics	Individual & Team	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	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	Elaborate the ethical issues and safety precautions in biotechnology research	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-
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	-	-	-	-	-	-3	-	-	-	-	-	-	-

Unit-1 : Basic Principles of Bioethics	3
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**
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*
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*
Designs, Copyrights and Geographical indications, Novelty and Utility, Patentable subjects and protection in biotechnology, Biodiversity	
Unit-5: Patens	*3*
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 (0% weightage)*	
		Formative CLA-1 Average of unit test (40%)		*Life Long Learning CLA-2 – (40%)*		*Summative (20%)*		
		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%*	*100 %*	

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