4. B.Tech. in Biotechnology

4. (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*

4. (b) Program Educational Objectives (PEO)

PEO - 1	*To impart knowledge in biological and chemical sciences for application in biological systems*
PEO - 2	*To develop skills in basic and applied fields of biotechnology leading to professionalism and leadership*
PEO - 3	*To provide hands-on training to students for carrying out independent research projects in emerging areas of biotechnology*

4. (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

4. (d) Mapping Program Educational Objectives (PEO) to Program Learning Outcomes (PLO)

	Program Learning Outcomes (PLO)														
	Graduate Attributes (GA)												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*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*
PEO - 2	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
PEO - 3	*M*	*H*	*H*	*H*	*H*	*H*	*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	*Ability to integrate biology and engineering technology for application in industry and research*
PSO - 2	*Able to implement the biotechnology concepts in the applied fields of biotechnology*
PSO - 3	*Able to contribute towards the advancement of biotechnology in the fields of research and management*

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

Humanities & Social Sciences including Management Courses (H)					
Course Code	Course Title	Hours/ Week L	T	P	C
18LEH101J	English	2	0	2	3
18LEH102J	Chinese				
18LEH103J	French				
18LEH104J	German	2	0	2	3
18LEH105J	Japanese				
18LEH106J	Korean				
18PDH101T	General Aptitude	0	0	2	1
18PDH102T	Management Principles for Engineers	2	0	0	2
18PDH103T	Social Engineering	2	0	0	2
18PDH201T	Employability Skills & Practices	0	0	2	1
Total Learning Credits					**12**

Engineering Science Courses (S)					
Course Code	Course Title	Hours/ Week L	T	P	C
18MES101L	Engineering Graphics and Design	1	0	4	3
18MES102J	Basic Civil and Mechanical Engineering	3	1	2	5
18EES102L	Electrical and Electronics Eng. Workshop	1	0	4	3
18CSS101J	Programming for Problem Solving	3	0	4	5
18CHS251T	Basic Chemical Engineering	3	0	0	3
18CHS252T	Chemical Engineering Principles	3	0	0	3
18CHS253L	Chemical Engineering Practice	0	0	4	2
Total Learning Credits					**24**

Professional Elective Courses (E) (Any 6 Courses)					
Course Code	Course Title	Hours/ Week L	T	P	C
	Sub-stream: Medical Biotechnology				
18BTE301T	Developmental Biology	3	0	0	3
18BTE302T	Cellular & Molecular Neuroscience	3	0	0	3
18BTE303T	Metabolic Disorders	3	0	0	3
18BTE304T	Infectious Diseases	3	0	0	3
18BTE401T	Cancer Biology	3	0	0	3
18BTE402T	Physiology of Stress and its Management	3	0	0	3
	Sub-stream: Pharmaceutical Biotechnology				
18BTE305T	Pharmaceutical Biotechnology	3	0	0	3
18BTE306T	Bioinformatics	3	0	0	3
18BTE307T	Drug Discovery and Drug Designing	3	0	0	3
18BTE308T	Marine Biotechnology	3	0	0	3
18BTE403T	Vaccine Biotechnology	3	0	0	3
18BTE404T	Molecular Basis of Drug action	3	0	0	3
	Sub-stream: Plant and Food Biotechnology				
18BTE309T	Plant nutrition and physiology	3	0	0	3
18BTE310T	Plant Hormones and Signaling	3	0	0	3
18BTE311T	Pathogenesis-Related Proteins In Plants	3	0	0	3
18BTE312T	Food Science and Nutrition	3	0	0	3
18BTE405T	Therapeutic Compounds from Plants	3	0	0	3
18BTE406T	Food safety and quality Management	3	0	0	3
	Sub-stream: Bioprocess Technology				
18BTE313T	Enzyme Engineering and Technology	3	0	0	3
18BTE314T	Membrane Technology	3	0	0	3
18BTE315T	Industrial Fermentation Technology	3	0	0	3
18BTE316T	Bioreactor Design	3	0	0	3
18BTE407T	Bioprocess Modelling and Simulation	3	0	0	3
18BTE408T	Bioprocess Plant Design	3	0	0	3
	Sub-stream: Environmental Biotechnology				
18BTE317T	Environmental Biotechnology	3	0	0	3
18BTE318T	Industrial Waste Management	3	0	0	3
18BTE319T	Bioenergy	3	0	0	3
18BTE320T	Environmental Microbiology. & Metagenomics	3	0	0	3
18BTE409T	Bioremediation Technology	3	0	0	3
18BTE410T	Environmental Biosensors	3	0	0	3
Total Learning Credits					**18**

Mandatory Courses (M)					
Code	Course Title	L	T	P	C
18LEM110L	Indian Art Form	0	0	2	0
18CYM101T	Environmental Science	1	0	0	0
18BTM191T	Bioethics and IPR	1	0	0	0

Basic Science Courses (B)					
Course Code	Course Title	Hours/ Week L	T	P	C
18PYB101J	Physics: Electromagnetic Theory, Quantum Mechanics, Waves and Optics	3	1	2	5
18CYB101J	Chemistry	3	1	2	5
18MAB101T	Calculus and Linear Algebra	3	1	0	4
18MAB102T	Advanced Calculus and Complex Analysis	3	1	0	4
18MAB303T	Bio-Statistics for Biotechnologists	3	1	0	4
18BTB103T	Human Physiology and Health	3	0	0	3
Total Learning Credits					**25**

Professional Core Courses (C)					
Course Code	Course Title	Hours/ Week L	T	P	C
18BTC101J	Biochemistry	3	0	2	4
18BTC102J	Cell Biology	3	0	2	4
18BTC103J	Microbiology	3	0	2	4
18BTC104T	Genetics and Cytogenetics	3	0	0	3
18BTC105J	Molecular Biology	3	0	2	4
18BTC106J	Immunology	3	0	2	4
18BTC107J	Bioprocess Principles	3	0	2	4
18BTC108J	Plant Biotechnology	3	0	2	4
18BTC201J	Gene manipulation and Genomics	3	0	2	4
18BTC202J	Bioprocess Engineering	3	0	2	4
18BTC203J	Animal Biotechnology	3	0	2	4
18BTC204T	Protein engineering and proteomics	3	0	0	3
18BTC301J	Bioseparation Technology	3	0	2	4
18BTC350T	Comprehension	0	1	0	1
Total Learning Credits					**51**

Open Elective Courses (O) (Any 5 Courses)					
Code	Course Title	L	T	P	C
18BTO101T	Human Health and diseases	3	0	0	3
18BTO102T	Modelling of biomolecules	3	0	0	3
18BTO103T	Activated carbon technology	3	0	0	3
18BTO104T	Defense Forces in our body	3	0	0	3
18BTO105T	Animal Models for Research	3	0	0	3
18BTO106T	Waste to Wealth to Wheels	3	0	0	3
18BTO107T	Fundamental Neurobiology	3	0	0	3
Total Learning Credits					**15**

7. Project Work, Seminar, Internship In Industry/ Higher Technical Institutions (P)					
Code	Course Title	L	T	P	C
18BTP101L	MOOC- 1				
18BTP102L	Industrial Training-1	0	0	2	1
18BTP103L	Seminar - 1				
18BTP104L	MOOC- 2				
18BTP105L	Industrial Training-2	0	0	2	1
18BTP106L	Seminar - 2				
18BTP107L	Minor Project	0	0	6	3
18BTP108L	Internship (4-6 weeks)				
18BTP109L	Project	0	0	20	10
18BTP110L	Semester Internship				
Total Learning Credits					**15**

Mandatory Courses (M)					
Code	Course Title	L	T	P	C
18PDM101L	Professional Skills and Practices	0	0	2	0
18PDM201L	Competencies in Social Skills	0	0	2	0
18PDM203L	Entrepreneurial Skill Development				
18PDM202L	Critical and Creative Thinking Skills	0	0	2	0
18PDM204L	Business Basics for Entrepreneurs				
18PDM301L	Analytical and Logical Thinking Skills	0	0	2	0
18PDM302L	Entrepreneurship Management				
18LEM101T	Constitution of India	1	0	0	0
18LEM102J	Value Education	1	0	1	0
18GNM101L	Physical and Mental Health using Yoga	0	0	2	0
18GNM102L	NSS	0	0	2	0
18GNM103L	NCC				
18GNM104L	NSO				
18LEM109T	Indian Traditional Knowledge	1	0	0	0

4. (f) Program Articulation (B.Tech. in Biotechnology)

Course Code	Course Name	Program Learning Outcomes (PLO)														
		Graduate Attributes												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
18BTC101J	Biochemistry	M	M	H	H	H	H	M	H	H	H	H	H	H	H	H
18BTC102J	Cell Biology	M	M	H	H	H	M	M	H	H	H	H	H	H	H	H
18BTC103J	Microbiology	M	M	H	H	H	H	H	H	H	H	H	H	H	H	H
18BTC104T	Genetics and Cytogenetics	H	H	H	H	H	H	M	M	H	H	H	H	H	H	H
18BTC105J	Molecular Biology	H	H	M	H	H	H	M	H	H	H	H	H	H	H	H
18BTC106J	Immunology	M	H	M	H	H	M	M	H	H	H	H	H	H	H	H
18BTC107J	Bioprocess Principles	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
18BTC108J	Plant Biotechnology	M	H	H	H	H	H	H	H	H	H	H	H	H	H	H
18BTC201J	Gene manipulation and Genomics	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
18BTC202J	Bioprocess Engineering	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
18BTC203J	Animal Biotechnology	M	H	H	H	H	H	H	H	H	H	H	H	H	H	H
18BTC204T	Protein engineering and proteomics	H	H	H	H	H	H	H	M	H	H	H	H	H	H	H
18BTC301J	Bioseparation Technology	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
18BTE301T	Developmental Biology	M	M	H	H	H	H	M	H	H	H	H	H	H	H	H
18BTE302T	Cellular & Molecular Neuroscience	M	M	H	H	H	M	M	H	H	H	H	H	H	H	H
18BTE303T	Metabolic Disorders	M	M	H	H	H	H	H	H	H	H	H	H	H	H	H
18BTE304T	Infectious Diseases	H	H	H	H	H	H	M	M	H	H	H	H	H	H	H
18BTE401T	Cancer Biology	H	H	M	H	H	H	M	H	H	H	H	H	H	H	H
18BTE402T	Physiology of Stress and its Management	M	H	M	H	H	M	M	H	H	H	H	H	H	H	H
18BTE305T	Pharmaceutical Biotechnology	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
18BTE306T	Bioinformatics	M	H	H	H	H	H	H	H	H	H	H	H	H	H	H
18BTE307T	Drug Discovery and Drug Designing	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
18BTE308T	Marine Biotechnology	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
18BTE403T	Vaccine Biotechnology	M	H	H	H	H	H	H	H	H	H	H	H	H	H	H
18BTE404T	Molecular Basis of Drug action	H	H	H	H	H	H	H	M	H	H	H	H	H	H	H
18BTE309T	Plant nutrition and physiology	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
18BTE310T	Plant Hormones and Signaling	M	M	H	H	H	H	M	H	H	H	H	H	H	H	H
18BTE311T	Pathogenesis-Related Proteins In Plants	M	M	H	H	H	M	M	H	H	H	H	H	H	H	H
18BTE312T	Food Science and Nutrition	M	M	H	H	H	H	H	H	H	H	H	H	H	H	H
18BTE405T	Therapeutic Compounds from Plants	H	H	H	H	H	H	M	M	H	H	H	H	H	H	H
18BTE406T	Food safety and quality Management	H	H	M	H	H	H	M	H	H	H	H	H	H	H	H
18BTE313T	Enzyme Engineering and Technology	M	H	M	H	H	M	M	H	H	H	H	H	H	H	H
18BTE314T	Membrane Technology	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
18BTE315T	Industrial Fermentation Technology	M	H	H	H	H	H	H	H	H	H	H	H	H	H	H
18BTE316T	Bioreactor Design	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
18BTE407T	Bioprocess Modelling and Simulation	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
18BTE408T	Bioprocess Plant Design	M	H	H	H	H	H	H	H	H	H	H	H	H	H	H
18BTE317T	Environmental Biotechnology	H	H	H	H	H	H	H	M	H	H	H	H	H	H	H
18BTE318T	Industrial Waste Management	H	M	M	M	M	M	M	M	H	H	H	M	H	H	H
18BTE319T	Bioenergy	H	M	M	M	M	M	M	M	H	H	H	M	H	H	H
18BTE320T	Environmental Microbiology. & Metagenomics	H	H	H	H	H	M	M	H	H	H	H	H	H	M	M
18BTE409T	Bioremediation Technology	H	H	H	H	H	M	M	H	H	H	H	H	H	M	M
18BTE410T	Environmental Biosensors	H	H	H	H	H	M	M	H	H	H	H	H	H	M	M
18BTP101L	MOOC- 1	H	M	M	M	M	M	M	M	H	H	H	M	H	H	H
18BTP102L	Industrial Training-1	H	M	M	M	M	M	M	M	H	H	H	M	H	H	H
18BTP103L	Seminar - 1	H	M	M	M	M	M	M	M	H	H	H	M	H	H	H
18BTP104L	MOOC- 2	H	M	M	M	M	M	M	M	H	H	H	M	H	H	H
18BTP105L	Industrial Training-2	H	M	M	M	M	M	M	M	H	H	H	M	H	H	H
18BTP106L	Seminar - 2	H	M	M	M	M	M	M	M	H	H	H	M	H	H	H
18BTP107L	Minor Project	H	H	H	H	H	M	M	H	H	H	H	H	H	M	M
18BTP108L	Internship (4-6 weeks)	H	H	H	H	H	M	M	H	H	H	H	H	H	M	M
18BTP109L	Project	H	H	H	H	H	M	M	H	H	H	H	H	H	M	M
18BTP110L	Semester Internship	H	H	H	H	H	M	M	H	H	H	H	H	H	M	M
	Program Average	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H

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

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

Semester - I

Code	Course Title	Hours/ Week L	T	P	C
18LEH101J	English	2	0	2	3
18MAB101T	Calculus and Linear Algebra	3	1	0	4
18PYB101J	Physics: Electromagnetic Theory, Quantum Mechanics, Waves and Optics	3	1	2	5
18MES101L	Engineering Graphics and Design	1	0	4	3
18MES102J	Basic Civil and Mechanical Engineering	3	1	2	5
18PDM101L	Professional Skills and Practices	0	0	2	0
18LEM101T	Constitution of India	1	0	0	0
18GNM101L	Physical and Mental Health using Yoga	0	0	2	0
	Total Learning Credits				20

Semester - II

Code	Course Title	Hours/ Week L	T	P	C
18LEH10XJ	Chinese / French / German / Japanese/ Korean	2	0	2	3
18MAB102T	Advanced Calculus and Complex Analysis	3	1	0	4
18CYB101J	Chemistry	3	1	2	5
18CSS101J	Programming for Problem Solving	3	0	4	5
18EES102L	Electrical and Electronics Eng. Workshop	1	0	4	3
18PDH101T	General Aptitude	0	0	2	1
18LEM102J	Value Education	1	0	1	0
18GNM102L	NSS	0	0	2	0
18GNM103L	NCC				
18GNM104L	NSO				
	Total Learning Credits				21

Semester - III

Code	Course Title	Hours/ Week L	T	P	C
18BTB103T	Human Physiology and Health	3	0	0	3
18CHS251T	Basic Chemical Engineering	3	0	0	3
18BTC101J	Biochemistry	3	0	2	4
18BTC102J	Cell Biology	3	0	2	4
18BTC103J	Microbiology	3	0	2	4
18BTC104T	Genetics and Cytogenetics	3	0	0	3
18PDH102T	Management Principles for Engineers	2	0	0	2
18PDM201L	Competencies in Social Skills	0	0	2	0
18PDM203L	Entrepreneurial Skill Development				
	Total Learning Credits				23

Semester - IV

Code	Course Title	Hours/ Week L	T	P	C
18CHS252T	Chemical Engineering Principles	3	0	0	3
18BTC105J	Molecular Biology	3	0	2	4
18BTC106J	Immunology	3	0	2	4
18BTC107J	Bioprocess Principles	3	0	2	4
18BTC108J	Plant Biotechnology	3	0	2	4
	Open Elective - I	3	0	0	3
18PDH103T	Social Engineering	2	0	0	2
18PDM202L	Critical and Creative Thinking Skills	0	0	2	0
18PDM204L	Business Basics for Entrepreneurs				
18CYM101T	Environmental Science	1	0	0	0
	Total Learning Credits				24

Semester - V

Code	Course Title	Hours/ Week L	T	P	C
18CHS253L	Chemical Engineering Practice	0	0	4	2
18BTC201J	Gene manipulation and Genomics	3	0	2	4
18BTC202J	Bioprocess Engineering	3	0	2	4
	Professional Elective – 1	3	0	0	3
	Professional Elective – 2	3	0	0	3
	Open Elective – 2	3	0	0	3
	Open Elective – 3	3	0	0	3
18BTP101L	MOOC- 1	0	0	2	1
18BTP102L	Industrial Training-1				
18BTP103L	Seminar - 1				
18PDM301L	Analytical and Logical Thinking Skills	0	0	2	0
18PDM302L	Entrepreneurship Management				
18LEM109T	Indian Traditional Knowledge	1	0	0	0
	Total Learning Credits				23

Semester - VI

Code	Course Title	Hours/ Week L	T	P	C
18MAB303T	Bio-Statistics for Biotechnologists	3	1	0	4
18BTC203J	Animal Biotechnology	3	0	2	4
18BTC204T	Protein engineering and proteomics	3	0	0	3
18BTC350T	Comprehension	0	1	0	1
	Professional Elective – 3	3	0	0	3
	Professional Elective – 4	3	0	0	3
	Open Elective – 4	3	0	0	3
18PDH201T	Employability Skills and Practices	0	0	2	1
18BTP104L	MOOC- 2	0	0	2	1
18BTP105L	Industrial Training-2				
18BTP106L	Seminar - 2				
18LEM110L	Indian Art Form	0	0	2	0
	Total Learning Credits				23

Semester - VII

Code	Course Title	Hours/ Week L	T	P	C
18BTC301J	Bioseparation Technology	3	0	2	4
	Professional Elective – 5	3	0	0	3
	Professional Elective – 6	3	0	0	3
	Open Elective – 5	3	0	0	3
18BTP107L	Minor Project	0	0	6	3
18BTP108L	Internship (4-6 weeks)				
18BTM191T	Bioethics and IPR	1	0	0	0
	Total Learning Credits				16

Semester - VIII

Code	Course Title	Hours/ Week L	T	P	C
18BTP109L	Project	0	0	20	10
18BTP110L	Semester Internship				
	Total Learning Credits				10

5. B.Tech. in Biotechnology with Specialization in Regenerative Medicine

5. (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*

5. (b) Program Educational Objectives (PEO)

PEO - 1	*To provide basic knowledge on biomaterials from the perspective of engineers.*
PEO - 2	*To learn the clinical relevance of stem cells along with biomaterials.*
PEO - 3	*To understand the potency of stem cells towards any cell-specific lineage at the cellular and molecular levels.*
PEO - 4	*To provide knowledge on immunobiology and immune responses related to regeneration and transplants.*
PEO - 5	*To encourage students to think solving the major limitations in the transplantation due to shortage of donors.*

5. (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*
PEO - 4	*H*	*H*	*H*
PEO - 5	*H*	*H*	*H*

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

5. (d) Mapping Program Educational Objectives (PEO) to Program Learning Outcomes (PLO)

	Program Learning Outcomes (PLO)														
	Graduate Attributes (GA)												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	*M*	*M*	*M*	*H*	*H*	*L*	*L*	*H*	*M*	*H*	*L*	*L*	*H*	*H*	*L*
PEO - 2	*M*	*M*	*M*	*H*	*H*	*L*	*L*	*H*	*M*	*H*	*L*	*L*	*H*	*H*	*L*
PEO - 3	*M*	*M*	*M*	*H*	*H*	*L*	*L*	*H*	*M*	*H*	*L*	*L*	*H*	*H*	*L*
PEO - 4	*M*	*M*	*M*	*H*	*H*	*L*	*L*	*H*	*M*	*H*	*L*	*L*	*H*	*H*	*L*
PEO - 5	*M*	*M*	*M*	*H*	*H*	*L*	*L*	*H*	*M*	*H*	*L*	*L*	*H*	*H*	*L*

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

PSO – Program Specific Outcomes (PSO)

PSO - 1	Gain knowledge and get expertise in the field of biomaterials related to tissue engineering
PSO - 2	Understand the significance of stem cells towards tissue engineering and regenerative medicine
PSO - 3	Develop the strategies for solving the problems associated with functional organ development in vivo

5. (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
18LEH101J	English	2	0	2	3
18LEH102J	Chinese	2	0	2	3
18LEH103J	French				
18LEH104J	German				
18LEH105J	Japanese				
18LEH106J	Korean				
18PDH101T	General Aptitude	0	0	2	1
18PDH102T	Management Principles for Engineers	2	0	0	2
18PDH103T	Social Engineering	2	0	0	2
18PDH201T	Employability Skills & Practices	0	0	2	1
Total Learning Credits					**12**

Engineering Science Courses (S)

Course Code	Course Title	Hours/ Week L	T	P	C
18MES101L	Engineering Graphics and Design	1	0	4	3
18MES102J	Basic Civil and Mechanical Engineering	3	1	2	5
18EES102L	Electrical and Electronics Eng. Workshop	1	0	4	3
18CSS101J	Programming for Problem Solving	3	0	4	5
18CHS251T	Basic Chemical Engineering	3	0	0	3
18CHS252T	Chemical Engineering Principles	3	0	0	3
18CHS253L	Chemical Engineering Practice	0	0	4	2
Total Learning Credits					**24**

5. Professional Elective Courses (E)
(Any 6 Courses)

Course Code	Course Title	Hours/ Week L	T	P	C
18BTE411T	Molecular Cell Biology	3	0	0	3
18BTE412T	Cell Communication and Signaling	3	0	0	3
18BTE413T	Stem Cell Technology	3	0	0	3
18BTE414T	Biomaterials in Tissue Engineering	3	0	0	3
18BTE415T	Nanotechnology in Regenerative Medicine	3	0	0	3
18BTE416T	Tissue Engineering for Regenerative Medicine	3	0	0	3
18BTE417T	Bioreactors in Tissue Engineering	3	0	0	3
18BTE418T	Developmental Biology in Tissue Engineering	3	0	0	3
18BTE419T	Advanced Immunology and Vascular Tissue Engineering	3	0	0	3
Total Learning Credits					**18**

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

Code	Course Title	L	T	P	C
18BTP101L	MOOC- 1	0	0	2	1
18BTP102L	Industrial Training-1				
18BTP103L	Seminar - 1				
18BTP104L	MOOC- 2	0	0	2	1
18BTP105L	Industrial Training-2				
18BTP106L	Seminar - 2				
18BTP107L	Minor Project	0	0	6	3
18BTP108L	Internship (4-6 weeks)				
18BTP109L	Project	0	0	20	10
18BTP110L	Semester Internship				
Total Learning Credits					**15**

Basic Science Courses (B)

Course Code	Course Title	Hours/ Week L	T	P	C
18PYB101J	Physics: Electromagnetic Theory, Quantum Mechanics, Waves and Optics	3	1	2	5
18CYB101J	Chemistry	3	1	2	5
18MAB101T	Calculus and Linear Algebra	3	1	0	4
18MAB102T	Advanced Calculus and Complex Analysis	3	1	0	4
18MAB303T	Bio-Statistics for Biotechnologists	3	1	0	4
18BTB103T	Human Physiology and Health	3	0	0	3
Total Learning Credits					**25**

Professional Core Courses (C)

Course Code	Course Title	Hours/ Week L	T	P	C
18BTC101J	Biochemistry	3	0	2	4
18BTC102J	Cell Biology	3	0	2	4
18BTC103J	Microbiology	3	0	2	4
18BTC104T	Genetics and Cytogenetics	3	0	0	3
18BTC105J	Molecular Biology	3	0	2	4
18BTC106J	Immunology	3	0	2	4
18BTC107J	Bioprocess Principles	3	0	2	4
18BTC108J	Plant Biotechnology	3	0	2	4
18BTC201J	Gene manipulation and Genomics	3	0	2	4
18BTC202J	Bioprocess Engineering	3	0	2	4
18BTC203J	Animal Biotechnology	3	0	2	4
18BTC204T	Protein engineering and proteomics	3	0	0	3
18BTC301J	Bioseparation Technology	3	0	2	4
18BTC350T	Comprehension	0	1	0	1
Total Learning Credits					**51**

Open Elective Courses (O)
(Any 5 Courses)

Course Code	Course Title	Hours/ Week L	T	P	C
18BTO101T	Human Health and diseases	3	0	0	3
18BTO102T	Modelling of biomolecules	3	0	0	3
18BTO103T	Activated carbon technology	3	0	0	3
18BTO104T	Defense Forces in our body	3	0	0	3
18BTO105T	Animal Models For Research	3	0	0	3
18BTO106T	Waste to Wealth to Wheels	3	0	0	3
18BTO107T	Fundamental Neurobiology	3	0	0	3
Total Learning Credits					**15**

Mandatory Courses (M)

Code	Course Title	L	T	P	C
18PDM101L	Professional Skills and Practices	0	0	2	0
18PDM201L	Competencies in Social Skills	0	0	2	0
18PDM203L	Entrepreneurial Skill Development				
18PDM202L	Critical and Creative Thinking Skills	0	0	2	0
18PDM204L	Business Basics for Entrepreneurs				
18PDM301L	Analytical and Logical Thinking Skills	0	0	2	0
18PDM302L	Entrepreneurship Management				
18LEM101T	Constitution of India	1	0	0	0
18LEM102J	Value Education	1	0	1	0
18GNM101L	Physical and Mental Health using Yoga	0	0	2	0
18GNM102L	NSS	0	0	2	0
18GNM103L	NCC				
18GNM104L	NSO				
18LEM109T	Indian Traditional Knowledge	1	0	0	0
18LEM110L	Indian Art Form	0	0	2	0
18CYM101T	Environmental Science	1	0	0	0
18BTM191T	Bioethics and IPR	1	0	0	0

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

Course Code	Course Name	Program Learning Outcomes (PLO)														
		Graduate Attributes												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
18BTC101J	*Biochemistry*	*M*	*M*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
18BTC102J	*Cell Biology*	*M*	*M*	*H*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
18BTC103J	*Microbiology*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
18BTC104T	*Genetics and Cytogenetics*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
18BTC105J	*Molecular Biology*	*H*	*H*	*M*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
18BTC106J	*Immunology*	*M*	*H*	*M*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
18BTC107J	*Bioprocess Principles*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
18BTC108J	*Plant Biotechnology*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
18BTC201J	*Gene manipulation and Genomics*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
18BTC202J	*Bioprocess Engineering*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
18BTC203J	*Animal Biotechnology*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
18BTC204T	*Protein engineering and proteomics*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
18BTC301J	*Bioseparation Technology*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
18BTE411T	*Molecular Cell Biology*	*M*	*M*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
18BTE412T	*Cell Communication and Signaling*	*M*	*M*	*H*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
18BTE413T	*Stem Cell Technology*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
18BTE414T	*Biomaterials in Tissue Engineering*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
18BTE415T	*Nanotechnology in Regenerative Medicine*	*H*	*H*	*M*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
18BTE416T	*Tissue Engineering for Regenerative Medicine*	*M*	*H*	*M*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
18BTE417T	*Bioreactors in Tissue Engineering*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
18BTE418T	*Developmental Biology in Tissue Engineering*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
18BTE419T	*Advanced Immunology and Vascular Tissue Engineering*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
18BTP101L	*MOOC- 1*	*H*	*M*	*M*	*M*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*H*	*H*
18BTP102L	*Industrial Training-1*	*H*	*M*	*M*	*M*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*H*	*H*
18BTP103L	*Seminar - 1*	*H*	*M*	*M*	*M*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*H*	*H*
18BTP104L	*MOOC- 2*	*H*	*M*	*M*	*M*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*H*	*H*
18BTP105L	*Industrial Training-2*	*H*	*M*	*M*	*M*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*H*	*H*
18BTP106L	*Seminar - 2*	*H*	*M*	*M*	*M*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*H*	*H*
18BTP107L	*Minor Project*	*H*	*H*	*H*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*M*
18BTP108L	*Internship (4-6 weeks)*	*H*	*H*	*H*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*M*
18BTP109L	*Project*	*H*	*H*	*H*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*M*
18BTP110L	*Semester Internship*	*H*	*H*	*H*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*M*
	Program Average	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*

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

Semester - I

Code	Course Title	Hours/ Week L	T	P	C
18LEH101J	English	2	0	2	3
18MAB101T	Calculus and Linear Algebra	3	1	0	4
18PYB101J	Physics: Electromagnetic Theory, Quantum Mechanics, Waves and Optics	3	1	2	5
18MES101L	Engineering Graphics and Design	1	0	4	3
18MES102J	Basic Civil and Mechanical Engineering	3	1	2	5
18PDM101L	Professional Skills and Practices	0	0	2	0
18LEM101T	Constitution of India	1	0	0	0
18GNM101L	Physical and Mental Health using Yoga	0	0	2	0
	Total Learning Credits				20

Semester - II

Code	Course Title	Hours/ Week L	T	P	C
18LEH10XJ	Chinese / French / German / Japanese/ Korean	2	0	2	3
18MAB102T	Advanced Calculus and Complex Analysis	3	1	0	4
18CYB101J	Chemistry	3	1	2	5
18CSS101J	Programming for Problem Solving	3	0	4	5
18EES102L	Electrical and Electronics Eng. Workshop	1	0	4	3
18PDH101T	General Aptitude	0	0	2	1
18LEM102J	Value Education	1	0	1	0
18GNM102L	NSS	0	0	2	0
18GNM103L	NCC				
18GNM104L	NSO				
	Total Learning Credits				21

Semester - III

Code	Course Title	Hours/ Week L	T	P	C
18BTB103T	Human Physiology and Health	3	0	0	3
18CHS251T	Basic Chemical Engineering	3	0	0	3
18BTC101J	Biochemistry	3	0	2	4
18BTC102J	Cell Biology	3	0	2	4
18BTC103J	Microbiology	3	0	2	4
18BTC104T	Genetics and Cytogenetics	3	0	0	3
18PDH102T	Management Principles for Engineers	2	0	0	2
18PDM201L	Competencies in Social Skills	0	0	2	0
18PDM203L	Entrepreneurial Skill Development				
	Total Learning Credits				23

Semester - IV

Code	Course Title	Hours/ Week L	T	P	C
18CHS252T	Chemical Engineering Principles	3	0	0	3
18BTC105J	Molecular Biology	3	0	2	4
18BTC106J	Immunology	3	0	2	4
18BTC107J	Bioprocess Principles	3	0	2	4
18BTC108J	Plant Biotechnology	3	0	2	4
	Open Elective - I	3	0	0	3
18PDH103T	Social Engineering	2	0	0	2
18PDM202L	Critical and Creative Thinking Skills	0	0	2	0
18PDM204L	Business Basics for Entrepreneurs				
18CYM101T	Environmental Science	1	0	0	0
	Total Learning Credits				24

Semester - V

Code	Course Title	Hours/ Week L	T	P	C
18CHS253L	Chemical Engineering Practice	0	0	4	2
18BTC201J	Gene manipulation and Genomics	3	0	2	4
18BTC202J	Bioprocess Engineering	3	0	2	4
	Professional Elective – 1	3	0	0	3
	Professional Elective – 2	3	0	0	3
	Open Elective – 2	3	0	0	3
	Open Elective – 3	3	0	0	3
18BTP101L	MOOC- 1	0	0	2	1
18BTP102L	Industrial Training-1				
18BTP103L	Seminar - 1				
18PDM301L	Analytical and Logical Thinking Skills	0	0	2	0
18PDM302L	Entrepreneurship Management				
18LEM109T	Indian Traditional Knowledge	1	0	0	0
	Total Learning Credits				23

Semester - VI

Code	Course Title	Hours/ Week L	T	P	C
18MAB303T	Bio-Statistics for Biotechnologists	3	1	0	4
18BTC203J	Animal Biotechnology	3	0	2	4
18BTC204T	Protein engineering and proteomics	3	0	0	3
18BTC350T	Comprehension	0	1	0	1
	Professional Elective – 3	3	0	0	3
	Professional Elective – 4	3	0	0	3
	Open Elective – 4	3	0	0	3
18PDH201T	Employability Skills and Practices	0	0	2	1
18BTP104L	MOOC- 2	0	0	2	1
18BTP105L	Industrial Training-2				
18BTP106L	Seminar - 2				
18LEM110L	Indian Art Form	0	0	2	0
	Total Learning Credits				23

Semester - VII

Code	Course Title	Hours/ Week L	T	P	C
18BTC301J	Bioseparation Technology	3	0	2	4
	Professional Elective – 5	3	0	0	3
	Professional Elective – 6	3	0	0	3
	Open Elective – 5	3	0	0	3
18BTP107L	Minor Project	0	0	6	3
18BTP108L	Internship (4-6 weeks)				
18BTM191T	Bioethics and IPR	1	0	0	0
	Total Learning Credits				16

Semester - VIII

Code	Course Title	Hours/ Week L	T	P	C
18BTP109L	Project	0	0	20	10
18BTP110L	Semester Internship				
	Total Learning Credits				10

6. B.Tech. in Biotechnology with Specialization in Genetic Engineering

6. (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*

6. (b) Program Educational Objectives (PEO)

PEO - 1	*To identify and solve clinical, industrial and agricultural problems through genetic engineering*
PEO - 2	*To gain knowledge in cloning strategies for bacteria, yeast, plants and animals.*
PEO - 3	*To know the economic, environmental, and social implications of genetic engineering research.*

6. (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

6. (d) Mapping Program Educational Objectives (PEO) to Program Learning Outcomes (PLO)

	Program Learning Outcomes (PLO)														
	Graduate Attributes (GA)												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*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*
PEO - 2	*H*	*H*	*H*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*
PEO - 3	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*

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

PSO – Program Specific Outcomes (PSO)

PSO - 1	*Ability to solve scientific problems through genetic approaches.*
PSO - 2	*Ability to implement the knowledge gained in the applied fields of genetic engineering.*
PSO - 3	*Ability to understand social and ethical responsibilities of genetic research.*

6. (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
18LEH101J	English	2	0	2	3
18LEH102J	Chinese				
18LEH103J	French				
18LEH104J	German	2	0	2	3
18LEH105J	Japanese				
18LEH106J	Korean				
18PDH101T	General Aptitude	0	0	2	1
18PDH102T	Management Principles for Engineers	2	0	0	2
18PDH103T	Social Engineering	2	0	0	2
18PDH201T	Employability Skills & Practices	0	0	2	1
Total Learning Credits					**12**

Engineering Science Courses (S)					
Course Code	Course Title	Hours/ Week L	T	P	C
18MES101L	Engineering Graphics and Design	1	0	4	3
18MES102J	Basic Civil and Mechanical Engineering	3	1	2	5
18EES102L	Electrical and Electronics Eng. Workshop	1	0	4	3
18CSS101J	Programming for Problem Solving	3	0	4	5
18CHS251T	Basic Chemical Engineering	3	0	0	3
18CHS252T	Chemical Engineering Principles	3	0	0	3
18CHS253L	Chemical Engineering Practice	0	0	4	2
Total Learning Credits					**24**

5. Professional Elective Courses (E) (Any 6 Courses)					
Course Code	Course Title	Hours/ Week L	T	P	C
18BTE420T	Human Genetics	3	0	0	3
18BTE421T	High Throughput Technologies in advanced biology	3	0	0	3
18BTE422T	Metabolic Engineering of microbes	3	0	0	3
18BTE423T	Genetics of Crop Improvement	3	0	0	3
18BTE424T	Molecular biology of Infectious diseases	3	0	0	3
18BTE425T	Molecular Diagnostics	3	0	0	3
18BTE426T	Gene therapy	3	0	0	3
18BTE427T	Functional genomics	3	0	0	3
18BTE428T	Plant Interactions	3	0	0	3
Total Learning Credits					**18**

7. Project Work, Seminar, Internship In Industry/ Higher Technical Institutions (P)					
Code	Course Title	L	T	P	C
18BTP101L	MOOC- 1				
18BTP102L	Industrial Training-1	0	0	2	1
18BTP103L	Seminar - 1				
18BTP104L	MOOC- 2				
18BTP105L	Industrial Training-2	0	0	2	1
18BTP106L	Seminar - 2				
18BTP107L	Minor Project	0	0	6	3
18BTP108L	Internship (4-6 weeks)				
18BTP109L	Project	0	0	20	10
18BTP110L	Semester Internship				
Total Learning Credits					**15**

Basic Science Courses (B)					
Course Code	Course Title	Hours/ Week L	T	P	C
18PYB101J	Physics: Electromagnetic Theory, Quantum Mechanics, Waves and Optics	3	1	2	5
18CYB101J	Chemistry	3	1	2	5
18MAB101T	Calculus and Linear Algebra	3	1	0	4
18MAB102T	Advanced Calculus and Complex Analysis	3	1	0	4
18MAB303T	Bio-Statistics for Biotechnologists	3	1	0	4
18BTB103T	Human Physiology and Health	3	0	0	3
Total Learning Credits					**25**

Professional Core Courses (C)					
Course Code	Course Title	Hours/ Week L	T	P	C
18BTC101J	Biochemistry	3	0	2	4
18BTC102J	Cell Biology	3	0	2	4
18BTC103J	Microbiology	3	0	2	4
18BTC104T	Genetics and Cytogenetics	3	0	0	3
18BTC105J	Molecular Biology	3	0	2	4
18BTC106J	Immunology	3	0	2	4
18BTC107J	Bioprocess Principles	3	0	2	4
18BTC108J	Plant Biotechnology	3	0	2	4
18BTC201J	Gene manipulation and Genomics	3	0	2	4
18BTC202J	Bioprocess Engineering	3	0	2	4
18BTC203J	Animal Biotechnology	3	0	2	4
18BTC204T	Protein engineering and proteomics	3	0	0	3
18BTC301J	Bioseparation Technology	3	0	2	4
18BTC350T	Comprehension	0	1	0	1
Total Learning Credits					**51**

Open Elective Courses (O) (Any 5 Courses)					
Course Code	Course Title	Hours/ Week L	T	P	C
18BTO101T	Human Health and diseases	3	0	0	3
18BTO102T	Modelling of biomolecules	3	0	0	3
18BTO103T	Activated carbon technology	3	0	0	3
18BTO104T	Defense Forces in our body	3	0	0	3
18BTO105T	Animal Models For Research	3	0	0	3
18BTO106T	Waste to Wealth to Wheels	3	0	0	3
18BTO107T	Fundamental Neurobiology	3	0	0	3
Total Learning Credits					**15**

Mandatory Courses (M)					
Code	Course Title	L	T	P	C
18PDM101L	Professional Skills and Practices	0	0	2	0
18PDM201L	Competencies in Social Skills	0	0	2	0
18PDM203L	Entrepreneurial Skill Development				
18PDM202L	Critical and Creative Thinking Skills	0	0	2	0
18PDM204L	Business Basics for Entrepreneurs				
18PDM301L	Analytical and Logical Thinking Skills	0	0	2	0
18PDM302L	Entrepreneurship Management				
18LEM101T	Constitution of India	1	0	0	0
18LEM102J	Value Education	1	0	1	0
18GNM101L	Physical and Mental Health using Yoga	0	0	2	0
18GNM102L	NSS	0	0	2	0
18GNM103L	NCC				
18GNM104L	NSO				
18LEM109T	Indian Traditional Knowledge	1	0	0	0
18LEM110L	Indian Art Form	0	0	2	0
18CYM101T	Environmental Science	1	0	0	0
18BTM191T	Bioethics and IPR	1	0	0	0

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

Course Code	Course Name	Program Learning Outcomes (PLO)														
		Graduate Attributes												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
18BTC101J	*Biochemistry*	*M*	*M*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
18BTC102J	*Cell Biology*	*M*	*M*	*H*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
18BTC103J	*Microbiology*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
18BTC104T	*Genetics and Cytogenetics*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
18BTC105J	*Molecular Biology*	*H*	*H*	*M*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
18BTC106J	*Immunology*	*M*	*H*	*M*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
18BTC107J	*Bioprocess Principles*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
18BTC108J	*Plant Biotechnology*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
18BTC201J	*Gene manipulation and Genomics*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
18BTC202J	*Bioprocess Engineering*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
18BTC203J	*Animal Biotechnology*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
18BTC204T	*Protein engineering and proteomics*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
18BTC301J	*Bioseparation Technology*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
18BTE420T	*Human Genetics*	*M*	*M*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
18BTE421T	*High Throughput Technologies in advanced biology*	*M*	*M*	*H*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
18BTE422T	*Metabolic Engineering of microbes*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
18BTE423T	*Genetics of Crop Improvement*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
18BTE424T	*Molecular biology of Infectious diseases*	*H*	*H*	*M*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
18BTE425T	*Molecular Diagnostics*	*M*	*H*	*M*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
18BTE426T	*Gene therapy*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
18BTE427T	*Functional genomics*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
18BTE428T	*Plant Interactions*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
18BTP101L	*MOOC- 1*	*H*	*M*	*M*	*M*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*H*	*H*
18BTP102L	*Industrial Training-1*	*H*	*M*	*M*	*M*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*H*	*H*
18BTP103L	*Seminar - 1*	*H*	*M*	*M*	*M*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*H*	*H*
18BTP104L	*MOOC- 2*	*H*	*M*	*M*	*M*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*H*	*H*
18BTP105L	*Industrial Training-2*	*H*	*M*	*M*	*M*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*H*	*H*
18BTP106L	*Seminar - 2*	*H*	*M*	*M*	*M*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*H*	*H*
18BTP107L	*Minor Project*	*H*	*H*	*H*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*M*
18BTP108L	*Internship (4-6 weeks)*	*H*	*H*	*H*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*M*
18BTP109L	*Project*	*H*	*H*	*H*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*M*
18BTP110L	*Semester Internship*	*H*	*H*	*H*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*M*
	Program Average	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*

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

Semester - I

Code	Course Title	Hours/ Week L	T	P	C
18LEH101J	English	2	0	2	3
18MAB101T	Calculus and Linear Algebra	3	1	0	4
18PYB101J	Physics: Electromagnetic Theory, Quantum Mechanics, Waves and Optics	3	1	2	5
18MES101L	Engineering Graphics and Design	1	0	4	3
18MES102J	Basic Civil and Mechanical Engineering	3	1	2	5
18PDM101L	Professional Skills and Practices	0	0	2	0
18LEM101T	Constitution of India	1	0	0	0
18GNM101L	Physical and Mental Health using Yoga	0	0	2	0
	Total Learning Credits				20

Semester - II

Code	Course Title	Hours/ Week L	T	P	C
18LEH10XJ	Chinese / French / German / Japanese/ Korean	2	0	2	3
18MAB102T	Advanced Calculus and Complex Analysis	3	1	0	4
18CYB101J	Chemistry	3	1	2	5
18CSS101J	Programming for Problem Solving	3	0	4	5
18EES102L	Electrical and Electronics Eng. Workshop	1	0	4	3
18PDH101T	General Aptitude	0	0	2	1
18LEM102J	Value Education	1	0	1	0
18GNM102L	NSS	0	0	2	0
18GNM103L	NCC				
18GNM104L	NSO				
	Total Learning Credits				21

Semester - III

Code	Course Title	Hours/ Week L	T	P	C
18BTB103T	Human Physiology and Health	3	0	0	3
18CHS251T	Basic Chemical Engineering	3	0	0	3
18BTC101J	Biochemistry	3	0	2	4
18BTC102J	Cell Biology	3	0	2	4
18BTC103J	Microbiology	3	0	2	4
18BTC104T	Genetics and Cytogenetics	3	0	0	3
18PDH102T	Management Principles for Engineers	2	0	0	2
18PDM201L	Competencies in Social Skills	0	0	2	0
18PDM203L	Entrepreneurial Skill Development				
	Total Learning Credits				23

Semester - IV

Code	Course Title	Hours/ Week L	T	P	C
18CHS252T	Chemical Engineering Principles	3	0	0	3
18BTC105J	Molecular Biology	3	0	2	4
18BTC106J	Immunology	3	0	2	4
18BTC107J	Bioprocess Principles	3	0	2	4
18BTC108J	Plant Biotechnology	3	0	2	4
	Open Elective - I	3	0	0	3
18PDH103T	Social Engineering	2	0	0	2
18PDM202L	Critical and Creative Thinking Skills	0	0	2	0
18PDM204L	Business Basics for Entrepreneurs				
18CYM101T	Environmental Science	1	0	0	0
	Total Learning Credits				24

Semester - V

Code	Course Title	Hours/ Week L	T	P	C
18CHS253L	Chemical Engineering Practice	0	0	4	2
18BTC201J	Gene manipulation and Genomics	3	0	2	4
18BTC202J	Bioprocess Engineering	3	0	2	4
	Professional Elective – 1	3	0	0	3
	Professional Elective – 2	3	0	0	3
	Open Elective – 2	3	0	0	3
	Open Elective – 3	3	0	0	3
18BTP101L	MOOC- 1	0	0	2	1
18BTP102L	Industrial Training-1				
18BTP103L	Seminar - 1				
18PDM301L	Analytical and Logical Thinking Skills	0	0	2	0
18PDM302L	Entrepreneurship Management				
18LEM109T	Indian Traditional Knowledge	1	0	0	0
	Total Learning Credits				23

Semester - VI

Code	Course Title	Hours/ Week L	T	P	C
18MAB303T	Bio-Statistics for Biotechnologists	3	1	0	4
18BTC203J	Animal Biotechnology	3	0	2	4
18BTC204T	Protein engineering and proteomics	3	0	0	3
18BTC350T	Comprehension	0	1	0	1
	Professional Elective – 3	3	0	0	3
	Professional Elective – 4	3	0	0	3
	Open Elective – 4	3	0	0	3
18PDH201T	Employability Skills and Practices	0	0	2	1
18BTP104L	MOOC- 2	0	0	2	1
18BTP105L	Industrial Training-2				
18BTP106L	Seminar - 2				
18LEM110L	Indian Art Form	0	0	2	0
	Total Learning Credits				23

Semester - VII

Code	Course Title	Hours/ Week L	T	P	C
18BTC301J	Bioseparation Technology	3	0	2	4
	Professional Elective – 5	3	0	0	3
	Professional Elective – 6	3	0	0	3
	Open Elective – 5	3	0	0	3
18BTP107L	Minor Project	0	0	6	3
18BTP108L	Internship (4-6 weeks)				
18BTM191T	Bioethics and IPR	1	0	0	0
	Total Learning Credits				16

Semester - VIII

Code	Course Title	Hours/ Week L	T	P	C
18BTP109L	Project	0	0	20	10
18BTP110L	Semester Internship				
	Total Learning Credits				10

ACADEMIC CURRICULA

Basic Science Courses

Regulations - 2018

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

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

Kattankulathur, Kancheepuram, Tamil Nadu, India

Course Code	18BTB101T	Course Name	BIOLOGY	Course Category	B	Basic Sciences	L	T	P	C
							2	0	0	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:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Recall the cell structure and function from its organization			
CLR-2 :	Discuss molecular and biochemical basis of an organism			
CLR-3 :	Compare enzyme reaction and photosynthesis			
CLR-4 :	Explain different types of biosensors			
CLR-5 :	Analyze the different types of bioremediation			
CLR-6 :	Relate the concept of nervous and immune system pertaining to diseases			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	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
CLO-1 :	Describe the cell growth, metabolism and reproduction.	1	80	80	L	H	H	H	-	M	L	H	H	H	-	H	L	H	H
CLO-2 :	Explain the concepts and experiments in biochemistry	2	85	75	M	H	H	M	-	-	M	H	L	H	-	H	L	H	H
CLO-3 :	Recognize the significance of photosynthesis	2	75	80	M	H	M	H	M	M	-	M	H	H	-	H	L	H	H
CLO-4 :	Discuss the different methods in enzyme catalytic functions	2	85	80	L	H	H	H	-	-	H	L	L	H	-	H	M	H	H
CLO-5 :	Analyze the role of biosensors and its applications	3	85	75	L	H	H	M	-	M	H	H	H	L	-	H	H	H	H
CLO-6 :	Explain the concepts of nervous system disorder and the diseases associated with it	2	80	80	M	H	H	H	L	H	M	M	H	H	-	H	H	H	H

Duration (hour)		6	6	6	6	6
S-1	SLO-1	Basics of cell biology: Relevance to Engineers	Biochemistry: Macromolecules, Biodiversity and its importance	Bioenergetics and metabolism	Molecular machines and motors	Nervous system:History of neuroscience
	SLO-2	Cell basic unit of life, Evidence for cell theory	Chemistry of life	Enzymes as biological catalysts, Significance of enzymes	Properties of ATP based protein molecular machines	Glial cells, Neurons
S-2	SLO-1	Cell structure and function	Biochemistry and human biology, DNA replication	Thermodynamics of enzymes	F0F1 ATP synthase motors, Coupling and coordination of motors	Action potential, Organization of nervous system
	SLO-2	Genetic Information, Protein structure	Transcription, Protein synthesis	Factors affecting enzyme activity, Effect of inhibitors on enzyme activity	Bacterial flagellar motor, Cytoskeleton	Central Nervous system, Peripheral nervous system
S-3	SLO-1	Cell metabolism	Eukaryotic and prokaryotic protein synthesis difference	Mechanism of enzyme action	Microtubules	Diseases of nervous system
	SLO-2	Carbohydrate metabolism, Fatty acid metabolism	Concept of genetic code, Stem cells	Enzyme strategies, Restriction enzymes	Microfilaments, Intermediate filaments	Computer- based neural networks
S-4	SLO-1	Homeostasis	Source of stem cells, Classification of stem cells	NMP kinases, Photosynthesis	Kinesin linear motor, Dynein motor	Immune system
	SLO-2	Pathways that alter homeostasis, Cell growth	Human embryonic stem cell, Importance and applications of stem cells	Light reactions, Photosystems	Biosensor	Fluid systems of the body, Innate immune system
S-5	SLO-1	Reproduction	Therapeutic cloning	ATP synthesis in chloroplasts	Resonant biosensors, Glucose biosensors	Cells of innate immune system, Adaptive immunity
	SLO-2	Eukaryotic cell division, Mitosis	Regenerative medicine	Calvin cycle	Bio detectors, Biosensor detection in pollutants	Diseases of immune system, Immune engineering
S-6	SLO-1	Meiosis, Cell differentiation	Bone tissue engineering	Significance of photosynthesis	Bioremediation	Cell signaling
	SLO-2	Neural crest	Gene therapy	Metabolism, Glycolysis	Bioventing and bio augmentation	Cell- surface receptors

Learning Resources	1. *S. Thyagarajan, N.Selvamurugan, R.A.Nazeer et.al., Biology for engineers McGraw Hill Education. 2012*	2. *Norman Lewis, Gabi Nindl Waite, Lee R. Waite et.al., Applied Cell and Molecular Biology for Engineers. McGraw-Hill Education. 2007*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Understand										
Level 2	Apply	*40%*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. C. N. Ramchand, Saksin Life sciences,ramchand@saksinlife.com	*1. Dr. K Subramaniam, IITM Chennai, subbu.iitm.ac.in*	*Dr. S. Thyagarajan, SRMIST*
2. Dr. Karthik Periyasamy, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*2. Dr. R. B. Narayanan, SVCE Chennai, rbn@svce.ac.in*	*Dr.S.Barathi, SRMIST*

Course Code	18BTB103T	Course Name	HUMAN PHYSIOLOGY AND HEALTH	Course Category	B	Basic Sciences	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	18BTC102J -Cell biology, 18BTC106J -Immunology
Course Offering Department	Biotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Devise understanding of human physiological systems for a better comprehension of the problems faced by human			
CLR-2 :	Create an understanding about nervous system that controls and maintains homeostasis			
CLR-3 :	Analyze about circulatory and respiratory system			
CLR-4 :	Analyze about digestive and excretory system			
CLR-5 :	Create an understanding about endocrine and reproductive system			
CLR-6 :	Create an understanding about how human body functions			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	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
CLO-1 :	Describe the structure and function of cell, communication and gene expression and homeostasis	1	80	70	H	H	H	H	-	M	L	H	H	H	-	H	H	H	H
CLO-2 :	Describe the classification of nervous system, function and diseases associated with it	2	80	70	H	H	H	H	-	H	M	H	H	H	-	H	H	H	H
CLO-3 :	Discuss the structure and function of heart, lung, abnormal functioning	2	80	70	M	H	M	H	M	M		M	H	H	-	H	H	H	H
CLO-4 :	Describe anatomy and function of digestive system and urinary system and its disturbances	2	80	70	H	H	H	H	-	L	H	L	H	H	-	H	H	H	H
CLO-5 :	Describe the types of endocrine system, its role in maintaining homeostasis and reproductive biology	2	80	70	H	H	H	H	-	M	H	H	H	L	-	H	H	H	H
CLO-6 :	Explain how human body function and reproduce with maintaining homeostasis	2	80	70	H	H	H	H	L	M	M	M	H	H	-	H	H	H	H

Duration (hour)		6	6	6	6	6
S-1	SLO-1	Cell structure and function	Classification of Nervous System	Heart: Structure, Chambers, valve	Anatomy of Digestive system	Endocrine organs and structure
	SLO-2	Adaptation, Degeneration and aging	Neuron structure and function	Cardiac cycle and Electro cardio gram	Mouth and Salivary glands	Pituitary gland: Parts
S-2	SLO-1	Cell junctions – Gap, Tight and contact	Nerve fibers classification and properties.	chronotropic, ionotropic agents, dromotropic, bathmotropic agents	Stomach: Parts, Structure, Glands, Functions, Properties	Pituitary gland: Regulation, Histology
	SLO-2	Active, Passive transport	Glial cells types, structure and function	Blood vessels – thromboembolism	composition and functions of gastric juice	Pituitary gland: Hormones secreted, functions
S-3	SLO-1	Types of transport	Synapse – Classification	atherosclerosis and arteriosclerosis	Pancreas, Liver	Thyroid gland: Histology and function
	SLO-2	Special type of transport of molecules across biological membranes	Synapse - Anatomy	Septal and valvular defects.	Gall bladder – Role in digestive system	Thyroid gland: Hormones
S-4	SLO-1	Homeostasis– Chemical equilibrium	Synapse - Functions (IPSP and EPSP	Circulation – Systemic and Pulmonary	Small intestine, large intestine	Synthesis of Thyroxine
	SLO-2	Tonicity and osmolality	Synapse - properties	Properties of cardiac muscle: Excitability – electrical potential and action potential	Digestion of Biomolecules	Parathyroid gland structure and function
S-5	SLO-1	control of homeostasis	Neurotransmitters synthesis	Rhythmicity – Natural and artificial pacemakers	Movements of gastrointestinal tracts and disorders	Mode of action and function - disorders
	SLO-2	Role of ions in homeostasis	Neurotransmitters – Types and function	Conductivity, Contractility and Refractory period	Digestion of carbohydrates protein and lipid.	Adrenal gland structure
S-6	SLO-1	Positive feedback regulation of Homeostasis	Action potential	Cardiac cycle and heart sounds and Heart disease	Gastrointestinal hormones	Cortical and medullary - functions
	SLO-2	Negative feedback regulation of Homeostasis	graded potential	Respiratory system: Introduction	Digestive system disorders	Endocrine functions of pancreas

S-7	SLO-1	*Acid-Base Balance: Hydrogen Ion and pH.*	*Brain anatomy and function*	*Types – external and internal respiration*	*Kidney structure and function*	*Insulin and glucagon*
	SLO-2	*Regulation by buffer systems*	*Spinal cord anatomy– Grey and White matter*	*Inspiration and expiration, Anatomy, functional unit*	*nephron structure*	*Diabetes*
S-8	SLO-1	*Acidosis*	*Limbic system: Autonomic Nervous System*	*Non-respiratory functions of respiratory tract*	*Role of hormone in urinary system.*	*Male reproduction organ structure*
	SLO-2	*Alkalosis.*	*Effects on various organ systems.*	*Mechanics of respiration, Pulmonary function tests: Lung volume – Tidal*	*Juxtaglomerular apparatus functions*	*Female reproduction organ structure*
S-9	SLO-1	*Regulation of gene expression*	*Nervous system disease and disorders*	*Inspiratory, Expiratory, Residual volumes; Lung capacities*	*Process of urine formation*	*Oogenesis*
	SLO-2	*Cell signaling and Signal transduction*	*Parkinson's disease,*	*Inspiratory, vital, Functional residual, Total lung capacities.*	*Factors affecting urine formation*	*Spermatogenesis*

Learning Resources	1. *K. Sembulingam, Prema Sembulingam, Essentials of Medical Physiology, Jaypee brothers medical publishers, 7th ed., 2016*	2. *Guyton and Hall, Textbook of Medical Physiology, (Guyton Physiology), Saunders, 13th ed., 2015)*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Understand										
Level 2	Apply	*40%*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. C. N. Ramchand, Saksin Life sciences, ramchand@saksinlife.com	*1. Dr. K Subramaniam, IITM Chennai, subbu.iitm.ac.in*	*Dr. S. Thyagarajan, SRMIST*
2. Dr. Karthik Periyasamy, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*2. Dr. Tamil Selvan, Anna University,Chennai, tamilselvan@annauniv.edu*	*Dr. S. Nageswaran, SRMIST*

ACADEMIC CURRICULA

Open Elective Courses

Regulations - 2018

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

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

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

Kattankulathur, Kancheepuram, Tamil Nadu, India

Course Code	18BTO101T	Course Name	HUMAN HEALTH AND DISEASES	Course Category	O	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:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	State the basic structural organization of human health system			
CLR-2 :	Summarize the etiology of human infectious diseases			
CLR-3 :	Describe immune system of human body and immune disorders			
CLR-4 :	Impart information about genetic disease			
CLR-5 :	Indicate the high risk diseases associated with modern society			
CLR-6 :	State about disease diagnosis and treatment strategies			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	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
CLO-1 :	Recall basic human biology at the genetic, cellular, and physiological levels	2	80	70	-	-	-	L	-	M	-	-	-	H	-	H	-	L	H
CLO-2 :	Interpret how the human body maintains a healthy balance, and how disturbances of this balance underlie diseases	2	85	75	-	-	-	L	-	M	-	-	-	H	-	H	-	L	H
CLO-3 :	Discuss about infectious organism and understand defense mechanism of our human body	2	75	70	-	-	-	L	-	M	-	-	-	H	-	H	-	L	H
CLO-4 :	Describe disease causing agents	2	85	80	-	-	-	L	-	M	-	-	-	H	-	H	-	L	H
CLO-5 :	Familiarize with modern biomedical scientific approaches to treat disease.	2	85	75	-	-		L	-	M	-	M	-	H	-	H	H	H	H
CLO-6 :	Demonstrates the importance of taking responsibility for one's own health	2	80	70	-	-	-	L	-	M	-	H	-	H	-	H	-	H	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	Introduction to human heath	Concepts of human disease	Immune system	Mendelian genetics	Disease Diagnosis
	SLO-2	Anatomy and physiology	Disease Disorder and syndrome	Physical chemical and cellular barrier	Genetics of simple and complex traits	Treatment strategy
S-2	SLO-1	Respiratory system	Pathology of disease	Types of Immune cell	Hereditary disease	Biomedical Instruments
	SLO-2	Circulatory system	Mechanism of disease	Humoral and cell mediated immunity	Karyotype preparation and analysis Chromosome abnormality	Biosensors
S-3	SLO-1	Digestive system	Infectious disease	Cells Involved in inflammation	Thalassemia	Drug designing and development
	SLO-2	Execratory system	Causative agents Bacteria, virus and parasites	Inflammatory Process	Cystic fibrosis	Computer aided drug designing
S-4	SLO-1	Reproductive system	Bacteria: Introduction Pathogenesis	Immune disorders	Duchene Muscular dystrophy	Drug metabolism
	SLO-2	Fertilization and embryogenesis	Bacterial toxins	Abscesses, ulcer, cellulitis And Allergy	Sickle cell anemia	ADME property of a drug
S-5	SLO-1	Cell structure	virulence of bacterial infection	Autoimmunity	Indian genetic disease database	Sources of drug- plants and microbes
	SLO-2	Tissue types	Antibiotic resistance strains	Immunodeficiency	Human gene mutation database	Route of administration
S-6	SLO-1	How body gets energy	Virus: An overview of replication cycle of virus	High risk disease of modern society	Principle class of metabolic disorders	Bulk Drugs and processing
	SLO-2	ATP Synthesis	Effect of virus infection in the host cell	Obesity, Hypertension and diabetics	Inherited Metabolic disorders	Active pharmaceutical ingredient

S-7	SLO-1	*Cell metabolism*	*Epidemiology*	*Neoplasm*	*Metabolic syndrome*	*Vaccines types, Recommendation by age*
	SLO-2	*Cell cycle*	*Roots of spreading, Emerging and reemerging virus*	*Oncogenes and tumor suppressor genes*	*Risk factors*	*Vaccines – Recent advancement*
S-8	SLO-1	*Checkpoints in cell division*	*Parasitosis, common parasites of human*	*Types of cancer*	*Lysozyme storage disease: Molecular basis*	*Immunotherapy*
	SLO-2	*Cell division -Mitosis and Meiosis*	*Plasmodium – life cycle and disease*	*Stages of cancer*	*List of proteins involved in LSD*	*Immunotherapeutic approaches currently in use*
S-9	SLO-1	*Growth factors- overview*	*Fungal Infections*	*Cancer in future*	*Balanced nutrition and Malnutrition*	*Stem cell therapy*
	SLO-2	*Types and function*	*Endemic mycoses in immunocompromised patients*	*Life style and cancer risk*	*Deficiency disease*	*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*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. C. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	*1. Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in*	*1. Dr. Lilly M Saleena, SRMIST*
2. Dr. Karthik Periyasamy, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*2. Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	*2. Dr.Priya Swaminathan, SRMIST*

Course Code	18BTO102T	Course Name	MODELLING OF BIOMOLECULES	Course Category	O	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:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	State the basic structural organization of human health system			
CLR-2 :	Summarize the etiology of human infectious diseases			
CLR-3 :	Describe immune system of human body and immune disorders			
CLR-4 :	Impart information about genetic disease			
CLR-5 :	Indicate the high risk diseases associated with modern society			
CLR-6 :	State about disease diagnosis and treatment strategies			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	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
CLO-1 :	Recall basic human biology at the genetic, cellular, and physiological levels	2	80	70	-	-	-	L	-	M	-	-	-	H	-	H	-	L	H
CLO-2 :	Interpret how the human body maintains a healthy balance, and how disturbances of this balance underlie diseases	2	85	75	-	-	-	L	-	M	-	-	-	H	-	H	-	L	H
CLO-3 :	Discuss about infectious organism and understand defense mechanism of our human body	2	75	70	-	-	-	L	-	M	-	-	-	H	-	H	-	L	H
CLO-4 :	Describe disease causing agents	2	85	80	-	-	-	L	-	M	-	-	-	H	-	H	-	L	H
CLO-5 :	Familiarize with modern biomedical scientific approaches to treat disease.	2	85	75	-	-		L	-	M	-	M	-	H	-	H	H	H	H
CLO-6 :	Demonstrates the importance of taking responsibility for one's own health	2	80	70	-	-	-	L	-	M	-	H	-	H	-	H	-	H	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	Introduction to human heath	Concepts of human disease	Immune system	Mendelian genetics	Disease Diagnosis
	SLO-2	Anatomy and physiology	Disease Disorder and syndrome	Physical chemical and cellular barrier	Genetics of simple and complex traits	Treatment strategy
S-2	SLO-1	Respiratory system	Pathology of disease	Types of Immune cell	Hereditary disease	Biomedical Instruments
	SLO-2	Circulatory system	Mechanism of disease	Humoral and cell mediated immunity	Karyotype preparation and analysis Chromosome abnormality	Biosensors
S-3	SLO-1	Digestive system	Infectious disease	Cells Involved in inflammation	Thalassemia	Drug designing and development
	SLO-2	Execratory system	Causative agents Bacteria, virus and parasites	Inflammatory Process	Cystic fibrosis	Computer aided drug designing
S-4	SLO-1	Reproductive system	Bacteria: Introduction Pathogenesis	Immune disorders	Duchene Muscular dystrophy	Drug metabolism
	SLO-2	Fertilization and embryogenesis	Bacterial toxins	Abscesses, ulcer, cellulitis And Allergy	Sickle cell anemia	ADME property of a drug
S-5	SLO-1	Cell structure	virulence of bacterial infection	Autoimmunity	Indian genetic disease database	Sources of drug- plants and microbes
	SLO-2	Tissue types	Antibiotic resistance strains	Immunodeficiency	Human gene mutation database	Route of administration
S-6	SLO-1	How body gets energy	Virus: An overview of replication cycle of virus	High risk disease of modern society	Principle class of metabolic disorders	Bulk Drugs and processing
	SLO-2	ATP Synthesis	Effect of virus infection in the host cell	Obesity, Hypertension and diabetics	Inherited Metabolic disorders	Active pharmaceutical ingredient

S-7	SLO-1	*Cell metabolism*	*Epidemiology*	*Neoplasm*	*Metabolic syndrome*	*Vaccines types, Recommendation by age*
	SLO-2	*Cell cycle*	*Roots of spreading, Emerging and reemerging virus*	*Oncogenes and tumor suppressor genes*	*Risk factors*	*Vaccines – Recent advancement*
S-8	SLO-1	*Checkpoints in cell division*	*Parasitosis, common parasites of human*	*Types of cancer*	*Lysozyme storage disease: Molecular basis*	*Immunotherapy*
	SLO-2	*Cell division -Mitosis and Meiosis*	*Plasmodium – life cycle and disease*	*Stages of cancer*	*List of proteins involved in LSD*	*Immunotherapeutic approaches currently in use*
S-9	SLO-1	*Growth factors- overview*	*Fungal Infections*	*Cancer in future*	*Balanced nutrition and Malnutrition*	*Stem cell therapy*
	SLO-2	*Types and function*	*Endemic mycoses in immunocompromised patients*	*Life style and cancer risk*	*Deficiency disease*	*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*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. C. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	*1. Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in*	*1. Dr. Lilly M Saleena, SRMIST*
2. Dr. Karthik Periyasamy, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*2. Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	*2. Dr.Priya Swaminathan, SRMIST*

Course Code	18BTO103T	Course Name	ACTIVATED CARBON TECHNOLOGY	Course Category	O	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 :	State a basic understanding of activated carbon and its industrial applications.
CLR-2 :	Demonstrate the preparation of the material from different sources of waste
CLR-3 :	Apply the engineering aspects of the adsorbents
CLR-4 :	Prepare the adsorbents for the waste water treatment plants
CLR-5 :	Analyze the problems of the industrial effluents that are hazardous to the environment
CLR-6 :	Apply a solution to solve the industrial effluent problems

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	Discuss about the activated carbon from different sources and subsequent knowledge to apply industrially	1	80	80
CLO-2 :	Prepare the activated carbon from different sources	2	85	75
CLO-3 :	Explain the kinetics on the adsorption of heavy metals, dyes and toxic substances	2	75	80
CLO-4 :	Evaluate mechanism of activated carbon that is ultimately responsible for removing the toxic substance from the effluent	2	85	80
CLO-5 :	Design an alternative adsorption process and present the solution to adsorption problems.	3	85	75
CLO-6 :	Formulate the activated carbon for better environment	2	80	80

Program Learning Outcomes (PLO)														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
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
H	H	H	H	-	M	L	H	H	H	H	H	H	H	H
H	H	H	H	-	-	M	H	H	H	H	H	H	H	H
M	H	M	H	M	M	-	M	H	H	H	H	H	H	H
H	H	H	H	-	-	H	L	H	H	H	H	H	H	H
H	H	H	H	-	M	H	H	H	L	H	H	H	H	H
H	H	H	H	L	M	M	M	H	H	H	H	H	H	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	Activated Carbon and Its Surface Structure	Principle of Adsorption Kinetics	Activated adsorption from solutions	Principle of AAS and its applications	Application of activated adsorption technology in the waste water treatment
	SLO-2	Basics of activated carbon	Effect of contact time on the adsorption characteristics	Types of isotherms for solution phase	AAS analysis of dyes adsorption by activated carbon	Application of Activated Carbon in Environmental Pollution
S-2	SLO-1	Historical Perspective ofActivated Carbon Adsorption and its Integration with Biological Processes	Effect of pH on the adsorption characteristics	Types of adsorption isotherm sorbent selection	Characterizing the pore structure of the carbon by SEM	Integration of Activated Carbon Adsorption with Biological Processes in Wastewater and Water Treatment
	SLO-2	Activated carbon-crystalline structure, porous structure and chemical structure	Effect of agitation and adsorbent dosage on the adsorption characteristics e	Regeneration of activated carbon	Proximate analysis of activated carbon prepared from various raw materials	Industrial waste water treatment using natural material as an adsorbent
S-3	SLO-1	Types of materials from different sources	Thermodynamic parameters like change in free energy, enthalpy and entropy for the process of removal	Batch adsorption kinetics	Principles of FTIR analysis for the prepared activated carbon	AC on the removal of hazardous organic and inorganic compounds from industrial waste water
	SLO-2	Preparation of granulated and powder activated carbon	Contact Oxidation Process Followed by Activated Carbon	Factors influencing adsorption from binary solution	X-ray refractive diffraction (XRD) studies for activated carbon	AC on the removal of hazardous gases and vapors from industrial flue gases
S-4	SLO-1	Influence of carbon-oxygen surface groups of adsorption properties	Models, and types of adsorption	Transport processes in adsorption from liquid phase on activated carbon	X-ray photoelectron spectroscopy (XPS) studies for activated carbon	Application of activated adsorption technology in pharmaceutical industries
	SLO-2	Influence of other surface groups of adsorption properties	Influencing factors for adsorption properties	Capillary transport in adsorption from liquid phase on activated carbon	Interpretation of results	Application of activated adsorption technology in leather industries
S-5	SLO-1	Chemical activation using acids	Influencing factors for the Adsorption equilibrium	Adsorption behaviour of Low-Bio-degradable Organics on Activated Carbon Surfaces	X-ray absorption spectroscopy (XAS) studies for activated carbon	Application of activated adsorption technology in food industries
	SLO-2	Chemical activation using alkalis	Development of adsorption isotherms	Adsorption behaviour of Non-Bio-degradable Organics on Activated Carbon Surfaces	Interpretation of analysis	Application of activated adsorption technology in paint industries

S-6	SLO-1	*Preparation of carbon from agricultural wastes*	*Linear, Freundlich, Langmuir adsorption isotherms*	*Design for packed columns*	*BET Principle and analysis*	*Adsorption for Textile Wastewater Treatment*
	SLO-2	*Preparation of activated carbon from agricultural waste using chemical agents*	*Temkin and Dubinin–Radushkevich isotherm models*	*Process design factors of fixed-bed adsorption columns*	*Interpretation of BET analysis*	*Improved Control of Pollutants through Integrated Adsorption and Biological Treatment*
S-7	SLO-1	*Preparation of activated carbon from lower cost materials*	*Adsorption Equilibria of the Light Hydrocarbon Gases on the Activated Carbon and Silica Gel*	*Phenol wastewater treatment by a two-step adsorption–oxidation process on activated carbon*	*Analysis and design of GAC and PAC Contactors*	*Application of activated adsorption technology in plating industries*
	SLO-2	*Effect of activating agents*	*Adsorption Equilibria of the heavy Hydrocarbon Gases on the Activated Carbon and Silica Gel*	*Hydrocarbon wastewater treatment process on activated carbon*	*Interpretation of results*	*Application of activated adsorption technology in dye industries*
S-8	SLO-1	*Activated carbon from e-waste such as PCB, Metallic and non-metallic components*	*Simulated Binary Isothermal Adsorption on Activated Carbon in Periodic Countercurrent Column Operation*	*Scale-up laboratory adsorption column*	*Thermal analysis of prepared activated carbon*	*Application of activated adsorption technology in drug industries*
	SLO-2	*Using physical and chemical methods for the preparation of AC from e waste*	*Solving problems*	*Criteria for scale up*	*Interpretation of results*	*Application of activated adsorption technology in brewing industries*
S-9	SLO-1	*pH, solubility and Iodine number of activated carbon*	*A Liquid-Phase Adsorption and rate of diffusion of phenol from aqueous solution into Activated Carbon*	*Adsorption of phenols onto granular activated carbon in a liquid–solid fluidized bed*	*Differential Scanning Calorimetry for the analysis of activated carbon*	*Adsorption of Normal Paraffins and Sulfur Compounds on Activated Carbon*
	SLO-2	*Different types of carbon Nano-materials: CNT, CNF, CNB, their structure*	*Solving problems*	*Desorption of phenols onto granular activated carbon in a liquid–solid fluidized bed*	*Interpretation of results*	*Application of activated adsorption technology in dairy industries*

Learning Resources	1. *Bansal, R.C. and M. Goyal, Activated Carbon Adsorption, Boca Raton, FL: CRC Press, 2013* 2. *Harry Marsh Francisco Rodríguez Reinoso, Activated Carbon, I Edition, Elsevier Science, June 2006* 3. *Douglas M. Ruthven, Principles of Adsorption and Adsorption Processes, Wiley, 1984*	4. *Jean Rouquerol, Francoise Rouquerol, Kenneth S.W.Sing, Adsorption by Powders and Porous Solids: Principles, Methodology and Applications, Academic Press, 1998* 5. *Richard I. Masel, Principles of Adsorption and Reaction on Solid Surfaces, Wiley, 1996*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Prabhakaran M, CK & Industries, ck_prabhu@yahoo.co.in	*1. Dr. Swarna V Kanth, CLRI, Anna University, chord@clri.res.in*	*1. Dr. M. Pandimadevi, SRMIST*
2. Mr.Vinod Kanth, Consultant,svkuvk71@yahoo.com	*2. Dr. R. Aravindan, CLRI, Anna Universwity, aravindhan@clri.res.in*	*2. Dr. B.Samuel Jacob, SRMIST*

Course Code	18BTO104T	Course Name	DEFENCE FORCES IN OUR BODY	Course Category	O	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:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Analyze the various components of the immune system			
CLR-2 :	Discuss the innate immune cells and their role in fighting against pathogens			
CLR-3 :	Demonstrate the adoptive immune system and their function			
CLR-4 :	Illustrate the methods and techniques used in immunology			
CLR-5 :	Discuss how the human body respond to pathogens			
CLR-6 :	Apply immunotherapy			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	Explain about the basic concept of immune system	1	80	80
CLO-2 :	Describe the different type of immune cells and organs	2	85	75
CLO-3 :	Analyse how the body respond to pathogens	2	75	80
CLO-4 :	Discuss about the immunotechniques used to assess immune functions	2	85	80
CLO-5 :	Evaluate immunity to infections	2	85	75
CLO-6 :	Describe immunotherapy	2	80	80

Program Learning Outcomes (PLO)														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
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
H	H	H	H		M	L	H	H	H	H	H	H	H	H
H	H	H	H			M	H	H	H	H	H	H	H	H
M	H	M	H	M	M		M	H	H	H	H	H	H	H
H	H	H	H			H	L	H	H	H	H	H	H	H
H	H	H	H		M	H	H	H	L	H	H	H	H	H
H	H	H	H	L	M	M	M	H	H	H	H	H	H	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	Introduction to the immune system	Introduction to innate immune system	Introduction to adaptive immune system	Antigen –antibody interaction	What is an infection?
	SLO-2	History of modern immunology	Components of the innate immune system	Components of the adaptive immune system	Forces in antigen-antibody interaction	Human infectious agents
S-2	SLO-1	What is immunity?	Anatomical barriers- Chemical and mechanical	Types of adaptive response	Affinity and avidity	Bacterial diseases
	SLO-2	Concept of self and non-self	Anatomical barriers- Biological	Innate versus adaptive immune response	Cross-reactivity and specificity	Immunity to bacteria
S-3	SLO-1	Primary lymphoid organ Blood marrow	Humoral components-complements	Antibody mediated immune response	Antibody as Immunoassays	Viral diseases
	SLO-2	Primary lymphoid organ Thymus	Humoral components-coagulation factors	What are antibodies and antigens?	Agglutination	Immunity to viruses
S-4	SLO-1	Hematopoietic stem cell	Cytokines	Immunoglobulin structure	Blood typing	Fungi and human diseases
	SLO-2	Development of blood cell lineage	Properties and functions of cytokines	Role of antibodies	Immuno electrophoresis	Immunity to fungi
S-5	SLO-1	Red blood cells and platelets	Phagocytosis and macrophages	Effect of antigen-antibody binding	Principle of ELISA Clinical utility	Protozoan and worms
	SLO-2	White Blood cells	Neutrophil granules and killing	Types of antibodies	Types of ELISA	Immunity to protozoan
S-6	SLO-1	The myeloid cells- granulocytic	NK cell cytotoxicity	Cell mediated immunity- T cells	Western Blot and confirmation	Vaccination-how does it work?
	SLO-2	The myeloid cells- monocytic	Dendritic cells and its action	Different types of T cells and their functions	ELISPOT- detection of virus	Different types of vaccination

S-7	SLO-1	*The lymphoid cells- T and B cells*	*Pathogen recognition*	*T cell receptor*	*Tissue sectioning*	*Immunodeficiency*
	SLO-2	*The lymphoid cells- NK cells*	*Innate immune receptors*	*How does a T cell recognize antigen?*	*Immunohistochemistry*	*Autoimmune diseases*
S-8	SLO-1	*Secondary lymphoid organs-Spleen*	*Inflammation and its process*	*Antigen presenting cells*	*Fluorescence and its utility in immunoassays*	*Introduction to cancer*
	SLO-2	*Secondary lymphoid organs-Lymph nodes*	*Signs of inflammation*	*Interaction of APC with the T cells*	*Flow cytometry*	*Immunity to cancer*
S-9	SLO-1	*The lymph*	*Mechanism of inflammation*	*Clonal selection*	*Isolation of immune cells*	*Strategies of cancer treatment*
	SLO-2	*The lymphatic system*	*Role of inflammation in diseases*	*Primary and secondary immune response*	*Activation of immune cells*	*Immunotherapy*

Learning Resources	1. *A.K. Chakravarty, Immunology and Immunotechnology,Oxford University Press, 2006* 2. *Peter Wood, Understanding Immunology,2nd ed., Pearson Education, 2006*	3. *Sudha Gangal, Shubhangi Sontakke, Textbook of basic and clinical immunology, Universities Press, 2013* 4. *Richard Coico, Geoffrey Sunshine, Immunology: A short course, 6th ed., Wiley-Blackwell, 2009*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. C. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	*1. Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in*	*1. Dr. E.Berla Thangam, SRMIST*
2. Dr. Karthik Periyasamy, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*2. Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	*2. Dr.Oindrilla.M, SRMIST*

Course Code	18BTO105T	Course Name	ANIMAL MODELS FOR RESEARCH	Course Category	O	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 :	Learn the basics of animal experiments
CLR-2 :	Apply the concept of living model organism and selection of appropriate model
CLR-3 :	Use of various animal models available
CLR-4 :	Analyze the different alternatives and ethical issues
CLR-5 :	Use pilot experiments to evaluate their working/living environment
CLR-6 :	Analyze animal experiment data and correlate with human case reports

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	Describe about the fundamentals of animal experiments	1	85	80
CLO-2 :	Recognize the similarities between anima models and humans	2	85	70
CLO-3 :	Discuss the knowledge on different animal models available	2	80	75
CLO-4 :	Explain the functions that can be studied in animal models	2	75	80
CLO-5 :	Analyze the animal alternatives and ethical issues	3	85	75
CLO-6 :	Interpret pilot experiments to study animal model experiment	3	80	80

Program Learning Outcomes (PLO)															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
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	
L	M	H	H	H	L	M	H		M	H	H	H	H	H	
M	M	H	H	H	M	M	H		M	H	H	M	L	M	
M	H	M	H	H	L	L	H		L	H	H	H	M	L	
M	H	H	H	H		H	H		L	H	H	M	M	M	
H	M	H	H	H		H	H	L	H	H	H	H	L	M	
H	H	H	H	H	M	M	M	L	H	H	H	H	M	H	

Duration (hour)		9	9	9	9	9
S-1	SLO-1	Introduction to biology of animals	Selection of animal models	Transgenesis and transgenic animal models	Drugs and compound administration	Animals in laboratory environment
	SLO-2	Structure and organs	Mammals, bovine, aquatic, insect	Knockout, Knockin, Mutation models	Need for animal models to test new compounds prior clinical study	Light cycle, temperature and humidity
S-2	SLO-1	Classification of animals	Mammal biology – life cycle	CRISPR cas 9	Oral administration	Pathogen free environment lab
	SLO-2	Vertebrate and Invertebrate	Rats, mice, sheep and bovine	UAS gal 4 systems	Nasal dosage	Precautions and protective gear to be followed by researchers
S-3	SLO-1	Human evolution	Rats – types of rats	Animal models for cataracts and retinitis pigmentosa	Inhalation	Housing and Animal husbandry
	SLO-2	Darwinism theory	Genetic background among different sub species	Animal models for Atherosclerosis and myocardial infarction	Inhalation related experiment animal models	Animal husbandry training
S-4	SLO-1	Human diseases	Mice – types of mice	Animal models for cardiac and cardiovascular disease	Inhalation related experiment animal models and issues that can be replicated	3 R`s and Alternative for animal models
	SLO-2	Need for animal models	Genetic background among different sub species	Animal models for metabolic syndrome	Invasive administrations – intravenous	Tissue culture – cell lines
S-5	SLO-1	Experimental animal models	Sheep and cow as animal models	Animal models for diabetes and obesity	Invasive administrations – intravenous and intra-peritoneal	Primary tissue culture
	SLO-2	Monkey, rat, rabbit - living animals models	Disease research on sheep and cow	Animal models for liver diseases	Invasive administrations – intraocular	3D cell culture reconstructing and replacing organs
S-6	SLO-1	Chicken, pig tissues – non living animal models	Aquatic animals models	Animal models for skin disorders and regeneration	Invasive administrations – intraocular and intramuscular	Limitation and ethical issues in research on humans
	SLO-2	Pig heart as cardiovascular model	Life cycle of zebra fish and Japanese rice fish and research	Animal models for stroke, olfactory and neuromuscular dysfunction	Invasive administrations – Subcutaneous	Lower order animal models

S-7	SLO-1	*Classical animal models used – squid*	*Hydra as an aquatic animal model*	*Animal models for schizophrenia*	*Invasive administrations – Subcutaneous*	*Ethical issues in using humans samples*
	SLO-2	*Nervous system in squid and early evidences*	*Life cycle and environmental toxin researches*	*Animal models for Alzheimer`s and Huntington disease*	*Non invasive drug administration*	*Ethical issues in using experiments animals*
S-8	SLO-1	*Classical animal models used – cats*	*Non vertebrate insect models – Drosophila and C. elegans*	*Animal models for Parkinson and multiple sclerosis.*	*Skin adsorption*	*Computer science – simulations and animal models*
	SLO-2	*Visuals tracks in cats and early evidences*	*Life cycle of C. elegans and research*	*Animal models for Mood disorders*	*Selecting appropriate drug administration route*	*Heart diseases and simulation*
S-9	SLO-1	*Classical animal models – primates*	*Life cycle of Drosophila as evolution models*	*Animal disorder for mania*	*Understand route of exposure in toxicity cases*	*Computational models*
	SLO-2	*Behavioral assays in primates.*	*Drosophila genetics*	*Animal disorder for stress coping and resilience.*	*Human-animal equivalent dose calculation and problems*	*Computational models to repalce animal cognition*

Learning Resources	1. *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*	2. *Micheal Conn P, Animal Models for the Study of Human Disease,2nd ed., Academic Press, 2017* 3. *Jerome Y Yager, Animal Models of Neuro-developmental Disorders, Human Press, 2015*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Dr. Karthik Periyasamy, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*2. Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	*2. Dr.R.A. Nazeer, SRMIST*

Course Code	18BTO106T	Course Name	WASTE TO WEALTH TO WHEELS	Course Category	O	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:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Identify the applications of engineering concepts for sustainable waste management			
CLR-2 :	Identify the applications of energy conversion technology			
CLR-3 :	Identify the significance of eco-friendly process			
CLR-4 :	Create insights to the concepts of zero-waste process			
CLR-5 :	Analyze the important fuel properties of wastes and biomass			
CLR-6 :	Utilize the concepts basic engineering calculations (mass and heat balances) for biomass based energy systems			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	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
CLO-1 :	Formulate the methodology for waste segregation based on international policy	1	80	70	H	H	M	M	M	H	H	H	M	H	M	H	M	H	H
CLO-2 :	Analyze calorific parameters of wastes and biomass	2	85	75	H	M	M	M	M	H	H	H	M	L	H	H	M	H	H
CLO-3 :	Apply thermo-chemical conversion process for waste to energy conversion	2	75	70	H	H	M	M	M	H	H	H	H	M	H	H	H	M	H
CLO-4 :	Apply bioprocessing techniques to convert waste to biofuel and value added chemicals	2	85	80	H	H	M	M	M	H	H	H	H	M	H	H	H	H	H
CLO-5 :	Identify the applications of mass and energy balance for making commercially viable Waste to wealth process	2	85	75	H	H	M	M	M	H	H	H	M	H	M	H	H	H	H
CLO-6 :	Describe the National policy towards biofuel production and Energy security	1	80	70	H	M	M	M	M	H	H	H	M	H	M	H	H	M	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	Sources of industrial wastes	Thermal processing of wastes: Combustion, Co-generation/co-firing	Catalytic depolymerization of biomass-derived oxygenated feedstocks	Treatment based on aerobic and anaerobic waste bioprocessing	Energy content estimation of wastes and products by bomb (solid and liquid)(ASTM)
	SLO-2	Sources of agro and MSW wastes	Pyrolysis and torrefecation	Biosynthetic pathway for lignin synthesis	Vermi-composting of solid wastes for bio-fertilizer; Vermi-wash	For gaseous fuel (ASTM)
S-2	SLO-1	Impact of wastes on biodiversity	Hydrolysis and plasma treatment for waste to energy conversion	Hydrolysis of cellulose from lignocellulosic wastes over novel solid acids	Production of hydrocarbons (bioalkanes) from lignocelluloses	Process calculations for energy and mass balance of waste and by product recovery
	SLO-2	Effect on food chain/food web	Catalytic conversion process	Inhibitory compounds of lignin degradation that impedes bioprocessing	Quality comparison between conventional and bio-based chemicals	Software hands on training for mass and energy balance
S-3	SLO-1	Waste segregation methodologies	Syngas production	Synthesis of polyols by hydrogenation / hydrogenolysis of cellulose and sugar	Production of biodiesel (Oil seeds/Algae)	Case : non-conventional transportation fuels and their manufacturers obtained by processing of wastes
	SLO-2	Hazardous and non-hazardous wastes	Flue gas filters and value addition from particulate matter	Role of green solvents and ionic liquids in fuel production	Whole crop biorefinery approach	Municipal leachate processing and value product development
S-4	SLO-1	Recalcitrant and non-recalcitrant wastes	Waste heat recovery	Hybrid energy system using biological routes	Oleagenous organisms (Fungi and yeast)	Management of post-energy recovery residues (bottom ash, fly ash, digestate)
	SLO-2	Xenobiotics and Rationale for bioprocessing	Hydrothermal electricity production	Clean coal technologies bioleaching and biosorption	Enzymatic transesterification Vs. Chemical methods	Bioenergy-Biochar energy cycle
S-5	SLO-1	Waste characterization	Bio refinery demonstration projects on ethanol	Unified oils and biodiesel from oil seeds and algae by chemical catalysis	Biobutanol, ABE synthesis, bioalkanes	R& D scope in WWW Gas to liquids (GTL) technology
	SLO-2	Calorific value estimation: Bomb and Junker's calorimeter	Case study on India's potential on second generation bioethanol	Case study on India's potential on second generation biodiesel from Jatropha	Biopolymers and plastics (PHA, PHB and PLA)	CO_2 sequestration by biological modes
S-6	SLO-1	Point source collection and non-point source wastes collection	Distillation technology for bioethanol	Fischer–Tropsch process – Gas to liquid fuels	Gaseous fuels: Biomethane	Landill fill emission control
	SLO-2	Role of smart dustbins	Adsorption technology for ethanol fractionation	Comparison of fuel quality standards from FT and fossil fuel	Energy conversion strategies from biogas	Land fill and flue gas recovery for its commercial application

S-7	SLO-1	*Energy crops – Terrestrial*	*Bio refinery demonstration projects on Biodiesel*	*3rd generation biofuel: For transportation*	*Biohydrogen and Gas to liquid fuel technologies*	*Current and Emerging Challenges to Renewable Energy Development*
	SLO-2	*Energy crops – Aquatic*	*Case study of implementation of Biodiesel project by Indian Railways*	*3rd generation biofuel: For value added hydrocarbons*	*ABE biosynthesis (Acetone Butanol and Ethanol)*	*Government policies for energy security*
S-8	SLO-1	*Potential Benefits of Replacing Fossil Fuels with Biofuel, Biomass and Biogas*	*Transesterification and distillation*	*Genetically modified (GM) organisms for improved fuel production*	*Metabolic pathway engineering for ABE biosynthesis*	*Community Participation in Renewable Energy Development*
	SLO-2	*Implication of fossil fuel on National economy, environment and energy security*	*Refining technologies for biodisesel*	*GM bioenergy crops and its implication for developing countries*	*Aircraft liquid biofuel from biomass feedstocks*	*Contract farming strategy for non-edible feedstock production*
S-9	SLO-1	*Political Drivers for Biofuel Development*	*By product processing of biodiesel production*	*Algal based technologies for biofuel and value added chemical preparation*	*Bio-alkanes and alkenes from waste biomass to be used as jet engines fuels*	*Combined industrial waste treatment for energy recovery*
	SLO-2	*Activities of MNRE, Government of India and International Energy Agency*	*Conversion of de-oiled cake into value added products*	*GM algae and its regulatory issues*	*New energy research Projects pertaining to transportation fuels in Global context*	*Urban and rural integration system for sustainable waste utilization for value added product generation*

Learning Resources	1. *David M. Mousdale, Biofuels: Biotechnology, Chemistry, and Sustainable Development, CRC Press, 2008* 2. *Roland A. Jansen, Second Generation Biofuels and Biomass, Wiley, 2013*	3. *A.H.Scragg, Biofuels, Production, Application and Development, CAB International, 2009* 4. *Robert C. Brown, Tristan R.Brown, Biorenewable Resources: Engineering New Products from Agriculture, 2nd ed., Wiley, 2014*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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2. Dr. Karthik Periyasamy, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*2. Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	*2. Dr. K.Ramani, SRMIST*

Course Code	18BTO107T	Course Name	FUNDAMENTAL NEUROBIOLOGY	Course Category	O	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:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Recall the brain function from its organization			
CLR-2 :	Discuss Molecular signaling in neurons			
CLR-3 :	Compare Neural basis of senses			
CLR-4 :	Explain different methods for studying neuro-immune functions			
CLR-5 :	Analyze genetic variations in brain development			
CLR-6 :	Analyze genetic variation and inheritance pertaining to nervous system disorders			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	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
CLO-1 :	Describe the fundamental organization of brain and its functions	1	80	80	L	H	H	H	-	M	L	H	H	H	H	H	L	H	H
CLO-2 :	Explain the concepts and experiments in the neurotransmitters	2	85	75	M	H	H	M	-	-	M	H	L	H	H	H	L	H	H
CLO-3 :	Recognize the pattern of brain energy metabolism	2	75	80	M	H	M	H	M	M	-	M	H	H	H	H	L	H	H
CLO-4 :	Discuss the different methods in the neuroendocrine and immune interactions	2	85	80	L	H	H	H	-	-	H	L	L	H	H	H	M	H	H
CLO-5 :	Analyze the role of genes in brain development and functions	3	85	75	L	H	H	M	-	M	H	H	H	L	H	H	H	H	H
CLO-6 :	Explain the concepts of nervous system disorder and the diseases associated with it	2	80	80	M	H	H	H	L	H	M	M	H	H	H	H	H	H	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	Basics of Neurobiology	Membrane potential	Brain energy metabolism at the cellular level	Nature of central systems	Disorders of the nervous system
	SLO-2	Understanding brain function	Action potential	Sensory systems	Survey methods	Developmental disorder:
S-2	SLO-1	Orientation of Central nervous system	Resting potential	Receptors to perceptions	Neuroendocrine circuits	Autism, Dyslexia, ADHD
	SLO-2	Peripheral nervous system	Electrochemical basis of nerve function	Chemical and somatic senses	Functions of neuroendocrine system	Mental Disorder
S-3	SLO-1	Levels of Neural organization	Electrical and Thermodynamic Forces in Passive Distribution of Ions	Molecular and neural basis of visual perception	Neuroendocrine tumors	Schizophrenia
	SLO-2	Concept of functional units	Hyperpolarization or Depolarization	Organization of autonomic nervous system and functions	Global epidemiology of neuroendocrine tumors	Degenerative disorders
S-4	SLO-1	Cellular basis of Neurobiology	Chemical basis for neuronal communication	Nature of motor system and its functions	Neuro-immune circuits	Alzheimer's disease
	SLO-2	Clinical issues in neurobiology	Ion pumps and Ion gradients	Reflexes and fixed motor responses	Neuro-immune functions	Parkinson's disease
S-5	SLO-1	Neuron terminology	Ion channels	Locomotion	Neuroendocrine-immune interactions in neurological disorders	Psychiatric disorder
	SLO-2	Cell biology of neurons and glia	Hyperpolarization-Activated Ionic Currents	Food intake and metabolism	Neuroendocrine-immune interactions in autoimmune diseases	Depression and anxiety
S-6	SLO-1	Differentiation of axon and dendrite	Neurotransmitters	Water intake and body fluids	Developmental genetics of the brain.	Vascular disorders
	SLO-2	Structural neuroscience methods: A brief history	Neuropeptides	Sleep, dreaming and wakefulness	Genes for human brain development	Stroke

S-7	SLO-1	*Sensorimotor, autonomic and enteric divisions*	*Receptors of neurotransmitters*	*Reward and motivation*	*Genes in neurological disorders.*	*Other disorders*
	SLO-2	*Synapses and spines*	*Non-classical neurotransmitters*	*Emotion and addiction*	*Epigenetics of the brain.*	*Epilepsy*
S-8	SLO-1	*Inhibitory circuit neurons*	*Synthesis of neurotransmitters and neuropeptides*	*Cognitive development and aging*	*Epigenetics in brain disorders*	*Drug addiction*
	SLO-2	*Inhibitory projection neurons*	*Release and metabolism of neurotransmitters*	*Cognitive impairment*	*Role of Environmental factors in neurodevelopment.*	*Neural Plasticity, Goat Brain Dissection*
S-9	SLO-1	*Excitatory neurons*	*Molecular mechanisms nerve terminal*	*Learning and memory*	*Exposure of lead and methyl mercury in neurodevelopmental disorders.*	*Understanding brain by Artificial Intelligence*
	SLO-2	*Neuroglia and glial sheaths*	*Molecular signaling in neurons*	*Language, communication and consciousness*	*Neurotoxins*	*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 Neurodevelopmental*and neurodegenerative disorders, Academic Press, 2015*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. C. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	*1. Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in*	*1. Dr. S. ThyagaRajan, SRMIST*
2. Dr. Karthik Periyasamy, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*2. Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	*2. Dr. R. VasanthaRekha, SRMIST*

ACADEMIC CURRICULA

Professional Core Courses

BIOTECHNOLOGY

Regulations - 2018

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

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

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

Kattankulathur, Kancheepuram, Tamil Nadu, India

Course Code	18BTC101J	Course Name	BIOCHEMISTRY	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Interpret the various aspects of biological macromolecules			
CLR-2 :	Interrelate between metabolism of biomolecules and the enzymes involved			
CLR-3 :	Comprehend principles behind estimation and analysis of biomolecules in the body fluids			
CLR-4 :	Evaluate the role of biochemistry in various biological processes and the role of biochemistryin making them economical			
CLR-5 :	Assess the metabolic diseases and disorders related to biomolecules			
CLR-6 :	Evaluate the basics of practical biochemistry and have an understanding on biomolecules			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)															
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	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	
CLO-1 :	Discuss in details the structures and reactions of biomolecules (proteins, lipids, nucleic acids, and carbohydrates)	1	80	70	L	-	-	H	H	-	-	-	H	H	-	H	H	H	H	
CLO-2 :	Describethe synthesis of biomolecules and their role in metabolic pathways along with their regulation	1	80	70	-	L	-	H	H	-	-	-	H	H	-	H	H	H	H	
CLO-3 :	Demonstrate an understanding of the metabolic pathways - the energy-yielding andenergy-requiring reactions in life	2	80	70	-	H	-	H	H	-	-	-	H	H	-	H	H	H	H	
CLO-4 :	Describe how these biochemical processes are not isolated but tightly integrated, with specific control sites and key junctions	2	80	70	-	L	-	H	H	-	-	-	H	H	-	H	H	H	H	
CLO-5 :	Demonstratethe role of biomolecules in metabolic diseases and disorders	2	80	70	-	H	-	H	H	-	-	-	H	H	-	H	H	H	H	
CLO-6 :	Explain the importance of laboratory safety and standard operating procedures of lab equipment	1	80	70	-	H	-	H	H	-	-	-	H	H	-	H	H	H	H	

Duration (hour)		15	15	15	15	15
S-1	SLO-1	History of Biochemistry, Chemical bonds	Introduction to metabolism	Introduction to amino acid metabolism	Introduction of Fatty acids metabolism	Metabolic relationships among the major human organs
	SLO-2	pH and Buffers	Carbohydrate metabolism	Transamination	Hormones role in the release of fatty Acids from adipose tissue	Introduction –Bioenergetics
S-2	SLO-1	Introduction and classification of carbohydrates	Glycolysis - Introduction	Deamination	Fatty acid oxidation - Introduction	High energy compounds
	SLO-2	Monosaccharaides – structure and function	Role of enzymes in glycolysis	Metabolism of ammonia	Oxidation	ATP synthesis
S-3	SLO-1	Disaccharides– structure and function	Pyruvate metabolism	Urea cycle	Energetics of fatty acid oxidation	Electron transport chain (ETC)
	SLO-2	Polysaccharides – structure and function	Regulation of glycolysis	Importance of urea cycle	Ketone bodies	Biological oxidation
S 4-5	SLO-1	Lab 1 - Introduction to commonly used instruments and laboratory safety	Lab 4 - Qualitative analysis of Disaccharides in food samples	Lab 7 - Estimate blood glucose, compare normal and diabetes mellitus samples	Lab 10: Repeat/Revision of experiments	Lab 13 - Quantitative analysis of proteins (Lowry's method)
	SLO-2					
S-6	SLO-1	Introduction and classification of amino acids	Citric acid cycle - Introduction	Biosynthesis of amino acids	Ketogenesis	Electron Carriers
	SLO-2	Introduction and classification of proteins	Regulation of Citric acid cycle	Tyrosine synthesis	Biosynthesis of fatty acids	Overview of pathway in the mitochondrial ETC
S-7	SLO-1	Primary Structure of proteins	Gluconeogenesis and energetics	Phenylalanine synthesis	Regulation of fatty acid synthesis	Various complexes in the mitochondrial ETC
	SLO-2	Secondary, Tertiary and Quaternary structure of proteins	Cori and Glucose-alanine cycle	Tryptophan synthesis	Eicosanoids and cholesterol biosynthesis	Chemiosmotic theory
S-8	SLO-1	Functions and biotechnological applications of proteins	Glycogen metabolism	Molecules derived from amino acids	Lipoproteins	Oxidative Phosphorylation
	SLO-2	Biological important peptides Enzymes – structure and function	Hormones regulate muscle use of glycogen	Neurotransmitters	Disorders of Lipid metabolism	Inhibitors of oxidative phosphorylation

S 9-10	SLO-1	*Lab 2 - Preparation and measurement of pH of standard buffers*	*Lab 5 - Qualitative analysis of Polysaccharides in food samples*	*Lab 8 - Acid hydrolysis and action of salivary amylase on starch*	*Lab 11 - Separation of amino acids on Thin Layer Chromatography*	*Lab 14 - Quantitative estimation of serum cholesterol*
	SLO-2					
S-11	SLO-1	*Enzyme kinetics*	*Various bioproducts produced from carbohydrate metabolism*	*Biosynthesis of lignin, tannin, and auxin*	*Biosynthesis of Pyrimidines*	*Glycerol phosphate Shuttle*
	SLO-2	*Industrial application of enzymes*	*Disorders of carbohydrate metabolism*	*Regulation of amino acid synthesis*	*Biosynthesis of Purine*	*Malate aspartate Shuttle*
S-12	SLO-1	*Introduction to Nucleic acids – DNA and RNA*	*Diabetes Mellitus – Types and diagnosis*	*Disorders of tyrosine metabolism*	*Degradation of purine and pyrimidines nucleotides*	*Photosynthesis*
	SLO-2	*Classification of lipids*	*Biochemical aspects of Diabetes mellitus*	*Disorders of phenyl alanine metabolism*	*Disorders of purine metabolism*	*Light and dark reactions*
S-13	SLO-1	*Classification of fatty acids*	*Oral medications of Diabetes mellitus*	*Disorders of heme metabolism*	*Disorders of pyrimidine metabolism*	*Carbon Dioxide Fixation: Calvin-Benson Cycle*
	SLO-2	*Cholesterol and cell membranes*	*Hyperglycemia and diabetic nephropathy*	*Medically important peptides and amino acid derivatives*	*Deoxyribonucleotide Biosynthesis*	*Regulation of Carbon Dioxide Fixation*
S 14-15	SLO-1	*Lab 3 - Qualitative analysis of Monosaccharide in food samples*	*Lab 6 - Qualitative analysis of lipids (triglycerides, cholesterol, phospholipids)*	*Lab 9 - Estimation of enzyme kinetic parameters*	*Lab 12 - Enzymatic hydrolysis of glycogen by α and β amylase*	*Lab 15 - Quantitative analysis of urea in serum*
	SLO-2					

Learning Resources	*1. U. Satyanarayana, U. Chakrapani, Biochemistry, 4th ed., Elsevier India, 2013* *2. David L. Nelson, Michael M. Cox, Lehninger Principles of Biochemistry, 7th ed., W.H. Freemen & Co., 2017*	*3. Jeremy M. Berg, John L. Tymoczko, Gregory J. Gatto, Lubert Stryer, Biochemistry, 8thed., 2015* *4. Donald Voet, Judith G. Voet, Charlotte W. Pratt, Fundamentals of Biochemistry: Life at the Molecular Level", 5th ed., John Wiley & Sons Inc., 2016*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Understand										
Level 2	Apply	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
	Analyze										
Level 3	Evaluate	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1 Dr. P. Bala Kumaran, Proklean Technologies (P) Limited, Chennai, genbalu86@gmail.com	*1.Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in*	*1. Dr. S. ThyagaRajan, SRMIST*
2. Dr. Karthik Periyasamy, Aurobindo Pharma Limited, Hyderabad karthikmpk@gmail.com	*2.Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	*2. Dr. V. Vinoth Kumar SRMIST*

Course Code	18BTC102J	Course Name	CELL BIOLOGY	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	State the basic concepts and understanding of cell structure and function			
CLR-2 :	Analyze the different strategies of organization of organelles			
CLR-3 :	Restate the concepts of structural and functional orientation in eukaryotes			
CLR-4 :	Create a platform to study the molecular mechanism of cellular transport			
CLR-5 :	Relate the applications of various receptors and their role in diseases			
CLR-6 :	Analyze the concept of cell signaling and their role in diseases			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	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
CLO-1 :	Discuss on the basic concepts of cell biology	2	80	70	M	M	-	H	-	-	-	H	-	-	-	-	H	H	H
CLO-2 :	Plan on designing and conducting experiments involving cell structures and functions	2	85	75	M	M	H	H	-	-	-	H	H	-	-	-	H	H	H
CLO-3 :	Recognize the basis of cell structure and its function in development and cell death	2	75	80	M	M	H	H	H	-	-	H	H	-	-	-	H	H	H
CLO-4 :	Describe the steps involved in cell-cell signaling in mammalian cell systems	2	85	80	M	M	H	H	H	H	H	H	H	-	-	-	H	H	H
CLO-5 :	Devise examples and advances in the different areas of diagnostic and therapeutic applications of cells	3	85	80	M	M	H	H	H	M	H	H	H	-	-	-	H	H	H
CLO-6 :	Design the experiments using routine and specialized cells to study cell proliferation, mitosis spread and karyotyping	3	80	75	M	M	H	H	H	M	H	H	H	-	-	-	H	H	H

Duration (hour)		15	15	15	15	15
S-1	SLO-1	Introduction to cell biology	Cell structure and function: Nucleus	Cytoskeleton	Principles of cell signaling	Cancer
	SLO-2	Origin and history of life	Internal organization of Nucleus	Types and function	Models of cell signaling	Introduction to cancer
S-2	SLO-1	Evolution of cell	Endoplasmic reticulum	Microfilaments	Intracellular signal transduction	Stages of cancer
	SLO-2	Evolution of metabolism	Protein folding and processing in ER	Intermediate filaments	Pathways in signal transduction	Types of cancer
S-3	SLO-1	Origin of prokaryotes	Lipid synthesis in SER	Microtubules	Function of cell surface receptors	Development of cancer
	SLO-2	Endosymbiosis	Export of proteins and lipids from ER	Re-organization of microtubules during mitosis	GPCR pathway	Hallmarks of cancer
S 4-5	SLO-1	Lab 1: Cell Morphology: Microscopic observation of eukaryotic cells	Lab 4: Cell Organelles: Nuclear staining of cells	Lab 7: Cell Proliferation: Mitotic index determination	Lab 10: Repeat/Revision of experiments	Lab 13: Cell differentiation: L6 myoblasts to L6 myotubes
	SLO-2					
S-6	SLO-1	Origin of eukaryotes	Golgi apparatus	Transport of molecules in cell	cAMP pathway	Oncogenes and tumor suppressor genes
	SLO-2	Differences between Prokaryotes & Eukaryotes	Protein sorting from Golgi	Passive diffusion	Receptor tyrosine kinase pathway	Targeted drug therapy
S-7	SLO-1	Development of multicellular organisms: Yeast, Amoeba & Volvox	Lysosomes	Active diffusion	MAPK pathway	Epithelial cell cancer
	SLO-2	Plant cells & Animal cells	Phagocytosis and autophagy	Ion channels	Cell division	Oral cancer
S-8	SLO-1	Cells as experimental models	Bioenergetics	Endocytosis	Cell cycle	Lung cancer
	SLO-2	Tools of cell biology	Metabolism	Phagocytosis	Mitosis and stages	Breast cancer

S 9-10	SLO-1 SLO-2	*Lab 2: Cell development: Embryogenesis in fruit fly and Zebrafish*	*Lab 5: Osmosis: Stomatal opening and closing*	*Lab 8: Karyotyping: G banding*	*Lab 11: Cell division: Mitotic cell division in onion root tip*	*Lab 14: Heterochromatin: Polytene chromosomes*
S-11	SLO-1	*Molecular composition of cell*	*Mitochondria- structure and function*	*Cell-cell interactions*	*Meiosis*	*Classification of breast cancer*
	SLO-2	*Biosynthesis of cellular constituents*	*Genetic system of mitochondria*	*Cell junctions*	*Programmed cell death:Necrosis and apoptosis*	*Treatment of breast cancer*
S-12	SLO-1	*Enzymes as biocatalysts*	*Chemiosmotic coupling*	*Adhesion junctions*	*Intrinsic and extrinsic pathway*	*Neurodegenerative diseases*
	SLO-2	*Central role of Enzymes*	*Chloroplasts*	*Tight junctions*	*Cell differentiation*	*Dementia*
S-13	SLO-1	*Cell membrane*	*Photosynthesis*	*Gap Junctions*	*Stem cells adult and embryonic*	*Alzheimer's disease*
	SLO-2	*Glycocalyx*	*Peroxisomes*	*Plasmodesmata*	*Therapeutic applications of stem cells*	*Diagnosis and treatment*
S 14-15	SLO-1 SLO-2	*Lab 3: Chromosome preparation: Metaphase spread preparation*	*Lab 6: Cellular fractionation: chloroplast*	*Lab 9: Cell viability: Determination of cell viability using typhan blue dye exclusion*	*Lab 12: Cell division: Meiosis in grass hopper*	*Lab 15: Histology: Sectioning of tissues using microtome and staining*

Learning Resources	*1. Channarayappa, Cell biology, Universities Press, 2010* *2. Rastogi, S.C, Cell Biology, New Age International publishers, 2005*	*3. ThyagaRajan et al., Biology for Engineers, Tata McGraw Hill Education Pvt. Ltd., New Delhi, 2012* *4. Ajoy Paul, Text book of cell and molecular biology, 2nd ed., Books & Allied (P) Ltd., 2009*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
Level 2	Apply Analyze	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
Level 3	Evaluate Create	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. C. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	*1. Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in*	*1. Dr. S. ThyagaRajan, SRMIST*
2. Dr. Karthik Periyasamy, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*2. Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	*2. Dr. S. Sujatha, SRMIST*

Course Code	18BTC103J	Course Name	MICROBIOLOGY	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Illustrate the fundamentals of Microbiology and different types of microorganisms and their characteristics
CLR-2 :	Demonstrate the fine structure of bacteria, their functions, growth and cultivation of microorganisms
CLR-3 :	Illustrate various infectious diseases and their mode of actions
CLR-4 :	Demonstrate the host-microbe interactions
CLR-5 :	Illustrate the various applications of microorganisms in various fields
CLR-6 :	Analyze the importance of Microbiology in various field applications

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	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
CLO-1 :	Illustrate the roles and characteristics of microorganisms	2	80	70	-	H	-	-	-	-		-	H	-	-	-	H	H	H
CLO-2 :	Identify growth of microorganisms, its impact in environment, applications of advanced microscopical techniques	2	85	75	-	H	H	-	-	-	H	-		-	-	-	H	H	H
CLO-3 :	Explain the role of microbes in public health and antimicrobial agents	2	75	80	H	-	H	M	H	-	H	-	H	-	H	-	H	H	H
CLO-4 :	Discuss various interactions of microbes with various microbes, animals and plants	2	85	80	H	-	H		H	-	M	-	H	-	H	-	H	H	H
CLO-5 :	Explain the applications of microbes and their products in various field	3	85	80	H	H	H	H	H	-	M	-	H	-	H	-	H	H	H
CLO-6 :	Illustrate the fundamental and applied Microbiology	2	80	75	H	H	H	H	H	-	M	-	H	-	H	-	H	H	H

Duration (hour)		15	15	15	15	15
S-1	SLO-1	Introduction to Microbiology	Nutritional requirements of bacteria	Fungi-Importance of fungi in various field applications	Microbial infections, transmission, and their mode of action	Introduction to Applied Microbiology
	SLO-2	Prokaryotes and Eukaryotes	Nutritional types of bacterium	Morphology of fungi	Sources of infection	Beneficial microbes and Microbial metabolites-overview
S-2	SLO-1	Basics of microbial existence- History of Microbiology	Physical nutrients requirement of the bacteria	Structural characteristics and ecological association of fungi	Portals of entry and Exit of microbes.	Microbial applications in Biotechnological field
	SLO-2	Characterization of microorganisms	Chemical nutrients requirement of the bacteria	Classification of fungi	Epidemiological terminologies-Infectious diseases caused by Vibrio cholerae	Microbial enzymes in various biotechnological applications
S-3	SLO-1	Classification and nomenclature of microorganisms	Types of culture media; Factors influencing bacterial growth	Sexual and Asexual Reproduction of fungi	Vibrio cholera-Mode of action	Microbial secondary metabolites-antibiotics
	SLO-2	Microscopic examination ofmicroorganisms Light Microscopy-Bright field; Dark field	Microbial growth phases	Cultivation of fungi	Vibrio cholera-Treatment	Microbial applications in agricultural field
S 4-5	SLO-1	Lab 1: Aseptic techniques and Media preparation (Both liquid and solid)	Lab 4: Staining Techniques (Simple staining, Gram staining, spore staining)	Lab 7: Enzyme based biochemical characterizations-Catalase test	Lab 10: Repeat/Revision of experiments	Lab 13: Antibiotic sensitivity test-Kirby-Bauer assay
	SLO-2					
S-6	SLO-1	Phase contrast; Fluorescent Microscopy	Types of bacterial culturing/fermentations with respect to growth phases	Preservation techniques of fungi	Sexually Transmitted diseases	Microbial applications in agricultural field
	SLO-2	Differential and specific staining methods	Microbial growth curve and kinetics	Fungal toxins	Acquired Immuno Deficiency syndrome (AIDS)	Advancements in agricultural field
S-7	SLO-1	Electron Microscopy techniques: Scanning and Transmission Electron Microscopy	Different methods of quantitative bacterial growth-Direct method	Bacterial viruses-Bacteriophages	HIV-Replication; Opportunistic Infections associated with AIDS; Treatment	Biocontrol agents-Biofertilizer
	SLO-2	Sample preparation techniques for SEM and TEM	Different methods of quantitative bacterial growth-Indirect method	Types of bacteriophages and their General characteristics	Fungal diseases	Microbial applications in Pharmaceutical field
S-8	SLO-1	Advanced Microscopic techniques-Confocal Microscopy	Utilization of energy in non-biosynthetic processes- Energy utilization-Bacterial motility	Morphology and structure of bacteriophages	Antibacterial agents-classification	Microbial applications in Environmental field

	SLO-2	*Scanning Probe Microscopy-Scanning Tunneling*	*Bacterial nutrient uptake mechanisms-Simple Diffusion, Active Transport, Group Translocation*	*Replication-Viruses of bacteria*	*Mode of actions of antibiotics*	*Microbes in the pollution removal and bioplastic syntheis*
S 9-10	SLO-1	*Lab 2: Isolation and enumeration of microorganisms from given sample*	*Lab 5: Motility test by Hanging drop method*	*Lab 8: Enzyme based biochemical characterizations-oxidase test*	*Lab 11: Triple sugar Iron agar test-H2S production*	*Lab 14: Identification of bacteria using 16s-rRNA sequencing*
	SLO-2					
S-11	SLO-1	*Scanning Probe Microscopy - Atomic Force Microscopy*	*Bioenergetics- utilization of energy in biosynthetic processes*	*Animal viruses-Classification*	*Multidrug resistance in bacterial pathogens-MDROs, MRSA, VRE*	*Control of Microorganisms-Physical, chemical and biological methods*
	SLO-2	*Morphology and fine structure of Bacteria*	*Biosynthesis of small molecules-synthesis of amino acids*	*Animal virus- Replication*	*Mechanisms of antibiotic resistance*	*Host-microbe interactions: Microbe-Microbe interaction*
S-12	SLO-1	*Size, Shape, And Arrangement of Bacterial Cells*	*Biosynthesis of macromolecules-synthesis of peptidoglycan*	*Viruses of cancer*	*Antifungal agents*	*Host-microbe interactions: Plant-microbe interaction*
	SLO-2	*External structure of bacteria*	*Synthesis of organic cell material in chemoautotrophic bacteria*	*Viroids and Prions*	*Mode of action of antiviral agents*	*Host-microbe interactions: Animal-microbe interaction*
S-13	SLO-1	*Cell organization*	*Bioenergetics of microbial metabolism*	*Plant viruses-Classification*	*Antiviral agents*	*Normal/indigenous flora and opportunistic flora of human body*
	SLO-2	*Internal structures of bacteria*	*Aerobic respiration and Anaerobic bioenergetics*	*Replication of plant viruses*	*Mode of action of antiviral agents*	*Probiotics and Prebiotics*
S 14-15	SLO-1	*Lab 3: Purification and preservation techniques of bacterial cultures*	*Lab 6: Biochemical Characterization of Bacteria–IMViC test*	*Lab 9: Enzyme based biochemical characterizations-Urease test*	*Lab 12: Casein and Starch Hydrolysis*	*Lab 15: Differentiation of live and dead cells using fluorescence Microscopy*
	SLO-2					

Learning Resources	*1. Pelczar et al., Microbiology, 7th ed., Mc Graw Hill, 2011* *2. Madigan et al., Brock Biology of microorganisms, 12th ed., Prentice Hall,2008* *3. Davis et al., Microbiology, 6th ed., Lippincott Williams and Wilkins, 2010*	*4. Prescott et al., Microbiology, 11th ed., Mc Graw Hill, 2011* *5. Brooks et al., Medical Microbiology, 26th ed., Lange Med. 2012*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Understand										
Level 2	Apply	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
	Analyze										
Level 3	Evaluate	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. S. Sam Gunasekar, Orchid Chemicals and Pharmaceuticals Ltd., sam@orchidpharma.com	*1. Dr. A. Gnanamani, CSIR-Central Leather Research Institute, agmani_2000@yahoomail.com*	*1. Dr. K. Ramani, SRMIST*
2.Dr. D. Gunaseelan, BIOCON Ltd., guna.sachin@gmail.com	*2. Dr. Anbumani Sadasivam, CSIR-Indian Institute of Toxicology Research,anbumani@iitr.res.in*	*2. Dr. R. Muthukumar, SRMIST*

Course Code	18BTC104T	Course Name	GENETICS AND CYTOGENETICS	Course Category	C	Professional Core	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	18BTC105J
Course Offering Department	Biotechnology	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Analyze the pattern of inheritance of genes in eukaryotes			
CLR-2 :	Use two and three factor cross in mapping of genes			
CLR-3 :	Use Karyotype in detecting mutation			
CLR-4 :	Apply different methods for mapping of genes in bacteria.			
CLR-5 :	Analyze genetic variations in a population.			
CLR-6 :	Analyze genetic variation and inheritance in living organisms.			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)															
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	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
CLO-1 :	Describe the fundamental Laws of Genetics and interaction of genes	1	80	80	H	H	H	H	-	M	L	H	H	H	H	H	H	H	H
CLO-2 :	Explain the concepts and experiments in the preparation of linkage map	2	85	75	H	H	H	H	-	-	M	H	H	H	H	H	H	H	H
CLO-3 :	Recognize the pattern of genetic disorders	2	75	80	M	H	M	H	M	M	-	M	H	H	H	H	H	H	H
CLO-4 :	Discuss the different methods in the construction of linkage map in bacteria	2	85	80	H	H	H	H	-	-	H	L	H	H	H	H	H	H	H
CLO-5 :	Analyze genes in the population	3	85	75	H	H	H	H	-	M	H	H	H	L	H	H	H	H	H
CLO-6 :	Explain the basic concepts and principles of nucleic acids in prokaryotic and eukaryotic organisms	2	80	80	H	H	H	H	L	M	M	M	H	H	H	H	H	H	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	Mendel's Experiments	Chromosome structure	Mutation	Bacterial genetics	Population genetics
	SLO-2	Law of segregation	Chromosome organization	Classification of mutation	Mechanisms of recombination	Allele frequency
S-2	SLO-1	Law of independent assortment	Giant chromosomes- polytene chromosome	Structural chromosomal aberration	Transformation in bacteria	Calculation of allele frequency in a population
	SLO-2	Problems in Mendelein inheritance	Lampbrush chromosome	Types of structural aberration	Mapping by transformation	Solving Problems
S-3	SLO-1	Allelic interaction	Linkage	Numerical chromosomal aberration - Aneuploidy	Recombination by generalized transduction	Calculation of genotype frequency in a population
	SLO-2	Lethal genes	Arrangement and types of linkage	Euploidy	Mapping by generalized transduction	Hardy-Weinberg equilibrium
S-4	SLO-1	Non-allelic interaction	Crossing over	Non-disjunction	Specialized transduction by lambda phage	Applications of Hardy Weinberg equilibrium
	SLO-2	Epistatis	Frequency of recombination	Aneuploids in humans	Mapping by specialized transduction	Solving Problems
S-5	SLO-1	Duplicate genes	Cytological basis of crossing over	Mosaics	Conjugation	Changes in allele frequency
	SLO-2	Complementary and inhibitory genes	Stern's experiment	Position effect	Recombination by conjugation	Changes in allele frequency by mutation
S-6	SLO-1	Multiple allelism -ABO	Mapping by two factor cross	Chromosome preparation from leukocyte culture	Interrupted mating analysis	Changes in allele frequency by migration
	SLO-2	Rh factor in Humans	Solving Problems	Chromosome preparation from bone marrow	Mapping by conjugation	Migration dynamics
S-7	SLO-1	Cytoplasmic inheritance	Mapping by three factor cross	Chromosome preparation from amniotic fluid and chorionic villi	Preparation of linkage maps in bacteria	Changes in allele frequency by selection

	SLO-2	*Pedigree analysis - Solving Problems*	*Solving Problems*	*Banding technique*	*Solving Problems*	*Selection dynamics*
S-8	SLO-1	*Mechanisms of sex determination*	*Combining of map segments*	*Karyotype preparation and analysis*	*Merozygote analysis*	*Random genetic drift*
	SLO-2	*Sex linked inheritance*	*Preparation of linkage map*	*Prenatal diagnosis*	*Fine structure mapping*	*Dynamics of random genetic drift*
S-9	SLO-1	*Epigenetics - reprogramming*	*Somatic cell hybridization*	*Fluorescent in situ hybridization*	*Solving Problems*	*Genetic equilibrium*
	SLO-2	*X-inactivation*	*HAT selection procedure*	*Comparative Genomic hybridization*	*Solving Problems*	*Solving Problems*

Learning Resources	*1. Gardner, Simmons, Sunstad, Principles of Genetics, 8th ed., John Wiley and Sons, Inc., 2006*	*2. Monroe W. Strickberger, Genetics, 3rd ed., PHI Learning, 2008*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember / Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply / Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate / Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. C. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	*1. Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in*	*1. Dr. S. Barathi, SRMIST*
2. Dr. Karthik Periyasamy, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*2. Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	*2. Dr. K. T. Ramyadevi, SRMIST*

Course Code	18BTC105J	Course Name	MOLECULAR BIOLOGY	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

Pre-requisite Courses	18BTC104T	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:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Illustrate the chemistry of polynucleotides			
CLR-2 :	Demonstrate the mode of DNA replication			
CLR-3 :	Demonstrate transcription and the processing of RNA			
CLR-4 :	Demonstrate protein synthesis and modification in regulation of cellular activities			
CLR-5 :	Illustrate the various regulatory elements that control gene expression at the transcriptional level			
CLR-6 :	Analyze the chemical and molecular processes that occur in the cells			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	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
CLO-1 :	Discuss on the basic concepts and principles of nucleic acids from the perspective of engineers	2	80	70	-	H	-	-	-	-	-	-	H	-	-	-	H	H	H
CLO-2 :	Illustrate the mechanism involved in the duplication of hereditary material.	2	85	75	-	H	H	-	-	-	H	-		-	-	-	H	H	H
CLO-3 :	Illustrate the mechanism and role of the nucleic acids in gene expression.	2	75	80	H	-	H	M	H	-	H	-	H	-	H	-	H	H	H
CLO-4 :	Discuss the structure and machinery of nucleic acids responsible for cell functioning.	2	85	80	H	-	H		H	-	M	-	H	-	H	-	H	H	H
CLO-5 :	Explain the regulation of gene expression under anabolic and catabolic conditions.	3	85	80	H	H	H	H	H	-	M	-	H	-	H	-	H	H	H
CLO-6 :	Explain the role of biological macromolecules which are essential to life.	2	80	75	H	H	H	H	H	-	M	-	H	-	H	-	H	H	H

Duration (hour)		15	15	15	15	15
S-1	SLO-1	Scope and history	Basic rules for replication	RNA polymerases in prokaryotic and eukaryotic cells	Genetic code	Gene regulation
	SLO-2	Proof for DNA as the genetic material	Chemistry of DNA synthesis	Types and function of RNA polymerases	wobble hypothesis	Principles of gene regulation
S-2	SLO-1	Proof for semi conservative replication	Semi discontinuous replication	Structure and function of the promoters	Translation in prokaryotic cells	Transcriptional gene regulation
	SLO-2	DNA constituents	Pulse chase and pulse labeling experiment	Fine structure of prokaryotic and eukaryotic genes	Initiation of translation	Post transcriptional gene regulation
S-3	SLO-1	Nucleoside and Nucleotide	Enzymes involved in replication	Transcription of RNA in prokaryotes - initiation	Elongation of translation	Activators
	SLO-2	Structure of DNA	Types and functions of DNA polymerases in prokaryotic and eukaryotic replication	Elongation and termination	Translocation	Co-activators
S 4-5	SLO-1 / SLO-2	Lab 1: Isolation of genomic DNA from bacteria	Lab 4: Plasmid DNA isolation	Lab 7: Polyacrylamide gel electrophoresis of DNA	Lab 10: Repeat/Revision of experiments	Lab 13: Ligation of digested DNA
S-6	SLO-1	Base pairing and base stacking	Proof reading activity	Transcription in eukaryotes	Termination of translation	Suppressors – Co-suppressors
	SLO-2	Models of DNA	5'-3' exonuclease activity and Topoisomerase activity	Structure of promoters in mRNA, rRNA, and tRNA genes	Ribosome recycling	Moderators, Silencers and Enhancers
S-7	SLO-1	Double helix	Events in the replication fork	Transcription of mRNA	Translation in eukaryotic cells	Operons
	SLO-2	Features of Watson and crick model	Telomeric DNA replication	Steps in transcription by RNA polymerase II	Polyribosome	Positive and negative regulation
S-8	SLO-1	Major and minor groove	Models of DNA replication – Bidirectional replication	Transcription of tRNA by RNA polymerase III	Post translational modifications	Lac Operon
	SLO-2	Forms of DNA - A, B, Z	Plasmid replication-theta model	Transcription of rRNA by RNA polymerase I	Protein folding	Regulation of Lac operon by glucose

S 9-10	SLO-1	*Lab 2: Qualitative analyses of genomic DNA*	*Lab 5: Qualitative analyses of plasmid DNA*	*Lab 8: Isolation of RNA*	*Lab 11: Restriction digestion of Plasmid DNA*	*Lab 14: Effect of UV rays in the bacterial cell growth*
	SLO-2					
S-11	SLO-1	*Structure and function of RNAs– mRNA, rRNA and tRNA*	*Strand displacement model*	*Processing of tRNA*	*Protein sorting and targeting*	*Trp Operon*
	SLO-2	*Secondary structures in RNA*	*Rolling circle model*	*Processing of rRNA*	*Types of Protein targeting*	*Control of Trp operon by Attenuator*
S-12	SLO-1	*DNA Topology*	*Bidirectional replication*	*Post transcriptional processing of mRNAs – 5'capping*	*Principles of protein sorting and targeting into mitochondria*	*Ara Operon*
	SLO-2	*Supercoiling – Twist - Writhe*	*Unidirectional replication*	*Polyadenylation*	*Principles of protein sorting and targeting into endoplasmic reticulum*	*Regulation of Ara operon*
S-13	SLO-1	*Linking number*	*DNA repair: Nucleotide excision and Mismatch repair*	*Splicing (including different types)*	*Principles of protein sorting and targeting into nucleus*	*Gal Operon*
	SLO-2	*Change in linking number*	*Photo-reactivation, Recombination repair and SOS repair*	*Alternative splicing*	*Principles of protein sorting and targeting into chloroplast*	*Regulation of Gal operon*
S 14-15	SLO-1	*Lab 3: Quantitative analyses of genomic DNA*	*Lab 6: Quantitative analyses of plasmid DNA*	*Lab 9: Qualitative and quantitative analyses of RNA*	*Lab 12: Restriction digestion of genomic DNA*	*Lab 15: Polymerase Chain Reaction*
	SLO-2					

Learning Resources	*1. James D Watson, Molecular Biology of Gene, Pearson Education, 2017* *2. Robert Weaver, Molecular Biology, McGraw-Hill, 2011*	*3. Benjamin Lewin, Genes IX, Benjamin Cummings, 2007* *4. G.M. Malacinski, David Friefelder, Essentials of Molecular Biology, 4th ed., Narosa Publishers 2008*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Understand										
Level 2	Apply	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
	Analyze										
Level 3	Evaluate	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. S. Sam Gunasekar, Orchid Chemicals and Pharmaceuticals Ltd., sam@orchidpharma.com	*1. Dr. A. Gnanamani, CSIR-Central Leather Research Institute, agmani_2000@yahoomail.com*	*1. Dr. K. Ramani, SRMIST*
2. Dr. D. Gunaseelan, BIOCON Ltd., guna.sachin@gmail.com	*2. Dr. Anbumani Sadasivam, CSIR-Indian Institute of Toxicology Research,anbumani@iitr.res.in*	*2. Dr. R. Muthukumar, SRMIST*

Course Code	18BTC106J	Course Name	IMMUNOLOGY	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Examine the science of immunology and a detailed study of various types of immune cells			
CLR-2 :	Distinguish immune systems produced molecules and their classification, structure and function			
CLR-3 :	Choose methods used in immunology, particularly the use of specific antibody in bio-molecular applications			
CLR-4 :	Evaluate knowledge about immune system, their cells, its interaction and how they fight against infectious diseases			
CLR-5 :	Analyze the dysregulation of immune system functioning and ways to strengthen immune system			
CLR-6 :	Evaluate the knowledge about how human body is designed and protected to fight against various pathogens			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	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
CLO-1 :	Describe the immune system and their structure and classification	1	80	70	M	-	H	H	L	L	L	H	-	H	M	H	M	H	H
CLO-2 :	Discuss about genetic control of antibody production, cellular immunology	2	80	70	M	M	-	H	H	M	H	H	-	H	M	H	M	H	H
CLO-3 :	Explain various methods to assess immune function, their application and interpretation of the results	2	80	70	M	M	L	H	H	-	-	H	M	H	M	H	H	H	H
CLO-4 :	Describe the role of the immune molecules in infectious diseases, autoimmunity, and cancer will be discussed	2	80	70	-	-	-	H	H	M	H	H	M	H	M	L	H	H	H
CLO-5 :	Discuss about hypersensitive immune reaction, vaccination and cancer immunology	2	80	70	M	M	-	H	H	-	H	H	M	H	H	M	H	H	H
CLO-6 :	Describe how immune cells, organ and processes function to protect human body against infective agents and cancer cells.	2	80	70	M	L	M	H	H	M	M	H	M	H	H	M	H	H	H

Duration (hour)		15	15	15	15	15
S-1	SLO-1	Overview of the immune system	Immunoglobulin structure	Isolation of immune cells from Human and animals	Major histo-compatibility Complex(MHC)	Hypersensitive reactions
	SLO-2	Development and differentiation of the hematopoietic stem cells	Immunoglobulin types and function	Antigen- antibody interaction	MHC – types and function	Type I and Type II reaction
S-2	SLO-1	Myeloid and Lymphoid lineage	Antibodies biological and functional properties	antibody affinity and avidity	MHC Class I	Type III and Type IV reaction
	SLO-2	Lymphatic system	Proteolytic digestion of antibodies	Hemaagglutination reaction	MHC Class II	Immune responses to infectious diseases introduction
S-3	SLO-1	Lymphoid organs - types	Monoclonal antibodies production	Coombs test – direct and indirect	antigen processing and presentations – Endogenous and Exogenous	Viral disease-HIV infection
	SLO-2	Innate lymphoid cells	Monoclonal antibodies applications	precipitation reaction	Diversity of MHC molecules	Bacterial disease-Tuberculosis
S 4-5	SLO-1	Lab 1:Laboratory safety principles and	Lab 4: Antigen – Antibody reaction I –	Lab 7: Ouchterlony gel diffusion	Lab 10: Active immunodiffusion – II –	Lab 13: Enzyme linked Immunosorbent
	SLO-2	Blood grouping	Widal test		Counter Current Immunoelectrophoresis	assay (ELISA) – DOT
S-6	SLO-1	Agglutination principle, blood group types Rhesus group types	Widal test - slide method and test tube method	Single radial immunodiffusion (SRID)	Antigen – Antibody interaction	Types of ELISA, Direct vs Indirect ELISA, Dot ELISA Sandwich ELISA
	SLO-2	incompatible blood transfusion and hemolytic disease	B Cell differentiation	titer value, zone of equivalence Quantitative Immuno assays	Standard and test antigen Rocket Immunoelectrophoresis	Parasitic disease-Malaria
S-7	SLO-1	Receptors of Innate Immune system	B cell receptor structure and B cell signal transduction	passive Immunodiffusion	Biology of T lymphocyte	Evading Mechanisms of pathogens
	SLO-2	Types of Immune cells, Innate Immunity	Antibody diversity	Precipitation reaction	T cell receptors and interaction with MHC	Vaccine history and principle
S-8	SLO-1	Anatomical and Physiological barriers	Light chain synthesis	Active Immunodiffusion – Rocket immunoelectrophoresis	T-cell maturation	Active and passive Immunization
	SLO-2	Acquired Immunity, clonal selection theory	Heavy chain synthesis Cytokine receptor structure	SDS-PAGE and Western blot	T-cell activation and differentiation	DNA vaccine, Edible vaccine and Adjuvants

S 9-10	SLO-1 SLO-2	*Lab 2: Total Leukocyte count*	*Lab 5: Antigen – Antibody reaction II -rapid plasma reagin (RPR) test*	*Lab 8: Repeat/Revision of experiments*	*Lab 11: Immunoprecipitation*	*Lab 14: Enzyme linked Immunosorbent assay (ELISA) – Plate*
S-11	SLO-1	*Types of blood cells* *Leukocyte counting*	*Flocculation reaction* *Rapid Plasma Reagin (RPR) test*	*Quantitative Immuno assays - Radio-immunoassay*	*Thymic selection – Positive and negative selection*	*Tumor Immunology introduction*
	SLO-2	*Comparative immunity - Plant Immune system*	*Cytokine types and function*	*Precipitation reaction, Immunoprecipitation*	*T-cell activation and cytokine secretion*	*Evidence for Tumor Immunity*
S-12	SLO-1	*Vertebrate and Invertebrate Immune system*	*Role of cytokines in diseases*	*Immunofluorescence – Direct and indirect*	*Result interpretation* *Counter current immuno electrophoresis*	*Tumor immuno therapy*
	SLO-2	*Immunogens, Antigens and Haptens*	*Complement system*	*Immunohistochemistry*	*Cytokine control of TH1 and TH2 CD4+*	*Autoimmunity introduction*
S-13	SLO-1	*Requirements for immunogenicity; major classes of antigens*	*Regulation of complement pathway*	*flow cytometry, ELISA and types*	*Function of CD8+ T cells, T Regulatory cells*	*Genetic Basis of Autoimmunity*
	SLO-2	*antigen recognition by T and B lymphocytes*	*Role of complement proteins in diseases*	*Cell culture and experimental models, analysis of gene expression*	*T-cell and B-cell cooperation, Pathways of Activation*	*Classification of auto-immunity*
S 14-15	SLO-1 SLO-2	*Lab 3: Differential Leukocyte count*	*Lab 6: Single radial immunodiffusion (SRID)*	*Lab 9: Active Immunodiffusion I - Rocket Immunoelectrophoresis*	*Lab 12: SDS-PAGE*	*Lab 15: Western blotting*

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 (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Understand										
Level 2	Apply	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
	Analyze										
Level 3	Evaluate	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. C. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	*1. Dr. Joe Varghese, CMC Vellore, joevarghese@cmcvellore.ac.in*	*1. Dr. S. Thyagarajan, SRMIST*
2. Dr. Karthik Periyasamy, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*2. Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in*	*2. Dr. S. Nageswaran, SRMIST*

Course Code	18BTC107J	Course Name	BIOPROCESS PRINCIPLES	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

Pre-requisite Courses	18BTC103J	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 :	Select the proper design offermenters and the fermentation process
CLR-2 :	Examine the process of media formulation and sterilization kinetics
CLR-3 :	Assess the metabolic stoichiometry and energetics of the biochemical process
CLR-4 :	Manage the various modes of operating and designing a bioreactor
CLR-5 :	Interpret the microbial growth and kinetics during formation of products
CLR-6 :	Analyze the basic principles of bioprocess engineering and the working of living cells

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	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
CLO-1 :	Explain the various aspects of fermenter and types of fermentation process	2	80	70	H	L	H	H	L	-	H	-	H	H	-	H	H	H	H
CLO-2 :	Practice the components of media and its prerequisites to produce bioproducts	3	80	70	H	M	H	H	L	-	H	-	H	H	-	H	H	H	H
CLO-3 :	Interpret the stoichiometry and energetics of product formation mediated by cell growth	3	80	70	H	H	H	H	L	-	H	-	H	H	-	H	H	H	H
CLO-4 :	Analyze and interpret key elements of the fermentation data to operate the bioreactor accordingly	2	80	70	H	M	H	H	M	-	H	-	H	H	-	H	H	H	H
CLO-5 :	Apply various models to understand the kinetics and mechanism of microbial growth	3	80	70	H	H	H	H	H	-	H	-	H	H	-	H	H	H	H
CLO-6 :	Employ fermentation skills to synthesize value added bioproducts	3	80	70	H	H	H	H	H	-	H	-	H	H	-	H	H	H	H

Duration (hour)		15	15	15	15	15
S-1	SLO-1	Outline of an integrated bioprocess	Criteria for a good medium	Stoichiometric of cell growth	Types of bioreactor	Mathematical models
	SLO-2	Upstream and downstream bioprocess	Types of media	Stoichiometric of product formation	Strategies for choosing a bioreactor	Mathematical Models - Classification
S-2	SLO-1	Process flow sheets of primary metabolite production	Various commercial media for microbial biotechnology	Elemental balance, degree of reduction	Modes of operation of bioreactor	Model formulation
	SLO-2	Process flow sheets of secondary metabolite production	Medium formulation – Carbon and Nitrogen source	Substrate and biomass	Batch operation – Theory	Unstructured, Nonsegregated models
S-3	SLO-1	Types of fermentation	Medium formulation – Growth factor and inducers	Electron balance	Growth kinetics of batch culture	Monod model
	SLO-2	Fermented products	Natural and synthetic media	Yield coefficient of biomass and product formation	Solving problem in growth kinetics	Blackman, tessier, moser and contois models
S 4-5	SLO-1	Lab 1 - Types of fermentation	Lab 4 - Medium formulation to maximize the biomass production	Lab 7 - Batch growth kinetics - Evaluation of doubling time	Lab 10: Repeat/Revision of experiments	Lab 13 - Quantification of biomass, ethanol and glucose
	SLO-2					
S-6	SLO-1	Fermenter – Various components	Animal culture media	Maintenance coefficients	Batch reactor – Logistic equations	Monod model modified for substrate inhibition
	SLO-2	Fermenter design	Plant culture media	Determination of stoichiometric coefficients	Performance equation of a batch reactor	Modified Monod models
S-7	SLO-1	Standard geometry of stirred tank bioreactor (STR)	Design of experiments	Solving problem in stoichiometric coefficients	Solving problem related to batch reactor	Unstructured Batch Growth Models
	SLO-2	Basic features of STR – Agitation	Plackett - Burman design (PBD)	Solving problem in stoichiometric coefficients	Fed-batch operation – theory	Product Formation Kinetics
S-8	SLO-1	Basic features of STR – Aeration	Response surface methodology (RSM)	Energetic analysis of microbial growth and product formation	Performance equation of a fed- batch reactor	Structured kinetics Model
	SLO-2	Basic features of STR – Miscellaneous items	Artificial neural network (ANN)	Oxygen transfer in aerobic culture	Solving problem related to fed-batch reactor	Structured product formation kinetic modeling

S 9-10	SLO-1	*Lab 2 - Bioreactor operation (demonstration)*	*Lab 5 - Screening of process parameters for bacterial biomass production by PBD*	*Lab 8 - Batch growth kinetics - Evaluation of specific growth rate*	*Lab 11 - Preparation of immobilized cells/enzyme*	*Lab 14 - Production of ethanol by Saccharomyces cerevisae*
	SLO-2					
S-11	SLO-1	*Summary of conventional bioreactor systems*	*Sterilization*	*Oxygen transfer in aerobic culture – problem*	*Continuous operation - Theory*	*Compartment model*
	SLO-2	*Summary of novel bioreactor systems*	*Kinetics of thermal death of microorganism*	*Determination of yield coefficients*	*Chemostat and Turbidostat*	*Williams two compartment model*
S-12	SLO-1	*Monitor and Control of physical parameters*	*Solving problem in sterilization kinetics*	*Solving problem in yield coefficients*	*Performance equation of a continuous reactor*	*Ramakrishna Model*
	SLO-2	*Monitor and Control of chemical parameters*	*Types of sterilization - batch*	*Solving problem in yield coefficients*	*Dopt – Significance*	*Product formation models*
S-13	SLO-1	*Monitor and Control of biological parameters*	*Types of sterilization - Continuous*	*Heat evolution in aerobic culture*	*Solving problem related to Dopt*	*Luedeking-piret Model*
	SLO-2	*Summary of Monitor and Control of fermentation parameters*	*Air sterilization*	*Analyze thermodynamic efficiency of cell growth*	*Stability analysis of bioreactor*	*Growth and non-growth associated kinetics*
S 14-15	SLO-1	*Lab 3 - Real-time monitoring of process (pH, temp etc.) parameters in bioreactor*	*Lab 6 - Media Sterilization*	*Lab 9 - Batch growth kinetics - Evaluation of yield coefficient*	*Lab 12 - Comparison of free and immobilized enzyme/cells kinetics*	*Lab 15 - Evaluation of ethanol yield and productivity by S. cerevisae*
	SLO-2					

Learning Resources	1. *Hall, Stephen J., Stanbury, Peter F., Whitaker, Allan, Principles of Fermentation Technology, 3rd ed., Butterworth– Heinemann, 2017* 2. *Pauline M. Doran, Bioprocess Engineering Principles, 2nd ed., Academic press, 2012*	3. *Carl-Fredrik Mandenius, Bioreactors: design, operation and novel applications, 1sted., Wiley-VCH Verlag GmbH & Co, 2016*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Understand										
Level 2	Apply	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
	Analyze										
Level 3	Evaluate	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. P. BalaKumaran, Proklean Technologies (P) Limited, Chennai,genbalu86@gmail.com	*1. Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in*	*1. Dr. M. VenkateshPrabhu,SRMIST*
2. Dr. Karthik Periyasamy, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*2. Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	*2. Dr. V. Vinoth Kumar, SRMIST*

Course Code	18BTC108J	Course Name	PLANT BIOTECHNOLOGY	Course Category	C	*Professional Core*	L	T	P	C
							3	0	2	4

Pre-requisite Courses	*18BTC103J*	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:*	**Learning**		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Illustrate the genome organization in plants and its regulations*			
CLR-2 :	*Employ the different methods for the development of transgenic plants*			
CLR-3 :	*Use the plants as production systems by altering the plant hormones for growth and developments*			
CLR-4 :	*Interpret the mechanisms for plant to cope up for biotic and abiotic stresses*			
CLR-5 :	*Apply the classical and modern plant breeding techniques for crop improvements*			
CLR-6 :	*Use the knowledge to increase plant production and protection through biotechnological approaches*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	**Learning**			**Program Learning Outcomes (PLO)**														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	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
CLO-1 :	*Discuss on the basics of plant genomes organizations and expressions*	*2*	*80*	*70*	-	*H*	-	*H*	-	-	-	-	*H*	-	-	-	*H*	*H*	*H*
CLO-2 :	*Demonstrate the various methods of genetic manipulations in plants*	*2*	*85*	*75*	*H*	*H*	*H*	*H*	*H*	-	*H*	*H*	*H*	-	*H*	-	*H*	*H*	*H*
CLO-3 :	*Illustrate the mechanism and role of plant tissue culture for mass multiplications*	*2*	*75*	*80*	*H*	*H*	*H*	*H*	*H*	-	*H*	-	*H*	-	*H*	-	*H*	*H*	*H*
CLO-4 :	*Discuss the molecular aspects of plant adaptability to various stresses*	*2*	*85*	*80*	*H*	*M*	*H*	*M*	-	-	*M*	-	*H*	-	*H*	-	*H*	*H*	*H*
CLO-5 :	*Explain the significance of plant breeding and genetic manipulations of plants for economic importance*	*3*	*85*	*80*	*H*	*H*	*H*	*H*	*H*	-	*M*	*H*	*H*	-	*H*	-	*H*	*H*	*H*
CLO-6 :	*Explain the basic concepts and to use the plant biotechnology techniques for crop improvements*	*2*	*80*	*75*	*H*	*H*	*H*	*H*	*H*	-	*H*	*H*	*H*	-	*H*	-	*H*	*H*	*H*

Duration (hour)		**15**	**15**	**15**	**15**	**15**
S-1	SLO-1	*Introduction and scope of plant molecular biology*	*Agrobacterium mediated gene transfer*	*Plant Tissue culture*	*Plant stresses*	*Introduction to crop improvement*
	SLO-2	*DNA, Chromatin, and Chromosome structure*	*The biology of Agrobacterium*	*Plasticity and totipotency of plant cells*	*Biotic stress*	*The distant past - Crop plant domestication and beyond*
S-2	SLO-1	*Chloroplast genome*	*Vector for plant transformations*	*The culture environment*	*Plant – pathogen interactions*	*The recent past -*
	SLO-2	*Genome Structure, evolution, expression, gene regulations*	*Ti plasmid*	*Physical and chemical factors*	*Prokaryotes, fungi and viruses*	*Hybrid seed production*
S-3	SLO-1	*Mitochondrial genome*	*t-DNA transfer and integration*	*Plant growth hormones*	*Disease resistance*	*Importance of green revolution*
	SLO-2	*Genome Structure, evolution, expression, gene regulations*	*transformation in plant with an example of Arabidopsis thaliana*	*Culture types*	*Natural disease resistance in plants*	*The (First) Green Revolution*
S 4-5	SLO-1 SLO-2	*Lab 1: Isolation of genomic DNA from plant tissues*	*Lab 4: Isolation and recombinant preparation of Ti plasmid*	*Lab 7: Preparation of plant tissue culture media*	*Lab 10: Repeat/Revision of experiments*	*Lab 13: Protoplast –Isolation, electro-fusion and regeneration*
S-6	SLO-1	*Nuclear genome*	*Direct gene transfer methods*	*Production of secondary metabolites*	*Biotechnological approach*	*Breeding technologies*
	SLO-2	*Genome size and organization*	*Advantages and disadvantages*	*Carbohydrates*	*Over expression of PR-proteins*	*Advances in breeding technologies*
S-7	SLO-1	*Introduction to gene and expression*	*Vectors*	*Metabolic engineering*	*Herbs as biotic stress factors*	*Practicing Now and*
	SLO-2	*Regulation of gene expressions*	*Optimization and binary vectors*	*Lipids*	*Types of herbicides*	*into the future*
S-8	SLO-1	*Gene transcription*	*Alternative markers and reporter genes*	*Molecular farming*	*Transgenic approach for improving tolerance to herbicide*	*Applications of breeding*
	SLO-2	*Organellar Self-Splicing Introns and Horizontal DNA transfer*	*Effect of selectable marker system to environment*	*Proteins*	*Plant based detoxification*	*Breeding for improved human health*

S 9-10	SLO-1	*Lab 2: Extraction of total RNA from plant tissues*	*Lab 5: Agrobacterium mediated gene transformation in Arabidopsis thaliana*	*Lab 8: Direct organogenesis of plants*	*Lab 11: Enhanced production of secondary metabolites in suspension cultures by using elicitors*	*Lab 14: Haploid productions/ Somatic embryogenesis*
	SLO-2					
S-11	SLO-1	*RNA modification*	*The genetic manipulation of pest resistance crop plants*	*Emerging applications*	*Abiotic stresses - nature*	*Breeding*
	SLO-2	*Post Transcriptional Gene Silencing (PTGS)*	*Bacillus thuringiensis (Bt) approach*	*Producing fine chemicals*	*Plant responses*	*For drought tolerance*
S-12	SLO-1	*Micro RNA*	*The use of Bt as a biopesticide*	*Plant derived compounds*	*The nature of water deficit stress*	*Innovations*
	SLO-2	*Production and interfering with gene for silencing*	*Bt-based genetic modification of plants*	*As a drugs*	*Various approaches for tolerance*	*In agriculture*
S-13	SLO-1	*DNA instability*	*Development of pest resistant crops*	*Current demand from plants*	*Salt stress*	*Revolutions*
	SLO-2	*Transposable Elements in plants*	*Clean gene technology – Copy nature strategy*	*Alternative fuels*	*Cold and heat stress*	*The Second Green Revolution*
S 14-15	SLO-1	*Lab 3: Qualitative and Quantitative analysis of nucleic acids from plant tissues*	*Lab 6: Demonstration of electroporation method of gene transformation in plants*	*Lab 9: Callus induction and indirect organogenesis*	*Lab 12: Quantification of stress induced secondary metabolites using HPLC*	*Lab 15: Quantification of t-DNA expressions from plants*
	SLO-2					

Learning Resources	1. *Slater. A, Scott.N.W, Fowler,M.R, Plant Biotechnology - The genetic manipulation of plants, Oxford University Press 2008* 2. *C Neil Stewart Jr. Plant Biotechnology and Genetics, John Wiley & Sons, Inc., New Jersey 2008*	3. *Carole L. Bassett, Regulation of gene expression in plants - The role of transcript structure and processing. Springer, 1st ed., 2007* 4. *Murray.D.R, Advanced methods in plant breeding and biotechnology, CAB International 1998*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Understand										
Level 2	Apply	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
	Analyze										
Level 3	Evaluate	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Senthil, EID Parry, Chennai, *parrynutraceuticals@parry.murugappa.com*	*1. Prof. Usha Vijayraghavan. IISc, Bangalore, uvr@mcbl.iisc.ernet.in*	*1. Dr. Sarada, SRMIST*
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ACADEMIC CURRICULA

Professional Core Courses

BIOTECHNOLOGY

Regulations - 2018

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

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

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

Kattankulathur, Kancheepuram, Tamil Nadu, India

Course Code	18BTC201J	Course Name	GENE MANIPULATION AND GENOMICS	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning	Program Learning Outcomes (PLO)

		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	*Discuss the basic concepts and principles of utilization of different expression vectors for cloning from the perspective of engineers*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	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
CLR-2 :	*Demonstrate the different strategies of gene cloning and construction of genomic and cDNA libraries*																		
CLR-3 :	*Analyse the concepts of structural and functional genomics*																		
CLR-4 :	*Apply advanced cutting-edge technologies*																		
CLR-5 :	*Assess the applications of recombinant DNA technology in animals, plants and microbial organisms*																		
CLR-6 :	*Prepare engineering students to develop the strategies on altering gene expression in vitro and in vivo*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*																		
CLO-1 :	*Explain the foundations of modern biotechnology*	*1*	*80*	*70*		*L*	*M*	*L*	*M*				*H*			*H*	*H*	*H*	*H*
CLO-2 :	*Design and conduct experiments involving genetic manipulation.*	*2*	*85*	*75*	*H*	*H*	*H*	*H*	*H*				*H*		*H*	*H*	*H*	*H*	*H*
CLO-3 :	*Use versatile techniques in recombinant DNA technology.*	*2*	*75*	*80*	*H*	*M*	*H*	*H*	*H*				*H*		*H*	*H*	*H*	*H*	*H*
CLO-4 :	*Describe the steps involved in the production of biopharmaceuticals in microbial and mammalian cell systems.*	*2*	*85*	*80*	*H*	*H*	*H*	*H*	*H*		*M*		*H*		*H*	*H*	*H*	*H*	*H*
CLO-5 :	*Apply modern biotechnology in the different areas like medicine, microbes, environment and agriculture.*	*2*	*80*	*80*	*H*	*M*	*H*	*H*	*H*	*L*	*H*		*H*		*H*	*H*	*H*	*H*	*H*
CLO-6 :	*Design the cloning experiments using routine and specialized vectors for such applications as plant transformation, protein expression and genomic DNA library construction etc.*	*2*	*80*	*75*	*H*	*H*	*H*	*H*	*H*		*M*		*H*		*H*	*H*	*H*	*H*	*H*

Duration (hour)		15	15	15	15	15
S-1	SLO-1	*Overview of cloning*	*DNA Library*	*DNA sequencing*	*Analysis of gene expression*	*Applications of cloning*
	SLO-2	*DNA cloning vectors*	*Preparation of DNA Libraries*	*Principles of DNA sequencing*	*Transcription and translation*	*Medical applications*
S-2	SLO-1	*Cell based DNA cloning*	*Genomic DNA library*	*Sanger's Dideoxy sequencing method*	*Post transcriptional and post translational regulations*	*Human and genetic diseases*
	SLO-2	*Cell free DNA cloning*	*Overlapping and non-overlapping DNA fragments*	*Automated DNA sequencing*	*Methods for protein expression*	*DNA vaccines*
S-3	SLO-1	*Plasmid vectors – pBR322*	*Choice of vectors*	*Next generation sequencing*	*Analysis of gene function*	*Gene therapy*
	SLO-2	*pUC vector*	*Evaluation of genomic DNA library*	*Genome sequencing*	*Factors influencing gene expression*	*Study of gene function in vivo*
S 4-5	SLO-1	*Lab 1: Restriction enzyme digestion of genomic DNA*	*Lab 4: Alkaline Phosphatase treatment for cloning*	*Lab 7: Transformation of recombinant vector in to E.Coli*	*Lab 10: Repeat/Revision of experiments*	*Lab 13: Qualitative and quantitative analyses of RNA*
	SLO-2					
S-6	SLO-1	*Phage vectors – Lambda insertion*	*cDNA library*	*Emulsion PCR*	*Manipulation of gene expression*	*Embryonic stem cells*
	SLO-2	*Lambda Replacement vector*	*Purification and separation of mRNA*	*Bridge PCR*	*Transcriptomics - Non-coding RNA*	*Applications in Embryonic stem cells*
S-7	SLO-1	*Cosmids*	*cDNA synthesis*	*RNA sequencing*	*Small RNAs, siRNAs*	*Transgenics*
	SLO-2	*M13 vector*	*cDNA library construction*	*Applications of NGS*	*MicroRNAs, lncRNA*	*Methods of producing transgenic mice*
S-8	SLO-1	*Phagemid*	*Evaluation of cDNA library*	*Labeling of nucleic acids*	*Expression in prokaryotic host cells*	*Over-expression*
	SLO-2	*pBluescript*	*Screening libraries*	*Random priming*	*Purification of expressed protein*	*Gene knock-in*
S 9-10	SLO-1	*Lab 2: Restriction enzyme digestion of Vector*	*Lab 5: Preparation of rDNA- Ligation of DNA fragment with cloning vector*	*Lab 8: Screening- Blue white selection*	*Lab 11: Expression in eukaryotic host cells*	*Lab 14: cDNA synthesis*
	SLO-2					
S-11	SLO-1	*Yeast vectors*	*Polymerase chain reaction (PCR)*	*Nick translation and End labeling*	*Expression in eukaryotic host cells*	*Gene knock-out*
	SLO-2	*Types of yeast vector*	*Semi quantitative PCR*	*RNA labeling*	*Mammalian expression vectors*	*Conditional knock-out*
S-12	SLO-1	*YAC*	*RNA-PCR*	*Non-isotopic labeling*	*Mutagenesis*	*Genome editing*
	SLO-2	*Expression vectors*	*Real time PCR*	*Structural genomics*	*in vitro mutagenesis*	*CRISPER-Cas9*

S-13	SLO-1	*Restriction enzymes*	*Types of qRT-PCR*	*comparative genomics*	*Site directed mutagenesis*	*Guide RNA*
	SLO-2	*Linker and homopolymer tailing*	*Applications of PCR*	*Microarray*	*Methods for site directed mutagenesis*	*Gene inactivation*
S 14-15	SLO-1	*Lab 3: Purification of digested DNA by column purification*	*Lab 6: Preparation of Competent cell*	*Lab 9: Identification of recombinants-isolation of rDNA*	*Lab 12: RNA isolation*	*Lab 15: Quantitative PCR (Real time PCR)*
	SLO-2					

Learning Resources	*1. Jeremy W. Dale and Malcolm von Schantz, "From Genes to Genomes," John Willey and Sons Publications, 2002* *2. Sandy-b-primrose, "Principles of Gene Manipulation and Genomics" Seventh Edition, 2012*	*3. S. B. Primrose and R. M. Twyman, "Principles of Gene Manipulation and Genomics"7th Edition,Wiley-Blackwell, 2006*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Understand										
Level 2	Apply	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
	Analyze										
Level 3	Evaluate	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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. N.Selvamurugan, SRMIST*
Dr. Karthik Periyasamy, Scientist I, Aurozymes Unit, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	*Dr. S.Barathi, SRMIST*

Course Code	18BTC202J	Course Name	BIOPROCESS ENGINEERING	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Demonstrate the various operational modes of bioreactor*			
CLR-2 :	*Illustrate about the various transport phenomena in bioprocess systems.*			
CLR-3 :	*Demonstrate the monitoring and control of various process parameters in bioreactors.*			
CLR-4 :	*Analyze the design and operation of various industrially important bioreactor*			
CLR-5 :	*Illustrate the various mathematical models of biological systems*			
CLR-6 :	*Illustrate the transformation of bioprocess engineering approaches from laboratory scale to commercial scale*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)															
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	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
CLO-1 :	*Analyze the various operations of the bioreactor and evaluating its performance.*	*2*	*80*	*70*	*H*	*H*	*H*	*H*			*H*		*H*		*H*	*H*	*H*	*H*	*H*
CLO-2 :	*Discuss the fundamental knowledge on mechanisms of oxygen transfer in biological systems.*	*2*	*85*	*75*	*H*	*H*	*H*	*H*			*H*		*H*		*H*	*H*	*H*	*H*	*H*
CLO-3 :	*Illustrate the procedures adopted for monitoring and control of process parameters in bioreactors.*	*2*	*75*	*80*	*H*	*H*	*H*	*M*			*H*		*H*		*H*	*H*	*H*	*H*	*H*
CLO-4 :	*Discuss on the design and operation of bioreactors for the cultivation of microbial, plant and animal cell cultures.*	*2*	*85*	*80*	*H*	*H*	*H*	*H*			*M*		*H*		*H*	*H*	*H*	*H*	*H*
CLO-5 :	*Explain the applicability of modeling preliminaries and software packages in bioprocess.*	*3*	*85*	*80*	*H*	*H*	*H*	*H*	*H*		*M*		*H*		*H*	*H*	*H*	*H*	*H*
CLO-6 :	*Explain the engineering approaches for successful commercialization of bioprocess operations.*	*2*	*80*	*75*	*H*	*H*	*H*	*H*	*H*		*M*		*H*		*H*	*H*	*H*	*H*	*H*

Duration (hour)		15	15	15	15	15
S-1	SLO-1	*Introduction to ideal reactors*	*Molecular Diffusion*	*Bioreactor Instrumentation and Control*	*Bioreactor configurations for production of metabolites from microbial sources*	*Introduction to mathematical modeling of biological systems*
	SLO-2	*Ideal reactor types*	*Role of Diffusion in Bioprocessing*	*Monitoring of biochemical parameters*	*Stirred tank reactor*	*Approaches to modelling cell growth*
S-2	SLO-1	*Ideal batch reactor - basics*	*Convective Mass Transfer*	*Instrumentation for Measurements of Active Fermentation*	*Packed bed reactor*	*A Model of Cell Growth Dynamics*
	SLO-2	*Performance equation: Ideal batch reactor*	*Oxygen Uptake in Cell Cultures*	*pH, temperature, and DO*	*Fluidized bed reactor*	*Sigle cell model*
S-3	SLO-1	*Ideal continuous reactor - basics*	*Oxygen Transfer in Fermenters*	*Chemical composition and exhaust gas analysis*	*Air lift loop reactor*	*Yeast model*
	SLO-2	*Performance equation: Ideal continuous reactor*	*Measuring Dissolved-Oxygen Concentrations*	*Water purity, pressure and mass*	*Case studies*	*Simulation software packages*
S 4-5	SLO-1	*Lab 1: Batch operation*	*Lab 4: Estimation of K_La by sulphite oxidation method*	*Lab 7: Enzyme Production - Medium optimization by RSM*	*Lab 10: Repeat/Revision of experiments*	*Lab 13: Analysis of various growth kinetic parameters of batch fermentation using Berkley Madonna software*
	SLO-2					
S-6	SLO-1	*Ideal plug flow reactor - basics*	*Estimating Oxygen Solubility*	*Mass flow rate, volumetric flow rate and broth level*	*Bioreactor configurations for production of metabolites from plant sources*	*Berkley Madonna software*
	SLO-2	*Performance equation: Ideal plug flow reactor*	*Mass-Transfer Correlations*	*Methods for on-line and off-line biomass estimation*	*Different types of bioreactors for plant cells, tissues and organs*	*Continuous fermentation process*
S-7	SLO-1	*Reasons for non-ideality in bioreactors*	*Measurement of K_La*	*On-line analysis of other chemical factors*	*Light Introducing Bioreactors*	*Fed batch fermentation process*
	SLO-2	*Measurement of non-ideality in bioreactors*	*Oxygen-Balance Method and Dynamic Method*	*State and parameter estimation techniques for biochemical process*	*Rotating Drum Bioreactor*	*MATLAB - Basics*
S-8	SLO-1	*Residence Time Distribution - Studies*	*Power correlation analysis for KLa*	*Control system in bioreactor*	*Balloon-type bubble bioreactors*	*Input and Output in MATLAB*
	SLO-2	*Non-ideal bioreactors*	*Oxygen Transfer in Large Vessels*	*Regulatory and multivariable control*	*Scale-up*	*Curve fitting tool*
S 9-10	SLO-1	*Lab 2: Fed batch operation*	*Lab 5: KLa determination by dynamic gassing method*	*Lab 8: Repeat/Revision of experiments*	*Lab 11: Wine production*	*Lab 14: Estimation of bacterial growth kinetic parameter using Curve Fitting tool in MATLAB*
	SLO-2					

S-11	SLO-1	*Axial Dispersion*	*Regime analysis of bioprocess*	*Computer-based data acquisition*	*Bioreactor configurations for production of metabolites from animal sources*	*Running simulation in MATLAB*
	SLO-2	*Dispersion Model*	*Mechanism of mixing in bioreactors*	*Artificial intelligence for the control of bioreactor systems*	*Cell culture - basics*	*Running simulation in SIMULINK*
S-12	SLO-1	*Application of dispersion model in design of continuous sterilizers*	*Scale-up of bioreactors*	*Application of Computer Control and Sensing Technologies for bioreactor systems*	*Hollow fire reactors*	*Dynamic simulation studies*
	SLO-2	*Tanks-in-Series Model*	*Scale-up of bioreactors based on power consumption – Gassed*	*Flow injection analysis – Introduction*	*Perfusion culture systems*	*Process Flow sheeting*
S-13	SLO-1	*Conversion from Tanks-in-Series Model*	*Scale-up of bioreactors based on power consumption – Ungassed*	*Various transport system - FIA*	*Sedimentation column perfusion systems*	*Examples of various primary metabolites process flow diagram*
	SLO-2	*Summary - Types of models for non-ideal (real) reactors*	*Scale-up of bioreactors based on oxygen transfer*	*FIA applications*	*Bioreactor strategies for maximizing product formation*	*Examples of various secondary metabolites process flow diagram*
S 14-15	SLO-1	*Lab 3: Sterilization kinetics*	*Lab 6: KLa determination by power correlation analysis*	*Lab 9: Monitoring of process and kinetics parameters in enzyme production – Shake flask studies*	*Lab 12: Prediction of flow behavior in fermentation broth*	*Lab 15: Repeat/Revision of experiments*
	SLO-2					

Learning Resources	*1. Kargi. F., Shuler. M.L., "Bioprocess Engineering: Basic Concepts", 3rd Edition. Prentice Hall, 2017.* *2. Doran. P. M., "Bioprocess Engineering Principles", Academic press, 2012* *3. Najafpour G., "Biochemical Engineering and Biotechnology", 2nd Edition, Elsevier Science, 2015*	*4. Scott F.H., "Elements of Chemical Reaction Engineering", 5th Edition, Pearson Education, Inc., 2015.* *5. Burstein L., "Matlab® in Bioscience and Biotechnology, Woodhead Publishing, 2011* *6. Schügerl K., Bellgardt K.-H., Bioreaction Engineering: Modeling and Control, Springer, 2000.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Understand										
Level 2	Apply	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
	Analyze										
Level 3	Evaluate	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. P. BalaKumaran, Proklean Technologies (P) Limited, Chennai, genbalu86@gmail.com	*Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in*	*Dr. V. Vinoth Kumar, SRMIST*
Dr. Karthik Periyasamy, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	*Dr. M. Venkatesh Prabhu, SRMIST*

Course Code	18BTC203J	Course Name	ANIMAL BIOTECHNOLOGY	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand animal breeding,controlling characters and disorders*
CLR-2 :	*Develop an understanding about transgenic animals*
CLR-3 :	*Inculcate the understanding of cell culture technique and production of valuable products from them*
CLR-4 :	*Emphasize on animal health thereby improving livestock production*
CLR-5 :	*Develop an understanding of alteration of animal body biological system*
CLR-6 :	*provide a basic understanding of animal biotechnology*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	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
CLO-1 :	*Impart theoretical knowledge on breeding, Characteristics of animals and biological markers for genetic diseases*	*2*	*80*	*70*		*H*							*H*			*M*	*H*	*H*	*H*
CLO-2 :	*Acquire knowledge on Embryo transfer, fertilization methods and transgenic animals*	*2*	*85*	*75*		*H*	*H*				*H*	*M*				*M*	*H*	*H*	*H*
CLO-3 :	*Illustrate on various cell culture techniques and their applications*	*2*	*85*	*80*	*H*		*H*	*M*	*H*		*H*	*H*	*H*		*H*	*H*	*H*	*H*	*H*
CLO-4 :	*Explain on microbial infections of animal thereby rendering prophylaxis*	*2*	*85*	*80*	*H*		*H*		*H*		*M*		*H*		*H*		*H*	*H*	*H*
CLO-5 :	*Gain knowledge about improvement of animals to increase the yield and quality of animal products*	*3*	*85*	*80*	*H*	*H*	*H*	*H*	*H*		*M*		*H*		*H*		*H*	*H*	*H*
CLO-6 :	*Assess the knowledge on animal biotechnology for its applications*	*2*	*80*	*75*	*H*	*H*	*H*	*H*	*H*		*M*		*H*		*H*		*H*	*H*	*H*

Duration (hour)		15	15	15	15	15
S-1	SLO-1	*Breed*	*Artificial insemination*	*Principles of sterile techniques and cell propagation*	*Vaccines for animal health*	*Use of biotechnology in livestock production*
	SLO-2	*Species*	*Super ovulation*	*Primary cell culture*	*Diseases in cattle:*	*Effects of Growth hormone*
S-2	SLO-1	*Different types of breeding: Pros & Cons*	*In vitro fertilization*	*secondary cell culture*	*Bacterial disease- symptoms and prevention*	*Manipulation of Growth hormone*
	SLO-2	*Inbreeding, Outbreeding*	*Embryo transfer*	*continuous cell lines*	*Viral disease -symptoms and prevention*	*Somatotropic hormone*
S-3	SLO-1	*Types of cross breeding*	*Embryo sexing*	*suspension cultures*	*Parasitic disease -symptoms and prevention*	*Recombinant Bovine Growth Hormone*
	SLO-2	*Up grading*	*Splitting and quality analysis of embryo*	*Chemically defined and serum free media for cell culture*	*Diseases in sheep & goat:*	*Thyroid hormone*
S 4-5	SLO-1	*Lab 1: Sterilization techniques for animal cell culture*	*Lab 4: Isolation and culture of Hepatocytes*	*Lab 7: Cell passaging*	*Lab 10: Mitochondrial staining by Rhodamine 123*	*Lab 13: Cytotoxicity-LDH assay*
	SLO-2					
S-6	SLO-1	*ChoosingTraits in farm animals*	*Pregnancy diagnosis*	*Scaling up of monolayer culture*	*Bacterial disease- symptoms and prevention*	*Probiotics as growth promoters:*
	SLO-2	*Quantitative trait loci*	*Cryopreservation of embryo*	*Scaling up of suspension culture*	*Viral disease -symptoms and prevention*	*Ideal characteristics*
S-7	SLO-1	*Marker assisted selection*	*Vitrification*	*Contamination: sources, types and eradication*	*Parasitic disease -symptoms and prevention*	*Mode of action of probiotics*
	SLO-2	*Single locus marker- RFLP*	*Slow programmed freezing*	*Preservation of animal cells*	*Introduction to animal vaccination*	*uses of probiotics*
S-8	SLO-1	*Multilocus marker- AFLP, SSR*	*Cloning for conservation of endangered species- Pros & Cons*	*characterization of animal cells*	*Vaccine production using animal cells*	*Manipulation of lactation*
	SLO-2	*RAPD in farm animals*	*Gene transfer techniques*	*Species identification*	*Live vaccines*	*Mammogenesis*
S 9-10	SLO-1	*Lab 2: Preparation of cell culture media*	*Lab 5: Cell counting and Viability*	*Lab 8: Cryopreservation of cells*	*Lab 11: Nuclear staining by Propidium iodide*	*Lab 14: Culture and differentiation of L6 cells*
	SLO-2					
S-11	SLO-1	*DNA Finger printing in animals*	*Transgenic animals – importance & methods of producing it*	*Organotypic culture*	*killed vaccines*	*Lactogenesis*
	SLO-2	*Applications of molecular markers*	*Transgenic mice*	*Types of organ culture*	*Conjugate vaccines*	*Galactopoiesis*

S-12	SLO-1	*Chromosomal aberrations*	*Transgenic fish*	*Application of animal cell culture*	*Anti Idiotypic vaccines*	*Manipulation of rumen microbial digestive system*
	SLO-2	*Genetic disorders: Cattle*	*Molecular farming*	*Cell cytotoxicity and viability assays*	*Subunit vaccines*	*Methods for manipulation*
S-13	SLO-1	*Sheep & Goat*	*Expression of therapeutic proteins*	*Cell culture as source of therapeutic products*	*Recombinant vaccines*	*Manipulation of wool growth*
	SLO-2	*Horse*	*Animal as a bioreactor*	*Tissue plasminogen activator*	*DNA vaccines*	*Factors affecting wool quality in sheep*
S 14-15	SLO-1	*Lab 3: Isolation and culture of Splenocytes*	*Lab 6: Primary culture using Chick embryo*	*Lab 9: Revival of Cryopreserved cells*	*Lab 12: Cell viability assay using MTT*	*Lab 15: Determination of glucose assay by GOD-POD method*
	SLO-2					

Learning Resources	1. Animal Biotechnology: Recent concepts and developments - P.Ramadas, MJP Publications, 2015. 2. Animal Biotechnology – M.M.Ranga, IIIrd edition, 2007	3. Culture of animal cells; a manual of basic technique - R.Ian Freshney, Vth edition, Wiley publications, 2006. 4. Textbook of Animal Biotechnology – P.Ramadas & S.Meerarani, IInd edition, 2002.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Understand										
Level 2	Apply	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
	Analyze										
Level 3	Evaluate	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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 I, Aurozymes Unit, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	*Dr. S.Subhashini, SRMIST*

Course Code	18BTC204T	Course Name	PROTEIN ENGINEERING AND PROTEOMICS	Course Category	C	Professional Core	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning	Program Learning Outcomes (PLO)

		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	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
CLR-1 :	*Distinguish the organizational levels of protein structure.*																		
CLR-2 :	*Appraise the structure-function correlation in selected proteins.*																		
CLR-3 :	*Interpret the structural basis of catalytic mechanism of proteolytic enzymes.*																		
CLR-4 :	*Construct 3D structure of protein from amino acid sequence.*																		
CLR-5 :	*Discuss on the experimetal techniques available for protein structure characterization.*																		
CLR-6 :	*Express the structural similarities existing at basal level in a group of proteins with similar functions*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*																		
CLO-1 :	*Interpret the properties of protein based on the sequence*	*1*	*80*	*80*	*H*	*H*	*H*	*H*		*M*	*L*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-2 :	*Recognize the 3D orientation of proteins and its correlation to the function oft the protein*	*2*	*85*	*75*	*H*	*H*	*H*	*H*			*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-3 :	*Design mutated proteins to obtain proteins with desired function*	*2*	*75*	*80*	*M*	*H*	*M*	*H*	*M*	*M*		*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-4 :	*Restate the biological significance of select group of proteins*	*2*	*85*	*80*	*H*	*H*	*H*	*H*			*H*	*L*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-5 :	*Explain the basics of available experimental techniqes for resolving protein structure*	*3*	*85*	*75*	*H*	*H*	*H*	*H*		*M*	*H*	*H*	*H*	*L*	*H*	*H*	*H*	*H*	*H*
CLO-6 :	*Devise strategies for prediction, modification and design novel proteins*	*2*	*80*	*80*	*H*	*H*	*H*	*H*	*L*	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Structure of amino acids*	*Role of Transcription factors in gene expression*	*Types and uses of proteases*	*Difficulties in generating crystals of Protein*	*Introduction to proteomics*
	SLO-2	*Properties of amino acids*	*Significance of TATA-box binding proteins (TBP)*	*Mechanism of action of serine proteases*	*Methods of generating crystals*	*Difference between functional genomics and proteomics*
S-2	SLO-1	*Role of Glycine and Proline in structure determination*	*Structural elucidation of TBP*	*Significance of Catalytic triad in serine proteases*	*Braggs law*	*Importance of sequencing of prtoein*
	SLO-2	*Ramachandran plot and its significance.*	*Nature of interaction between TBP and DNA*	*Importance of oxyanion hole for the catalytic activity*	*Instrumentation setup for diffraction studies*	*Edmund sequencing method*
S-3	SLO-1	*Interactions that stabilize secondary structures*	*Structural elucidation of p53*	*Specificity of Trypsin towards cleavage of lysine and arginine amino acid bonds*	*Phase determination*	*Array based proteomics*
	SLO-2	*Structural features of alpha helix*	*Nature of interaction between p53 and DNA*	*Specificity of Chymotrypsin and subtilisin*	*Role of Fourier transformation to overcome phase problem*	*Two hybrid system*
S-4	SLO-1	*Types of alpha helices*	*Effect of mutations in the DNA binding domain of p53*	*Domains of Immunoglobulin*	*Multi-wavelength Anomalous Diffraction experiments*	*2D gel electrophoresis*
	SLO-2	*Parallel beta-strand structure*	*Effects of mutations in the oligomerization and Nuclear localization region*	*Class-switching in Immunoglobulins*	*Recent advances in diffraction studies*	*Advantages and limitations of 2D gel electrophoresis*
S-5	SLO-1	*Anti-parallel beta-strand structure*	*Structural elucidation of leucine zipper*	*Immunoglobulin fold*	*NMR principle*	*Mass Spectrometry - Principle*
	SLO-2	*Beta turns, loops and other secondary structures*	*Interaction of leucine zipper and DNA*	*Secondary structures in hyper-variable loop region*	*Instrumentation in NMR*	*Instrumental setup in MS*
S-6	SLO-1	*Super-secondary structures*	*Structure-function correlation in actin*	*Structural orientation in antigen binding site*	*NOE & NOE-COSY*	*Ionisation by MALDI*
	SLO-2	*Difference between motiffs & domains*	*Structure-function correlation in myosin*	*Nature of interaction between antigen and antibody*	*Coupling constants*	*Ionisation by ESI & EI*
S-7	SLO-1	*Types of motiffs*	*Role of ATP in muscular contraction*	*Significance of CDR3 loop in antibody*	*Chemical Shifts*	*Time of Flight concept & peptide mass fingerprinting*
	SLO-2	*Types of domains*	*Structural elucidation of GPCR*	*Mechanism of activation of T-Cell*	*Dipolar Coupling constants*	*Tandem MS and MS/MS*

S-8	SLO-1	*Monomeric and polymeric proteins*	*Types of GPCR*	*Prediction of 3D structure from amino acid sequence*	*Isothermal Titration Calorimetry (ITC) Principle*	*SALSA algorithm*
	SLO-2	*hydrophobic collapse & theories of folding*	*Mechanism of activation of GPCR*	*Homology modelling and threading*	*Instrumentation of ITC*	*De novo algorithms*
S-9	SLO-1	*Levinthal paradox*	*Structural elucidation of Tyrosine kinase receptor*	*Enhancing binding affinity of T4 lysozyme*	*Determination enthalpy, entropy and free energy*	*Revision of entire units*
	SLO-2	*Role of chaperons and heat shock proteins*	*Interactions that activate Tyrosine kinase receptor*	*Enhancing stability in T4 lysozyme*	*Prediction of binding energy and multiple binding sites by ITC*	*Revision of entire units*

Learning Resources	*1. Brandon.C, Tooze.J, "Introduction to Protein Structure", 2nd Edition - Garland Publishing, Taylor & Francis group, 1999.* *2. Twyman. R. M, "Principles of Proteomics", Garland Scientific Publishers, 2004.* *3. Chatwal. G. R, "Instrumental methods of Chemical Analysis", Himalaya Publishing House, 5th Edition, 2011.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%) #			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Understand										
Level 2	Apply	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
	Analyze										
Level 3	Evaluate	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. P. BalaKumaran, Proklean Technologies (P) Limited, Chennai, genbalu86@gmail.com	*Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in*	*Mr. S. Karthik, SRMIST*
Dr. Karthik Periyasamy, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	*Dr. Vasantha Rekha, SRMIST*

Course Code	18BTC301J	Course Name	BIOSEPARATION TECHNOLOGY	Course Category	C	Professional core	L	T	P	C
							3	0	2	4

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning	Program Learning Outcomes (PLO)

		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	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
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*																		
CLR-6:	*Familiarize with separation, isolation, purification, polishing and formulation techniques*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*																		
CLO-1:	*Categories the products into various sectors*	*H*	*80*	*70*	*H*	*H*	*H*	*H*	*L*				*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-2:	*Identify the unit operation for separation*	*H*	*90*	*80*	*H*	*H*	*H*	*H*	*L*				*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-3:	*Adapt the best methods of isolation of products*	*H*	*80*	*80*	*H*	*H*	*H*	*H*	*L*				*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-4:	*Identify the sophisticated equipment for purification*	*H*	*80*	*80*	*H*	*H*	*H*	*H*	*L*				*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-5:	*Know the polishing and formulation of the products*	*H*	*80*	*90*	*H*	*H*	*H*	*H*	*L*				*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-6:	*Acquired knowledge in down streaming of Biomaterials*	*H*	*90*	*90*	*H*	*H*	*H*	*H*	*L*				*H*	*H*	*H*	*H*	*H*	*H*	*H*

Duration (hour)		15	15	15	15	15
S-1	SLO-1	*Introduction to Bio- separation process*	*Solid –Liquid Separation*	*Isolation of products*	*Purification of products*	*Product Formulation*
	SLO-2	*Importance of bioseparation in biotechnological processes*	*Biomass and particulate debris separation techniques*	*Adsorption-Chemistry of adsorption*	*Diafiltration*	*Crystallization- Basic concepts*
S-2	SLO-1	*Problems and requirements of bio-product purification*	*Flocculation-Pretreatment of broth*	*Batch Adsorption*	*Electro dialysis*	*Crystallization principles*
	SLO-2	*Different sectors of products in biotechnology*	*The electric double layer*	*Problems*	*Isoelectric focusing*	*Batch crystallizers*
S-3	SLO-1	*Engineering analysis in Bio separation- Stages of Bio separation*	*Forces Between Particles and Flocculation by Electrolytes*	*Continuous stirred tank adsorption*	*Electrophoretic separation of protein*	*Continuous crystallizers*
	SLO-2	*Basic principles of Engineering analysis*	*The Schulze–Hardy Rule Flocculation Rate Polymeric Flocculants*	*Fixed bed adsorption*	*Solving Problems*	*Solving Problems*
S-4-5	SLO-1	*Lab1. Cell disruption by Sonication*	*Lab 4. Separation of cells by Flocculation*	*Lab 7. Extraction of protein by aqueous two phase extraction*	*Lab 10. Detection and Estimation of Ethanol by Gas Chromatography*	*Lab 13. Crystallization of bioproducts*
	SLO-2					
S-6	SLO-1	*Process and product quality*	*Sedimentation Principles*	*Extraction*	*Chromatography principles*	*Crystallizer design*
	SLO-2	*Criteria for process development*	*Sedimentation Methods and coefficients*	*Chemistry of Extraction*	*Instruments and practice*	*Scale-up*
S-7	SLO-1	*Process Economics and Cost analysis*	*Centrifugation*	*Batch Extraction*	*Normal phase chromatography*	*Drying- principles*
	SLO-2	*Solving Problems*	*Tubular centrifuge*	*staged Extraction*	*Reversed phase chromatography,*	*Adiabatic and Conduction drying*
S-8	SLO-1	*Chemical and application range of Bioproducts*	*Disk Centrifuge*	*Differential Extraction- aqueous two phase.*	*Ion exchange chromatography*	*Dryer description and operations-Vacuum shelf dryer*
	SLO-2	*Sectors of Products*	*Ultra Centrifuge*	*Three phase Extraction Super critical Extraction*	*Gel permeation chromatography*	*Batch Vacuum rotary dryer*
S 9-10	SLO-1	*Lab 2. Cell disruption by Enzymatic method*	*Lab 5. Cell separation by Batch Filtration*	*Lab 8. Protein separation by Ultra filtration*	*Lab 11. Protein separation by column chromatography*	*Lab 14. Freeze drying of Biomaterial*
	SLO-2					
S-11	SLO-1	*Cell disruption methods for intracellular products*	*Filtration*	*Precipitation*	*Bio affinity chromatography*	*Freeze dryer*

	SLO-2	*Physical Cell Disruption*	*Filter Media and Equipment's*	*Precipitation by salt, Non solvents and large scale precipitation*	*Hydrophobic interaction chromatography*	*Spray dryer*
S-12	SLO-1	*Chemical and Enzymatic cell disruption*	*Theory of filtration*	*Cross flow filtration*	*Chiral chromatography*	*Conduction drying*
	SLO-2	*Solving Problems*	*Batch Filtration*	*Micro and Ultra filtration*	*Analysis of purity*	*Problems*
S-13	SLO-1	*Mechanical Cell Disruption*	*Continuous Rotary filters*	*Design of Ultra filtration*	*Scale-up in chromatography*	*Adiabatic drying*
	SLO-2	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*
S14-15	SLO-1	*Lab 3. Cell disruption by High pressure Homogenizer*	*Lab 6. Cell separation by Centrifugation*	*Lab 9. Protein Concentration by salting out method*	*Lab 12. Protein separation by Gel Electrophoresis*	*Lab 15. Drying of Bioproducts*
	SLO-2					

Learning Resources	*1. Harrison. R.G., Todd. P., Rudge S.R, Petrides. D.P, "Bioseparation Science and Engineering" Oxford University press, 2003.* *2. Belter. P.A., Cussler, E., "Bioseparations", Wiley, 1985.* *3. Nooralabettu Krishna Prasad, "Downstream Process Technology: A New Horizon In Biotechnology", PHI Learning Private Limited 2013*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Understand										
Level 2	Apply	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
	Analyze										
Level 3	Evaluate	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

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Dr. P. BalaKumaran, Proklean Technologies (P) Limited, Chennai, genbalu86@gmail.com	*Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in*	*1 Dr.M.Venkatesh Prabhu SRM IST*
Dr. Karthik Periyasamy, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	*2 Dr. Y.Ravichandran SRM IST*

Course Code	18BTC350T	Course Name	COMPREHENSION	Course Category	C	Professional Core	L	T	P	C
							0	1	0	1

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:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Acquire skills to develop knowledge in biochemical principles*			
CLR-2 :	*Acquire skills to solve real world problems in medical biotechnology*			
CLR-3 :	*Acquire skills in gene manipulation and recombinant DNA technology*			
CLR-4 :	*Acquire skills in enzyme technology and bioremeddiation*			
CLR-5 :	*Acquire skills in bioseparation technology*			
CLR-6 :	*Acquire skills to solve real world problems in the broad domain of biotechnology*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Program Learning Outcomes (PLO)														
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
					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
CLO-1 :	*Practice and gain confidence and competence to solve problems in biochemical principles*	*3*	*85*	*80*	*H*	*H*	*H*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*M*	*L*	*M*
CLO-2 :	*Practice and gain confidence and competence to solve problems in medical biotechnology*	*3*	*85*	*80*	*H*	*H*	*M*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*M*	*M*	*M*
CLO-3 :	*Practice and gain confidence and competence to solve problems in gene manipulation and recombinant DNA technology*	*3*	*85*	*80*	*H*	*H*	*M*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*M*	*L*	*M*
CLO-4 :	*Practice and gain confidence and competence to solve problems in enzyme technology and bioremeddiation*	*3*	*85*	*80*	*H*	*H*	*M*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*M*	*M*	*M*
CLO-5 :	*Practice and gain confidence and competence to solve problems in bioseparation technology*	*3*	*85*	*80*	*H*	*H*	*H*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*M*	*L*	*M*
CLO-6 :	*Practice and gain confidence, competence to solve problems in the domain of biotechnology and competitive examinations in biotechnology*	*3*	*85*	*80*	*H*	*H*	*M*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*M*	*M*	*M*

Duration (hour)		3	3	3	3	3
S-1	SLO-1	*Tutorial on biochemistry*	*Tutorial on genetics and gene mainpulation*	*Tutorial on microbiology*	*Tutorial on bioprocess technology*	*Tutorial on bioinformatics*
	SLO-2	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*
S-2	SLO-1	*Tutorial on cell biology and molecular biology*	*Tutorial on immunology*	*Tutorial on plant biotechnology*	*Tutorial on medical biotechnology*	*Problem environmental biotechnology*
	SLO-2	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*
S-3	SLO-1	*Tutorial on bioseparation technology*	*Tutorial on pharmaceutical biotechnology*	*Tutorial on animal biotechnology*	*Tutorial on protein engineering*	*Tutorial on fermentation technology*
	SLO-2	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*

Learning Resources	*2. Pranav Kumar and Usha Mina,Life Sciences, Fundamentals and Practice, Pathfinder Publication, 2016*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (100% weightage)								Final Examination	
		CLA – 1 (20%)		CLA – 2 (30%)		CLA – 3 (30%)		CLA – 4 (20%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember / Understand	-	*40%*	-	*30%*	-	*30%*	-	*30%*	-	-
Level 2	Apply / Analyze	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-	-
Level 3	Evaluate / Create	-	*20%*	-	*30%*	-	*30%*	-	*30%*	-	-
	Total	100 %		100 %		100 %		100 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. C. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	*1. Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in*	*1. Dr.Vinoth Kumar, SRMIST*
2. Dr. Karthik Periyasamy, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*2. Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	*2.Dr.Samuel Jacob, SRMIST*

ACADEMIC CURRICULA

Professional Elective Courses

BIOTECHNOLOGY

Regulations - 2018

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

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

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

Kattankulathur, Kancheepuram, Tamil Nadu, India

Course Code	18BTE301T	Course Name	DEVELOPMENTAL BIOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
CLR-1 :	*Describe the mechanisms of developmental patterning and organization*			
CLR-2 :	*Discuss fertilization, gametogenesis and sex determination*			
CLR-3 :	*Compare developmental patterns among metazoan, drosophila and zebrafish*			
CLR-4:	*Explain somites and their derivatives.*			
CLR-5:	*Describe metamorphosis and organogenesis*			
CLR-6:	*Analyze birth defects and endocrine disruptors*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Analyze the mechanisms of cell to cell communication*	*1*	*80*	*80*
CLO-2 :	*Describe the fundamental organization of reproduction and flowering in plants*	*2*	*85*	*75*
CLO-3 :	*Explain the concepts and experiments in the early development, cleavage and axis formation*	*2*	*75*	*80*
CLO-4 :	*Recognize the various pathways of organogenesis*	*2*	*85*	*80*
CLO-5 :	*Discuss about the various endocrine receptors*	*3*	*85*	*75*
CLO-6 :	*Explain the concepts of development in health and diseases*	*2*	*80*	*80*

Program Learning Outcomes (PLO)															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
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
L	*H*	*H*	*H*		*M*	*L*	*H*	*H*	*H*	*H*	*H*	*L*	*H*	*H*
M	*H*	*H*	*M*			*M*	*H*	*L*	*H*	*H*	*H*	*L*	*H*	*H*
M	*H*	*M*	*H*	*M*	*M*		*M*	*H*	*H*	*H*	*H*	*L*	*H*	*H*
L	*H*	*H*	*H*			*H*	*L*	*L*	*H*	*H*	*H*	*M*	*H*	*H*
L	*H*	*H*	*M*		*M*	*H*	*H*	*H*	*L*	*H*	*H*	*H*	*H*	*H*
M	*H*	*H*	*H*	*L*	*H*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Mechanisms of Developmental Organization*	*Sex determination*	*Early Development: Cleavage, Gastrulation and Axis formation*	*Building with mesoderm*	*Development in health diseases*
	SLO-2	*The cycle of life*	*Chromosomal sex determination*	*Developmental Patterns among the Metazoa*	*Endoderm*	*Genetic errors of human development*
S-2	SLO-1	*Epigenesis and cleavage*	*Mammalian Pattern of sex determination*	*Early development in the Nematode C. elegans*	*Organogenesis*	*Birth defects*
	SLO-2	*Evolutionary embryology*	*Genetic mechanisms*	*Early Drosophila Development*	*Paraxial mesoderm*	*Endocrine disruptors*
S-3	SLO-1	*Cell Specification:*	*Wnt family and signaling*	*Early Zebrafish Development*	*The somites and their derivatives*	*BPA and reproductive health*
	SLO-2	*Mechanisms of Developmental Patterning*	*Hormonal regulation of sexual phenotype*	*Early Development in Mammals*	*Intermediate and lateral plate mesoderm*	*Cancer*
S-4	SLO-1	*Autonomous and conditional specification*	*Environmental sex determination*	*Building with Ectoderm: The vertebrate nervous system and Epidermis*	*Heart, Blood, and Kidneys*	*Defects in paracrine pathways*
	SLO-2	*Cell identities*	*Gametogenesis*	*Neural tube formation and patterning*	*Development of the tetrapod limb*	*Cancer and stem cell hypothesis*
S-5	SLO-1	*Differential Gene Expression*	*Spermatogenesis*	*Brain growth*	*The endoderm*	*Development and the environment*
	SLO-2	*Mechanisms of Cell Differentiation*	*OOgenesis*	*Neural crest cells*	*The tubes and organs for digestion*	*Diet-induced polyphenisms*
S-6	SLO-1	*Differential RNA processing*	*Fertilization*	*Axonal specificity*	*Organs and tubes for respiration*	*Developmental symbiosis*
	SLO-2	*Cell-to-Cell communication*	*Structure of gametes*	*Ectodermal Placodes*	*Postembryonic development*	*Biotic regulation*
S-7	SLO-1	*Juxtacrine signaling*	*Translocation and capacitation*	*Epidermis*	*Metamorphosis*	*Abiotic regulation*
	SLO-2	*Mechanisms of Morphogenesis*	*Thermotaxis and chemotaxis*	*Cell Signaling*	*The hormonal reactivation and development*	*Symbiotic regulation of development*
S-8	SLO-1	*Cadherins and cell adhesions*	*Fusion of genetic material*	*Fibroblast growth factors*	*Regeneration*	*Development and Evolution*
	SLO-2	*Stem cells: Their potential and their niches*	*Activation of mammalian egg*	*RTK pathway*	*Aging and senescence*	*Developmental mechanisms*
S-9	SLO-1	*Human model systems*	*Flowering*	*The Hedgehog family*	*Differentiation of dermal, ground, and vascular tissues in plants*	*Evolutionary changes*
	SLO-2	*Development in Plants*	*Reproduction in Plants*	*The TGF-β superfamily*	*Techniques in embryology*	*Mechanisms of evolutionary changes*

Learning Resources	1. *Scott F. Gilbert, Michael J. F. Barresi. Developmental Biology, Sinauer Associates-Oxford University Press; 11 edition, 2016* 2. *JMW Slack Essentials of Developmental Biology 3rd Edition Wiley-Blackwell;.2012*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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Dr. Karthik Periyasamy, Scientist I, Aurozymes Unit, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	*Dr.R.Vasantharekha, SRMIST*

Course Code	18BTE302T	Course Name	CELLULAR AND MOLECULAR NEUROSCIENCE	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Recall the brain function from its organization*			
CLR-2 :	*Discuss Molecular signaling in neurons*			
CLR-3 :	*Compare Neural basis of senses*			
CLR-4:	*Explain different methods for studying neuro-immune functions*			
CLR-5:	*Describethe cortical structures pertaining to emotions and feelings*			
CLR-6:	*Analyze genetic* variation and inheritance pertaining to nervous system disorders			
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*			
CLO-1 :	*Analyze the role of genes in brain development and functions*	*1*	*80*	*80*
CLO-2 :	*Describe the fundamental organization of brain and its functions.*	*2*	*85*	*75*
CLO-3 :	*Explain the concepts and experiments in the ion channels and NEUROTRANSMITTERS*	*2*	*75*	*80*
CLO-4 :	*Recognize the various pathways of sensory system*	*2*	*85*	*80*
CLO-5 :	*Discuss the different methods in the neuroendocrine and immune interactions*	*3*	*85*	*75*
CLO-6 :	*Explain the concepts of nervous system disorder and the diseases associated with it*	*2*	*80*	*80*

Program Learning Outcomes (PLO)														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
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
L	*H*	*H*	*H*		*M*	*L*	*H*	*H*	*H*	*H*	*H*	*L*	*H*	*H*
M	*H*	*H*	*M*			*M*	*H*	*L*	*H*	*H*	*H*	*L*	*H*	*H*
M	*H*	*M*	*H*	*M*	*M*		*M*	*H*	*H*	*H*	*H*	*L*	*H*	*H*
L	*H*	*H*	*H*			*H*	*L*	*L*	*H*	*H*	*H*	*M*	*H*	*H*
L	*H*	*H*	*M*		*M*	*H*	*H*	*H*	*L*	*H*	*H*	*H*	*H*	*H*
M	*H*	*H*	*H*	*L*	*H*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Genetics of nervous system*	*Electrical signals*	*Somatic sensory system-Pain*	*Cognition-Speech and Language*	*Diseases and injuries of the nervous system*
	SLO-2	*Advent of genomics in the assembly of brain*	*Long-distance transmission of Electrical signals*	*Touch and Proprioception*	*Overview of cortical structures*	*Alzheimer's disease*
S-2	SLO-1	*Model organisms in neuroscience*	*The ionic basis of resting membrane potential*	*Pain and its pathways*	*Sleep and Wakefulness*	*Hutington's disease*
	SLO-2	*Development of the nervous system*	*Voltage-dependent membrane permeability*	*Visual and Vestibular pathways*	*The circadian cycle of sleep and wakefulness*	*Neuromuscular Disorders: Myasthenia gravis*
S-3	SLO-1	*Molecular basis of neural induction*	*Ion channels and transporters*	*Retinal circuitry*	*Emotions-Memory*	*Basal ganglia disorders: Parkinson's disease*
	SLO-2	*Initial differentiation of neurons and glia*	*Diversity of ion channels*	*Phototransduction*	*Early theories of emotional brain*	*Pharmacological targets of Parkinsons disease*
S-4	SLO-1	*Cellular Components of the Nervous system*	*Synaptic transmission-Neurotransmitters and their receptors*	*Motor neuron circuits-Motor neuron control by the CNS*	*Kluver-Bucy syndrome*	*Spinal Cord Injury*
	SLO-2	*Neurons and Glia*	*Chemical and electrical synapses*	*Motor units*	*Brain reward circuitry*	*Traumatic Brain Injury (TBI)*
S-5	SLO-1	*Organization of nerves*	*Molecular signaling in neurons*	*The Corticospinal and Corticobulbar Tracts*	*Learning*	*chronic traumatic encephalopathy*
	SLO-2	*Pre synaptic terminals*	*Activation of signaling pathways*	*Upper motor neurons*	*Memory consolidation and Priming*	*Stroke*
S-6	SLO-1	*Neural Circuits*	*Second messengers*	*Disorders of basal ganglia*	*Cognition-Speech and Language*	*Blood Supply to Brain*
	SLO-2	*Myotactic reflex*	*Nuclear signaling*	*Molecular mechanisms involved in synapse formation*	*Sex and Sexuality*	*Transient Ischemic Attack*
S-7	SLO-1	*Organization of the Nervous system*	*Synaptic plasticity*	*Molecular basis of trophic interactions*	*Neuroanatomical basis for brain functions.*	*Acute stroke treatment*
	SLO-2	*Divisons of nervous system*	*Short and long-term synaptic plasticity*	*Construction and modification of neural circuits*	*Hypothalamus and endocrine system*	*Prevention of stroke*
S-8	SLO-1	*Central nervous system*	*Synaptic transmission-Neurotransmitters and their receptors*	*Repair and Regeneration in nervous system*	*Hormones of endocrine system and its regulation*	*Dementia*
	SLO-2	*Peripheral nervous system*	*Properties of neurotransmitters*	*Hypoxia/Ischemia in mammalian brain*	*Interactions between neuroendocrine system and immune system*	*Mild cognitive impairment*

S-9	SLO-1	*Structural and Functional analysis of the Nervous system*	*Receptors of neurotransmitters*	*Axon Growth after Brain Injury*	*Neural-Immune interactions in the periphery*	*Alzheimer's dementia*
	SLO-2	*Cellular diversity of nervous system*	*Unconventional neurotransmitters*	*Goat brain dissection*	*Nervous-immune system role in health and disease*	*Prevention and treatment*

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 (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Dr. Karthik Periyasamy, Scientist I, Aurozymes Unit, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	*Dr.R.Vasantharekha, SRMIST*

Course Code	18BTE303T	Course Name	METABOLIC DISORDERS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18BTC101J	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:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Learn about the basic principles of metabolic regulation*			
CLR-2 :	*Understand the importance of genetics in medicine and in metabolic diseases.*			
CLR-3 :	*Learn about the role of enzymes in various metabolic disorders*			
CLR-4:	*The common genetic diseases in our society and the reason for it.*			
CLR-5:	*Learn about various treatment strategies of metabolic disorders.*			
CLR-6:	*Learn about the basic principles of metabolic regulation*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*understand the metabolic principles*	*2*	*80*	*70*
CLO-2 :	*able to solve the metabolic problems of specific nutrients*	*2*	*85*	*75*
CLO-3 :	*able to apply knowledge in metabolic control*	*2*	*75*	*80*
CLO-4 :	*Know the importance of genetics in medicine and in metabolic diseases.*	*2*	*85*	*80*
CLO-5 :	*Realize how genetic diseases are common in our society and the reason for it.*	*3*	*85*	*80*
CLO-6 :	*Understand the various treatment strategies of metabolic disorders*	*2*	*80*	*75*

Program Learning Outcomes (PLO)														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
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
L	*M*	*L*	*H*	*H*	*H*			*H*	*H*	*H*	*H*	*L*	*M*	*L*
L	*M*	*H*	*H*	*H*	*H*	*M*		*H*	*H*	*H*	*H*	*L*	*M*	*H*
L	*H*	*M*	*H*	*H*	*H*	*L*		*H*	*H*	*H*	*H*	*L*	*H*	*M*
L	*H*	*L*	*H*	*H*	*H*	*H*		*H*	*H*	*H*	*H*	*L*	*H*	*L*
L	*M*	*L*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*L*	*M*	*L*
L	*H*	*H*	*H*	*H*	*H*	*M*		*H*	*H*	*H*	*H*	*L*	*H*	*H*

Duration (hour)		15	15	15	15	15
S-1	SLO-1	*Introduction to metabolic disorders*	*Carbohydrate metabolic pathways and its associated deficiencies*	*Nitrogen metabolism and its target organs Aminoacid synthesis transport and storage*	*Inborn error of lipid metabolism*	*Disorders of Fat soluble vitamins*
	SLO-2					
S-2	SLO-1	*Principles of metabolic regulation- Garrod's hypothesis*	*Glycolysis*	*Metabolism of branched chain aminoacids Phenylketonuria, tyrosinemia, homocystinuria, maple syrup urine disease, Alkaptonuria, Albinism*	*Hyperlipidemia*	*Disorders of water soluble vitamins*
	SLO-2					
S-3	SLO-1	*Regulation of enzyme activity Covalent modifications and reversible modifications*	*Glycogenesis*	*Amino acid transport disorders: Cystinuria, Dicarboxylic aminoaciduria, Hartnup disease*	*Hypercholesterolemia and its associated disorders*	*Disorders of coenzymes*
	SLO-2					
S 4-5	SLO-1	*phosphorylation, dephosphorylation,*	*Glycogenolysis, Gluconeogenesis*	*Inborn error of purine metabolism*	*Hypolipoproteinemia*	*Disorders of cofactors*
	SLO-2					
S-6	SLO-1	*adenylation and disulphide reduction*	*Congenital disorders of Glycosylation*	*adenylosuccinatelyase deficiency, adenosine monophosphate deaminase deficiency*	*Tangier disease*	*Biotinidase deficiency*
	SLO-2					
S-7	SLO-1	*Overview of inherited metabolic disease processes*	*Galactosaemia Fructosaemia*	*Nucleotide salvage - Lesch-Nyhan syndrome*	*Lipodystrophy*	*Holocarboxylase synthetase deficiency*
	SLO-2					
S-8	SLO-1	*Accumulation of substrate*	*Lactose intolerance*	*adenine phosphoribosyltransferase deficiency - Adenosine deaminase deficiency, Xanthinuria – Pyrimidine metabolism*	*Lipid storage disorders: Sphingolipidoses: ganglioside- globoside- sphingomyelin- sphingosine- sulfatide-related*	*Pantothenate kinase-associated neurodegeneration*
	SLO-2					
S 9-10	SLO-1	*Accumulation of minor metabolites*	*Glycogen storage diseases*	*Inborn error of pyrimidine metabolism: Oroticaciduria*	*Fatty-acid metabolism disorders, biotinidase deficiency, malonicaciduria*	*Methylmalonic academia*
	SLO-2					
S-11	SLO-1	*Deficiency of product, Secondary metabolic phenomena*	*Insulin, glucose homeostasis and diabetes mellitus*	*Miller syndrome, Dihydropyrimidine dehydrogenase deficiency*	*Sjögren–Larsson syndrome*	*Familial isolated vitamin E deficiency*
	SLO-2					
S-12	SLO-1	*Introduction to metabolic disorders*	*Carbohydrate metabolic pathways and its associated deficiencies*	*Nitrogen metabolism and its target organs Aminoacid synthesis transport and storage*	*Inborn error of lipid metabolism*	*Disorders of Fat soluble vitamins*
	SLO-2					

S-13	SLO-1 SLO-2	*Principles of metabolic regulation- Garrod's hypothesis*	*Glycolysis*	*Metabolism of branched chain aminoacids Phenylketonuria, tyrosinemia, homocystinuria, maple syrup urine disease, Alkaptonuria, Albinism*	*Hyperlipidemia*	*Disorders of water soluble vitamins*
S 14-15	SLO-1 SLO-2	*Regulation of enzyme activity Covalent modifications and reversible modifications*	*Glycogenesis*	*Amino acid transport disorders: Cystinuria, Dicarboxylic aminoaciduria, Hartnup disease*	*Hypercholesterolemia and its associated disorders*	*Disorders of coenzymes*

Learning Resources	*1. Robert K. Murray, Darryl K. Granner, Peter A. Mayes, Harper's Illustrated Biochemistry 30th Edition, 2003* *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*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*Dr. Sib Sankar Roy, CSIR-IICB, Kolkatta, sibsankar@iicb.res.in*	*Dr. Koustav Sarkar, SRMIST*

Course Code	18BTE304T	Course Name	INFECTIOUS DISEASES	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Discuss about the different infections and infectious diseases*			
CLR-2 :	*Describe details of bacterial infections and bacterial diseases*			
CLR-3 :	*Explain different viral infections, viral diseases and vaccines*			
CLR-4:	*State about the protozoan and fungal infections and diseases associated with them*			
CLR-5:	*Record the different strategies to combat common infectious diseases and the impact of infectious diseases.*			
CLR-6:	*Identify newer approaches/alternative methods for controlling infectious diseases*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Demonstrate general understating of the infectious diseases and their causative agents*	*1*	*80*	*80*
CLO-2 :	*Illustrate the bacterial infections and ways to tackle different bacterial diseases.*	*2*	*85*	*75*
CLO-3 :	*Interpret the viral infections, vaccine development and challenges*	*2*	*75*	*80*
CLO-4 :	*Discuss about the protozoan and fungal infections and methods to combat them*	*2*	*85*	*80*
CLO-5 :	*Categorize the infectious diseases and their social impact*	*3*	*85*	*75*
CLO-6 :	*Analyze the reimmerging infections and their control*	*2*	*80*	*80*

Program Learning Outcomes (PLO)														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
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
H	*H*	*H*	*H*		*M*	*L*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
H	*H*	*H*	*H*			*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
M	*H*	*M*	*H*	*M*	*M*		*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
H	*H*	*H*	*H*			*H*	*L*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
H	*H*	*H*	*H*		*M*	*H*	*H*	*H*	*L*	*H*	*H*	*H*	*H*	*H*
H	*H*	*H*	*H*	*L*	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Origin of Infection*	*Introduction to pathogenic and non pathogenic bacteria*	*History of viral infections*	*Introduction to Protozoan Diseases*	*Antibacterial: Antibiotics*
	SLO-2	*Evolution of infectious diseases*	*Common bacterial diseases in humans*	*Different Viral diseases*	*Different protozoan diseases*	*Mode of actions of antibiotics*
S-2	SLO-1	*Concept of Infection: Immunity*	*Basic mechanism of Bacterial pathogenesis*	*Viral pathogenesis*	*Severity of protozoan diseases*	*Antibiotic resistance*
	SLO-2	*Immune surveillance*	*Bacterial survival in host cells-Quoram sensing*	*Viral life cycle*	*General mode of action of protozoa*	*MDR and XDR strains*
S-3	SLO-1	*Concept of Infection: Virulence*	*Bacterial virulence factors: Microbial structures*	*Virus genomes and structure*	*Pathogenesis of protozoan diseases: Case study: Plasmodium*	*Antivirals: Vaccines*
	SLO-2	*Concept of Pathogenesis*	*Bacterial virulence factors: Microbial structures: Toxins*	*Host –virus interactions*	*Host response to Prozoan*	*Impact of vaccine in viral disease control*
S-4	SLO-1	*Causative agents of infectious diseases-Virus*	*Host response to Bacterial infection*	*Host Immune reaction against viruses*	*Molecular signaling against Protozoa*	*Challenges in viral vaccine developments*
	SLO-2	*Causative agents of infectious diseases-Bacteria*	*Molecular cell signaling involved in Bacterial diseases*	*Viral evasion of host immune surveillance*	*Hypersensitivity and autoimmunity associated with Protozoan infections*	*Antiviral compounds*
S-5	SLO-1	*Causative agents of infectious diseases-Protozoa and Parasites*	*Host Immune response to bacteria*	*Antiviral pathways*	*General fungal diseases*	*Antimalarial drug development*
	SLO-2	*Causative agents of infectious diseases-Other causative agents*	*Bacterial immune evasion: Molecular Mimicry*	*Mutations in viral genome*	*Mode of action of fungal diseases*	*Mode of action of antimalarial drugs*
S-6	SLO-1	*Disease epidemiology*	*Strategies for antibacterial therapy: Antibiotics*	*Viral diseases and antibody response*	*Immune response against fungal infection*	*Development of Vaccine for Malaria*
	SLO-2	*Steps involved in epidemiology*	*Other antibacterial compounds*	*Vaccine against viral diseases*	*Case study: Candidiasis*	*Challenges for the development of antimalarial drugs*
S-7	SLO-1	*Epidemiological case studies-Bacteria*	*Gut bacteria and their role in pathogenesis*	*Antivirals compounds for viral infections*	*Infection caused by Yeast*	*Infectious diseases and life style*
	SLO-2	*Epidemiological case studies-Bacteria*	*Bacterial vaccines*	*Challenges in vaccine production against certain virtues*	*Mode of action of Yeast infection*	*Beneficial gut microflora*

S-8	SLO-1	*Epidemiological case studies-Virus*	*Case study: E. Coli infection*	*Case study: Influenza*	*Case study: Ring warm*	*Neglected diseases*
	SLO-2	*Epidemiological case studies-Virus*	*Case study: Tuberculosis*	*Case study: Dengue*	*Strategies to combat Protozoan infections*	*Reemerging infectious diseases*
S-9	SLO-1	*Trends in Current epidemiology-Bacterial infections*	*Case study: Pneumonia*	*Case study: HPV*	*Strategies to combat fungal and yeast infections*	*Sexually transmitted diseases and awareness*
	SLO-2	*Trends in Current epidemiology-Viral infections*	*Case study: Helicobacter and gastric cancer*	*Case study: HIV and AIDS*	*Zoonotic diseases*	*Infectious disease and social issues*

Learning Resources	*1. Brenda A. Wilson, Abigail A. Salyers, Dixie D. Whitt, Malcolm E. Winkler, "Bacterial pathogenesis: a molecular approach": 3rd Edition- ASM Press, 2011.* *2. Alan Cann, "Principles of Molecular Virology": 6th Edition-Academic Press, 2015* *3. Vincent Racaniello, "Principles of Virology":4th Edition- ASM Press, 2015* *4. Tracey Lamb, "Immunity to Parasitic Infections": Willy Blackwell, 2012.* *5. Malcolm D. Richardson, David W. Warnock, "Fungal Infection: Diagnosis and Management": 4th Edition- Willy Blackwell, 2012.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18BTE401T	Course Name	CANCER BIOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Describe the genes, 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:	*Explain different methods for studying neuro-immune functions*			
CLR-5:	*Describe the role of stem cells in cancer treatment*			
CLR-6:	*Analyze the role of nuclear medicine and alkaloids in cancer*			
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*			
CLO-1 :	*Analyze the role of diet in different forms of cancer*	*1*	*80*	*80*
CLO-2 :	*Describe the fundamental assays in hazard identification*	*2*	*85*	*75*
CLO-3 :	*Explain the concepts and experiments in cancer development*	*2*	*75*	*80*
CLO-4 :	*Recognize the various pathways of cancer and pain*	*2*	*85*	*80*
CLO-5 :	*Discuss the different methods in the neuroendocrine and immune interactions in cancer*	*3*	*85*	*75*
CLO-6 :	*Explain the concepts of cancer detection and therapy*	*2*	*80*	*80*

Program Learning Outcomes (PLO)														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
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
L	*H*	*H*	*H*		*M*	*L*	*H*	*H*	*H*	*H*	*H*	*L*	*H*	*H*
M	*H*	*H*	*M*			*M*	*H*	*L*	*H*	*H*	*H*	*L*	*H*	*H*
M	*H*	*M*	*H*	*M*	*M*		*M*	*H*	*H*	*H*	*H*	*L*	*H*	*H*
L	*H*	*H*	*H*			*H*	*L*	*L*	*H*	*H*	*H*	*M*	*H*	*H*
L	*H*	*H*	*M*		*M*	*H*	*H*	*H*	*L*	*H*	*H*	*H*	*H*	*H*
M	*H*	*H*	*H*	*L*	*H*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Basic concepts of cancer: Oncogenes and tumor suppressor genes*	*DNA structure and stability*	*Signal transduction*	*Stem cells and cancer*	*Cancer therapy and detection*
	SLO-2	*Risk factors, Pathogenesis, treatment and future prospects*	*Spontaneous DNA damage*	*Growth factors and receptors*	*Self- renewal and its molecular mechanisms*	*Modalities of treatment*
S-2	SLO-1	*The cell cycle*	*DNA repair*	*EGF growth factor receptor signaling*	*Hedgehog signaling pathway*	*Nuclear medicine*
	SLO-2	*cyclin and cyclin dependent kinases*	*Clinical applications of DNA repair biomarkers*	*Ras activation*	*Polycomb group proteins*	*Chemotherapeutic agents*
S-3	SLO-1	*Mechanisms of CdK regulation.*	*Epigenetics*	*Activation of MAPK pathways*	*Therapeutic strategies*	*Plant alkaloids*
	SLO-2	*Tumor suppressor genes*	*Epigenome and its implications*	*Oncogenes*	*Tumor micro environment in cancer*	*Antibiotics*
S-4	SLO-1	*Knudson's two-hit hypothesis*	*Carcinogenesis*	*Immune system*	*Macrophages and tumor progression*	*Hormonal agents*
	SLO-2	*P53 and control of cell cycle*	*Causes of cancer*	*Effector mechanisms in cancer immunity*	*SMAD signaling centers*	*Biological therapy*
S-5	SLO-1	*Molecular pathways of p53*	*Cancer risk factors*	*NF-KB signaling pathway*	*Invasion and metastasis*	*Immunotherapy and hematopoietic growth factors*
	SLO-2	*Myc transcription factor*	*Types of carcinogens*	*JAK/STAT and cancer*	*Cell adhesion molecules*	*Cancer prevention and early detection*
S-6	SLO-1	*Powers of Myc oncoprotein*	*Bacteria and cancer*	*Neuroendocrine system*	*Angiogenesis*	*Screening techniques and diagnostic tests*
	SLO-2	*Role of myc oncoprotein in regulating pRb*	*Hormones and cancer*	*Neurotransmitters and GPCR signaling*	*Tumor angiogenesis and neovasculature*	*Imaging and cancer*
S-7	SLO-1	*TGF role in cancer*	*Ecogenetics and cancer risk*	*Estrogen signaling pathways*	*VEGF signal transduction*	*X-Ray CT, MRI, and radio imaging*
	SLO-2	*pRb's role in cancer*	*Mutations*	*Growth factors, and growth factor receptors*	*Angiogenic inhibitors*	*Optical imaging*
S-8	SLO-1	*Tumor suppressor genes*	*Carcinogen metabolism*	*Wnt signaling*	*Vascular targets*	*Tumor vasculature metabolism*
	SLO-2	*Cell cycle and cancer*	*Biotransformation and cancer risk*	*Implications in cancer therapy*	*Pain and physiology of pain perception*	*Contrast agents in cancer molecular imaging*
S-9	SLO-1	*Different forms of cancer*	*Cancer prevention*	*Apoptosis and Cancer*	*Neuropathic cancer pain*	*Bioinformatics for pathway interaction*
	SLO-2	*Diet and cancer*	*Hazard identification assays*	*Bcl-2 and cancer*	*Pain therapy*	*Population screening challenge*

Learning Resources	1. *Lauren Pecorino, Molecular Biology of Cancer: Mechanisms, Targets, and Therapeutics, Oxford University Press; 4th edition, 2016* 2. *Robert A. Weinberg, The Biology of Cancer Garland Science; 2nd edition , 2013* 3. *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 (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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.ThyagaRajan, SRMIST*
Dr. Karthik Periyasamy, Scientist I, Aurozymes Unit, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	*Dr.R.Vasantharekha, SRMIST*

Course Code	18BTE402T	Course Name	PHYSIOLOGY OF STRESS AND ITS MANAGEMENT	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Describe the homeostasis and control systems in stress*			
CLR-2 :	*Discuss stress neuroendocrinology*			
CLR-3 :	*Recall the behavioral response to stress*			
CLR-4:	*Explain different disorders of stress*			
CLR-5:	*Describe the role of age and emotion in stress*			
CLR-6:	*Analyze the role of education I managing stress*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*			
CLO-1 :	*Analyze the role of endocrine and immune system in stress*	*1*	*80*	*80*
CLO-2 :	*Describe the role of brain and neurotransmitters in stress*	*2*	*85*	*75*
CLO-3 :	*Explain the concepts and experiments in stress and stressors*	*2*	*75*	*80*
CLO-4 :	*Recognize the various pathways of stress related disorders*	*2*	*85*	*80*
CLO-5 :	*Discuss the different methods in the management of stress*	*3*	*85*	*75*
CLO-6 :	*Explain the concepts of diet, exercise and life style in managing stress*	*2*	*80*	*80*

Program Learning Outcomes (PLO)														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
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
L	*H*	*H*	*H*		*M*	*L*	*H*	*H*	*H*	*H*	*H*	*L*	*H*	*H*
M	*H*	*H*	*M*			*M*	*H*	*L*	*H*	*H*	*H*	*L*	*H*	*H*
M	*H*	*M*	*H*	*M*	*M*		*M*	*H*	*H*	*H*	*H*	*L*	*H*	*H*
L	*H*	*H*	*H*			*H*	*L*	*L*	*H*	*H*	*H*	*M*	*H*	*H*
L	*H*	*H*	*M*		*M*	*H*	*H*	*H*	*L*	*H*	*H*	*H*	*H*	*H*
M	*H*	*H*	*H*	*L*	*H*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Homeostasis and control systems*	*Stress neuroendocrinology*	*Behavioral responses to stress*	*Stress of Boredom*	*Awareness about managing stress.*
	SLO-2	*Endocrine system*	*limbic forebrain*	*Behavioral sources of stress*	*Anxiety disorders*	*Extra role in behavior*
S-2	SLO-1	*HPA axis*	*Noradrenergic system*	*Impairment of response inhibition*	*Panic disorder*	*Managing stress and behavior*
	SLO-2	*Limbic modulation of HPA axis*	*Corticotropin releasing hormone*	*lack of motivation*	*Social anxiety disorder*	*Extra role in education settings*
S-3	SLO-1	*Nervous system and stress disorder*	*CRF family with role in HPA axis*	*Aggressive behavior*	*Cognitive behavior therapy*	*Relaxation.*
	SLO-2	*Hippocampus and depression*	*Intracellular signaling mediating external signals of stress*	*Physiological components of stress response*	*Post-traumatic syndromes*	*Effective communication.*
S-4	SLO-1	*Parasymapthetic system*	*Catecholamines and MAP kinases*	*Interactions of behavioral and physiological components*	*Evolution and treatment*	*Intervention of caregivers*
	SLO-2	*Fight/flight responses*	*microRNAs-Telomeres*	*Environmental factors*	*Distress*	*Institutional care*
S-5	SLO-1	*Rest/digest responses*	*Role of micro-RNA in fear conditioning*	*Impact of environmental factors on stress*	*Psychological concomitants of distress*	*Managing anger and coping with anxiety.*
	SLO-2	*Immune system*	*Neural circuitry of stress, fear and anxiety*	*Differential exposure*	*Chronic stress.*	*Psychophysiological and biological perspective*
S-6	SLO-1	*Innate Immunity*	*Serotonergic systems modulates anxiety*	*Vulnerability of environmental stressors*	*Fear.*	*Meditation model*
	SLO-2	*Adaptive immunity*	*Locus coeruleus facilitate stress*	*Psychological stressors*	*Emotional inhibition*	*Eating behavior and healthy lifestyle*
S-7	SLO-1	*Stress and its underpinnings*	*Neurons and central autonomic control*	*Historical and general considerations*	*Aggressive behavior and social stress.*	*Human research related to stress in food intake*
	SLO-2	*Kinds of stress*	*Stress-Hippocampal neurogenesis.*	*Conceptual developments*	*Acute and chronic stress models*	*Mechanisms relating stress to eating*
S-8	SLO-1	*Norepinephrine in stress*	*Neurons modulate HPA axis*	*Methodological considerations*	*Aging and psychological stress.*	*Exercise*
	SLO-2	*Noradrenergic control of stress*	*Epigenetics and stress and neural network*	*Cognition and stress*	*Age-related disease*	*Time management and stress reduction plan*
S-9	SLO-1	*Allostasis*	*Epigenetics and stress response*	*Cognitive origin of stress*	*Stress response and central role of brain*	*General principles of prevention*
	SLO-2	*Allostatic load*	*Transgenerational effects of epigenetic stress markers*	*Cognitive consequences of stress*	*Job-related stress.*	*Physical and mental well-being*

Learning Resources	1. *George Fink. Stress: Concepts, Cognition, Emotion, and Behavior: Handbook in Stress. Academic Press. First edition. 2016* 2. *George Fink, Stress: Neuroendocrinology and neurobiology; Academic Press. First edition. 2017*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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.ThyagaRajan, SRMIST*
Dr. Karthik Periyasamy, Scientist I, Aurozymes Unit, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	*Dr.R.Vasantharekha, SRMIST*

Course Code	18BTE305T	Course Name	PHARMACEUTICAL BIOTECHNOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18BTC101J	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:*	Learning
CLR-1 :	*Appraise the changes the drug and human system undergoes when consumed*	1
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, toxicity and uses of antibiotics and anti-tubercular drugs*	
CLR-5:	*Describe the regulation of drugs in Indian Government and its initiatives in promoting Indian System of medicine*	
CLR-6:	*Distinguish various parameters to be considered during drug discovery process*	

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Select appropriate target, drug-like candidates based on desired pharmacokinetic and pharmacodynamic parameters*	*1*	*80*	*80*
CLO-2 :	*Estimate the dose of drug to be administered for individuals*	*2*	*85*	*75*
CLO-3 :	*Explain the logical usage of drugs and suggest appropriate treatment*	*2*	*75*	*80*
CLO-4 :	*Justify the choice of drugs for microbial infection in an individual*	*2*	*85*	*80*
CLO-5 :	*Underline the significance of stringent laws pertaining to manufacturing, distribution and sale of drugs in India*	*3*	*85*	*75*
CLO-6 :	*Illustrate the process of pre-clinical investigation of drug designing*	*2*	*80*	*80*

Program Learning Outcomes (PLO)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	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
CLO-1	*M*	*H*	*L*	*H*			*L*	*H*	*L*	*L*	*L*	*H*	*H*	*H*	*H*
CLO-2	*M*	*H*	*L*	*H*			*L*	*H*	*M*	*L*	*H*	*H*	*H*	*H*	
CLO-3	*L*	*H*	*M*	*H*		*M*		*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-4	*H*	*H*	*H*	*H*			*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-5	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-6	*H*	*H*	*H*	*H*	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Basic concepts*	*Plateau principle*	*Pharmacovigilance*	*Mechanism of action of Tetracyclines*	*Mechanism of action of Amphoterycin B*
	SLO-2	*Pharmacopoeia and Essential Drugs*	*Target level strategy*	*Casualty assessment*	*Uses, Spectrum of activity, toxicity of Tetracyclines*	*Spectrum of activity and adverse effects of Amphoterycin B*
S-2	SLO-1	*Local routes of drug administration*	*Prolongation of drug action*	*Side, secondary and toxic effects of drugs*	*Mechanism of action of aminoglycoside antibiotics*	*Mechanism of action of Griseofulvin*
	SLO-2	*Systemic routes of drug administration*	*Target delivery devices*	*Accidental overdose of drugs and the treatment*	*Classification, Uses of aminoglycosides*	*Mechanism of action of Imidazoles and Triazoles anti-fungal agents*
S-3	SLO-1	*Influence of pH on transport of molecules across membranes*	*Principles of drug action*	*Drug Intolerance and Drug allergy*	*Mechanism of action of Macrolide antibiotics*	*Indian Drug Regulatory System*
	SLO-2	*Passsive transport and facilitated transport*	*Mechanism of drug action on enzymes*	*Drug abuse and Treatment*	*Classification of Macrolide antibiotics*	*Drug Regulatory body - CDSCO*
S-4	SLO-1	*Absorption of Drugs*	*Mechanism of drug action on Ion channels*	*Classification of anti-microbial agents based on chemical structure*	*Spectrum of activity of Macrolide antibiotics*	*Hierarchy at CDSCO*
	SLO-2	*Bioavailability*	*Mechanism of drug action on transporters*	*Classification of anti-microbial agents based on mechanism of action*	*Uses and toxicity of Macrolide antibiotics*	*Good clinical Practices*
S-5	SLO-1	*Distribution and Redistribution of drugs*	*Action-Effect sequence*	*Drug modification and alteration of target site by microorganisms*	*Treatment of Urinary tract infections*	*Role of Pharmacists in Drug regulation*
	SLO-2	*Tissue storage, placental & brain transport*	*Transducer mechanism*	*Reduction in drug accumulation and alteration of metabolic pathway by microorganisms*	*Structure, adverse effects of Isoniazid*	*Functions of State Drug-Inspectors*
S-6	SLO-1	*Biotransformation of drugs and types*	*Dose-Response Relationship*	*Mechanism of action of Co-trimoxazole*	*Mechanism of action of Isoniazid*	*Functions of CDSCO*
	SLO-2	*Cytochrome P450*	*Therapeutic efficiency*	*Uses and adverse effects of cotrimoxazole*	*Structure, adverse effects of Rifampicin*	*Functions of Central Drug-Inspectors*
S-7	SLO-1	*Non-synthetic biotransformation reactions*	*Synergystic drug action*	*Mechanism of action of Fluoroquinolones*	*Mechanism of action of Rifampicin*	*Ayurvedic Formulary of India*

	SLO-2	*Synthetic biotransformation of drugs*	*Antagonistic drug action*	*Classification, Uses and adverse effects of Fluoroquinolones*	*Structure, Mechanism of action, adverse effects of Pyrazinamide*	*Ayurvedic Dosage Forms*
S-8	SLO-1	*Inhibition of drug metabolism*	*Fixed dose combination of drugs*	*Structure of beta-lactum antibiotics*	*Structure, Mechanism of action, adverse effects of Ethambutol*	*Ayurvedic Pharmacopoeia of India*
	SLO-2	*Induction of microsomal enzymes*	*Factors modifying drug action*	*Classification of beta-lactum antibiotics*	*Tuberculosis in pregnant and lactating women*	*Ayurvedic, Unani, Siddha drugs undertaken by British commission*
S-9	SLO-1	*Routes of excretion of drugs*	*Pharmacogenetics and Pharmacogenomics*	*Uses of beta-lactum antibiotics*	*Tuberculosis in HIV infected individuals in India*	*Indian Government Initiatives to promote Ayurvedic products*
	SLO-2	*Rate of Clearance and Plasma half-life*	*Drug dosage in individuals with hepatic, renal, heart and thyroid problems*	*Adverse effects of beta-lactum antibiotics*	*Mycobacterium Avium Complex infections in India*	*Indian Government Initiatives to promote Unani and Siddha products*

Learning Resources	1. *Rang and Dale, "Pharmacology", Churchill Livingstone, 2007.* 2. *Tripathi.K.D, "Essentials of Medical Pharmacology", Jaypee Brothers Medical Publishers, New Delhi, 7th Edition, 2013.* 3. *http://www.cdsco.nic.in/forms/contentpage1.aspx?lid=1888* 4. *cdsco.nic.in/writereaddata/guidance%20documents.pdf*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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Dr. Karthik Periyasamy, Scientist I, Aurozymes Unit, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	*Mr. M. K. Jaganathan, SRMIST*

Course Code	18BTE306T	Course Name	BIOINFORMATICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
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 motifs and patterns*			
CLR-6:	*Analyze uses of Python programming in Bioinformatics applications*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	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
CLO-1 :	*Describe the applications of bioinformatics to build databases for universal usage*	*1*	*80*	*80*	*H*	*H*	*H*	*H*		*M*	*L*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-2 :	*Explain the concepts and tools to build alignment between similar sequences of DNA or Protein*	*2*	*85*	*75*	*H*	*H*	*H*	*H*			*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-3 :	*Recognize the pattern of lineages and evolution*	*2*	*80*	*80*	*M*	*H*	*M*	*H*	*M*	*M*		*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-4 :	*Discuss the different methods in the construction the structure of a protein*	*2*	*85*	*80*	*M*	*H*	*H*	*H*			*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-5 :	*Analyze the importance of conserved regions in a molecular sequence*	*3*	*85*	*75*	*M*	*H*	*H*	*H*		*M*	*H*	*M*	*H*	*L*	*H*	*H*	*H*	*H*	*H*
CLO-6 :	*Explain the basic concepts and principles of Programming in Python for bioinformatics*	*3*	*80*	*80*	*H*	*H*	*H*	*H*	*L*	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Bioinformatics significance*	*Introduction on databases & biological databases*	*Sequence alignment*	*Motifs and Patterns prediction*	*Introduction of Python and text editors*
	SLO-2	*Applications of bioinformatics*	*Uses of biological databases*	*Global Pairwise Alignment Algorithm*	*Databases for motif prediction*	*String datatype*
S-2	SLO-1	*Internet basics: Connecting to internet*	*Primary sequence databases, Nucleotide*	*Solving problems*	*Databases for patterns and blocks*	*Tuples datatype*
	SLO-2	*Internet Protocols*	*Protein sequence database*	*Local Pairwise Alignment Algorithm*	*Secondary Database Searching*	*Lists datatype*
S-3	SLO-1	*HTML script*	*Primary structure databases*	*Database searching*	*Secondary structure prediction*	*Flow control: If else*
	SLO-2	*Webpage creation*	*PDB file format*	*BLAST*	*Tools for secondary structure prediction*	*For loop*
S-4	SLO-1	*Human genome project*	*Fasta, GCG, VFF etc..*	*FASTA*	*Specialized secondary structure prediction*	*While loop*
	SLO-2	*Uses of human genome project*	*Secondary databases*	*Multiple Sequence Alignment:*	*Tertiary structure prediction*	*Reading and Writing files*
S-5	SLO-1	*The NCBI data model: Introduction*	*secondary sequence databases*	*Progressive and Iterative Alignment*	*Comparative modelling*	*Modules in Python*
	SLO-2	*SEQ-Ids*	*secondary structure databases*	*Tools for pairwise alignment*	*Abinitio modelling*	*Functions*
S-6	SLO-1	*BIOSEQs and BIOSEQ-SETs*	*SCOP*	*tools for multiple sequence alignment*	*Validation of tertiary structure*	*Regular expressions: Syntax*
	SLO-2	*SEQ-ANNOT and SEQ-DESCR*	*CATH*	*Application of Multiple Sequence Alignment*	*tools for homology modeling*	*Regex examples*
S-7	SLO-1	*Genbank database*	*Composite protein databases*	*Databases Of Multiple Alignment*	*tools for structure validation*	*Biopython*
	SLO-2	*Genbank Flat file*	*Metabolic databases*	*Molecular Phylogeny*	*Structure visualization tools*	*Advantages of python in bioinformatics*
S-8	SLO-1	*Sequence submission to Genbank*	*SNP databases*	*Methods of phylogeny*	*rasmol*	*Components of biopython: Alphabet*
	SLO-2	*Online and offline tools*	*Whole genome , medelian disease databases*	*types of trees*	*Chemical structure building tools*	*Seq, Seq object, SeqUtils*
S-9	SLO-1	*Entrez , INSDC*	*chemical structure databases*	*Tools for phylogeny*	*file formats for small molecules*	*Align and clustalw with Biopython*
	SLO-2	*Other databases in NCBI*	*bibliographic databases*	*PAM and BLOSUM*	*file format conversion tools*	*BLAST Running and Processing with Biopython*

Learning Resources	1. Andreas D Baxevanis & B F Francis, "Bioinformatics- A practical guide to analysis of Genes & Proteins", John Wiley, 2002 2. T K Attwood, D J Parry-Smith," Introduction to Bioinformatics", Pearson Education, 1st Edition, 11th Reprint 2005. 3. Jin Xiong, "Essential Bioinformatics", Cambridge University Press, 2006 4. Sebastian Bassi, "Python for Bioinformatics", 2nd Edition CRC Press, 2017.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr. Raghu R.Schrondinger, raghu.rangaswamy@schrodinger.com	*Dr.G. Ramesh kumar, AU-KBC Research Centre, gramesh@au-kbc.org*	*Dr. Priya Swaminathan, SRM Institute of Science & Technology, priya.s@ktr.srmuniv.ac.in*
Dr. Karthik Periyasamy, Scientist I, Aurozymes Unit, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*Prof. R. B. Narayanan, SVCE,Chennai, rbn@svce.ac.in*	*Mr. M.K.Jagannathan, SRM Institute of Science & Technology, jaganathan.m@ktr.srmuniv.ac.in*

Course Code	18BTE307T	Course Name	DRUG DISCOVERY AND DRUG DESIGNING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*State the basic concepts of drug discovery and drug design processes*			
CLR-2 :	*State the basic concepts of target identification and target characterization*			
CLR-3 :	*Explain about the various computational tools in drug discovery*			
CLR-4:	*Discuss about the pharmacophore Model and QSAR*			
CLR-5:	*Discuss about the quantum mechanics in drug design, De novo and future developments in drug design*			
CLR-6:	*Explain the basic concepts of drug discovery and drug design processes and computational tools used in the drug designing.*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Explain basic concepts of drug design processes for a various number of drug development scenarios.*	*1*	*85*	*80*
CLO-2 :	*Explain the basic concept of target identification and target characterization*	*1*	*85*	*80*
CLO-3 :	*Compare the different computational tools for drug designing and the computer software used in the drug designing.*	*2*	*80*	*70*
CLO-4 :	*Explain the basic concepts of pharmacophore Model and QSAR.*	*1*	*80*	*70*
CLO-5 :	*Summarize the basic concepts of Quantum Mechanics in drug designing and De nova ligand synthesis.*	*1*	*85*	*80*
CLO-6 :	*Summarize the basic concepts in the drug design process and the computational techniques used in the drug design process.*	*1*	*80*	*70*

Program Learning Outcomes (PLO)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	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
CLO-1 :	*L*	*H*	*H*	*H*	*H*		*M*	*M*	*H*			*H*	*H*	*H*	*H*
CLO-2 :	*L*	*H*	*H*	*H*	*H*		*H*		*H*			*H*	*H*	*H*	*H*
CLO-3 :	*M*	*H*	*H*	*H*	*H*		*H*		*H*			*H*	*H*	*H*	*H*
CLO-4 :	*M*	*H*	*H*	*H*	*H*		*H*		*H*			*H*	*H*	*H*	*H*
CLO-5 :	*M*	*H*	*H*	*H*	*H*		*H*		*H*			*H*	*H*	*H*	*H*
CLO-6 :	*M*	*H*	*H*	*H*	*H*		*H*		*H*			*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to the drug discovery process*	*Target Identification: Primary Sequence and Metabolic Pathway,*	*introduction to computational tools in drug discovery*	*what is a pharmacophore Model*	*Quantum Mechanics in drug designing*
	SLO-2	*The sequence of research activities in the development of new drug*	*Crystallography and 2D NMR, Homology Models and Protein Folding in target identification*	*Introduction to Homology Model Building*	*Components of a Pharmacophore Model*	*When quantum mechanics is superior to molecular mechanics?*
S-2	SLO-1	*Terminology related to drug testing: "hits," "leads," "drug candidates," "drugs,"*	*Analysis of Target Mechanism: Kinetics and Crystallography, Automated Crevice Detection,*	*Importance of sequence similarity in homology modeling*	*Creating a Pharmacophore Model from the Active Compounds*	*Quantum Mechanics Algorithms*
	SLO-2	*Criteria that may be necessary to move a compound series onto the lead development stage*	*Transition Structures and Reaction Coordinates.*	*Steps for Building a Homology Model*	*Advantages of pharmacophore searching*	*Quantum Mechanics Software used in drug designing*
S-3	SLO-1	*Compound Testing: Biochemical Assays*	*Introduction to Molecular Dynamics Simulations*	*Homology Model creation*	*Creating a Pharmacophore Model from the Active Site*	*Modeling systems with metal atoms*
	SLO-2	*Compound Testing: Cell-Based Assays,*	*Molecular dynamics in target characterization*	*Homology Model validation*	*Example of Pharmacophore Model from the Active Site*	*Increased accuracy*
S-4	SLO-1	*Compound Testing: Animal Testing*	*Pharmacophore identification*	*Molecular Mechanics: Brief Introduction to Molecular Mechanics*	*Searching Compound Databases*	*Computing reaction paths*
	SLO-2	*alternatives to animal testing*	*Deriving and using 3D pharmacophores*	*How molecular mechanics are utilized in drug design.*	*Reliability of search Results*	*Computing spectra*
S-5	SLO-1	*Compound Testing: Human Clinical Trials*	*The Drug Design Process for a Known Protein Target: The Structure-Based Design Process*	*Force Fields for Drug Design*	*QSAR*	*Structure-based De novo Ligand synthesis*
	SLO-2	*Phases in clinical trials*	*The Drug Design Process for a Known Protein Target: Initial Hits and Compound Refinement, ADMET*	*common force fields and their usage*	*Conventional QSAR versus 3D-QSAR*	*Example of De novo Ligand synthesis*

S-6	SLO-1	*Effect of Molecular Structure on Activity*	*What is Drug Resistance*	*Introduction to Molecular Docking*	*The QSAR Process*	*Nonquantitative predictions*
	SLO-2	*Effect of Molecular Structure on Bioavailability*	*Mechanisms of resistance to the drug*	*Search Algorithms in Molecular Docking*	*Descriptors*	*Quantitative predictions*
S-7	SLO-1	*Drug Side Effects and Toxicity*	*The Drug Design Process for an Unknown Target: The Ligand-Based Design Process*	*The Docking Process: Preparation of Protein and Ligand*	*Automated QSAR Programs*	*Future Developments in Drug Design: Individual Patient Genome Sequencing*
	SLO-2	*Multiple Drug Interactions*	*The Drug Design Process for an Unknown Target: Initial Hits and Compound Refinement, ADMET*	*Setting the Bounding Box*	*QSAR versus Other Fitting Methods*	*Analysis of the Entire Proteome*
S-8	SLO-1	*Metrics for Drug-Likeness*	*Drug Design for Other Targets*	*Docking Options and Running the Docking Calculation*	*The 3D-QSAR Process*	*Drugs Customized for Ethnic Group or Individual Patient*
	SLO-2	*The Lipinski rule of fives*	*Drug design issues that arise in situations other than competitive inhibition of proteins.*	*Analysis of docking Results*	*Criteria are used to construct conformers*	*Application of Genetic Manipulation in drug designing*
S-9	SLO-1	*Exceptions to the Rules*	*Targets inside cells*	*Docking software*	*3D-QSAR Software Packages*	*Cloning and Stem Cells in drug design*
	SLO-2	*Examples of successful drugs that do not obey the "rules."*	*Targets within the central nervous system*	*An important criterion for selecting a docking program.*	*Advantage and disadvantages of 3D-QSAR Software*	*Longevity*

Learning Resources	1. *Young, "Computational Drug Design: a Guide for Computational and Medicinal Chemists", Wiley, 2009* 2. *Andrew Leach, "Molecular Modeling: Principles and applications," 2nd edition, Pearson Education, 1996* 3. *Andrew Leach, "An introduction to Chemoinformatics," Springer, 2007* 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.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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*	*Mr. Jaganathan. M. K. SRMIST*
Dr. Karthik Periyasamy, Scientist I, Aurozymes Unit, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	*Dr. S. Priyaswaminathan. SRMIST*

Course Code	18BTE308T	Course Name	MARINE BIOTECHNOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
CLR-1 :	*Learn the knowledge of the living and non-living resources.*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-2 :	*Analyze the pharmacological potency of toxins.*			
CLR-3 :	*Apply the biopolymers from various sources.*			
CLR-4:	*Understand the commercialization of marine and aquaculture resources.*			
CLR-5:	*Control measures of various marine pollution.*			
CLR-6:	*Analyze the techniques on the resource management.*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Describe the economically important marine resources and their wealth.*	1	80	80
CLO-2 :	*Explain the natural toxins.*	2	85	75
CLO-3 :	*Distinguish the availability of bioactive compounds.*	2	80	80
CLO-4 :	*Analyze the useful natural products.*	2	85	80
CLO-5 :	*Know the degradation process for discharged wastes.*	3	85	75
CLO-6 :	*Explain the diseases of cultivable animals and its controlling measures.*	2	80	80

Program Learning Outcomes (PLO)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	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
CLO-1	*M*	*H*	*H*	*H*	*H*		*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-2	*M*	*H*	*H*	*H*	*H*		*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-3	*H*	*H*	*H*	*H*	*H*		*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-4	*M*	*H*	*M*	*M*	*H*		*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-5	*M*	*M*	*H*	*H*	*H*		*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-6	*M*	*H*	*H*	*H*	*H*		*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Zonation of the Sea*	*Toxic marine animals*	*Bioactive compounds*	*Oil spills and accidents*	*Shrimp diseases*
	SLO-2	*Motion of the Ocean*	*Octopus, venomous spines, stings*	*Biopolymers, Omega-3 fatty acids*	*Fate of spilled oil*	*Monodon baculovirus, vibriosis, larval mycosis*
S-2	SLO-1	*Living resources*	*Sources of toxins*	*Free radicals*	*Biosurfactants*	*Fish diseases*
	SLO-2	*Corals, seaweeds and mangroves*	*TTX, conotoxin*	*Antioxidant enzymes, peptides*	*Microbes in biodegradation*	*Rhabdovirus, erythrodermatitis, gill disease*
S-3	SLO-1	*Non-living resources*	*Various effects of toxin*	*Biopolymers*	*Harmful blooms*	*Antibiotics in aquaculture*
	SLO-2	*Oil, gas and salts*	*Intoxication, stings*	*Collagen, gelatin*	*Blue-green algal bloom, red tides*	*Oxytetracycline, enrofloxacin*
S-4	SLO-1	*Economically important animals*	*Puffer fish toxins*	*Anticoagulant substances*	*Marine harmful biotoxins*	*Immunostimulants*
	SLO-2	*FInfishes*	*Tetrodotoxin*	*Heparin*	*Impacts of bloom*	*Objectives and characteristics of immunostimulants*
S-5	SLO-1	*Penaeid shrimps*	*Intoxication of puffer toxin*	*Biomaterials*	*Pesticide pollution*	*Common immunostimulants*
	SLO-2	*Penaeus indicus*	*Pharmacological effects*	*Chitin, Chitosan*	*Organochlorine, organophosphate esters*	*Muramyl dipeptide, levamisole*
S-6	SLO-1	*Non-penaeid shrimps*	*Molluscan venoms*	*Poly unsaturated fatty acids*	*Heavy metal pollution*	*Tools to diagnose the disease*
	SLO-2	*Metapenaeus brevicornis*	*Conotoxin*	*Omega 3-fatty acids*	*Minamata disease*	*Agar gel precipitation, fluorescent antibody test*
S-7	SLO-1	*Marine crabs*	*Pharmacology of conotoxin*	*Applications of Omega 3-fatty acids*	*Chemical and biological modification*	*Water quality management*
	SLO-2	*Portunidae crabs*	*Clinical effects of conotoxin*	*Antiinflammatory, cardiovascular, diabetes*	*Biosorption, factors affecting*	*Temperature*
S-8	SLO-1	*Edible Oysters*	*Seafood poisoning*	*Fat soluble pigments*	*Solid waste pollution*	*Salinity*
	SLO-2	*Oyster reefs*	*Ciguateratoxin*	*Carotenoids*	*Plastic waste degradation*	*Dissolved oxygen, pH*
S-9	SLO-1	*Pearl Oysters*	*Sources of ciguateratoxin*	*Sources of carotenoids*	*Microbes for degradation*	*Nutrients*
	SLO-2	*Pinctada species*	*Jacks, sturgeon, grouper, snappers*	*Micro algae, sponges, mollusks, crustaceans*	*Factors affecting degradation*	*Ammonia*

Learning Resources	1. *Milton Fingerman and Rachakonda Nagabhushanam, "Recent Advances in Marine Biotechnology (Series) Biomaterials and Bioprocessing", Science Publishers, 2009.* 2. *Proksch and Werner E.G.Muller, "Frontiers in Marine Biotechnology", Horizon Bioscience, 2006.* 3. *Le Gal, Y., Ulber, R, "Marine Biotechnology I: Advances in Biochemical Engineering/Biotechnology", (Series editor: T. Scheper) Springer-Verlag Berlin Heidelberg. Vol. 96, 2005.* 4. *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 (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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Dr. Karthik Periyasamy, Scientist I, Aurozymes Unit, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	*Dr.R.Jaiganesh, SRMIST*

Course Code	18BTE403T	Course Name	VACCINE BIOTECHNOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18BTC106J	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:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
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*			
CLR-6:	*Analyze the immunization of an organism against antigen*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Acquire theoretical knowledge on conventional strategies in vaccine production*	*1*	*80*	*80*
CLO-2 :	*Exemplify the students with vaccine production techniques*	*2*	*85*	*75*
CLO-3 :	*Distinguish various types of vaccine*	*2*	*75*	*80*
CLO-4 :	*Devise various methods for vaccine delivery*	*2*	*85*	*80*
CLO-5 :	*Explain the guidelines for vaccine production and delivery*	*3*	*85*	*75*
CLO-6 :	*Illustrate the basic concepts of vaccination and prophylaxis*	*2*	*80*	*80*

Program Learning Outcomes (PLO)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	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
CLO-1 :	*H*	*H*	*H*	*H*		*M*	*L*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-2 :	*H*	*H*	*H*	*H*	*M*		*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-3 :	*M*	*H*	*M*	*H*	*M*	*M*		*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-4 :	*H*	*H*	*H*	*H*	*M*		*H*	*L*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-5 :	*H*	*H*	*H*	*H*		*M*	*H*	*H*	*H*	*L*	*H*	*H*	*H*	*H*	*H*
CLO-6 :	*H*	*H*	*H*	*H*	*L*	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*History of vaccine development*	*Technology related to monitoring seed lot for better production*	*Types of vaccines*	*Immunomodulators*	*Guidelines for vaccine management*
	SLO-2	*Types of Immunity*	*Temperature Monitoring*	*Vaccine efficacy*	*Innovative methods of delivering immunogens*	*Regulatory issues in vaccine development*
S-2	SLO-1	*Conventional strategies for vaccine improvement*	*Sterilization*	*Inactivated toxins*	*liposomes*	*Regulatory bodies for vaccine management*
	SLO-2	*Current development in vaccines*	*Environmental strategies for better production*	*Inactivated whole bacteria*	*Mechanism of liposome formation*	*Environmental effects of recombinant vaccines*
S-3	SLO-1	*Types of vaccines*	*quality assurance and related areas in vaccine production*	*Inactivated whole virus*	*Classification of liposomes*	*Disease security and biosecurity principles*
	SLO-2	*Live vaccine*	*Analysis of vaccine efficiency*	*Live attenuated bacteria*	*Methods of liposomes preparation*	*Assessing and Monitoring Safety of Vaccines*
S-4	SLO-1	*Attenuated vaccine*	*Vaccine Production techniques*	*Live attenuated viruses*	*Characterisation of liposomes*	*OIE – structure and mission*
	SLO-2	*subunit vaccine*	*growing the microorganisms in maximum titre*	*Subunit vaccines*	*Therapeutic applications of liposomes*	*OIE guidelines for vaccine seed lot management*
S-5	SLO-1	*Peptide vaccine*	*Steps involved in vaccine production*	*Polysaccharide vaccines*	*role of liposomes in delivering vaccines*	*OIE guidelines for the method of vaccine production*
	SLO-2	*killed vaccine*	*Selecting the strain for vaccine production*	*Conjugated vaccines*	*Advantages & disadvantages of liposomes*	*OIE Guidelines for Production facility*
S-6	SLO-1	*Types of adjuvants*	*Culturing bacteria*	*Recombinant DNA vaccines*	*Microspheres*	*Documentation of the manufacturing process*
	SLO-2	*Mode of action of adjuvants*	*Culturing virus*	*Differences between traditional and recombinant vaccine*	*Types of microspheres*	*Guidelines for manufacture of vaccine with an example*
S-7	SLO-1	*PRR ligands*	*Isolation and purification of microbes*	*Edible vaccines*	*Methods of preparing microspheres*	*In process control and batch control*
	SLO-2	*Methods to access vaccine efficacy*	*Inactivation of Microorganism*	*Plasma derived vaccines*	*Characterisation and applications of microspheres*	*organization and responsibilities*
S-8	SLO-1	*Quality control in vaccine production*	*Preservation techniques*	*Virus like particles*	*ISCOMS-Properties of ISCOM based vaccines*	*documentation and evaluation of data*

	SLO-2	Preservation of industrially important microbes	Preservation of industrially important microorganisms	HPV L1 VLP vaccine	Types of ISCOM	Test on final products
S-9	SLO-1	monitoring of microorganisms	Preservation using low temperature	Nanoparticles in vaccine delivery	components of ISCOM	General manufacturing recommendations
	SLO-2	Seed lot systems	freeze drying	Induction of immune responses by nanoparticle based vaccine	Induction of antibody responses by ISCOMs	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.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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 I, Aurozymes Unit, Aurobindo Pharma Limited, Hyderaba, karthikmpk@gmail.com	*Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	*Dr. Suvankar Ghorai, SRMIST*

Course Code	18BTE404T	Course Name	MOLECULAR BASIS OF DRUG ACTION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*State the basic knowledge of drug targets and molecular cloning of these targets.*			
CLR-2 :	*Discuss the recent advancement and development in human drug target : G-protein coupled receptors.*			
CLR-3 :	*Discuss the recent advancement and development in human drug target : ion channels*			
CLR-4:	*Discuss the recent advancement and development in human drug target : transporter proteins*			
CLR-5:	*Explain how an individual's genetic makeup influences their response to therapeutic drugs.*			
CLR-6:	*Discuss about the drug targets and their role in health and disease.*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Summaries about the drug targets and method to clone drug targets.*	1	85	80
CLO-2 :	*Explain about G protein coupled receptors.*	1	80	70
CLO-3 :	*Explain about various ion channels.*	1	80	75
CLO-4 :	*Explain about various transporters*	1	85	80
CLO-5 :	*Discuss how an individual's genetic makeup influences their response to therapeutic drugs.*	1	80	70
CLO-6 :	*Summaries about the drug targets and their role in health and disease.*	2	85	80

Program Learning Outcomes (PLO)														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
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
L	*H*	*H*	*H*	*H*		*M*	*M*	*H*			*H*	*H*	*H*	*H*
L	*H*	*H*	*H*	*H*		*H*		*H*			*H*	*H*	*H*	*H*
L	*H*	*H*	*H*	*H*		*H*		*H*			*H*	*H*	*H*	*H*
L	*H*	*H*	*H*	*H*		*H*		*H*			*H*	*H*	*H*	*H*
L	*H*	*H*	*H*	*H*		*H*	*H*	*H*			*H*	*H*	*H*	*H*
L	*H*	*H*	*H*	*M*		*H*	*M*	*H*			*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to molecular pharmacology*	*Introduction to GPCRs and Heterotrimeric G-protein*	*introduction to ion channels*	*introduction Transporter proteins*	*Types of genetic variation*
	SLO-2	*Outline of molecular pharmacology based approaches used to interrogate drug targets.*	*molecular structure of GPCR*	*Classification of ion channels*	*classification of Transporter proteins*	*Thiopurine S-methyltransferase, and Cardiac K+channel polymorphisms*
S-2	SLO-1	*Molecular pharmacology vs traditional pharmacology*	*Classification of GPCR*	*introduction to Voltage-gated ion channels*	*Transporter families of pharmacological interest*	*Polymorphisms affecting drug metabolism*
	SLO-2	*Importance of molecular pharmacology.*	*Activation of GPCR*	*structure of Voltage-gated ion channels*	*The major facilitator superfamily (MFS)*	*Different Scenario how the polymorphisms affecting drug metabolism*
S-3	SLO-1	*Nature of the Drug targets*	*Signal transduction pathways - phospholipase C and adenylyl cyclase*	*Voltage-gated ion channels in health and disease*	*MFS in health*	*Methods for detecting genetic polymorphisms*
	SLO-2	*Future drug targets*	*Measurement of phospholipase C and adenylyl cyclase activation*	*Voltage-gated ion channels and neurotransmission*	*Role MFS in disease*	*PCR-RFLP analysis and Large-scale SNP analysis*
S-4	SLO-1	*Introduction to molecular cloning – from DNA to drug discovery*	*Desensitization and down-regulation of GPCR signalling*	*Voltage-gated ion channels and muscle contraction*	*The neurotransmitter: sodium symporter (NSS)*	*Genetic variation in drug transporters*
	SLO-2	*The relevance of recombinant DNA technology to pharmacology/drug discovery*	*Role of GPCR phosphorylation in desensitisation*	*Voltage-gated Ca2+ channels*	*Gltph transporters*	*Multi-drug resistance protein MDR1 (P-glycoprotein)*
S-5	SLO-1	*The 'cloning' of drug targets*	*Constitutive GPCR activity*	*Voltage-gated Na+ channels*	*Leucine Transporter(LeuTAa)*	*Multi-drug resistance associated protein (MRP) transporters*
	SLO-2	*Cloning using peptide sequence(s)*	*Promiscuous G-protein coupling*	*Voltage-gated K+ channels*	*NSS in health and disease*	*Organic anion-transporting polypeptide (OATP) transporters*
S-6	SLO-1	*Synthesis of cDNA, and construction of a cDNA library*	*Agonist-directed signalling*	*Other types of voltage-gated ion channels*	*Sodium antiporters*	*Genetic variation in G protein coupled receptors*
	SLO-2	*screening of a cDNA library*	*Allosteric modulators of GPCR function*	*CatSper channels*	*NhaA Na+:H+ antiporter (NhaA) family*	*Genetic variation within the adrenergic receptor family*

S-7	SLO-1	*Cloning using a specific antibody, a functional assay and Polymerase chain reaction.*	*Pharmacological chaperones for GPCRs*	*Ligand-gated ion channels*	*The cell penetrating peptides (CPP)*	*β1-adrenergic receptor single nucleotide polymorphisms*
	SLO-2	*What information can DNA cloning provide?*	*Some key examples of GPCR mutations and their associated disease*	*Pentameric ligand-gated ion channel family*	*CPP in health and disease*	*Are β1AR SNPs risk factors for heart failure?*
S-8	SLO-1	*Pharmacologic profile of the 'cloned' and the 'native' drug target*	*GPCR dimerisation*	*Nicotinic acetylcholine receptors*	*ATPase transporters*	*β2AR SNPs and asthma*
	SLO-2	*'cloned' and the 'native' drug target*	*Methods to study GPCR dimerisation*	*5-HT3 receptor channels and GABAA receptors*	*ATPase transporters in health and disease*	*β2AR SNPs and cardiovascular function*
S-9	SLO-1	*Reverse pharmacology*	*GPCR splice variants 1*	*P2X receptor structure, signalling and pharmacology*	*Role of transporters in drug pharmacokinetics*	*Functional consequences of the Trp64Arg SNP*
	SLO-2	*Reverse pharmacology illustrated on orphan GPCRs*	*Clinical and pathophysiological relevance of GPCR splice variants*	*Therapeutic potential of P2X receptors*	*Role of transporters in cellular homeostasis*	*β3AR Trp64Arg SNP: disease associations*

Learning Resources	1. *Chris Lloyd Mills, Fiona Freeman, Christian Thode, Shiva Sivasubramaniam, John Dickenson, "Molecular pharmacology : from DNA to drug discovery ",Wiley-Blackwell, 2012.* 2. *Michael Palmer, Alice Chan, Thorsten Dieckmann, John Honek, "Biochemical Pharmacology", Wiley, 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 (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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*	*Mr. Jaganathan. M. K. SRMIST*
Dr. Karthik Periyasamy, Scientist I, Aurozymes Unit, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	*Mr. S. karthik. SRMIST*

Course Code	18BTE309T	Course Name	PLANT NUTRITION AND PHYSIOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Understand the food production can be limited by the availability of fresh water and nutrients*			
CLR-2 :	*Analyze the role of proton pumps in plant nutrition*			
CLR-3 :	*Illustrate the flow of each of the macronutrients from soil into the plant body*			
CLR-4:	*Compare and evaluate the symptoms of macronutrient deficiencies*			
CLR-5:	*Study the roles of plants and soil microbes on global nutrient cycles*			
CLR-6:	*Interpret the plant responses to deficiency, limitation and a toxic level of a micronutrient*			
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*			
CLO-1 :	*Describe the Plant-water relations, uptake and transport*	*1*	*80*	*80*
CLO-2 :	*Explain the contributions of two different transporters to plant salinity tolerance*	*2*	*85*	*75*
CLO-3 :	*Recognize the positive and negative impacts of the use of chemically synthesized fertilizers*	*2*	*75*	*80*
CLO-4 :	*Discuss the different ways to calculate Nutrient use efficiency*	*2*	*85*	*80*
CLO-5 :	*Explain the important of influx and efflux transporters*	*3*	*85*	*75*
CLO-6 :	*Gain knowledge about the biological functions of each of the micronutrients*	*2*	*80*	*80*

Program Learning Outcomes (PLO)														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
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
M	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
M	*M*	*H*	*H*	-	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
M	-	*M*	*H*	*M*	*H*	*H*	-	*H*	*H*	*H*	*H*	*H*	*H*	*H*
-	*H*	*H*	*H*	-	*H*	*H*	*L*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
M	*H*	*H*	*H*	*H*	*H*	*H*	-	*H*	*M*	*H*	*H*	*H*	*H*	*H*
M	*M*	*H*	*H*	-	*H*	*H*	*M*	*H*	*M*	*H*	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Plant Nutrition*	*Nutrient uptake and transport*	*Overview*	*Potassium*	*Introduction*
	SLO-2	*Water & mineral nutrients*	*Overview*	*Plant nutrient requirements and fertilizers*	*The ashes in the pot, potash*	*Micronutrients and Metals*
S-2	SLO-1	*Mineral nutrients*	*Energizing the membrane*	*Macronutrients - N, P, K, S,Mg, and Ca*	*Potassium uptake and remobilization*	*Nutrients movement*
	SLO-2	*Macronutrients & micronutrients*	*Plasma membrane proton ATPases*	*The most abundant mineral element in a plant*	*Biphasic uptake response*	*The apo- and symplast & membrane transporters*
S-3	SLO-1	*Water uptake and transport*	*Vacuolar pumps*	*Nitrogen metabolism*	*Sulfur*	*Iron*
	SLO-2	*Physical laws*	*Vacuolar H+-ATPase and Vacuolar H+-PPase*	*Uptake, assimilation and remobilization*	*Global cycles and cells*	*Abundant, important, and largely insoluble*
S-4	SLO-1	*Membrane-bound water channels*	*Potassium Uptake*	*Nitrogen regulation*	*Sulfur uptake*	*Copper*
	SLO-2	*Aquaporins*	*Uptake & response*	*Nitrogen sensing, signaling and deficit responses*	*SULTR transporters*	*Critical for aerobic life*
S-5	SLO-1	*Movement of water*	*Potassium Transport*	*Strategies to mitigate the environmental consequences of N fertilizers*	*Sulfur – metabolic regulation*	*Zinc*
	SLO-2	*Water moves through Soil – Plant – Atmosphere Continuum (SPAC)*	*Co-transporters, channels, The guard cell model*	*Field-based practices and breeding*	*Addressing S-deficiency in plants*	*Deficiency common in plants and people*
S-6	SLO-1	*Water uptake in roots*	*Potassium Homeostasis*	*The most diverse set of functions*	*Magnesium*	*Manganese*
	SLO-2	*From soil to stele*	*K+ mobilization is critical for K+ homeostasis*	*Phosphorus*	*Magnesium in rocks and cells*	*Central to the water-splitting, oxygen-evolving reaction*
S-7	SLO-1	*SPAC*	*Sodium Toxicity, Transport, and Tolerance*	*Phosphate acquisition*	*Mg - Uptake and assimilation*	*Zinc: Deficiency common in plants and people, Nickel: Necessary but rarely limiting*
	SLO-2	*Flow of water through the xylem*	*The challenges of soil salinization*	*Mining & foraging*	*MRS/ MGT family*	*Manganese: Central to the water-splitting, oxygen-evolving reaction. Metal tolerance and metal hyper accumulation*

S-8	SLO-1	*SPAC*	*Sodium toxicity and tolerance*	*Phosphate uptake & transport*	*Calcium*	*Toxic metals and metalloids*
	SLO-2	*From leaf to air*	*Halophytes and salt-tolerant plants*	*PHT1 family*	*Low free cytosolic levels*	*Arsenic, Cadmium, Aluminum*
S-9	SLO-1	*Water deficit*	*Ion pumps, channels*	*Strategies*	*Calcium uptake and transport*	*Essential micronutrient*
	SLO-2	*Plant responses*	*Transporters contribute to Na+ tolerance*	*Improve crop plant phosphorus use efficiency*	*Calcium signaling*	*Boron, Silicon, Chlorine, Selenium*

Learning Resources	1. *Lincoln Taiz and Eduardo Zeiger, "Plant Physiology", Third edition. Panima Publishing Corporation, 2003.* 2. *Teaching Tools in Plant Biology: Lecture Notes. The Plant Cell (online) http://www.plantcell.org/content/teaching-tools-plant-biology*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. Senthil, EID Parry, Chennai, parrynutraceuticals@parry.murugappa.com	*Prof .Usha Vijayraghavan. IISc, Bangalore, uvr@mcbl.iisc.ernet.in*	*Dr. R. Pachaiappan, SRMIST*
Dr. G. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	*Prof. Akhilesh. S. Raghubanshi, Banaras Hindu University, Varanasi, asr@bhu.ac.in*	*Dr. D.V.L. Sarada, SRMIST*

Course Code	18BTE310T	Course Name	PLANT HORMONES AND SIGNALING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Illustrate how plant hormones contribute to their growth, development, reproduction and stress responses*			
CLR-2 :	*Understand the fundamental properties, tropic movement and mechanism of actions of auxin*			
CLR-3 :	*Interpret the effects of Cytokinin, and its receptor perception & signaling*			
CLR-4:	*Study the interaction between Gibberllins receptors and regulation of physiological functions*			
CLR-5:	*Interpret the phenotypes of Arabidopsis seedlings mutated in ethylene perception, and reconstruct a genetic pathway from double mutant phenotypes*			
CLR-6:	*Illustrate the interactions of the core signaling for controlling the functions of Abscisic acid in plants*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Gain knowledge on major plant hormones*	*1*	*80*	*80*
CLO-2 :	*Explain the history, synthesis, transport and functions of auxin in plant life*	*2*	*85*	*75*
CLO-3 :	*Describe the cytokinin biosynthetic pathway, two methods of analyzing and protein kinase cascade*	*2*	*75*	*80*
CLO-4 :	*Discuss the processes that control the accumulation of bioactive GAs, role of DELLAs and physiological responses*	*2*	*85*	*80*
CLO-5 :	*Gain knowledge the different physiological responses to ethylene*	*3*	*85*	*75*
CLO-6 :	*Explain the ways that ABA affects development of roots, fruits and seeds*	*2*	*80*	*80*

Program Learning Outcomes (PLO)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	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
CLO-1 :	*L*	*M*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-2 :	*M*	*M*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*
CLO-3 :	*M*	*M*	*M*	*H*	*M*	*M*	*H*	*M*	*H*	*M*	*H*	*H*	*H*	*H*	*H*
CLO-4 :	*M*	*M*	*H*	*H*	*H*	*M*	*M*	*M*	*H*	*M*	*H*	*H*	*H*	*H*	*H*
CLO-5 :	*L*	*H*	*M*	*H*	*M*	*M*	*H*	*M*	*H*	*L*	*H*	*H*	*H*	*H*	*H*
CLO-6 :	*M*	*M*	*H*	*H*	*L*	*M*	*H*	*M*	*H*	*M*	*H*	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*What are phytohormones*	*Historical studies of auxin*	*Overview*	*History and overview*	*Abscisic acid*
	SLO-2	*Types*	*Classical studies*	*The discovery of cytokinins*	*Inhibitor of an inhibitor*	*Plant processes*
S-2	SLO-1	*Overview of hormone action*	*Auxin signaling pathway*	*Cytokinin homeostasis*	*GA synthesis and homeostasis*	*Biosynthesis and homeostasis*
	SLO-2	*Signaling*	*Biosynthesis and homeostasis*	*Structure of major CKs*	*GA deactivation & transport*	*Zeaxanthin epoxidase, NCED, VP14 & CYP707A*
S-3	SLO-1	*Hormones and vegetative developments*	*Tools in auxin research*	*The Agrobacterium tmr gene is a CK biosynthesis gene*	*GA perception and signaling*	*Transport*
	SLO-2	*Auxin & cytokinin*	*Experimental evidences*	*CYP735A*	*GID1 encodes a GA receptor*	*ABA movement*
S-4	SLO-1	*Vegetative development*	*Auxin transport*	*Formation of active CKs*	*GA-regulated growth repressors*	*Perception and signaling*
	SLO-2	*Strigolactones, Gibberellins & Brassinosteroids*	*Polar auxin transport*	*LONELY GUY, IPT over expression*	*DELLA proteins*	*PYR/ RCAR*
S-5	SLO-1	*Hormonal control of reproductive development*	*Chemiosmotic model*	*CK inactivation by conjugation or degradation*	*GA's roles in whole-plant physiology*	*ABI1 encodes a PP2C protein phosphatase*
	SLO-2	*Transition to flowering, development of flowers and fruits*	*Auxin moves through efflux and influx carrier proteins*	*Cytokinin oxidase*	*Response to salt stress, seed germination and Flowering*	*PP2C binds ABA + receptor & SnRK kinase similarly*
S-6	SLO-1	*Reproductive development*	*Types of carrier proteins*	*CK acts as a paracrine and a long-distance signal*	*Ethylene is a gaseous hormone*	*Calcium-dependent protein kinases*
	SLO-2	*Ethylene & Abscisic Acid*	*AUX1 / LAX, ABCB family & PIN family*	*PUP and ENT*	*Triple response*	*Transcription factors are major targets of SnRK2s and CDPKs*
S-7	SLO-1	*Hormonal responses to abiotic stress*	*Auxin perception - receptors*	*CK perception and signaling*	*Ethylene synthesis and homeostasis*	*ABA's roles in the control of guard cell turgor*
	SLO-2	*Abscisic Acid*	*ABP1, TIR1 and AFP protein family of F-box proteins*	*Two-component-like system*	*Burg and Thimann's studies, The Yang cycle*	*SnRK2s and PP2Cs contribute to guard cell responses*
S-8	SLO-1	*Hormonal responses to biotic stress*	*Auxin signaling*	*Downstream of the receptors*	*Ethylene response*	*ABA in whole-plant processes*

	SLO-2	*Jasmonates & Salicylates*	*Aux/IAA proteins, auxin-responsive transcription factors*	*Histidine phosphotransfer proteins (HPTs) and response regulators (RRs)*	*Receptors and downstream signaling*	*drought stress*
S-9	SLO-1	*Hormonal crosstalk*	*Auxin action*	*CK action in whole-plant processes*	*Ethylene's roles*	*surviving extreme desiccation*
	SLO-2	*Cross-talk in defense signaling*	*Whole-plant processes*	*Abiotic and biotic stress responses*	*Whole-plant processes*	*systemic stress responses*

Learning Resources	*1. Lincoln Taiz and Eduardo Zeiger, "Plant Physiology", Third edition. Panima Publishing corporation, 2003.* *2. Davies, P. J., "Plant Hormones -Biosynthesis, Signal Transduction, Action", Third Edition, Springer 2010.* *3. Teaching Tools in Plant Biology: Lecture Notes. The Plant Cell (online) http://www.plantcell.org/content/teaching-tools-plant-biology.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. Senthil, EID Parry, Chennai, parrynutraceuticals@parry.murugappa.com	*Prof .Usha Vijayraghavan. IISc, Bangalore, uvr@mcbl.iisc.ernet.in*	*Dr. R. Pachaiappan, SRMIST*
Dr. Karthik Periyasamy, Scientist I, Aurozymes Unit, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*Prof. Santa Ram Joshi., Department of Biotechnology & Bioinformatics North Eastern Hill University, Shillong-793022, Meghalaya, srjoshi2006@gmail.com*	*Dr. D.V.L. Sarada, SRMIST*

Course Code	18BTE311T	Course Name	PATHOGENESIS - RELATED PROTEINS IN PLANTS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Understand the six different types of pathogens by kingdom and by mode of pathogenicity*			
CLR-2 :	*Analyze the role of plant defence proteins against pathogens*			
CLR-3 :	*Understand the knowledge about the structural, catalytic mechanism and regulation of PR*			
CLR-4:	*Compare and evaluate the plant – insect and other pathogen interactions*			
CLR-5:	*Study the roles of PR-Proteins in physiological and developmental processes in plants*			
CLR-6:	*Interpret the plant molecular responses to biotic factors*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*			
CLO-1 :	*Describe the three ways that plants defend themselves against pathogens*	*1*	*80*	*80*
CLO-2 :	*Explain the physiological functions of pathogenesis related proteins in plants*	*2*	*85*	*75*
CLO-3 :	*Comprehend the concept of cell wall degrading enzymes produced from plants as a defence*	*2*	*75*	*80*
CLO-4 :	*Discuss the different ways of resistance to pathogens at molecular level*	*2*	*85*	*80*
CLO-5 :	*Explain the importance of PR-Proteins in agriculture crop development*	*3*	*85*	*75*
CLO-6 :	*Gain knowledge about the signals, synthesis, binding to the receptor and role during plant – pathogen interactions*	*2*	*80*	*80*

Program Learning Outcomes (PLO)														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
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
M	*H*	*H*	*H*	-	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
M	-	*H*	*H*	-	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
H	*M*	-	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
-	*M*	*H*	*H*	-	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
H	*H*	*H*	*H*	*H*	*H*	*H*	-	*H*	*M*	*H*	*H*	*H*	*H*	*H*
H	*M*	*H*	*H*	-	*H*	*H*	*M*	*H*	*M*	*H*	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Pathogens make plants sick*	*Introduction*	*Plant chitinases*	*The PR-6 Family*	*PR gene expression*
	SLO-2	*Pathogens include viruses, bacteria, fungi, oomycetes and nematodes*	*PR- 1 Proteins*	*PR-3, 4, 8, 11*	*Proteinase Inhibitors in Plant-Microbe and Plant-Insect Interactions*	*Signals and Putative Receptors that Activate PR Gene Expression*
S-2	SLO-1	*Brief history*	*Characterization*	*Structure of the Proteins*	*Occurrence and Structure*	*Receptors*
	SLO-2	*Plant pathology*	*Acidic and basic proteins*	*PR-3, A Plant-Specific Chitinase Family (Family 19,), Family 18, The Ubiquitous*	*Plant Proteinase Inhibitors with Potential Defensive Capabilities*	*Leucine-rich repeat receptor kinases , LysM receptor proteins*
S-3	SLO-1	*The disease triangle concept*	*Occurrence*	*PR-8/Class III Chitinases, PR-11 Chitinases*	*Proteinases and Proteinase Inhibitors*	*Pathogens Activate PR Genes by Different Pathways*
	SLO-2	*Pathogen, Host, Environment*	*PR - proteins from other organisms & Functions*	*Other Related Proteins, The PR-4 Family*	*Plant–Microbe Interactions*	*Reactive oxygen species (ROS), salicylic acid (SA), ethylene, and jasmonates*
S-4	SLO-1	*Strategies of pathogenicity*	*Expression of PR-1*	*Catalytic Mechanisms and Specificities*	*Proteinases and Proteinase Inhibitors*	*Transcriptional Regulation of PR Gene Expression*
	SLO-2	*Pathogen lifestyles – biotropy, necrotrophy, and hemibiotrophy*	*Pathogens/wounds, salicylic acid, ethylene and other hormones, UV light and developmental stimuli*	*Family 18 & 19 Chitinases*	*Plant–Insect Interactions*	*W-box, GCC box, MRE-like sequence & G-box*
S-5	SLO-1	*Plant immune responses*	*PR-1 promoter analysis*	*Structure and Regulation of the Genes*	*Ribosome inactivating proteins (RIP)*	*GCC box-binding proteins*
	SLO-2	*Pathogen-triggered & Effector-triggered immunity*	*Acidic and basic proteins*	*Chib (PR-8) and Chic (PR-11) Genes*	*Structure*	*EREBP-1, EREBP-2, EREBP-3, and EREBP-4*
S-6	SLO-1	*Pathogen-recognition receptors*	*Introduction*	*Functions of Plant Chitinases*	*RIP*	*Genetic studies of PR gene expression*
	SLO-2	*PTI stimulates production of phytoalexins, reactive oxygen and callose*	*PR-2 – β-1,3-Glucanases*	*Antifungal and other physiological*	*Function, and Engineering*	*SA-inducible promoter-GUS,*
S-7	SLO-1	*Recognition and response to effectors through paired R proteins*	*Structural classes*	*PR-5 - Thaumatin-like proteins*	*Plant defensins*	*Transgenic plants*
	SLO-2	*ETI and biochemical response*	*PR-2 Nomenclature*	*Occurrence, Physico-Chemical properties*	*Introduction*	*Over expression of PR proteins*
S-8	SLO-1	*Induction*	*Biological functions of β-1,3-Glucanases*	*Biological properties*	*Protein Structure*	*PR Proteins*

	SLO-2	*Pathogenesis Related proteins (PR-Proteins)*	*Plant reproductive and defence*	*Taste, Antifungal Activity, TLPs as Anti-Freeze Proteins & TLPs as Inhibitors?*	*Disulfide-linked cysteine residues*	*Antifungal and insecticidal proteins*
S-9	SLO-1	*PRs, and PR like proteins*	*Regulation of β-1,3-Glucanases expression*	*Regulation of TLP Expression*	*Antimicrobial Activities*	*PR proteins in Rice*
	SLO-2	*Occurrence, properties and functions*	*Developmental and hormonal & pathogenic*	*Microbial Infection, Osmotic Stress, Abscisic Acid and Ethylene, Salicylate, Methyl Jasmonate, and Elicitors, Wounding.*	*Structure activity relationships, Mode of action*	*IR72 and IR64*

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.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. Senthil, EID Parry, Chennai, parrynutraceuticals@parry.murugappa.com	*Prof .Usha Vijayraghavan. IISc, Bangalore, uvr@mcbl.iisc.ernet.in*	*Dr. R. Pachaiappan, SRMIST*
Dr. G. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	*Prof. Appa Rao Podile, Central University, Hyderabad, podilerao@gmail.com*	*Dr. D.V.L. Sarada, SRMIST*

Course Code	18BTE312T	Course Name	FOOD SCIENCE AND NUTRITION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
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:	*Design balanced meal preparation*			
CLR-6:	*Identify antinutritional factors in food*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Define basic concepts of Food and Nutrition*	2	80	70
CLO-2 :	*Formulate food with daily dietary allowances*	2	80	70
CLO-3 :	*Identify the scope and prospects of food science in food industries*	2	80	70
CLO-4 :	*Design diet according to energy requirements of the body*	2	80	70
CLO-5 :	*Design diet for different age group and for people under diseased condition*	3	80	70
CLO-6 :	*Evaluate food constituents and its importance*	2	80	70

Program Learning Outcomes (PLO)															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
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
	H	*H*			*H*		*H*	*H*				*H*	*H*	*H*
	H	*H*				*H*						*H*	*H*	*H*
M	*H*	*H*	*M*	*H*		*M*		*H*		*H*		*H*	*H*	*H*
H		*H*		*H*		*M*		*H*		*H*		*H*	*H*	*H*
H	*H*	*H*	*H*	*H*		*M*		*H*		*H*		*H*	*H*	*H*
H	*H*	*H*	*H*	*H*		*H*	*H*	*H*		*H*	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Food as a source of energy*	*Functions of protein, fat and carbohydrates and their dietary requirements*	*Carbohydrates- dietary requirements and functions, deficiency in diet*	*Function and daily intake of water*	*New trends in nutrition-nutitional value of fast food and junk food*
	SLO-2	*Macro and micro nutrients*	*Sources of Carbohydrates*	*Nutritional significance of carbohydrates ,*	*Daily loss of body water and deficiency of water*	*Probiotics and prebiotics*
S-2	SLO-1	*Carbohydrate, Fat and Protein*	*Classification of Carbohydrates*	*Digestion, metabolism and absorption of carbohydrates*	*Sources of vitamins*	*Antioxidants*
	SLO-2	*Food requirement in human body*	*Polysaccharides –Starch and dietary fibers*	*Nutritional significance of proteins*	*Fat soluble vitamins –A,D,E, and K*	*Nutraceuticals*
S-3	SLO-1	*Planning balanced diets to meet the requirements of different age groups*	*Chemical composition of cereals*	*Animal sources of protein*	*Water soluble Vitamins-B-complex vitamins, Anemia –preventing vitamins and Vitamin-C*	*Fortification*
	SLO-2	*Solving Problems-*	*Nutritional value of cereals*	*Digestion, metabolism and absorption of protein*	*Effect of cooking on vitamins*	*Significance of nutritional labeling*
S-4	SLO-1	*Energy requirements of the body*	*Protein- dietary requirements, functions, and deficiency in diet*	*Nutritional significance of lipids*	*stability of vitamin during food processing*	*Trans fatty acids*
	SLO-2	*Calculations of energy value based on proximate principles*	*Sources of Protein*	*Classification of lipids*	*toxicity due to vitamins*	*Role of photochemical*
S-5	SLO-1	*BMR, Test for basal metabolism and Factors affecting BMR*	*Chemical composition of pulses (grams and dhal)*	*Plant Sources of fat/oil*	*bioavailability of vitamins*	*Naturally occurring food toxicants in foods*
	SLO-2	*Estimation of energy requirements*	*Nutritional value of pulses*	*Marine and animal sources of fat/oil*	*reasons for losses of vitamins in foods*	*protease inhibitors*
S-6	SLO-1	*Instrumental methods to calculate caloric value of food*	*Antinutritional factors in pulses*	*Digestion, metabolism and absorption of fat*	*Role of these constituents in food industry*	*hemagglutinins*
	SLO-2	*RDS's for specific nutrients*	*Chemical composition of oil seeds*	*The food pyramid*	*Mineral in food*	*goitrogens*
S-7	SLO-1	*Dietary allowances fixed by FAO*	*effect of processing on the nutritional value of food grains (cereals and pulses)*	*Therapeutic diets – A brief account.*	*Classification of minerals*	*lathyrogens*

	SLO-2	*Dietary allowances fixed by WHO*	*Chemical composition of cereals*	*Planning of balanced meal*	*Sources of minerals in food*	*toxic amino acids*
S-8	SLO-1	*Recommended dietary allowances for Indians fixed by ICMR*	*Nutritional value of cereals*	*Dietary requirement for different Age group*	*stability status of minerals in food*	*naturally occurring carcinogens in food*
	SLO-2	*comparison of Indian dietary allowances with that of FAO/WHO standards*	*Chemical composition of pulses (grams and dhal)*	*Dietary requirement for women at different stages of life*	*Nutritional value of fruits*	*Carcinogens produced during food processing and storage*
S-9	SLO-1	*Modifying energy content of meals*	*Nutritional value of pulses*	*Meal frequency pattern and variety in balanced diet*	*Nutritional value of vegetables*	*Acrylamide formation in food*
	SLO-2	*Under weight/,overweight/obesity*	*Antinutritional factors in pulses*	*Calculating nutritional value of a recipe*	*Nutritional value of biverages*	*furan formation in 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. *Ahuja, K.J, Nath Prem and K.R.M Swamy Food and Nutrition, 2010. Studium Press Pvt. Ltd., New Delhi.,* 4. *Shakuntala Manay and Shadasharasamy "Foods; Facts and principles", 1997. New Age international Publishers, New Delhi. ,*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. S. Sam Gunasekar, Orchid Chemicals and Pharmaceuticals Ltd., sam@orchidpharma.com	*1. Dr. A. Gnanamani, CSIR-Central Leather Research Institute, agmani_2000@yahoomail.com*	*Dr. K.A.Athmaselvi, SRMIST*
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Course Code	18BTE405T	Course Name	THERAPEUTIC COMPOUNDS FROM PLANTS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Gain knowledge on historical uses of plants and plant parts as medicines and traditional knowledge*			
CLR-2 :	*Understand the techniques involved in Bioprospecting*			
CLR-3 :	*Understand the major secondary metabolic pathways that produce pharmaceutically important compounds*			
CLR-4:	*understand the structures and roles of the major classes of photochemicals with medicinal properties*			
CLR-5:	*Gain insight into engineering for enhanced production of pharmaceutically important metabolites in planta*			
CLR-6:	*know the mechanism of action of major known pharmaceutically important compounds in therapeutics*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Identify plants and plant parts used as medicine traditionally*	*1*	*80*	*80*
CLO-2 :	*Apply techniques to screen plants for drugs and medicines*	*2*	*85*	*75*
CLO-3 :	*Analyze the secondary metabolic pathways that produce several medicinally important compounds*	*2*	*75*	*80*
CLO-4 :	*Deduce structure activity relationship*	*3*	*85*	*80*
CLO-5 :	*Predict the metabolic branch points that can be targeted for engineering*	*3*	*85*	*75*
CLO-6 :	*Explain the mechanism of action of major known pharmaceutically important compounds in therapeutics*	*2*	*80*	*80*

Program Learning Outcomes (PLO)														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
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
L		*M*	*H*		*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
H	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
H	*H*	*M*	*H*	*H*	*M*		*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
H	*H*	*H*	*H*	*H*		*L*	*L*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
H	*H*	*H*	*H*	*H*	*H*	*H*	*L*	*H*	*L*	*H*	*H*	*H*	*H*	*H*
H	*H*	*H*	*H*	*H*	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Plants vs Medicinal Plants*	*Overview of extraction and purification of Phytoconstituents*	*Primary vs Secondary Metabolism*	*In vitro Synthesis – Advantages and dis advantages*	*Therapeutic Applications of Phytoconstituents*
	SLO-2	*Taxonomy and validation of Herbal Medicine*	*Extraction Techniques*	*Examples of Major Secondary Metabolic Pathways*	*Omics, Systems and Semi synthetic methods*	*Potential drugs available in the market*
S-2	SLO-1	*Traditional Indian Medicine*	*Different Types*	*The Mevalonate Pathway*	*Metabolic Engineering - Strategies*	*Mechanisms of Action*
	SLO-2	*Traditional Chinese Medicine*	*Advantages and Limitations of Extraction Techniques*	*Examples*	*Alteration, Silencing and augmentation of functions*	*Analgesic action of alkaloids (Morphine)*
S-3	SLO-1	*Traditional Knowledge*	*Analytical Techniques - Spectrometry*	*The Shikmate Pathway*	*Pioneering studies microbial synthesis of plant metabolites*	*Antihyperglycemic action of alkaloids (Piperene)*
	SLO-2	*Ethanobotany*	*Purification*	*Examples*	*Reconstitution of metabolic pathways in microbes*	*Anti cancer activity of alkaloids (Berberine)*
S-4	SLO-1	*Quality Assurance of Herbal Medicines*	*Analytical Techniques – Chromatography*	*The Phenyl Propanoid and the Polyketide Pathway*	*Host Selection and Pathway reconstitution*	*Anticancer activity of Vinca alkaloids*
	SLO-2	*Over the Counter Herbal Medicines*	*Bioassay Guided Fractionation*	*Examples*	*Optimization*	*Antibacterial action of alkaloids (ciproflaxicin)*
S-5	SLO-1	*Plant Extracts vs Purified Compounds*	*Identification*	*Biosynthesis of Alkaloids*	*Metabolic Engineering for alkaloid production in Yeast*	*Neurostimulatory effects of alkaloids*
	SLO-2	*Quest for Active Compounds*	*Analytical Techniques –Mass Spectrometry*	*Tissue Cultures for production of metabolites*	*Metabolic Engineering for terpenoid production in Yeast*	*Neuroprotective effects of alkaloids*
S-6	SLO-1	*Modern Approaches*	*Standardization*	*Examples*	*Metabolic Engineering for carotenoid production in Yeast*	*Antiinflammatory mechanism of action of flavanoids*
	SLO-2	*Screening plants for Drugs*	*Clinical Validation*	*Organ Cultures for production of metabolites*	*Metabolic Engineering for caffeine production in Yeast*	*Antimalarial action of Terpenoids (Quinine)*
S-7	SLO-1	*Plant Families associated with Drug Production*	*Example from TIM to clinical trials*	*Examples*	*Other Examples*	*Antimalarial action of Terpenoids (Artemesin)*

	SLO-2	*Drug discovery by relatedness*	*Example from TCM to clinical trials*	*Hairy Root Cultures as a means for enhanced metabolite production*	*Metabolic Engineering in Plants and Plant Cell Cultures*	*Terpenoids against Trypaonosomes*
S-8	SLO-1	*Phytoconstituents*	*Central Drugs Control Standard Organization*	*Manipulation of hairy roots for metabolite production*	*Metabolic Engineering of Terpenoids in Plants*	*Terpenoids against Leishmanias*
	SLO-2	*Alkaloids*	*Drugs Technical Advisory Board (DTAB) and Drugs Consultative Committee (DCC)*	*Production of Gingsenolides*	*Metabolic Engineering of Alkaloids in Plants*	*Ephedra- Use and Misuse*
S-9	SLO-1	*Flavanoids*	*Regulatory Approval*	*In vitro production – Role of Endophytes*	*Metabolic Engineering of Flavanoids in Plants*	*Ginseng – The Panacea*
	SLO-2	*Terpenoids*	*Pharmacovigilence*	*Production of Taxol*	*High throughput methods to identify genes intermediates and pathways*	*Traditional vs Western Medicine*

Learning Resources	1. *Trease and Evans Pharmacognosy, William Evans, Sixteenth Edition Elsivier 2009* 2. *Phytochemical Methods – A guide to Modern Techniques in Plant Analysis, Harborne Springer 1998* 3. *Text Book of Pharmacognasy and Phytochemistry, First Edition, Biren Shah, Elsevier 2009* 4. *Fundementals of Pharmacognosy and Phytotherapy Second Edition Michael Heinrich, Joanne Barnes, Simon Gibbons and Elizabeth M. Williamson, Elsivier 2012*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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. R. Pachaiappan, SRMIST*
Dr. Karthik Periyasamy, Scientist I, Aurozymes Unit, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	*Dr. Sarada, DVL,SRMIST*

Course Code	18BTE406T	Course Name	FOOD SAFETY AND QUALITY MANAGEMENT	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Describe safety limits of food additives and risk assessment*
CLR-2 :	*Memorize to prepare HACCP based SOP*
CLR-3 :	*Prepare HACCP program to any food industry*
CLR-4:	*Apply quality auditing in the food industries*
CLR-5:	*Describe ISO 9000, ISO 14000, ISO 22000*
CLR-6:	*Employ ISO 22000 in food industry*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Describe about the food safety terms*	*2*	*80*	*70*
CLO-2 :	*Identify the issues of food safety and quality*	*2*	*80*	*70*
CLO-3 :	*Explain the process of food safety analysis*	*2*	*80*	*70*
CLO-4 :	*Describe basic concepts of Food Safety and Quality Management*	*2*	*80*	*70*
CLO-5 :	*Set up and operate HACCP, SOP and ISO 22000 for food industries*	*3*	*80*	*70*
CLO-6 :	*Practice quality auditing methods in the food industries*	*2*	*80*	*70*

Program Learning Outcomes (PLO)														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
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
	H				*H*		*H*	*H*				*H*	*H*	*H*
	H	*H*				*H*						*H*	*H*	*H*
M	*H*	*H*	*M*	*H*		*H*		*H*		*H*		*H*	*H*	*H*
H		*H*		*H*		*M*		*H*		*H*		*H*	*H*	*H*
H	*H*	*H*	*H*	*H*		*M*		*H*		*H*		*H*	*H*	*H*
H	*H*	*H*	*H*	*H*		*M*		*H*		*H*	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Definition of Quality, Dimensions of Quality*	*Safety limits of Food additives*	*Sampling*	*Quality of Foods*	*Seven old and new Quality management tools*
	SLO-2	*Quality Planning, Quality costs*	*Risk assessment and risk benefit Indices of human exposure*	*concept, methods and importance of sampling*	*Quality Standards - mandatory and optional standards*	*Statistical process control*
S-2	SLO-1	*Basic concepts of Food Safety and Quality Management*	*acute toxicity*	*Statistical Process and Quality Control*	*Food Safety Systems*	*Mean & range chart, P chart and C chart*
	SLO-2	*Historical Review, Principles of FSQM*	*mutagenicity and carcinogenicity*	*concept, importance and tools*	*ISO 9000, ISO 14000, ISO 22000*	*Seven deadly wastages*
S-3	SLO-1	*Leadership Concepts*	*reproductive and developmental toxicity*	*Control charts*	*Mechanism of developing and fixing food standards*	*PDCA cycle*
	SLO-2	*Quality Council, Quality Statements*	*teratogenicity, neurotoxicity and behavioral effect, immunotoxicity*	*importance, types, design process control limits*	*Good Manufacturing Practice*	*Quality circle, Quality audit, Internal audit*
S 4-5	SLO-1	*Strategic Planning*	*Determination of the limit for addition NOEL – Method of determining toxicity*	*Errors in process control*	*HACCP Standards of Weights*	*Continuous improvement of productivity proficiency testing for product quality*
	SLO-2	*Barriers to Food Safety Implementation*				
S-6	SLO-1	*Barriers to Food Safety Implementation*	*LD50, FSSAI regulations and GRAS additives.*	*Process Capability.*	*HACCP Standards of Measures*	*Six Sigma Concept*
	SLO-2	*Definition of Quality, Dimensions of Quality*	*Safety limits of Food additives*	*Sampling*	*Quality of Foods*	*Seven old and new Quality management tools*
S-7	SLO-1	*Quality Planning, Quality costs*	*Risk assessment and risk benefit Indices of human exposure*	*concept, methods and importance of sampling*	*Quality Standards - mandatory and optional standards*	*Statistical process control*
	SLO-2	*Basic concepts of Food Safety and Quality Management*	*acute toxicity*	*Statistical Process and Quality Control*	*Food Safety Systems*	*Mean & range chart, P chart and C chart*
S-8	SLO-1	*Historical Review, Principles of FSQM*	*mutagenicity and carcinogenicity*	*concept, importance and tools for quality control*	*ISO 9000, ISO 14000, ISO 22000*	*Seven deadly wastages*
	SLO-2	*Leadership Concepts*	*reproductive and developmental toxicity*	*quality control charts*	*Mechanism of developing and fixing food standards*	*PDCA cycle*

S-9	SLO-1 SLO-2	*Quality Council, Quality Statements*	*teratogenicity, neurotoxicity and behavioral effect, immunotoxicity*	*importance, types, design process*	*Good Manufacturing Practice*	*Quality circle, Quality audit, Internal audit*

Learning Resources	1. *Andres Vasconcellos J. 2 nd edition. Quality Assurance for the Food industry - A practical approach. 2005, CRC press.* 2. *Inteaz Alli. 1st edition, Food quality assurance - Principles & practices. 2004, CRC Press. New York.*	3. *Sara Mortimore and Carol Wallace. 3rd edition HACCP - A practical approach.2013, Chapman and Hall, London.* 4. *Roday, S. 2 nd edition Food Hygiene and Sanitation, 201,Tata McGraw-Hill Education.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Dr. D. Gunaseelan, BIOCON Ltd., guna.sachin@gmail.com	*Dr. Anbumani Sadasivam, CSIR-Indian Institute of Toxicology Research,anbumani@iitr.res.in*	*Dr. R.Preetha, SRMIST*

Course Code	18BTE313T	Course Name	ENZYME ENGINEERING AND TECHNOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
CLR-1 :	*Discuss the basics of enzyme mechanism, classification, and factors affecting enzyme activity*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-2 :	*Analyze the kinetics of enzyme action, inhibition, and their regulation*			
CLR-3 :	*Examine the sequential procedure of the enzyme purification process*			
CLR-4:	*Apply the various methods of enzyme immobilization and evaluating their kinetic efficiency*			
CLR-5:	*Discuss the applications of enzymes in various industries*			
CLR-6:	*Demonstrates the importance of enzymes in engineering research and industries*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Recognize the basic nature of enzyme, classification and their mechanism of working*	*1*	*80*	*80*
CLO-2 :	*Describe the various kinetic mechanisms and regulation of enzyme actions*	*2*	*85*	*75*
CLO-3 :	*Formulate the succession of enzyme purification and their characterization*	*2*	*75*	*80*
CLO-4 :	*Illustrate the methods of enzyme immobilization and evaluating the effectiveness of immobilization*	*2*	*85*	*80*
CLO-5 :	*Assess the extent of enzyme applications in various industries*	*3*	*85*	*75*
CLO-6 :	*Interpret the mechanisms of enzyme action and evaluating their importance in various applications*	*2*	*80*	*80*

Program Learning Outcomes (PLO)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	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
CLO-1 :	*H*	*M*	*L*	*H*	*M*		*H*		*H*		*H*		*H*	*H*	*H*
CLO-2 :	*H*	*H*	*H*	*H*	*H*		*H*		*H*				*H*	*H*	*H*
CLO-3 :	*M*	*L*	*H*	*H*	*H*		*H*		*H*		*H*		*H*	*H*	*H*
CLO-4 :	*H*	*H*	*H*	*H*	*H*		*H*		*H*		*M*		*H*	*H*	*H*
CLO-5 :	*H*	*L*	*H*	*H*	*M*		*H*		*H*		*H*	*H*	*H*	*H*	*H*
CLO-6 :	*H*	*H*	*H*	*H*	*H*		*H*		*H*		*H*	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Chemical nature of enzymes*	*Basics of enzyme kinetics*	*Production of enzymes on a commercial scale*	*Enzyme immobilization*	*Applications of enzymes - Food processing*
	SLO-2	*Characteristics of enzymes*	*Michaelis Menten Kinetic equation*	*Nature of the extraction medium*	*Advantages and disadvantages*	*Starch and sucrose industries*
S-2	SLO-1	*Enzymes and their actions*	*Significance of Michaelis-Menten Kinetics*	*Extraction of soluble enzymes*	*Physical methods of enzyme immobilization*	*Dairy industries*
	SLO-2	*Mechanism of enzyme action*	*Solving problems in enzyme kinetics*	*Extraction of membrane-bound enzymes*	*Chemical methods of enzyme immobilization*	*Brewing industries*
S-3	SLO-1	*Structural components of enzymes*	*Evaluation of Michaelis-Menten kinetic parameters*	*Technologies for enzyme production*	*Carrier-based immobilization*	*Beverage industries*
	SLO-2	*The active site of an enzyme*	*Line weaver Burk plot, Hanes Woolf plot and Eadie Hofstee plot*	*Recovery and purification methods for enzymes*	*Carrier free immobilization*	*Leather industries*
S-4	SLO-1	*Cofactors and coenzymes*	*Turn over number, Catalytic efficiency*	*Cell disruption*	*Immobilization by using porous support*	*Textile industries*
	SLO-2	*Role of cofactors and coenzymes*	*Enzyme Inhibitors*	*Solid-liquid separation*	*Mass transfer effects and diffusion limitations*	*Detergent industries*
S-5	SLO-1	*Classification of enzymes*	*Types of enzyme inhibition*	*Concentration*	*Immobilization by using non-porous support*	*Pulp and paper industries*
	SLO-2	*Enzyme commission classification of enzymes*	*Competitive inhibition*	*Precipitation*	*Mass transfer effects and diffusion limitations*	*Polymer industries*
S-6	SLO-1	*Oxidoreductase,Transferase, Hydrolase*	*Uncompetitive inhibition*	*Liquid- liquid extraction*	*Stabilization of immobilized enzymes in aqueous environment*	*Analytical applications of enzymes*
	SLO-2	*Lyase, Isomerase, Ligase*	*Noncompetitive inhibition*	*Ion exchange chromatography*	*Stabilization of immobilized enzymes in non-aqueous environment*	*Diagnostic applications of enzymes*
S-7	SLO-1	*Enzyme-substrate complex formation models*	*Substrate inhibition*	*Gel filtration, Affinity chromatography*	*Electrostatic and steric effects in immobilized enzyme systems*	*Role of enzymes - Pharmaceuticals*

	SLO-2	*Lock and Key and Induced fit models*	*Feedback inhibition*	*Criteria of purity – Electrophoresis*	*Analyzing the effectiveness factor of immobilized enzymes*	*Medicine*
S-8	SLO-1	*Mechanisms of enzyme catalysis*	*Enzyme deactivation model*	*Isoelectric focusing, Capillary electrophoresis*	*Applications of immobilized enzyme systems*	*Medical research*
	SLO-2	*Proximity and orientation effects, Conformational distortion*	*Allosteric activation and inhibition*	*Monitoring of purification of enzymes*	*Limitations of immobilized enzyme systems*	*Agriculture*
S-9	SLO-1	*Factors affecting enzyme activity*	*Solving problems in enzyme inhibition*	*Determination of molecular weight of enzymes- MALDI-TOF*	*Solving problems in enzyme immobilization and their kinetics*	*Environment protection*
	SLO-2	*Effect of substrate, enzyme and inhibitor concentration on enzyme activity*	*Solving problems in enzyme inhibition*	*Drying and packing*	*Solving problems in enzyme immobilization and their kinetics*	*Biofuels development*

Learning Resources	*1. Trevor Palmer and Philip L Bonner. "Enzymes: Biochemistry, Biotechnology, Clinical Chemistry," East-West Press, 2004.* *2. Syed Tanveer Ahmed Inamdar. "Biochemical Engineering: Principles and Concepts "Third Edition, PHI Learning Pvt. Ltd., 2012* *3. Kargi. F., Shuler. M.L., "Bioprocess Engineering: Basic Concepts," 3rd Edition. Prentice Hall, 2017.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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, vinothkumar.v@ktr.srmuniv.ac.in*
Dr. Karthik Periyasamy, Scientist I, Aurozymes Unit, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	*Ms. P.Radha, SRMIST, radha.p@ktr.srmuniv.ac.in*

Course Code	18BTE314T	Course Name	MEMBRANE TECHNOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
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*			
CLR-6:	*Get acquaint on membranes for industrial application*			
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*			
CLO-1 :	*Apply membranes for bioprocess industries*	2	80	90
CLO-2 :	*Demonstrate methods of casting membrane*	2	85	90
CLO-3 :	*Utilize the selection of membranes for micro and Macro molecules separation*	2	75	80
CLO-4 :	*Apply membrane for dialysis*	2	90	85
CLO-5 :	*Demonstrate membrane for distillation and production*	2	80	80
CLO-6 :	*Explain membrane in upstream and downstream process economically*	2	80	80

Program Learning Outcomes (PLO)														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
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
M	*M*	*H*	*M*	*M*						*H*	*H*	*H*	*H*	*H*
M	*M*	*H*	*M*	*M*						*H*	*H*	*H*	*H*	*H*
M	*M*	*H*	*M*	*L*						*H*	*H*	*H*	*H*	*H*
M	*M*	*H*	*M*	*M*						*H*	*H*	*H*	*H*	*H*
M	*M*	*H*	*M*	*M*						*H*	*H*	*H*	*H*	*H*
M	*M*	*H*	*M*	*H*						*H*	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Overview of membrane separation process*	*Membrane Types, Materials, Preparation and Characterization*	*Reverse Osmosis, Nano filtration, Ultra filtration, and Microfiltration*	*Dialysis, pervaporation and electro dialysis*	*Membrane distillation, Membrane bioreactors and industrial membranes*
	SLO-2	*Equilibrium and rate controlled separation*	*Types of Synthetic Membranes- Micro porous Membranes*	*Concept of osmosis*	*Principles of Dialysis*	*Membrane contactors, Principles*
S-2	SLO-1	*What is membrane?*	*Asymmetric, thin film*	*Determination of osmotic pressure and thermodynamics of osmosis*	*Dialysis membranes*	*Advantages and Disadvantages*
	SLO-2	*Basic principles of Membrane Separation*	*Electrically Charged Inorganic Membrane*	*Phenomena of Reverse osmosis*	*Mass transfer in dialysis*	*Applications*
S-3	SLO-1	*Historical development of Membranes*	*Membrane Modules-Plate and frame, Tubular.*	*Models of Reverse osmosis*	*Design of Dialysis membranes*	*Membrane Distillation*
	SLO-2	*Golden age of Membranes*	*Spiral wound and Hollow fiber*	*Design and operating parameters*	*Applications and its advantages.*	*Mechanism*
S-4	SLO-1	*Classification of Membrane Processes*	*Typical Flow pattern*	*Design of Reverse Osmosis module*	*Principles*	*Membrane recycle bioreactors*
	SLO-2	*Pressure driven, Concentration gradient and Electrical Potential*	*Membrane Material*	*Principles , Transport Mechanism*	*Operation of Pervaporation*	*Plug flow bioreactors*
S-5	SLO-1	*Advantages of Membrane Processes*	*Pore Characterization*	*Mass transfer and Industrial Application of Nano filtration*	*Application of Pervaporation*	*Perstraction*
	SLO-2	*Disadvantages of Membrane Processes*	*General Methods of Membrane Manufacture*	*Process Limitation*	*Design of pervaporation modules*	*Flux and separation in Perstraction*
S-6	SLO-1	*Biotechnology Industry*	*Phase Inversion Method,*	*Basic principles of Ultra filtration Types of Ultra filtration*	*Factors affecting pervaporation*	*Membrane Chromatography*
	SLO-2	*Micro and Macromolecule Separation*	*Track–etching*	*Factors affecting Ultra filtration and membrane flux of ultra filtration*	*Applications*	*Design and application*
S-7	SLO-1	*Chemical and Pharmaceutical Industry*	*Sol-gel Peptisation Method*	*Principles of Microfiltration*	*Principles of Electro dialysis Ion Exchange Membranes*	*Membranes in Wastewater Treatment*
	SLO-2	*Recovery of salt, acid and Bases*	*Interfacial Polymerization*	*Microfiltration Membranes*	*Energy requirements*	*Design and Application*
S-8	SLO-1	*Food and Dairy Industry*	*Melt pressing*	*Mechanism of Transport*	*Current utilization and Efficiency*	*Membrane in Desalination*

	SLO-2	*Dairy, animal Products , Fruits and Vegetables etc.*	*Film Stretching*	*Flow characterization*	*Application*	*Membrane in in Fuel cells*
S-9	SLO-1	*Electrochemical Industry*	*Template Leaching*	*Fouling and applications in Microfiltration*	*Batch electro- dialysis*	*Biomedical application of membranes*
	SLO-2	*Effluent Treatment Plant*	*Ion Exchange Membrane Preparation*	*Energy Consideration and Application*	*Continuous electro- dialysis*	*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.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18BTE315T	Course Name	INDUSTRIAL FERMENTATION TECHNOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
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*			
CLR-6:	*Instigate knowledge on food fermentation, food flavourants, preservants and SCP*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Accomplish knowledge on improvement of strain development for primary and secondary metabolites*	2	80	70
CLO-2 :	*Explain the upstream and Downstream fermentation process of organic acids and aminoacids*	2	85	75
CLO-3 :	*Describe the industrial scale methodologies for Antibiotic and microbial enzyme production*	3	75	80
CLO-4 :	*Understand enzyme biotransformation biostratergies and recombinant protein production with commercial and medical importance*	3	85	80
CLO-5 :	*Apprehend the food fermentation process and its preservants used for improving the shelf period*	3	85	80
CLO-6 :	*Decipher the availability and application of various food colourants, flavourants and SCP*	2	80	75

Program Learning Outcomes (PLO)														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
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
H	*H*	*H*	*H*			*H*		*H*		*H*	*H*	*H*	*H*	*H*
H	*H*	*H*	*H*			*H*		*H*		*H*	*H*	*H*	*H*	*H*
H	*H*	*H*	*M*	*H*		*H*		*H*		*H*	*H*	*H*	*H*	*H*
H	*H*	*H*	*H*	*H*		*M*		*H*		*H*	*H*	*H*	*H*	*H*
H	*H*	*H*	*H*	*H*		*M*		*H*		*H*	*H*	*H*	*H*	*H*
H	*H*	*H*	*H*	*H*		*M*		*H*		*H*	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	
S-1	SLO-1	*Introduction to industrial fermentations*	*Production of primary metabolites*	*Production of secondary metabolites*	*Recombinant protein production*	*Food fermentations*
	SLO-2	*Chronological Development of the Fermentation Industry*	*Organic acids fermentation*	*Antibiotic production*	*Insulin - Upstream process*	*Cheese and Yogurt fermentation*
S-2	SLO-1	*Isolation and Screening of Industrially Important Microorganisms*	*Citric acid – Upstream process*	*Carbohydrate containing antibiotic: Streptomycin - Upstream process*	*Insulin - Downstream process*	*Sauerkraut and Soy sauce fermentation*
	SLO-2	*Types of fermentation process*	*Citric acid – Downstream process*	*Streptomycin - Downstream process*	*Interferon - Upstream process*	*Food flavoring agents' fermentations*
S-3	SLO-1	*Microbial growth metabolism*	*Lactic acid – Upstream process*	*Macro cyclic lactones: Erythromycin - Upstream process*	*Interferon - Downstream process*	*Mono sodium glutamate fermentation*
	SLO-2	*Microbial metabolites*	*Lactic acid – Downstream process*	*Erythromycin - Downstream process*	*Production of nucleosides and nucleotides*	*γ-decalactone fermentation*
S-4	SLO-1	*Strain development*	*Acetic acid – Upstream process*	*Peptide antibiotic: Bacitracin - Upstream process*	*5' Inosine monophosphate*	*Food preservative fermentation*
	SLO-2	*Improvement of Strains Producing Primary metabolites*	*Acetic acid – Downstream process*	*Peptide antibiotic: Bacitracin - Downstream process*	*5' Guanosine monophosphate*	*Nisin fermentation*
S-5	SLO-1	*Improvement of Strains Producing Secondary metabolites*	*Amino acids fermentation*	*Industrial Enzyme production*	*Enzyme biotransformations*	*Food colorants fermentation*
	SLO-2	*Preservation of Industrially Important Cell Cultures and Microorganisms*	*L-glutamic acid - Upstream process*	*Protease - Upstream process*	*Steroid transformations*	*Monascus pigments fermentation*
S-6	SLO-1	*Inoculum Development*	*L-glutamic acid – Downstream process*	*Protease - Downstream process*	*Antibiotic transformations*	*Carotenoid production*
	SLO-2	*Aseptic Inoculation of Plant Fermenters*	*L-lysine – Upstream process*	*Lipase - Upstream process*	*Biopolymers fermentation*	*Astaxanthin Production*
S-7	SLO-1	*Measuring Process Variables*	*L-lysine – Downstream process*	*Lipase - Downstream process*	*Xanthan gum*	*Production of single cell protein*
	SLO-2	*Product development:*	*L-tryptophan - Upstream process*	*Vitamins production*	*Polyhydroxyalkanoates*	*Bel – symba – pekilo – pruteen processes*
S-8	SLO-1	*Regulation and safety*	*L-tryptophan - Downstream process*	*Cyanaocobalamin - Upstream process*	*Polyhydroxybutyrate*	*Beverages*
	SLO-2	*Use of Process flowcharts*	*Solvents fermentation*	*Cyanaocobalamin - Downstream process*	*Agrochemicals production*	*Brewing process*

S-9	SLO-1	*Use of Process block diagrams*	*Acetone - Butanol – Ethanol - Upstream process*	*Riboflavin - Upstream process*	*Bacillus thuringenesis*	*Wine production*
	SLO-2	*Examples*	*Acetone - Butanol – Ethanol - Downstream process*	*Riboflavin - Downstream process*	*Artemisinin*	*Cider production*

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.* 4. *Waites M. J., Morgan N.L., Rockey J.S., Higton G., "Industrial Microbiology: An Introduction", Blackwell Science, 2013.*	5. *Saran S., Babu V., Chuabey A., "High Value Fermentation Products: Human Health", Scrivener Publishing, 2019* 6. *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 (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Dr. Karthik Periyasamy, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	*Dr. M. Venkatesh Prabhu, SRMIST*

Course Code	18BTE316T	Course Name	BIOREACTOR DESIGN	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18BTC107J	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 basic design and development of Bioreactors and its operation*
CLR-2 :	*Design the air driven reactors*
CLR-3 :	*Acquire knowledge on different types of Solid state bioreactors and its operation*
CLR-4:	*Learn about the sequential batch reactor and biofilm reactors*
CLR-5:	*Know about the modeling, simulation, Control and CFD analysis of bioraector*
CLR-6:	*Familiarized with concept of design and application of reactors*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Know the basic design of reactor*	*1*	*85*	*80*
CLO-2 :	*Acquire knowledge on air driven reactor*	*2*	*90*	*80*
CLO-3 :	*Know about reactors for solid state fermentation*	*2*	*80*	*80*
CLO-4 :	*Have knowledge on biofilm reactor*	*2*	*80*	*80*
CLO-5 :	*Know about modeling, simulation and control system used in reactor*	*2*	*85*	*80*
CLO-6 :	*Acquire the basic knowledge on design of SMF and SSF and its control*	*2*	*80*	*80*

Program Learning Outcomes (PLO)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	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
CLO-1 :	*H*	*H*	*H*	*H*	*M*				*H*	*M*	*H*	*H*	*H*	*H*	*H*
CLO-2 :	*H*	*H*	*H*	*H*	*M*				*H*	*M*	*H*	*H*	*H*	*H*	*H*
CLO-3 :	*H*	*H*	*H*	*M*	*L*				*H*	*M*	*H*	*H*	*H*	*H*	*H*
CLO-4 :	*H*	*H*	*H*	*H*	*M*				*H*	*M*	*H*	*H*	*H*	*H*	*H*
CLO-5 :	*H*	*H*	*H*	*H*	*M*				*H*	*M*	*H*	*H*	*H*	*H*	*H*
CLO-6 :	*H*	*H*	*H*	*H*	*H*				*H*	*M*	*H*	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Understanding of Bioreactor Design*	*Air Driven Reactors*	*Solid State Fermentation Bioreactors*	*Sequential Batch ,Biofilm and Trickle flow reactors*	*Bioreactor Modeling, simulation , control and CFD analysis*
	SLO-2	*Basics and importance of bioreactors*	*General features of bubble column and airlift reactor*	*Solid-State Bioreactor Fundamentals: Selection and design of SSF reactors*	*Sequential Batch reactors*	*Modeling and Simulation*
S-2	SLO-1	*Guidelines for bioreactor design*	*Factors influencing mass transfer in bubble column*	*Heat transfer in SSF reactors*	*Bioreactors containing microbial films*	*Types of Modelling*
	SLO-2	*General requirement for Mechanical construction of Bioreactor*	*Flow patterns , liquid mixing and gas dispersion in bubble column, Mass and Heat transfer in bubble column*	*Mass transfer in SSF reactors*	*Completely mixed microbial reactor*	*Types of simulation*
S-3	SLO-1	*Design of thin walled , internal pressure, stirred tank reactor*	*Airlift bioreactors*	*Laboratory and pilot scale of solid state bioreactor*	*Microbial film Bioreactor*	*Steps involved in Modeling*
	SLO-2	*Solving Problems*	*Design and construction of the airlift loop reactor*	*Industrial scale of solid state bioreactor*	*Design and Construction*	*Steps*
S-4	SLO-1	*Development of bioreactors*	*Modeling in Air Lift Reactor*	*Classification of SSF Bioreactor*	*Trickle flow reactor*	*Methods and strategies for bioreactor control*
	SLO-2	*Instrumentations to control a bioreactor*	*Mass and Energy Balance*	*Mode of Operation*	*Design and Construction*	*Control loop*
S-5	SLO-1	*Sensors*	*Hydrodynamics in ALR*	*Un aerated and Unmixed Bioreactor*	*Theory of Trickle flow reactor*	*Analogue and digital control*
	SLO-2	*Probes in bioreactor*	*Three phase flow in ALR*	*Design and Construction*	*Physical model*	*Control algorithm*
S-6	SLO-1	*Common operations of bioreactor*	*Mixing*	*Forcefully – Aerated bioreactors without mixing*	*Mathematical model of Trickle flow reactor*	*Physical control of Bioreactor*
	SLO-2	*Types of Reactor*	*Oxygen transfer in ALR*	*Design and Construction*	*Solving Problems*	*Methods*
S-7	SLO-1	*Performance of Batch Reactor*	*Design of fluidized bed bioreactor*	*Rotating –Drum and Stirred –Drum bioreactors*	*Performance analysis of Trickle flow reactor*	*Computers in control of Bioreactor*
	SLO-2	*Solving Problems*	*Operation of fluidized bed bioreactor*	*Continuously mixed bioreactors*	*High substrate concentration and low substrate concentration*	*Solving Problems*

S-8	SLO-1	*Performance of Continuous reactor*	*Design and operation of inverse fluidized bed bioreactor*	*Mixed ,Forcefully – Aerated Bioreactors*	*Calculation of parameter estimation*	*Control Strategy for Bioreactor*
	SLO-2	*Performance of Continuous reactor with recycle*	*Models in Fluidized bed bioreactor*	*Design and Construction*	*Problems*	*Solving Problems*
S-9	SLO-1	*Fed Batch Reactor*	*Hydrodynamics of fluidized bed rector*	*Intermittently Mixed bioreactors*	*Design method*	*CFD analysis in Bioreactor design.*
	SLO-2	*Solving Problems*	*Solving Problems*	*Design and Construction*	*Calculation procedure and Evaluation of parameter estimation*	*Solving Problems*

Learning Resources	1. *Scragg. H., "Bioreactors in Biotechnology", Ellis Horwood series, 1991.* 2. *B.Atkinson.,"Biochemical Reactors",Pion limited,London,1974* 3. *Panda. T., "Bioreactors: Analysis and Design", McGraw Hill Education (India) Private Limited, 2011* 4. *Riet. K. V., Tramper. J., "Basic Bioreactor Design", 2nd ed., Marcel Dekker, Inc., New York, 1991.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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Course Code	18BTE407T	Course Name	BIOPROCESS MODELLING AND SIMULATION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Illustrate the knowledge on various mathematical models of biological systems.*			
CLR-2 :	*Explore the modelling of bioprocess with a view to engineering application.*			
CLR-3 :	*Demonstrate the advanced software knowledge for the automation of bioprocess systems.*			
CLR-4:	*Demonstrate the Use of Superpro software to design a bioprocess system for the production of bioproducts.*			
CLR-5:	*Analyze the solutions of various mathematical problems using MATLAB.*			
CLR-6:	*Familiarize the students with the various bioprocess models and softwares.*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Describe the fundamental laws and concepts about the mathematical modeling*	*2*	*80*	*70*
CLO-2 :	*Explain about the various mathematical models in biochemical engineering systems*	*2*	*85*	*75*
CLO-3 :	*Discuss the application of SuperPro Design for analysis of material and energy balance of biochemical reaction*	*3*	*75*	*80*
CLO-4 :	*Explain the basic concepts of MATLAB, data analysis and interpretation of data*	*3*	*85*	*80*
CLO-5 :	*Explain the basic concepts of SIMULINK, data analysis and interpretation of data*	*3*	*85*	*80*
CLO-6 :	*Accomplish knowledge about the fundamentals of modeling and simulations of bioprocess*	*2*	*80*	*75*

Program Learning Outcomes (PLO)															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
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
H	*H*	*H*	*H*			*H*		*H*		*H*	*H*	*H*	*H*	*H*
H	*H*	*H*	*H*			*H*		*H*		*H*	*H*	*H*	*H*	*H*
H	*H*	*H*	*M*	*H*		*H*		*H*		*H*	*H*	*H*	*H*	*H*
H	*H*	*H*	*H*	*H*		*M*		*H*		*H*	*H*	*H*	*H*	*H*
H	*H*	*H*	*H*	*H*		*M*		*H*		*H*	*H*	*H*	*H*	*H*
H	*H*	*H*	*H*	*H*		*M*		*H*		*H*	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Models - Introduction*	*Basic Mathematical Models*	*Introduction to Superpro*	*MATLAB - Introduction*	*Modeling of Batch Culture Using MATLAB – basics*
	SLO-2	*Basic modeling principles*	*Setting up a model*	*Developing a Process Model*	*MATLAB - basics*	*Batch Culture – programme*
S-2	SLO-1	*Introduction of mathematical modeling*	*Continuous flow tanks - enclosed vessel*	*Process design*	*MATLAB - Data analysis*	*Batch Culture – expected outputs*
	SLO-2	*Uses of mathematical modeling*	*Continuous flow tanks - mixing vessel*	*Process Modeling and Simulation*	*Curve fitting - Introduction*	*Modeling of Fed-batch Culture Using MATLAB – basics*
S-3	SLO-1	*Classification of modeling techniques*	*Steam jacketed vessel*	*Process flow diagrams*	*Curve fitting using MATLAB - Theory*	*Fed-batch Culture – programme*
	SLO-2	*Grouping of models into opposite pairs*	*Steam jacketed vessel - open and closed*	*Process flow diagram to produce human insulin*	*Curve fitting using MATLAB – examples*	*Fed-batch Culture – expected outputs*
S-4	SLO-1	*Classification based on Mathematical complexity*	*Batch distillation – basics*	*The -Galactosidase Process*	*Numerical Integration*	*Modeling of Continuous Culture Using MATLAB – basics*
	SLO-2	*Classification of models according to scale*	*Batch distillation model*	*The Industrial Wastewater Treatment Process*	*Numerical Integration Techniques*	*Continuous Culture – programme*
S-5	SLO-1	*Fundamental laws – Expression and examples*	*Bioprocess modeling*	*Procedures & Operations*	*Trapezoidal Rule*	*Continuous Culture – expected outputs*
	SLO-2	*Energy equations*	*Modelling approaches for biomanufacturing operations*	*Resources*	*Trapezoidal Rule - Problems*	*Process Simulation*
S-6	SLO-1	*Energy equations - expression and examples*	*Types of bioprocess model*	*Scheduling*	*Simpson's Rule*	*Simulink - Introduction*
	SLO-2	*Continuity equations*	*Mathematical models of microbial process*	*Process Properties & Simulation*	*Simpson's Rule - Problems*	*Simulink - basics*
S-7	SLO-1	*Continuity equations – expression and examples*	*Applying mechanistic models in bioprocess development*	*Economics*	*Euler's Method*	*Simulation of gravity flow tank*
	SLO-2	*Transport equations*	*Model formulation for aerobic cultivation of budding yeast*	*Reports*	*Euler's Method - Problems*	*Simulation of three isothermal CSTR*

S-8	SLO-1	*Transport equations expression and examples*	*Parameter identifiable analysis*	*Material-Balance Calculations*	*Runge-Kutta 4th Order Method*	*Simulation by Simulink in Batch Culture*
	SLO-2	*Equations of motion*	*Uncertainty analysis*	*Material-Balance Problems*	*Runge-Kutta 4th Order Method - Problems*	*Simulation by Simulink in fed-batch Culture*
S-9	SLO-1	*Chemical kinetics*	*Metabolic flux modelling (MFM)*	*Energy-Balance Calculations*	*Programming with MATLAB*	*Simulation by Simulink in continuous Culture*
	SLO-2	*Examples*	*MFM as a tool to analyze the behavior of genetically modified yeast strain*	*Energy-Balance Problems*	*Program design and development*	*Expected outputs of Batch, Continuous and Fed-batch fermentation process*

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.* 5. *Franks. R.G.E., "Mathematical Modeling in Chemical Engineering", John Wiley and Sons, Inc., 2004.*	6. *Biquette. W.B., "Process Dynamics- Modeling analysis with simulation", Prentice Hall; 1 edition, 1998.* 7. *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.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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Course Code	18BTE408T	Course Name	BIOPROCESS PLANT DESIGN	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Equip the students with designing aspects for industrial scale fermenter*			
CLR-2 :	*Infer various scale up and scale down parameters for good optimization process*			
CLR-3 :	*Understand the factors involved in heat and mass transfer studies for controlling process parameters*			
CLR-4:	*Envisage the guidelines for plant operation and its risk assessment*			
CLR-5:	*Decipher process economics involved in industrial operations*			
CLR-6:	*Instigate the production strategies in protein and other metabolites with commercial importance*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Manage Inoculum development and nutritional balance for product conversion.*	*2*	*80*	*70*
CLO-2 :	*learn about the mass and energy balance of bioprocess*	*2*	*85*	*75*
CLO-3 :	*develop and optimize the process parameters for the industries*	*3*	*75*	*80*
CLO-4 :	*apply design factors for scale up in the industry*	*3*	*85*	*80*
CLO-5 :	*evaluate the process plant design for regulatory compliance*	*3*	*85*	*80*
CLO-6 :	*design a plant layout for processing of biological materials*	*2*	*80*	*75*

Program Learning Outcomes (PLO)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	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
CLO-1 :	*H*	*H*	*H*	*H*			*H*		*H*		*H*	*H*	*H*	*H*	*H*
CLO-2 :	*H*	*H*	*H*	*H*			*H*		*H*		*H*	*H*	*H*	*H*	*H*
CLO-3 :	*H*	*H*	*H*	*M*	*H*		*H*		*H*		*H*	*H*	*H*	*H*	*H*
CLO-4 :	*H*	*H*	*H*	*H*	*H*		*M*		*H*		*H*	*H*	*H*	*H*	*H*
CLO-5 :	*H*	*H*	*H*	*H*	*H*		*M*		*H*		*H*	*H*	*H*	*H*	*H*
CLO-6 :	*H*	*H*	*H*	*H*	*H*		*M*		*H*		*H*	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Design-Project Procedure*	*Heat and Mass Transfer studies*	*Selection of bioprocess equipment - upstream*	*Plant location and site selection*	*Cash Flow for Industrial Operations*
	SLO-2	*Types of Designs*	*Effect of scale on oxygenation*	*Selection of bioprocess equipment - downstream*	*Plant Layout*	*Cumulative Cash Position*
S-2	SLO-1	*Feasibility Survey*	*mixing and sterilization*	*Specifications of bioprocess equipment*	*Plant operation and control*	*Factors affecting investment and production costs*
	SLO-2	*Flow Diagrams*	*Inoculum development and nutrient availability*	*Mechanical design of reactors*	*Techniques Used in Site and Plant Layout*	*Capital Investments*
S-3	SLO-1	*Process Flow sheeting*	*Bioreactor scale-up*	*Heat transfer equipment*	*Utility supply aspects*	*Estimation of Capital Investment*
	SLO-2	*Equipment Design*	*Scale-up - constant power consumption per volume*	*Heat exchangers and Evaporators*	*Environmental Considerations*	*Cost Indexes*
S-4	SLO-1	*Equipment Selection*	*Scale-up - mixing time*	*Mass transfer equipment*	*Equipment cleaning aspects*	*Cost Factors in Capital Investment*
	SLO-2	*Comparison of Different Design-Projects*	*Scale-up - impeller tip speed (shear)*	*Finite-Stage Contactors*	*Culture cell banks*	*Estimating Equipment Costs by Scaling*
S-5	SLO-1	*Material balance*	*Scale-up - mass transfer coefficients*	*Continuous contactors - Packed towers*	*cGMP guidelines*	*Purchased-Equipment Installation*
	SLO-2	*Material balance calculations*	*Problems*	*Pressure Drop*	*Global Regulatory Environment*	*Methods for estimating capital investment*
S-6	SLO-1	*Examples*	*Scale up of downstream processes*	*Factors Influencing Plate and Column Efficiencies*	*Key Pharmaceutical Regulations Related to Design and Engineering*	*Estimation of Total Product Cost*
	SLO-2	*Problems*	*Adsorption*	*Piping and instrumentation*	*Implications for Performance and Compliance*	*Fixed Charges*
S-7	SLO-1	*Energy balance*	*Adsorption (LUB method)*	*HAZOPS Study*	*Risk Assessments*	*Case study – Commodity chemicals*
	SLO-2	*Energy balance calculations*	*Chromatography*	*Safety checklist for identifying process hazards*	*Validation*	*Cost analysis of enzyme production*
S-8	SLO-1	Examples	Chromatography (constant resolution etc.)	Materials of construction for bioprocess plants	Project Plans	Bioethanol from Corn Stover

	SLO-2	*Problems*	*Filtration (constant resistance etc.) -*	*Classification of stainless steels by alloy content and microstructure*	*Detailed Design Phase*	*Furfural and lignin from Corn Stover*
S-9	SLO-1	*Scale-Up in Design*	*Centrifugation (equivalent times etc.)*	*Low- and high-temperature Materials*	*Process Safety Management*	*Insulin production*
	SLO-2	*Factors in equipment scale-up and design*	*Scale-down related aspects*	*Economics in Selection of Materials*	*Safety Indices*	*Monoclonal Antibody Production*

Learning Resources	1. *Jacobs T., Signore A. A., "Good Design Practices for GMP Pharmaceutical Facilities", 2nd edition, Taylor and Francis, 2017.* 2. *Peters M. S., Timmerhaus. K. D., "Plant Design and Economics for Chemical Engineers", 5th Edition, McGrawHill Book Co., 2003* 3. *Perry R. H., Green D. W., "Perry's Chemical Engineers' Handbook", 9th Edition, McGraw Hill Book Co., 2018.* 4. *Towler G., Sinnott R., "Chemical Engineering Design - Principles, Practice and Economics of Plant and Process Design, Elsevier, 2007.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Dr. Karthik Periyasamy, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	*Dr. M. Venkatesh Prabhu, SRMIST*

Course Code	18BTE317T	Course Name	ENVIRONMENTAL BIOTECHNOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

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 overview of biological approach for the conversion of various environmental pollutants*
CLR-3 :	*Understand the importance of biotechnology in the environmental management*
CLR-4:	*Understand various biotechnological contributions to the industries to reduce the environmental pollution*
CLR-5:	*Educate the relevant information about recovery of bioproducts from industrial wastes*
CLR-6:	*Identify the novel technology for the environmental pollution abatement*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	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
CLO-1 :	*Understand the biotechnological solutions for the treatment of industrial liquid and solid wastes*	*1*	*80*	*80*	*H*	*H*	*H*	*H*	*M*	*M*	*L*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-2 :	*Acquire knowledge in aerobic and anaerobic biological treatment technologies*	*2*	*85*	*75*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-3 :	*Understand the importance of biotechnology in the environmental pollution management*	*2*	*75*	*80*	*M*	*H*	*M*	*H*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-4 :	*Understand the bioconversion pathways for the degradation of various xenobiotic compounds*	*2*	*85*	*80*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*L*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-5 :	*Gain knowledge on the recovery of high value-added bioproducts from industrial wastes*	*3*	*85*	*75*	*H*	*H*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*L*	*H*	*H*	*H*	*H*	*H*
CLO-6 :	*Choose from an array of options to turn waste into economic goods*	*2*	*80*	*80*	*H*	*H*	*H*	*H*	*L*	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Environmental pollution-water, air, soil*	*Recent trends in Biological wastewater treatment*	*Xenobiotics and recalcitrants*	*Recent trends in Biodegradation of industrial wastes*	*Waste to Wealth*
	SLO-2	*Perspectives of liquid and solid wastes*	*Aerobic biological treatment technologies*	*Environmental effects of Xenobiotics and recalcitrants*	*Contributions of Biotechnology for the environmental managements and industrial applications*	*Value-added bioproducts from Industrial wastes*
S-2	SLO-1	*Overview of stages of wastewater treatment*	*Anaerobic digestion process*	*Biodegradation of xenobiotics*	*Microbial enzymes for environmental applications*	*Slaughterhouse industry wastes*
	SLO-2	*primary, secondary and tertiary treatment*	*Stages of anaerobic digestion process*	*Mechanisms of Biodegradation of xenobiotics -Reductive/Oxidative/Hydrolytic*	*Advantages of immobile cells or enzymes over free cells and enzymes*	*Recovery of enzymes from slaughterhouse industry waste for industrial applications*
S-3	SLO-1	*Physicochemical technologies for the liquid waste disposal*	*Anaerobic Biological treatment technologies*	*Aliphatic and Hydrocarbons*	*Role of Biocatalysts in pollutant removal*	*Recovery of secondary metabolites from slaughterhouse industry waste for industrial applications*
	SLO-2	*Coagulation, Flocculation, Sedimentation*	*Advantages of anaerobic digestion processes over aerobic digestion processes*	*Biotransformation of Aliphatic and Hydrocarbons*	*Application of Immobilized cells in pollutants removal*	*Leather industry wastes*
S-4	SLO-1	*Chemical precipitation*	*Microbiology of anaerobic digester*	*Aromatic Hydrocarbons*	*Role of Biocatalysts in pollutant removal – Immobilized Enzymes*	*Types of solid wastes generated from leather industry*
	SLO-2	*Pros and Cons of chemical precipitation*	*Factors affecting anaerobic digestion process*	*Biotransformation of Aromatic Hydrocarbons*	*Application of Immobilized enzymes in pollutants removal*	*Recovery of enzymes from leather industry wastes for industrial applications*
S-5	SLO-1	*Filtration processes-mechanisms*	*Attached growth system-Biofilm*	*Polyaromatic hydrocarbons*	*Classification of dyes and their effects on the environment*	*Recovery of secondary metabolites from leather industry wastes for industrial applications*
	SLO-2	*Types of filtration processes*	*Biofilm development process*	*Biotransformation of Polyaromatic hydrocarbons*	*Microbial dye decolourization*	*Plastic wastes*
S-7	SLO-1	*Adsorption processes-Activated carbon technology-applications*	*Biofilm Technologies in environmental pollution management*	*Polycyclic aromatic Hydrocarbons*	*Enzyme based dye decolourization*	*Environmental impacts*

	SLO-2	*Ion Exchange processes-applications*	*Advantages of attached growth system over suspended system*	*Biotransformation of Polycyclic aromatic Hydrocarbons*	*Biodegradation of textile dyes*	*Recycling of plastic wastes*
S-8	SLO-1	*Solid waste disposal-Effects*	*Nutrients removal-Eutrophication*	*Halogenated hydrocarbons*	*Laccases and their role in Bioremediation of Industrial wastes*	*Bioplastics*
	SLO-2	*Secured Landfill, Bacterial and Vermi composting, incineration/pyrolysis*	*Recent advances in Nitrogen removal*	*Biotransformation of halogenated hydrocarbons*	*Heavy metal toxicity to the environment*	*Renewable resources for energy generation*
S-9	SLO-1	*Advanced oxidation processes for recalcitrants treatment*	*Biological Phosphorous Removal*	*Oil pollution and its effect on the environment*	*Microbial heavy metal removal-mechanisms*	*Alternate technologies for Energy recovery*
	SLO-2	*Electrolysis-Cu removal*	*EBPR process-mechanisms*	*Microbial treatment of oil pollution*	*Role of biosurfactants, Extracellular polysaccharides and siderophores in the heavy metal removal*	*Biomass residue as a fertilizer*

Learning Resources	1. *Bruce E.Rittmann and Perry L.McCarty, Environmental Biotechnology: Principles and Applications, McGraw Hill.2001.* 2. *Bimal C Bhattacharyya, Environmental Biotechnology, Oxford University press, 2007.* 3. *Milton Wainwright, an Introduction to Environmental Biotechnology, Springer, 1999.* 4. *P.Rajendran, P.Gunasekaran, Microbial Bioremediation, MJP Publishers, India, 2006.*	5. *Ram Chandra, Advances in biodegradation and bioremediation of industrial wastes, CRC Press, Taylor&Francis, 2015.* 6. *Hanes Joachim Joardening, Environmental Biotechnology, Concepts and Applications, 2017.* 7. *Chatterjee A.K, Introduction to Environmental Biotechnology, Prentice Hall of India, 2011.*

SLO – Session Learning Outcome

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. S. Sam Gunasekar, Orchid Chemicals and Pharmaceuticals Ltd., sam@orchidpharma.com	*1. Dr. A. Gnanamani, CSIR-Central Leather Research Institute, agmani_2000@yahoomail.com*	*1 Dr. K.Ramani SRM Inst. of Science & Technology, ramani.k@ktr.srmuniv.ac.in*
2. Dr. D. Gunaseelan, BIOCON Ltd., guna.sachin@gmail.com	*2. Dr. Anbumani Sadasivam, CSIR-Indian Institute of Toxicology Research,anbumani@iitr.res.in*	*2 Dr. B.Samuel Jacob SRM Inst. of Science & Technology, Samueljacob.b@ ktr.srmuniv.ac.in*

Course Code	18BTE318T	Course Name	INDUSTRIAL WASTE MANAGEMENT	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Identify the relevant information about industrial solid waste reduction and hazardous waste management*			
CLR-2 :	*Identify the applications of energy conversion technology*			
CLR-3 :	*Demonstrate the state of the art in technology, organizational and legislative developments and practices*			
CLR-4:	*Create insights to the waste characterization aspects*			
CLR-5:	*Analyze the mass balance and carbon foot print for a given industrial process*			
CLR-6:	*Utilize the concepts environmental regulation and inculcate in newly developed treatment technologies*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	1	2	3
CLO-1 :	*Formulate an insight into the pollution from major industries including the sources and characteristics of pollutants*	*1*	*80*	*70*
CLO-2 :	*Analyze the mode of treatment based on waste characteristics*	*2*	*85*	*75*
CLO-3 :	*Design of wastewater treatment plants to attain standard limits*	*2*	*75*	*70*
CLO-4 :	*Assess the impact of industrial wastes on the environmental compartments (land, water and air)*	*2*	*85*	*80*
CLO-5 :	*Analyze and choose approportate strategy to convert waste to economic goods*	*2*	*85*	*75*
CLO-6 :	*Develop knowledge on environmental regulations and legal aspects*	*1*	*80*	*70*

Program Learning Outcomes (PLO)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	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
CLO-1 :	*H*	*H*	*M*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*M*	*H*	*M*	*H*	*H*
CLO-2 :	*H*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*M*	*L*	*H*	*H*	*M*	*H*	*H*
CLO-3 :	*H*	*H*	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*M*	*H*
CLO-4 :	*H*	*H*	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*
CLO-5 :	*H*	*H*	*M*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-6 :	*H*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*M*	*H*	*H*	*M*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to industrial wastes and their impacts-Industrial wastes - Sources*	*Standards for waste disposal & methods of waste reduction –*	*Treatment and disposal of industrial effluents*	*Biodegradation/ Recycling Of Industrial Wastes*	*Environmental Concerns, Legislations And Environmental Impact Assessment*
	SLO-2	*Classification of industrial wastes*	*Standards for disposal of treated effluents, solid wastes and gaseous emissions from different industries*	*Stages of effluent treatment- primary, secondary and tertiary*	*Immobilized cell and enzyme technologies for the effluent treatment*	*Environmental Assessment and Management Systems*
S-2	SLO-1	*Industrial waste generation scenario in India*	*Characteristics of industrial wastewater-COD, BOD and TOC*	*Physicochemical treatment-Coagulation, flocculation and their mechanisms*	*Energy recovery from hybrid treatment technology*	*Applicable federal and provincial environmental regulations*
	SLO-2	*Industrial waste generation scenario in Global context*	*Solids analysis – TDS, TSS and VSS*	*Precipitation –heavy metal removal-Merits and Demerits*	*Case study f sustainable technologies from European Union*	*Environmental impact assessment (EIA) legislation and regulatory framework*
S-3	SLO-1	*Environmental impacts*	*Characteristics of industrial wastewater-, TKN, Ammonia, Chloride, Sulfide and Sulfate*	*Secondary Biological treatment: Aerobic-activated sludge process,*	*Algal based technologies for nutrient and pollutant removal*	*EIA applied to solid and liquid waste management*
	SLO-2	*Threat to biodiversity*	*Metal analysis using AAS and ICP-MS*	*Sequential batch process. fluidized bed reactor*	*Bioreactor designs for algal based wastewater*	*Environmental toxicology assessment and regulations*
S-4	SLO-1	*Toxicity of industrial effluents*	*Removal of heavy metals by physico-chemical process*	*Secondary Biological treatment: Anaerobic-UASB, MBR –Merits and Demerits*	*Bioelectricity production through MFC with leachate and wastewater*	*Management of toxic chemicals*
	SLO-2	*Case studies of industrial toxicity (Bhopal gas leak, Chernobyl etc.)*	*Biological process for heavy metal removal*	*High rate bioreactors*	*Water splitting technologies*	*Nuclear waste management*
S-5	SLO-1	*Functions of Regulatory bodies-State and Central Pollution Control Board*	*Individual and Common Effluent Treatment Plants*	*Reprocessing of bio-sludge for value addition*	*Bioplastic synthesis from the compounds derived from wastewater*	*Effluent control, air pollution control and urban development*
	SLO-2	*Common effluent treatment plants for textile and tannery industry wastewater treatment*	*Case study of Indian industries waste treatment through common effluent treatment process*	*Energy recovery from sludge*	*Polymer synthesis from the compounds derived from wastewater*	*Pollution abatement in national river bodies: Case studies*

S-6	SLO-1	*Selection of candidate technologies for waste treatment based on characteristics*	*Volume and strength reduction*	*Removal of refractory organics-strategies*	*Plastics degrading bacteria*	*Environmental auditing*
	SLO-2	*Rationale for biological treatment over convetional methods*	*Material and process modifications*	*Advanced oxidation processes*	*Phytoremediation for removal of heavy metals*	*ISO 14001:2015 And its implication in environmental assessment*
S-7	SLO-1	*The solid waste landfill*	*4R principles– Recycle, reuse and by-product recovery*	*Photo-oxidation process*	*Bioremediation of hydrocarbon contaminated wastewater of refinery plants through super bugs (GM Pseudomonas putida)*	*Carbon foot print for an industry*
	SLO-2	*Leachate management*	*Waste treatment flow sheets for selected industries such as Textiles, Tanneries, Pharmaceuticals, Electroplating industries,*	*Volatile organic compound (VOC) removal by Evaporation*	*Ocean cleaning for oil spill using super bugs*	*Carbon credit*
S-8	SLO-1	*The process of composting Industrial wastes*	*Dairy, Sugar, Paper, distilleries, Steel plants, Refineries, fertilizer, thermal power plants*	*Air and steam stripping*	*Biosurfactants for bioremediation and biodegradation of various pollutants discharged from industrial waste*	*Occupational Safety and Health Assessment*
	SLO-2	*Vermi-composting and its advantages*	*Hazardous waste management– Physico chemical treatment*	*Adsorption processes (Activated carbon)*	*Mechanism of biosurfactant based technologies for solids reduction in wastewater*	*Waste Hazard identification and problem formulation*
S-9	SLO-1	*Hierarchy of Potential Implementation waste management Strategies*	*Solidification and incineration – Zero discharge*	*Colour removal from wastewater from textile industries*	*Application of nanotechnology for waste degradation*	*Life cycle assessment of industrial wastes*
	SLO-2	*Waste management pyramid*	*Secure land fills*	*Role of microorganisms and enzymes for dye removal*	*Nano-enzymes for pollutant removal*	*Implications of biological agents on environment for pollutant removal*

Learning Resources	1. *Eckenfelder, W.W., (1999) "Industrial Water Pollution Control ", Mc-Graw Hill.* 2. *Clair N. Sawyer, Perry L. McCarty, "Chemistry for Environmental Engineering and Science" McGraw-Hill, 1978* 3. *Metcalf & Eddy Inc.Wastewater Engineering: Treatment and reuse 2016*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

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2.Dr. D. Gunaseelan, BIOCON Ltd., guna.sachin@gmail.com	*2. Dr. Anbumani Sadasivam, CSIR-Indian Institute of Toxicology Research,anbumani@iitr.res.in*	*Dr. B.Samuel Jacob SRM Inst. of Science & Technology, ssamueljacob.b@ ktr.srmuniv.ac.in*

Course Code	18BTE319T	Course Name	BIOENERGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning
CLR-1 :	*Identify the potent biomass resources for energy production*	1
CLR-2 :	*Identify the applications of energy conversion technology*	2
CLR-3 :	*Demonstrate the significance of environmental benefits of bioenergy*	3
CLR-4:	*Create insights to the concepts of sustainable and green technologies*	
CLR-5:	*Analyze the important wastes to energy conversion*	
CLR-6:	*Utilize the concepts scale up strategies for biomass based energy production*	

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Formulate the appropriate biofuel production based on available feedstocks*	*1*	*80*	*70*
CLO-2 :	*Analyze cell wall components of biomass*	*2*	*85*	*75*
CLO-3 :	*Apply thermo-chemical conversion process for biomass conversion to produce biofuel*	*2*	*75*	*70*
CLO-4 :	*Apply enzymatic process to convert biomass t fuel and value added chemicals*	*2*	*85*	*80*
CLO-5 :	*Employ synthetic routes for ease and fast biofuel prouction*	*2*	*85*	*75*
CLO-6 :	*Describe the National policy towards biofuel production and Energy security*	*1*	*80*	*70*

Program Learning Outcomes (PLO)	1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1	*H*	*H*	*M*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*M*	*H*	*M*	*H*	*H*
CLO-2	*H*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*M*	*L*	*H*	*H*	*M*	*H*	*H*
CLO-3	*H*	*H*	*M*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*M*	*H*
CLO-4	*H*	*H*	*M*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-5	*H*	*H*	*M*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-6	*H*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*M*	*H*	*H*	*M*	*H*

		Introduction to Sources of energy	First Generation Bioenergy	Second & Third Generation Bioenergy	Fourth generation bioenergy and next generation bio-molecules	Policies and future R&D of biofuels & Bioenergy
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Non-renewable Resources (Fossil fuel)*	*Sugar and Starch based bioenergy*	*2nd generation (Non-edible lignocellulosics)*	*CO_2 biosequestration and biofuel production strategies*	*Policies and Future R&D of Biofuels & Bioenergy*
	SLO-2	*Alternate and renewable resources (Solar, wind and biomass based)*	*Corn, sugarcane, sugar beets, soybeans, canola oil, fryer grease, and coconut oil*	*Wood bioenergy*	*Use of plants and microalgae for CO_2 sequestration*	*National biofuel policy framework*
S-2	SLO-1	*Bioenergy – Classification (Liquid and gaseous biofuel)*	*Fuel from food crops*	*Pretreatment strategies for biofuel production*	*Synthetic (bio)fuels*	*Evaluation of current and future R&D needs*
	SLO-2	*An overview of bioenergy in Global and national context*	*Consequences for food crops as fuel source*	*Green chemicals for biomass pretreatment*	*Sustainability aspects of synthetic biofuels*	*Focus area such as Mission Innovations India and Horizon 2020*
S-3	SLO-1	*Rationale of biomass power sustainable environment*	*Role of cell wall components (Lignin, cellulose and hemicelluloses) in different plants for ethanol production*	*Rationale for biological pretreatment over physical and chemical modes.*	*Pyrolysis bio-oil/bio-char*	*Legal framework to support sustainable development and increased use of biofuels*
	SLO-2	*Treatment technologies for biomass to useful energy*	*Bottlenecks in biomass conversion to fuels*	*Bioethanol plant design and its components*	*Hydrogenated biodiesels*	*Need for International cooperation and intervention in biofuel sectior in India*
S-3	SLO-1	*Circular & Biobased Economy*	*Recalcitrant lignin and its biochemistry*	*Bio refinery demonstration projects of Bioethanol*	*Pyrolysis diesel*	*Government policies and programs with regard to biofuels*
	SLO-2	*Environment impact over biofuel usage*	*Importance of cellulose and hemicelluloses*	*Sustainable Solid and liquid waste management*	*Comparative analysis of different grades of diesel based on ASTM*	*R and D focus area for biofuel in India*
S-4	SLO-1	*Feedstocks – Food Vs Feed Vs Fuel*	*Conversions Process: Physico-chemical*	*Biomethanation process*	*Dimethyl ether (DME)*	*Investment opportunities on biofuels worldwide*
	SLO-2	*Characteristics for feedstock for bioenergy*	*Constraints of conventional processing technologies*	*Microbiology of anaerobic digestion*	*Bio-synthetic natural gas (SNG)*	*Industrial opportunities of biofuels in India – at a glance*

S-5	SLO-1	*Waste resources – Industrial (solid and liquid) and MSW*	*Biological route and Enzymatic Conversion*	*Biological Processes for Hydrogen Production*	*Comparative analysis of CNG/SNG/bio-gas based on ASTM*	*Economic, Social and Ecological Impacts of Bioenergy*
	SLO-2	*Agro waste resources – Crop residues and by-products*	*Enzymology for conversion of biomass to biofuels – Ligninolytic enzymes (MnP, LiP and laccase)*	*Dark fermentation and algal based technologies*	*Bio-butanol production*	*Comparative analysis of National and Global Levels*
S-6	SLO-1	*Energy crops – Terrestrial*	*Mechanism of depolymerization of lignin by enzymes and whole cells*	*3rd generation biofuel*	*ABE biosynthesis (Acetone Butanol and Ethanol)*	*Current and Emerging Challenges to Bioenergy Development*
	SLO-2	*Energy crops – Aquatic*	*Hexose sugar conversion to ethanol*	*Need for 3rd generation biofuels*	*Bottlenecks in ABE fermentation; Types of feedstocks preferred*	*Impact of solar and wind energy over biomass energy*
S-7	SLO 1	*Potential Benefits of Replacing Fossil Fuels with Biofuel, Biomass and Biogas*	*Pentose sugar conversion to ethanol*	*Genetically modified organisms for improved fuel production*	*Metabolic pathway engineering for ABE biosynthesis*	*Community Participation in Renewable Energy Development*
	SLO 2	*Cradle to grave approach of waste raw materials for bioenergy development*	*By-products of ethanol production and its*	*Case study of insect ruminant biology for biofuel production*	*Case study of GM microbes on ABE fermentation*	*Techno-economic feasibility for biofuel production*
S-8	SLO 1	*Political Drivers for Biofuel Development*	*Inhibitory products of bioethanol production*	*GM plants for enhanced biomass for ethanol production*	*Bio-alkanes and alkenes from waste biomass*	*Combined industrial waste treatment for energy recovery*
	SLO 2	*Consequences of Burning Fossil Fuel*	*Plausible contaminants from bioethanol production and its re-utilization*	*GM based oil crops for biodiesel production*	*Economic advantage of chemicals production from biomass*	*Zero-discharge concept for wastewater from industries and energy recovery process*
S-9	SLO 1	*Mitigation of Global Warming*	*Biodiesel from vegetable oils*	*Hybrid energy system through biomass*	*New energy research Projects in Global context*	*Urban and rural integration system for sustainable waste utilization*
	SLO 2	*Carbon dioxide sequestration Approaches*	*Transesterification process*	*Algal based technologies for biofuel and value added chemical preparation*	*New energy research Projects in Indian context*	*Life-cycle Analysis of Biofuels*

Learning Resources	1. *David M. Mousdale, "Biofuels: Biotechnology, Chemistry, and Sustainable Development, "CRC Press, 2008.* 2. *Roland A. Jansen, "Second Generation Biofuels and Biomass", Wiley – VCH Verlag GmbH Co., 2013.*	3. *A.H.Scragg, "Biofuels, Production, Application and Development", CAB Internaional, 2009* 4. *Robert C. Brown and Tristan R.Brown, "Biorenewable Resources: Engineering New Products from Agriculture," Wiley-Blackwell Publishing, 2nd Edition, 2014.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18BTE320T	Course Name	ENVIRONMENTAL MICROBIOLOGY. & METAGENOMICS	Course Category	E	Professional Elective Course	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:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Provide the awareness on the microbial applications in the environmental pollution abatement*			
CLR-2 :	*Give an overview of indigenous microbes on environmental bioremediation*			
CLR-3 :	*Educate the molecular insights on conservation of biodiversity*			
CLR-4:	*Understand the environmental metagenomics for novel species identification*			
CLR-5:	*Apply the metaproteomic concepts for environmental samples*			
CLR-6:	*Educate the soil microbiome and biofilm organisms in the environment*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	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
CLO-1 :	*Apply the concepts of microbial diversity and its taxonomic make up.*	*1*	*80*	*80*	*H*	*H*	*H*	*H*	*M*	*M*	*L*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-2 :	*Understand the extremophiles and its uses in Biotechnology.*	*2*	*85*	*75*	*H*	*H*	*H*	*H*	*M*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-3 :	*Apply Metagenomics data to describe taxonomic make-up and ecological processes of microbial communities from a range of environments*	*2*	*75*	*80*	*M*	*H*	*M*	*H*	*M*	*M*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-4 :	*Assemble and annotate genomes by identifying genes*	*2*	*85*	*80*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*L*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-5 :	*Apply next generation sequencing technology.*	*3*	*85*	*75*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*L*	*H*	*H*	*H*	*H*	*H*
CLO-6 :	*Understand the soil microbiome and biofilm organisms in the environmental cleanup*	*2*	*80*	*80*	*H*	*H*	*H*	*H*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Microbial diversity*	*Extremophiles*	*Environmental Metagenomics*	*Environmental meta proteomics*	*Soil microbiome and biofilms*
	SLO-2	*Microbial existence in the environment*	*Extremophiles-various types*	*Importance of metagenomics in microbial ecology*	*Importance of metaproteomics in microbial ecology*	*The soil microbiome — from metagenomics to metaphenomics*
S-2	SLO-1	*Biodiversity and its relationship with Environment*	*Extremophiles in the environmental management*	*Metagenomics-types, steps*	*Gel-based proteomics: 2-DE*	*Influence of soil structure and connectivity on the soil metaphenome*
	SLO-2	*Classification of microorganisms*	*Role of Acidophilic microorganisms and their biomolecules in Environmental remediation*	*Molecular Diversity and Metagenomics*	*Gel-based proteomics: DIGE*	*Influence of physiological status on the soil metaphenome*
S-3	SLO-1	*Role of microorganisms in the sustainability of biosphere*	*Role of alkalophilic microorganisms and their biomolecules in Environmental remediation*	*Concept of e-DNA (environmental DNA)*	*Gel-based proteomics: BN-PAGE*	*Influence of microbial community interactions on the soil metaphenome*
	SLO-2	*Culturability/unculturability and microbial ecology principles*	*Role of psychrophilic microorganisms in Environmental remediation*	*Diversity of Microbes in different environments*	*Merits and demerits of gel-based proteomic techniques*	*Role of soil microbiome for improving soil health under changing climate*
S-4	SLO-1	*Classification of microorganisms-Bacteria, Yeasts, Moulds, Viruses, Protozoans*	*Role of mesophilic microorganisms and in Environmental remediation*	*Conventional methods to study diversity; Cultured and Uncultured Methods*	*Gel-free proteomics: Isotope-Coded Affinity Tag (ICAT)*	*Biofilm mediated decontamination of pollutants from the environment*
	SLO-2	*Lichens and their role in the biosphere.*	*Role of thermophilic microorganisms in Environmental remediation*	*16S-rDNA sequencing of microbial communities*	*Isobaric Tagging for Relative and Absolute Quantitation (iTRAQ)*	*Role of Biofilms in Bioremediation*
S-5	SLO-1	*Mycorrhiza-types*	*Role of barophilic microorganisms in Environmental remediation*	*Partial community analysis methods - Genetic fingerprinting techniques - T-RFLP*	*Multidimensional Protein Identification Technology -MudPIT)*	*Strategies for Use of Biofilms in Remediation*
	SLO-2	*Mycorrhiza-Environmental applications*	*Role of osmophilic microorganisms in Environmental remediation*	*Partial community analysis methods - Genetic fingerprinting techniques - DGGE*	*Merits and demerits of gel-free proteomic techniques*	*Biofilm Survival Strategies in Polluted Environments*
S-6	SLO-1	*Photosynthetic organisms and their environmental applications*	*Halophiles- types*	*Partial community analysis methods - Genetic fingerprinting techniques RISA*	*Application of gel-free techniques in biological systems*	*Molecular Methods for the Assessment of Microbial Biofilms in Bioremediation*

	SLO-2	*Anoxygenic photosynthetic microbes*	*Halophiles- their biomolecules in Environmental remediation*	*Partial community analysis methods - Genetic fingerprinting techniques LH-PCR microarrays*	*Protein microarrays*	*Detoxification of Hexavalent Chromium from Industrial Wastewater using a Bacterial Biofilm System*
S-7	SLO-1	*General characteristics of purple and green sulphur bacteria.*	*Molecular aspects of extremophiles- Genes, Protein s and Enzymes.*	*Partial community analysis methods - Genetic fingerprinting techniques RAPD*	*Isotope-Coded Protein Label (ICPL)*	*Biofilm-mediated Degradation of PAHs and Pesticides*
	SLO-2	*Oxygenic photosynthetic microbes*	*Perspectives of Archaebacteria in Environment- distinguishing features*	*Partial community analysis methods - Genetic fingerprinting techniques DNA microarrays*	*Combined FRActional DIagonal Chromatography (COFRADIC)*	*Metagenome Analyses of Multispecies Microbial Biofilms*
S-8	SLO-1	*General characteristics of Cyanobacteria and Prochlorales*	*Phylogenetic groups of Archaebacteria, Ecology and habitats of Archaebacteria,*	*Whole community analysis methods: DNA-DNA reassociation,*	*Application of gel-free techniques in biological systems*	*Metagenomic approach for the biofilm community analysis*
	SLO-2	*Methanogens*	*Physiology of Archaebacteria-their role in environmental sustainability*	*Whole community analysis methods: G+C fractionation*	*Mass Spectrometry; Matrix Assisted Laser Desorption and Ionization (MALDI)*	*Metagenomic Approaches for Understanding New Concepts in Microbial Science*
S-9	SLO-1	*Methanogenic-General characteristics and properties*	*Role of Archaebacteria in the environmental pollution management*	*Whole genome sequencing; DNA Microarray Technology*	*Electronspray Ionization (ESI)*	*Accessing the Soil Metagenome for Studies of Microbial Diversity*
	SLO-2	*Methanogens –Environmental applications*	*Magneto tactic bacteria.*	*Next Generation Technology*	*Mass spectrometry data analysis – computational tools.*	*Recent Advances and Perspectives in Metagenomic Studies of Soil Microbial Communities*

Learning Resources	1. *Joanne M Willey, Joanne Willey, "Prescott's Microbiology," McGraw-Hill Education; 9th edition, 2013.* 2. *Stephen P. Hunt and Frederick J. Livesey, "Functional Genomics"Oxford University Press, 2000.* 3. *R. M. Twyman, "Principles of Proteomics", Taylor & Francis, 2nd edition, 2008.*	4. *Diana Marco Universidad Nacional de Cordoba, Argentina "Metagenomics: Current Innovations and Future Trends", Caister Academic Press, 2011.* 5. *Maier, R.M. Pepper, I.L and Gerba, "Environmental Microbiology," C.P. Academic press, 2000.* 6. *Gavin Lear, "Biofilms in Bioremediation: Current Research and Emerging Technologies", Caister Academic Press, 2016.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. S. Sam Gunasekar, Orchid Chemicals and Pharmaceuticals Ltd., sam@orchidpharma.com	*1. Dr. A. Gnanamani, CSIR-Central Leather Research Institute, agmani_2000@yahoomail.com*	*Dr. Ramani, SRMIST*
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Course Code	18BTE409T	Course Name	BIOREMEDIATION TECHNOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
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 :	*Educate the molecular insights on conservation of biodiversity*			
CLR-4:	*Apply the metagenomic approach for the environmental microbial analysis*			
CLR-5:	*Apply the metaproteomic approach for the environmental applications*			
CLR-6:	*Demonstrate the application of biofilm communities in environmental applications and their metagenomic approach*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Apply the concepts of biodiversity and their importance.*	*1*	*80*	*80*
CLO-2 :	*Understand the extremophiles and its applications in environmental remediation.*	*2*	*85*	*75*
CLO-3 :	*Use metagenomics data to describe the taxonomic make-up and ecological processes of microbial communities from a range of environments.*	*2*	*75*	*80*
CLO-4 :	*Assemble and annotate genomes by identifying genes.*	*2*	*85*	*80*
CLO-5 :	*Apply next generation sequencing technology.*	*3*	*85*	*75*
CLO-6 :	*Analyze the biofilm communities in the soil microbiome and their metagenomic strategies.*	*2*	*80*	*80*

Program Learning Outcomes (PLO)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	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
CLO-1 :	*H*	*H*	*H*	*H*		*M*	*L*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-2 :	*H*	*H*	*H*	*H*			*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-3 :	*M*	*H*	*M*	*H*	*M*	*M*		*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-4 :	*H*	*H*	*H*	*H*			*H*	*L*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-5 :	*H*	*H*	*H*	*H*		*M*	*H*	*H*	*H*	*L*	*H*	*H*	*H*	*H*	*H*
CLO-6 :	*H*	*H*	*H*	*H*	*L*	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Principles of bioremediation*	*Bioremediation technologies*	*Bioremediation project management*	*Microbial oxidation of heavy metals*	*Nuclear waste bioremediation*
	SLO-2	*Introduction to Bioremediation: Types of Bioremediation*	*Bioremediation Techniques: bio stimulation & bio augmentation*	*Defining the project and goals*	*Bioleaching*	*Microbes in pollution Remediation*
S-2	SLO-1	*Bioremediation Mechanisms*	*In situ and ex situ remediation technologies : (Bio) venting*	*Site characterization*	*Biomining*	*Heavy metal toxicity in the environment*
	SLO-2	*Microbes for Bioremediation*	*In situ and ex situ remediation technologies : (Bio)sparging*	*Screening and selecting remediation alternatives*	*Microbial sources for the oxidation of minerals from ores*	*Heavy metal bioremediation*
S-3	SLO-1	*Metabolic process involved in bioremediation*	*In situ and ex situ remediation technologies : (Bio)stripping*	*Process design*	*Bio-oxidation mechanisms*	*Various reactors for heavy metal removal*
	SLO-2	*Factors affecting bioremediation*	*In situ and ex situ remediation technologies : (Bio)sorption barriers*	*Remediation field activities- Aerobic Bioremediation*	*Enzymes for heavy metal detoxification*	*Actinides pollutant removal strategeis*
S-4	SLO-1	*Metabolic process involved in bioremediation*	*In situ and ex situ remediation technologies : Biofilters*	*Bioremediation of Surface Soils*	*Bacterial oxidation of pyrite*	*Nuclear waste disposal methods*
	SLO-2	*Limitations of Bioremediations*	*In situ and ex situ remediation technologies : Bioreactors*	*Fate and transport of contaminants in the Vadose zone*	*Siderophores*	*Case studies of nuclear accidents and its further remediation stratgies*
S-5	SLO-1	*Mycoremediation,*	*Use of bioreactors for bioremediation*	*Anoxic/Anaerobic Bioremediation: Anoxic/Anaerobic Environment*	*Bacterial oxidation of chalcopyrite*	*Types of nuclear wastcs and environmental effects*
	SLO-2	*Phytoremediation technologies.*	*Molecular techniques in bioremediation*	*Potential anaerobic Bioremediation*	*Metallothinenis and Biosurfactants from microbial sources and their role in heavy metal removal*	*Natural nuclear wastes*
S-6	SLO-1	*Xenobiotics and recalcitrant Man-made pollution*	*Application, specific advantages and disadvantages of bioremediation technologies,*	*Anoxic/Anaerobic Processes – Fermentation*	*Bacterial oxidation Sphalerite*	*Man-made nuclear wastes*
	SLO-2	*Dyes and Detergents*	*Use of bioreactors for bioremediation.*	*Bioremediation in fresh water and marine systems*	*Heavy metal bioremediation by filamentous fungi*	*In situ disposal strategies*

S-7	SLO-1	*PAH and Aliphatic hydrocarbons*	*Soil bioreactors: Dry and slurry bioreactors*	*Bioremediation in marine systems*	*Microbial Desulfurization of coal*	*Bioremediation of oil/hydrocarbon contaminated sites*
	SLO-2	*Ocean oil spills and its consequences*	*Anaerobic and aerobic bioreactors for ex situ remediation*	*Natural Attenuation process*	*Biosorption by live and dead cells*	*Pathways for hydrocarbon degradation*
S-8	SLO-1	*Heavy metals leach in ground water*	*Composting of recalcitrant wastes*	*Ground water bioremediation*	*Extraction of metals from ores and metal recovery*	*Nuclear waste management by microbial intervention*
	SLO-2	*Antibiotics in wastewater*	*Land farm bioremediation for in situ wastes*	*Water desalination*	*Nano-sponges*	*e-waste management by microbial intervention*
S-9	SLO-1	*Volatile organic compounds (VOCs)*	*Fungal bioremediation*	*Reverse osmosis for toxic pollutant removal*	*Microbial enhanced oil recovery (MEOR)*	*Case studies of e-waste industries*
	SLO-2	*Radioactive compounds*	*Functionality of fungal enzymes*	*Membrane technology for pollutant removal*	*Nano material for metal recovery and treatment*	*Emerging contaminants*

Learning Resources	1. *Principles and Applications" McGraw-Hill, 2001.* 2. *Agarwal S. K., "Environmental Biotechnology", APH Publishing, 2000* 3. *Martin Alexander, "Biodegradation & Bioremediation", Academic press, 1999.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. S. Sam Gunasekar, Orchid Chemicals and Pharmaceuticals Ltd., sam@orchidpharma.com	*1. Dr. A. Gnanamani, CSIR-Central Leather Research Institute, agmani_2000@yahoomail.com*	*Dr. K.Ramani, SRMIST*
2.Dr. D. Gunaseelan, BIOCON Ltd., guna.sachin@gmail.com	*2. Dr. Anbumani Sadasivam, CSIR-Indian Institute of Toxicology Research,anbumani@iitr.res.in*	*Dr.W.Richard Thilagaraj, SRMIST*

Course Code	18BTE410T	Course Name	ENVIRONMENT BIOSENSORS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Understand the fundamentals of biosensors*			
CLR-2 :	*Educate the various types of biosensors*			
CLR-3 :	*Identify and choose the biosensor for the environmental monitoring*			
CLR-4:	*Apply various types of biosensors for the environmental applications*			
CLR-5:	*Design the biosensor based on the pollutant parameters*			
CLR-6:	*Apply the biomolecules in the development of biosensors*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	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
CLO-1 :	*Describe the fundamental principles of biosensors*	*1*	*80*	*80*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-2 :	*Explain the biosensor concepts for pollutant monitoring*	*2*	*85*	*75*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-3 :	*Design the biosensors for the detection of emerging contaminants*	*2*	*75*	*80*	*M*	*H*	*M*	*H*	*M*	*M*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-4 :	*Apply the specific biomolecules for the sensor development for the pollutants monitoring*	*2*	*85*	*80*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-5 :	*Apply the nanomaterial for the development of environmental biosensors*	*3*	*85*	*75*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*
CLO-6 :	*Understand the importance of novel biosensor development for the environmental applications*	*2*	*80*	*80*	*H*	*H*	*H*	*H*	*H*	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Short Biosensor History*	*Biotransducers*	*Application of biosensors for Environmental Monitoring- Detection of Organic Compounds*	*DNA, Biological Recognition & Receptor based Sensors*	*Nanotechnology-based Biosensor*
	SLO-2	*Fundamentals of Biosensors*	*Classification of Biosensors*	*Polychlorinated biphenyls (PCB)*	*A Fiber Optic DNA Sensor for Rapid Detection of Environmental E.coli*	*Multi-analyte determination*
S-2	SLO-1	*Components of Biosensor*	*Electrochemical Biosensors*	*Endocrine-disrupting chemicals*	*Application of electrochemical DNA-Biosensor to Environmental problems*	*Miniaturisation*
	SLO-2	*Types of Biosensors*	*Electrochemical Immunosensors*	*Antibiotics*	*Application of nucleic acid based optical bioprobe for environmental and pharmaceutical analysis*	*Mass Production*
S-3	SLO-1	*Characteristics of Biosensor*	*Optical Biosensors*	*Pesticides*	*Lipid-based enzyme electrodes for environmental pollution control- Lipid based sensors for continuous monitoring or rapid screening of environmental pollutants in the field.*	*Network Systems*
	SLO-2	*Biosensor Technologies*	*Electronic Biosensors*	*Hormones*	*Immunochemical assays for pesticides and PCBs*	*Validation*
S-4	SLO-1	*Types of Bioreceptors*	*FET- based Electronic Biosensors*	*Application of Biosensors for Environmental Monitoring- Detection of Inorganic Compounds*	*Direct piezoelectric immunosensor for pesticides*	*Bioengineering (GMO)*
	SLO-2	*Sensing Techniques of Biosensors*	*Piezoelectric Biosensors*	*Heavy Metals*	*Enzyme sensors for detection of pesticides families*	*Biosensors for environmental monitoring- An EPA perspective*
S-5	SLO-1	*Biosensors Development for Environmental Monitoring*	*Gravimetric Biosensors*	*Inorganic phosphate and nitrate*	*Biosensors for water quality and exposure assessment issues*	*Microsystem Technology in Biosensors*
	SLO-2	*Architectural Design*	*Pyroelectric Biosensors*	*Application of Biosensors for Environmental Monitoring- Detection of Biological Compounds*	*Nanomaterials- based biosensor for detection of environmental pollutants*	*Recent biosensors for the detection of pathogens*
S-6	SLO-1	*Bio element and Sensor Element Coupling*	*Impedimetric Biosensors*	*Biosides*	*Recent progress in biosensors for environmental monitoring*	*Recent biosensors for the detection of potentially toxic elements*

	SLO-2	*Various Coupling Mechanisms*	*Amperometric Biosensors*	*Whole cell bacteria detection*	*Application of nucleic acid hybridization for the detection of organisms*	*Recent biosensors for the detection of Toxins*
S-7	SLO-1	*Covalent Fabrication*	*Ion Channel Switch*	*Estimation of Biological Oxygen Demand (BOD)*	*Enzyme-based electrochemical biosensors to detect pharmaceuticals residues in waste water*	*Recent biosensors for the detection of Endocrine disrupting chemicals*
	SLO-2	*Matrix Immobilization*	*Optical Biosensors*	*Microbial Detection*	*Biosensor for the detection of antibiotics residues in milk*	*Recent biosensors for the detection and monitoring of air pollutants*
S-8	SLO-1	*Membrane Encapsulation*	*Microarrays*	*Antibiotic resistant organisms*	*Lipid membranes based biosensor for the rapid detection of toxins*	*Recent biosensors for the detection and monitoring of water pollutants*
	SLO-2	*Physical Adsorption Fabrication*	*Surface Plasmon Resonance*	*Application of Biosensors for Environmental Monitoring- Detection of Air Pollutants*	*Nucleic acid based biosensors for environmental pollution monitoring*	*Future sensing system based on conjugation of biosensor and drones for monitoring remote areas*
S-9	SLO-1	*Nano Biosensors*	*Reagentless Fluorescent (RF) Biosensors*	*Biosensors for direct monitoring and indoor air quality and exposure assessment issues*	*Reporter genes based biosensors for chemical contamination sensing*	*Recent biosensors for the detection of pollutants in effluents*
	SLO-2	*Advantages of nanotechnological approaches to biosensor development*	*Glucose Biosensors*	*Application in Biodefense Biosensing*	*Biosensor for the detection of antibiotics in Poultry effluent*	*Recent biosensor for the detection of contaminants in effluent treatment plant*

Learning Resources	1. *Biosensors for Direct Monitoring of Environmental Pollutants in Field edited by D.P. Nikolelis, Ulrich J. Krull, Joseph Wang, Marco Mascini..* 2. *Chemical Sensors and Biosensors: Fundamentals and Applications edited by F.G. Bănică, Wiley, 2012 W. Strickberger, "Genetics," 3 rd edition – Phi Learning, 2008*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18BTE411T	Course Name	MOLECULAR CELL BIOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
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:	*Analyze transcriptomics and its applications in tissue engineering*			
CLR-5:	*Create insights on genome reprogramming.*			
CLR-6:	*Utilize the strategies for novel gene editing techniques for tissue engineering*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Identify gene regulation in stem cells.*	*2*	*85*	*80*
CLO-2 :	*Analyze gene expression in stem cells and artificial generation of pluripotency.*	*2*	*80*	*75*
CLO-3 :	*Identify the applications of growth factor signaling and their receptor molecules.*	*2*	*80*	*75*
CLO-4 :	*Analyze the regulation of molecules involved in self-renewal of stem cells.*	*2*	*85*	*80*
CLO-5 :	*Discuss stem cell death mechanisms.*	*2*	*85*	*80*
CLO-6 :	*Explain nerve cell regeneration, cell survival and cell death.*	*2*	*80*	*75*

Program Learning Outcomes (PLO)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	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
CLO-1 :	*H*	-	*M*	*H*	-	-	-	*H*	-	-	-	*H*	*H*	*H*	*H*
CLO-2 :	*M*	-	*M*	*H*	-	-	-	*M*	-	-	-	*M*	*H*	*H*	*H*
CLO-3 :	*M*	-	*M*	*H*	-	-	-	*H*	-	-	-	*H*	*H*	*H*	*H*
CLO-4 :	*M*	-	*M*	*H*	-	-	-	*H*	-	-	-	*M*	*H*	*H*	*H*
CLO-5 :	*H*	-	*M*	*H*	-	-	-	*M*	-	-	-	*H*	*H*	*H*	*H*
CLO-6 :	*H*	-	*M*	*H*	-	-	-	*H*	-	-	-	*M*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to nucleic acids - genetic material,*	*Overview of Central dogma.*	*Principles of membrane organization membrane proteins*	*Differentiation in Early Development*	*Newborn screening: Neonatal PKU*
	SLO-2	*Structure and physicochemical properties of elements.*	*Characteristics promoter and enhancer sequences.*	*cytoskeletal proteins Extra cellular matrix*	*Potency, Commitment,*	*Cystic fibrosis and sweat tests.*
S-2	SLO-1	*Primary and secondary structure of DNA*	*Transcriptional bubble - prokaryotic and eukaryotic RNA polymerase*	*cell-cell junctions, various types of transport across cell membrane.*	*Polarity and the specification of asymmetric divisions.*	*Prenatal diagnosis of diseases, amniotic fluid*
	SLO-2	*Watson & Crick model*	*RNA synthesis- Fidelity of RNA synthesis. Inhibitors of transcription.*	*Protein sorting and trafficking, cargo proteins.*	*Cellular differentiation of the Nervous system*	*Fetal blood examination.*
S-3	SLO-1	*Hogsteen base pairing, Triple helix, Quadruple helix.*	*Differences in prokaryotic and eukaryotic transcription.*	*Growth factor signaling, cell-cell communication*	*Neuronal and Glial Progenitors in Adult Brain,*	*Karyotyping, Chromosomal abnormalities by cytogenetics.*
	SLO-2	*DNA super-coiling*	*Regulatory elements*	*Mechanism of action of different class of hormones.*	*Epithelial Stem Cells; Adult Progenitor Cells,*	*Restriction fragment length polymorphism (RFLP)*
S-4	SLO-1	*Linking number- satellite*	*Mechanism of transcription regulation.*	*Cell cycle –Molecules controlling cell cycle*	*Mesenchymal Stem Cells, Plasticity*	*Polymerase chain reaction (PCR)*
	SLO-2	*DNA replication*	*Transcription termination.*	*Cancer, role of Ras and Raf Oncogenesis and apoptosis.*	*De-differentiation and redifferentiation*	*Nuclear injection*
S-5	SLO-1	*Meselson & Stahl experiment bi–directional DNA replication*	*Splicing - nuclear export of mRNA - mRNA stability.*	*Cell culture and immortalization of cells and its applications.*	*Cancer cells and cancer stem Cells.*	*stem cell transplantations for sickle-cell anemia, hemophilia,*
	SLO-2	*Proteomics of DNA replication*	*Role of gene expression in microRNA*	*Molecular Basis of Pluripotency*	*Hematopoietic Stem Cells.*	*Stem cell transplantation for cancer (leukemia and myeloma).*
S-6	SLO-1	*Overview of differences in prokaryotic and eukaryotic DNA replication*	*LncRNA, snoRNA, piRNA*	*Induced pluripotency.*	*Stem Cells and tissue engineerings.*	*Muscular dystrophy and stem cell therapy*
	SLO-2	*Role of telomerase in aging and cancer*	*srRNA, siRNA and shRNA.*	*Cell cycle regulators in Stem Cells*	*Embryonic Stem Cells in Tissue Engineering.*	*Stem cell therapy*
S-7	SLO-1	*Mutagens, DNA mutations and their mechanism*	*Genetic code: Elucidation of genetic code*	*Stem Cell Niches,*	*Organ culture*	*Neurodegenerative disease*

	SLO-2	*Telomere replication in eukaryotes DNA Repair.*	*Codon degeneracy, Wobble hypothesis and its importance*	*Change of Phenotype and Differentiation,*	*Characterization and maintenance of murine and human embryonic stem cells,*	*Stem cell transplantation*
S-8	SLO-1	*DNA mismatch, Base-excision*	*Prokaryotic and eukaryotic ribosomes.*	*Aging and stem cell renewal, Quiescent Stem Cells.*	*Differentiation of embryonic Stem Cells*	*Dementia*
	SLO-2	*Nucleotide-excision and direct repair DNA recombination*	*Prokaryotic and eukaryotic translation and post-translational modification*	*Lineage tracing experiments in stem cells*	*Embryonic stem cell cloning*	*Neurodegenerative disease*
S-9	SLO-1	*Homologous, site-specific and DNA transposition*	*Regulation of gene expression with reference to λ phage life cycle.*	*Techniques used to study cells: flow cytometry and Confocal Microscopy.*	*Therapeutic cloning of stem cells*	*CRIPSR/Cas9 system-gene editing*
	SLO-2	*Operon concept - Lac and Trp operon*	*Eukaryotic gene regulation*	*Antibody labeling and Immunohistochemistry*	*Genomic Reprogramming*	*Applications of CRISPR/CAS-9 techniques in regenerative medicine.*

Learning Resources	1. *Fundamentals of Biochemistry. Life at the molecular level by Donald Voet, Judith G. Voet and Charlotte W. Pratt. Willey 2016.* 2. *Tietz Fundamentals of Clinical Chemistry and Molecular Diagnostics, Carl A. Burtis, David E. Bruns. 7th ed. Elsevier, 2014.* 3. *Practical Clinical Biochemistry, Harold Varley, Interscience Publishers Inc, 2005*	4. *Lecture Notes Clinical Biochemistry (8th Edition). Simon Walker, S., Ashby, P. , Rae, P., and Beckett, G., Blackwell, 2010.* 5. *Textbook of Biochemistry With Clinical Correlations. Devlin, D.M., (Ed). Wiley-Liss, 2010.*

SLO – Session Learning Outcome

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Sudarshan Reddy Oncosimis Biotech Pvt. Ltd. email: info@oncosimis.com	*1. Dr. C. Parthasarathy, University of Oklahoma Parathasarathy-chandrakesan@ouhsc.edu*	*1. Dr. P. Kanagaraj, SRMIST kanagarajp@srmist.edu.in*
2. Mr.J.B. Vijayakumar BioArtis Life Sciences Pvt. Ltd. email: contact@bioartis.in	*2. Dr. R. Ilangovan , University of Madras Ilnagovan2000@yahoo.com*	*2. Dr. N. Selvamurugan, SRMIST selvamur@srmist.edu.in*

Course Code	18BTE412T	Course Name	CELL COMMUNICATION AND SIGNALING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

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:	*Encourage engineering students to think solving neural degenerative diseases with stem cells*
CLR-6:	*Analyze the molecular mechanism of stemness- signaling pathways and transcription factors*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Apply the basic understanding of gene regulation in stem cells*	*2*	*85*	*80*
CLO-2 :	*Manipulate the gene expression in stem cells and artificial generation of pluripotency*	*2*	*80*	*75*
CLO-3 :	*Identify the applications of growth factor signaling and their receptor molecules*	*2*	*80*	*80*
CLO-4 :	*Apply the regulation of molecules involved in self-renewal of stem cells*	*2*	*85*	*80*
CLO-5 :	*Discuss the stem cell death mechanisms*	*2*	*80*	*85*
CLO-6 :	*Analyze nerve cell regeneration, cell survival and cell death.*	*2*	*80*	*80*

Program Learning Outcomes (PLO)														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
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
H	*H*	-	*H*	-	-	-	*M*	-	*H*	-	*H*	*H*	*H*	*H*
M	*M*	-	*M*	-	-	-	*M*	-	*H*	-	*H*	*H*	*H*	*H*
H	*M*	-	*M*	-	-	-	*M*	-	*H*	-	*H*	*H*	*H*	*H*
H	*H*	-	*M*	-	-	-	*M*	-	*H*	-	*H*	*H*	*H*	*H*
M	*M*	-	*H*	-	-	-	*M*	-	*H*	-	*H*	*H*	*H*	*H*
H	*M*	-	*H*	-	-	-	*M*	-	*H*	-	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Germ line stem cells*	*cell surface receptor mediated signal transduction*	*Stem cell aging and apoptosis*	*Neural stem cells*	*Regeneration, Stem Cells, and the Evolution of Tumor Suppression*
	SLO-2	*Embryonic fate cell decision*	*Growth factor and receptors*	*Regulation and significance apoptosis in stem cells*	*Neural progenitors*	*Smads - Polycomb genes*
S-2	SLO-1	*Interaction between stem cells and their niche*	*tyrosine kinases Mediated signaling (Ras-Raf-MAP-MEK)*	*Stem cell necrosis*	*The heterogeneity of adult neural stem cells*	*Cellular signaling of Akt/PKB - β-catenin*
	SLO-2	*Transcriptional regulatory circuitry in embryonic stem cells*	*Wnt -signaling*	*Intrinsic - extrinsic pathways of apoptosis*	*Emerging complexity of neural niche*	*Induced pluripotency (iPSc)*
S-3	SLO-1	*Gene expression during development*	*Notch signaling pathways*	*Death ligands, cytokines and tumor necrosis factor*	*Neural stem cell signaling*	*Epithelial-mesenchymal transition (EMT)*
	SLO-2	*Maintenance of totipotency and its factors*	*Hedgehog singling*	*Role of apoptosis in hematopoiesis*	*Neural stem cell homeostasis*	*EMT markers*
S-4	SLO-1	*Pluripotency associated transcription factors*	*Hippo signaling*	*Apoptosis resistance in stem cells*	*Galecitin-1 in neural stem cells*	*Growth factor induced differentiation of stem cells*
	SLO-2	*Tissue specific multipotency*	*Insulin-like growth factor signaling*	*Anti-apoptotic molecules expression in stem cells*	*Human ESC-derived Neural Rosettes and neural stem cell progression*	*Pancreatic stem cells*
S-5	SLO-1	*Stem cells with no tissue specificity*	*NfκB signaling pathways*	*Caspase mediated apoptosis*	*CNS fluids and neuronal differentiation*	*Beta cell differentiation factors and transplantation*
	SLO-2	*Transcriptional network controlling pluripotency in ES cells*	*TGFβ -activing/nodal BMP-signaling*	*Apoptosis transcription factors and regulators*	*Neurotransmitter-induced stem cell differentiation*	*Stem cell therapy for obesity*
S-6	SLO-1	*Alternative splicing in embryonic stem cells*	*FGF signaling pathways*	*Heat shock proteins*	*cholinergic-dopaminergic signals*	*Leukemia, lymphoma and Myeloma*
	SLO-2	*Niche required for inducing stem cell control*	*Hemotopoiesis and signaling molecules*	*Apoptosis intracellular kinases*	*Nerve cell growth factor*	*Bone marrow transplantation*
S-7	SLO-1	*Homeostasis and Feed-back regulation in niche*	*Progenitor cell differentiation factors*	*Apoptosis adaptor proteins*	*Induced regeneration of neuronal cells*	*Cytokine and chemokine therapies*
	SLO-2	*Cytokines and growth factors maintenance of stemness*	*Colony stimulating factor and its receptor signaling pathways*	*Small molecules-induced apoptosis*	*Neurosphere culture*	*Cancer stem cell - cell survival and tumor maintenance*

S-8	SLO-1	*Modeling for stem cell asymmetry*	*Platelet-derived growth factor signaling pathways*	*Inhibitors of apoptosis in cancer stem cells*	*Astrocyte, oligodendrocyte differentiation*	Mechanism of cancer stem cell resistance
	SLO-2	*Pluripotency genes, expression and regulation*	*Role of oncogenes in embryonic stem cells*	*Cellular senescence pathways*	*Glial cell differentiation*	Targeting cancer stem cells
S-9	SLO-1	*Epigenetic changes in DNA*	*Steroid hormone receptor signaling pathways*	*Telomerase in adult and pluripotent stem cells and Telomerase shortening*	*Pathophysiology of neuronal stem cell signaling*	Selective killing of cancer stem cells
	SLO-2	*Epigenetic changes in histones*	*Effects of melatonin and seratonin in stem cells*	*Autoimmune destruction of stem cells*	*Multiple sclerosis, Parkinson's and Alzhimer's*	Nanocarrier mediated drug delivery

Learning Resources	1. *The science of stem cells - Jonathan M.W Slack - Wiley Blackwell - 2018.* 2. *Transcriptional and Translational regulation of stem cells - (Advances in experimental medicine and biology - Gary Hime and Helen Abud, 2013.* 3. *Stem cell regulators (Vitamins and Hormones Book 87) - Gerald Litwack - Academic Press – 2011* 4. *Control and regulation of stem cells- Bruce Stillman, David Stewart, Terri Grodzicker - Cold Spring Harbor Laboratory -2008*

SLO – Session Learning Outcome

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Mr.J.B. Vijayakumar *BioArtis Life Sciences Pvt. Ltd. email: contact@bioartis.in*	*2. Dr. R. Ilangovan* *University of Madras* *Ilnagovan2000@yahoo.com*	*2. Dr. R. Satish, SRMIST* *satisr@srmist.edu.in*

Course Code	18BTE413T	Course Name	STEM CELL TECHNOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning
CLR-1 :	*Provide basic knowledge on embryogenesis from the perspective of engineers.*	1
CLR-2 :	*Create an interest to know about the different types of stem cells, its isolation, differentiation and transdifferentiation.*	2
CLR-3 :	*Develop awareness about cancer stem cells, iPSCs and importance of stem cell niches.*	3
CLR-4:	*Initiate interest on signaling pathways, epigenetics and latest techniques on gene editing.*	
CLR-5:	*Generate interest on applications and uses of stem cells and create awareness on ethics and regulations of stem cell research.*	
CLR-6:	*Encourage engineering students to develop the strategies for ex vivo for tissue development and disease*	

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Apply knowledge about embryogenesis, stem cells and its characteristics.*	*2*	*80*	*70*
CLO-2 :	*Gain knowledge on different types of stem cells isolation of ESCs, its specialized functions and transdifferentiation.*	*3*	*85*	*70*
CLO-3 :	*Discuss about cancer stem cells, iPSCs and stem cell niches.*	*2*	*80*	*75*
CLO-4 :	*Identify the role of signaling pathways, epigenetics and genome editing in engineering of stem cells.*	*2*	*80*	*70*
CLO-5 :	*Utilize application of stem cells in tissue engineering, treatment of different diseases & ethics and regulations of stem cell research.*	*3*	*80*	*70*
CLO-6 :	*Apply knowledge on CRISPR/Cas9 gene editing system.*	*3*	*80*	*70*

Program Learning Outcomes (PLO)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	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
CLO-1 :	-	-	*H*	*M*	-	-	*M*	*H*	-	*H*	-	*H*	*H*	*H*	*H*
CLO-2 :	-	-	*H*	*M*	-	-	*M*	*H*	-	*H*	-	*H*	*H*	*H*	*H*
CLO-3 :	-	-	*H*	*M*	-	-	*M*	*H*	-	*H*	-	*H*	*H*	*H*	*H*
CLO-4 :	-	-	*H*	*M*	-	-	*M*	*H*	-	*H*	-	*H*	*H*	*H*	*H*
CLO-5 :	-	-	*H*	*M*	-	-	*M*	*H*	-	*H*	-	*H*	*H*	*H*	*H*
CLO-6 :	-	-	*H*	*M*	-	-	*M*	*H*	-	*H*	-	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Overview of Stem cells*	*ESCs –IVF, Primate and Mouse ES cells, Markerss*	*Adult stem cells (ASC)-advantages and disadvantages*	*ESC pluripotency and signaling- JAK-STAT pathway*	*Stem Cells in Tissue Engineering*
	SLO-2	*Early development of embryos*	*Nuclear transfer technology in ES cells*	*Sources of ASCs and its properties and its role as specialised cells in differentiation*	*Activin/Nodal/TGFβ Signaling Pathway*	*Therapeutic Applications*
S-2	SLO-1	*Stem Cells in research*	*Human ESCs*	*Transdifferentiation-Definition*	*FGF Signaling Pathway*	*Parkinson's disease*
	SLO-2	*Totipotent, multipotent, oligopotent*	*Isolation and culturing of hESC's*	*Fusion experiments*	*Wnt signaling and Insulin-like growth factors*	*Factors for a Successful Cell Therapy in PD- Problems*
S-3	SLO-1	*"Stemness": Definitions, Criteria*	*Differentiation of stem cells*	*Experiments on transdifferentiation*	*HSC signaling pathways- Notch*	*Autograft, allograft and xenograft-stem cells*
	SLO-2	*Criteria and Standard of stemness*	*Stem Cell Niche in Regenerative Medicine-Stem cells and their niches*	*Intestine-oseophagus cell transition, lens regeneration, liver to pancreas and vice versa*	*Wnt signaling*	*Bone defects-biomaterials- stem cells-osteoprogenitors-osteoblasts*
S-4	SLO-1	*Formation of stem cells*	*Stem Cells derived from early mouse embryos-ES cells*	*Induced pluripotent stem cells (iPSCs)-Methodology*	*TGF signaling*	*Stem Cells for Spinal Cord Injury-Introduction*
	SLO-2	*Embryonic and adult stem cells*	*EC cells*	*Induced pluripotent stem cells (iPSCs)-Applications*	*SMAD signalling*	*Common strategies toward regeneration of the damaged spinal cord.*
S-5	SLO-1	*Potency of Stem Cells*	*EG cells*	*SCNT*	*Epigenetic control of stem cells-experimental background*	*Stem Cell treatment for diabetes-Types of diabetes*
	SLO-2	*Types and classification of stem cells based on potency*	*TS cells*	*Cell fusion, treatment*	*Effects of global histone modifications*	*Development of cell-based therapies for diabetes*
S-6	SLO-1	*Types of stem cells –Embryonic stem cells (ESCs)*	*Systems/models for ES differentiation*	*Cancer stem cells- Isolation*	*DNA methylation in differentiated versus undifferentiated cells*	*Cardiac tissue engineering using stem cells-Methodology*
	SLO-2	*Types of stem cells-Adult stem cells (ASCs)*	*3D bioprinting using stem cells*	*Cancer stem cells -Characterization*	*Effect of TSA on stem cell differentiation*	*Cardiac tissue engineering using stem cells - Applications*
S-7	SLO-1	*Differences between ESCs and ASCs*	*Formation of early extraembryonic lineages*	*Cancer Stem Cells - properties, origin*	*Transcriptional factors network*	*Stem cell treatment for burns*

	SLO-2	*Similarities between ESCs and ASCs*	*Pluripotent cell development*	*Cancer Stem Cells - Theories*	*Effects of histone demethylases*	*Transplantable matrices*
S-8	SLO-1	*Identification and characterization of ESCs at cellular level*	*Formation of somatic lineages—Haematopoietic Lineages*	*CSCs and Metastasis: The Primary TME*	*Epigenetics in somatic cells*	*Ethics of Stem Cell Research- The Ethics of Destroying Human Embryos for Research*
	SLO-2	*Identification and characterization of ESCs at molecular level*	*Formation of somatic lineages—Neuronal Lineages*	*CSCs and Metastasis: Metastatic Niche*	*Epigenetics in iPSCs*	*The Ethics of Using Human Embryonic Stem Cells in Research*
S-9	SLO-1	*Identification and characterization of ASCs at cellular level*	*Therapeutic cloning using ESCs-Disease cell model development*	*Breast cancer metastasis*	*Genome Editing in Stem Cells- ZFN, TALENS*	*Regulations governing Stem Cell research-ICMR, Drugs and Cosmetic Act*
	SLO-2	*Identification and characterization of ASCs at molecular level*	*Reproductive cloning using ESCs*	*Tumor suppressor and Proto-oncogenes*	*CRISPR/CAs9 strategies, Design of DNA donor templates for gene knock-ins*	*Stem Cell as the investigational new drug*

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.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. B.R.Desikachari, Medical Directior, Westminster Health Care, Chennai, brdesikachari@hotmail.com	*1. Prof .Halagowder D,Univ. of Madras, hdrajum@yahoo.com*	*1. Dr. Devi.A, SRMIST devia@srmist.edu.in*
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Course Code	18BTE414T	Course Name	BIOMATERIALS IN TISSUE ENGINEERING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
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 and mechanical properties of selected biomaterials.*			
CLR-4:	*Analyze the design and mechanical properties of selected biomaterials for specific medical applications.*			
CLR-5:	*Demonstrate good manufacturing of biomaterials*			
CLR-6:	*Analyze the strategies for global marketing of biomaterials*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Program Learning Outcomes (PLO)														
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
					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
CLO-1 :	*Explain the basic techniques to manufacture scaffolds from raw biomaterials and explain the different prerequisites for the biomaterials.*	*2*	*80*	*70*			*M*	*M*				*H*		*H*		*H*	*H*	*H*	*H*
CLO-2 :	*Illustrate the types of biomaterials for biomedical applications.*	*2*	*75*	*80*			*M*	*M*				*H*		*H*		*H*	*H*	*H*	*H*
CLO-3 :	*Explain the biological problems in tissue engineering that require engineering expertise to solve them.*	*2*	*80*	*70*			*M*	*M*				*H*		*H*		*H*	*H*	*H*	*H*
CLO-4 :	*Explain the applications of biomaterials for various biomedical applications.*	*2*	*80*	*75*			*M*	*M*				*H*		*H*		*H*	*H*	*H*	*H*
CLO-5 :	*Explain good manufacturing of biomaterials related their applications.*	*3*	*80*	*70*			*M*	*M*				*H*		*H*		*H*	*H*	*H*	*H*
CLO-6 :	*Illustrate global marketing of biomaterials for commercialization*	*2*	*85*	*75*			*M*	*M*				*H*		*H*		*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to biomaterials*	*Introduction to tissue engineering*	*Bioactive molecules*	*Applications of biomaterials*	*Biomaterials and their applications in medicine*
	SLO-2	*Properties and salient features of biomaterials*	*Basic concepts in tissue engineering*	*Classification and role of bioactive molecules in tissue engineering*	*Healthcare*	*Biomedical applications*
S-2	SLO-1	*Elements of Biomaterials*	*Fundamentals of tissue engineering*	*Stimuli responsive in biomaterials*	*Biomaterials in biomedical applications*	*Technical considerations of biomaterials*
	SLO-2	*Metals, implants*	*Complexity of tissue engineering*	*Stimuli responsive in polymers*	*Tissue engineering*	*Commercialization of biomaterials*
S-3	SLO-1	*Biomaterials preparation*	*Tissues*	*Biomimetics*	*wound care und suture materials,*	*Regulatory strategies for biomaterials*
	SLO-2	*Biomaterials characterization*	*Organization of tissues in vertebrate body*	*Dental and bone*	*vascular implants and bio-inspired materials*	*Monitoring of regulatory strategies for biomaterials*
S-4	SLO-1	*Processing of different bioceramic and*	*Cell sources*	*Drug deliveries*	*Biomimetic devices*	*Clinical development with biomaterials*
	SLO-2	*Properties of bioceramics*	*Stem cells*	*Nanoparticles in drug delivery*	*Organ transplant*	*Endpoint strategies for biomaterials*
S-5	SLO-1	*Processing of different polymeric materials*	*Cell lineages*	*Designing of nanoparticles for drug delivery*	*Tissue Construction*	*Clinical evaluation of biomaterials*
	SLO-2	*Properties of polymeric materials*	*Osteoblasts*	*Targeted delivery*	*Bioartificial tissues*	*Approval threshold of biomaterials*
S-6	SLO-1	*biocomposites materials*	*Cell-material interactions*	*Peptides in drug delivery*	*Connective tissues*	*Supply chain of biomaterials*
	SLO-2	*Polymers-ceramics*	*Cell-material response*	*Proteins in drug delivery*	*Regeneration of connective tissues*	*Biomaterials control*
S-7	SLO-1	*Physical properties of biomaterials*	*Assessment of biocompatibility of biomaterials*	*DNAs in drug delivery*	*Targeting ligands in drug delivery*	*Strategies of global marketing*
	SLO-2	*Chemical properties of biomaterials*	*MTT and cytotoxicity assays*	*RNAs, oligos in drug delivery*	*Targeting ligands in cancer treatment*	*Regulatory controls in global marketing*
S-8	SLO-1	*Mechanical properties of biomaterials*	*Cell viability assays*	*Surface modifications*	*Tissue regeneration and growth and repair*	*Global authorization of biomaterials*
	SLO-2	*Thermal properties off biomaterials*	*Antibacterial assessment of biomaterials-*	*Applications in drug delivery*	*Cell growth and repair*	*Global marketing of biomaterials*
S-9	SLO-1	*Evaluation of biomaterials*	*In vitro evaluation of biomaterials-*	*Advantages and limitations of biomaterials in drug delivery*	*Drug discovery*	*Post-market surveillance approaches for biomaterials*
	SLO-2	*Biological response*	*In vivo evaluation of biomaterials*	*Limitations of biomaterials in drug delivery*	*Impact of drug discovery and development*	*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. *Nanocomposite science and technology, Pulickel M. Ajayan, Linda S. Schadler and Paul V. Braun, Wiley-VCH, 2005* 3. *Ulrich Meyer, Thomas Meyer, Jörg Handschel, Hans Peter Wiesmann (2009): Fundamentals of Tissue Engineering and Regenerative Medicine, Springer* 4. *Regenerative Medicine and Tissue Engineering, Edited by Jose A. Andrades, ISBN 978-953-51-1108-5, Publisher: InTech,2013* 5. *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 (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Expert
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Course Code	18BTE415T	Course Name	NANOTECHNOLOGY IN REGENERATIVE MEDICINE	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Provide an overview of the distinctive features of nanotechnology and their application to bio-medical problems from the perspective of engineers.*
CLR-2 :	*Obtain knowledge on cutting-edge nanomedicine technologies for sensing and imaging, drug delivery, and other therapeutic applications.*
CLR-3 :	*Develop the strategies for drug delivery.*
CLR-4:	*Initiate interest for utilizing nanotechnology in environmental applications.*
CLR-5:	*Generate interest on applications related to therapeutic applications.*
CLR-6:	*Encourage engineering students to develop nanomaterials in intellectual property perspective.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Explain the basics of nanobiotechnology in relation to nanomedicine*	*1*	*75*	*70*
CLO-2 :	*Learn about the role of nanomaterials as vehicles for drug delivery*	*3*	*80*	*70*
CLO-3 :	*Obtain the knowledge on nanomedical devices and their applications*	*2*	*80*	*70*
CLO-4 :	*Learn about various types of nanobiosensors and their applications*	*2*	*85*	*75*
CLO-5 :	*Discuss about toxicity of nanomaterials and its remediation*	*2*	*80*	*70*
CLO-6 :	*Gain knowledge on nanomaterials in therapeutic applications.*	*2*	*80*	*70*

Program Learning Outcomes (PLO)															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
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
		H	*M*	*M*				*M*	*H*		*H*	*H*	*H*	*H*
		H	*M*	*M*				*M*	*H*		*H*	*H*	*H*	*H*
		H	*M*	*M*				*M*	*H*		*H*	*H*	*H*	*H*
		H	*M*	*M*				*M*	*H*		*H*	*H*	*H*	*H*
		H	*M*	*M*				*M*	*H*		*H*	*H*	*H*	*H*
		H	*M*	*M*				*M*	*H*		*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Basics of nanobiotechnology in relation to nanomedicine*	*Nanomaterials as vehicles for drug delivery*	*nanorobots in medicine*	*Introduction- nanobiosensors*	*Nanomaterials exhibiting toxicity*
	SLO-2	*Scientific principles of nanomedicine*	*Types of Nanomaterials*	*nanorobots in nanosurgery*	*Biosensing Techniques*	*Physico-chemical characteristics dependent toxicity*
S-2	SLO-1	*Nanotools – types*	*criteria and selection of Nanomaterials*	*nanocameras*	*unique properties of nanobiosensors*	*Toxicity – carbon nanotubes,*
	SLO-2	*Nanotools – various techniques of detection*	*Sources of Nanomaterials*	*Application of nanocameras*	*nanobiosensors*	*quantam dots toxicity*
S-3	SLO-1	*Scanning Tunneling microscope*	*Drug loading and release*	*nanochips*	*Preparation of nanobiosensors- immobilsation stratergies*	*Toxicity – Gold nanomaterials,*
	SLO-2	*Atomic Force Microscope*	*biodegradation*	*nanoimplants*	*covalent conjugation technique*	*silver nanoparticles toxicity*
S-4	SLO-1	*Functional biological nanomaterials nanoengines*	*Nanomaterial clearance*	*nanomaterials for bone and cartilage applications*	*Preparation of nanobiosensors- Self assembled monolayer nanomaterial*	*Handling, storage and disposal of nanomaterials*
	SLO-2	*Functional biological nanomaterials nanoengines*	*Types of nanomaterials for clearance*	*nanomaterials for vascular applications and skin disorders*	*Nano biosensors for protein and DNA detection*	*Remediation in case of nanomaterials spills*
S-5	SLO-1	*Nanomaterials and their Production*	*nanopolymers*	*Nanogenetics*	*Detection methods – optical detection*	*In vitro and in vivo toxicity assessment of nanoparticles*
	SLO-2	*Nanomaterials and their Production*	*Classification of biopolymers*	*nanoparticle-based therapy for genetic diseases*	*Detection methods- electronic detection*	*Embryonic Toxicity of Nanoparticles*
S-6	SLO-1	*Nanodevices-Quantum Computing*	*magnetic nanoparticles – preparation and properties*	*Cell Delivery of Therapeutic Nanoparticles*	*In vivo Biosensors*	*quantitative nanostructure-toxicity relationship*
	SLO-2	*Spintronics, Photonic and fluidic devices*	*magnetic nanoparticles - applications*	*nanomaterials for delivery in cells- nerve cell repair*	*Nanowire Biosensors*	*Modelling the Toxicity of Nanoparticles*
S-7	SLO-1	*Impact of nanotechnology - Scientific and technical Impacts*	*nanotubes, dendrimers*	*Applications of Nanofibers in Tissue Engineering*	*Cantilever Biosensors*	*Green Synthesis of Nanoparticles – mechanism*

	SLO-2	*Environmental Impacts*	*Nano immunotherapy*	*Applications of Nanofibers in Tissue Engineering*	*Applications – DNA nanobiosensor*	*Green Synthesis of Nanoparticles – Applications*
S-8	SLO-1	*Grand challenges of nanomedicine*	*Nanomaterials for vaccine delivery*	*nanomaterials for stem cells growth*	*Applications – Protein biosensor*	*Nanoparticles: Environmental Problems*
	SLO-2	*Ethical issues*	*Types of nanomaterials as vaccine adjuvants*	*Stem Cell Tracking with Nanoparticles*	*whole cell biosensor applications*	*nanotoxicity regulations*
S-9	SLO-1	*Government Promotion of Advancements in Nanomedicine*	*Nanotechnology and Diagnostic Imaging*	*Nanomaterials for Stem Cell Imaging*	*Nanobiosensor in diagnostics*	*nanomaterials intellectual property perspective*
	SLO-2	*Government Evaluation, Policy and Regulation of Nanotechnology*	*Nanomaterials as contrast agents in clinical use*	*Nanotechnology in the regulation of stem cell behavior*	*Biosensors in forensic sciences*	*nanomaterials intellectual property perspective*

Learning Resources	1. *Zoraida P. Aguilar. Nanomaterials for Medical Applications (2012), Elsevier Publications* 2. *Harry F. Tibbals, Medical Nanotechnology and Nanomedicine Perspectives in Nanotechnology (2017), CRC Press*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

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

Course Code	18BTE416T	Course Name	TISSUE ENGINEERING FOR REGENERATIVE MEDICINE	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Describe the fundamentals of tissue engineering and tissue repairing from the perspective of engineers*			
CLR-2 :	*Express knowledge on clinical applications of tissue engineering*			
CLR-3 :	*Identify the basic concept behind tissue engineering*			
CLR-4:	*State engineering students to think more on artificially generated tissues for their tissue engineering applications*			
CLR-5:	*Discuss the knowledge on 3D-bioprinting*			
CLR-6:	*Explain the strategies for innovative bioactive research on tissue engineering*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Apply the components of the tissue architecture*	*1*	*80*	*70*
CLO-2 :	*Illustrate the characteristics of stem cells and their relevance in medicine*	*3*	*85*	*75*
CLO-3 :	*Employ an awareness about the properties and broad applications of biomaterials*	*2*	*80*	*70*
CLO-4 :	*Demonstrate the role of tissue engineering and stem cell therapy in organogenesis*	*2*	*80*	*70*
CLO-5 :	*Illustrate the developing methods and new biomaterials for the construction of functional tissue and organ substitute\s*	*2*	*75*	*80*
CLO-6 :	*Analyze the testing of biomaterials in vitro and in vivo*	*2*	*80*	*70*

Program Learning Outcomes (PLO)														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
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
H	*H*	*H*	*M*		*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
H	*H*	*H*	*M*			*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
M	*H*	*H*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
H	*H*	*H*	*M*			*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
H	*H*	*H*	*M*		*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
H	*H*	*H*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Cellular Basis of Regeneration*	*Tissue types*	*Fundamentals of biomaterials science*	*Introduction to Stem Cells*	*Discussion on Stem cell therapy*
	SLO-2	*Molecular Basis of Regeneration*	*Tissue components*	*Concept of biocompatibility*	*Different types of Stem cells*	*Discussion on Molecular therapy*
S-2	SLO-1	*Introduction to tissue engineering*	*Tissue repair*	*Classes of biomaterials*	*Hematopoietic differentiation pathway of stem cells*	*Therapies for spinal cord injury, muscular dystrophy*
	SLO-2	*Basic definitions used tissue engineering*	*Engineering wound healing*	*Basic properties of Biomaterials*	*Potency of stem cells*	*Orthopedic applications*
S-3	SLO-1	*Current scope of development in tissue engineering*	*Sequence of events of wound healing*	*Disinfection and sterilization of biomaterials*	*Plasticity of stem cells*	*Stem cells and Gene therapy*
	SLO-2	*Use of tissue engineering in therapeutics*	*Three-Dimensional Cell Culture*	*Physico-chemical properties of biomaterials:*	*Sources of embryonic stem cells*	*Tissue engineering of bones*
S-4	SLO-1	*Components used in tissue engineering*	*Organ Culture*	*Mechanical (elasticity, yield stress, ductility, toughness, strength, fatigue, hardness, wear resistance)*	*Sources of hematopoietic and mesenchymal stem cells*	*Tissue engineering of cartilages*
	SLO-2	*Primary cells, cell lines and immortalization of cells*	*Organotypic Culture*	*Tribological (friction, wear, lubricity)*	*Stem Cell markers, FACS analysis*	*Neural tissue engineering*
S-5	SLO-1	*Measurement of tissue characteristics, appearance, cellular component*	*Introduction to Basic wound healing*	*Morphological and texture, Physical (electrical, optical, magnetic, thermical)*	*Differentiation of Stem cell systems- Liver*	*Skin tissue engineering*
	SLO-2	*Cellular fate processes, Cell differentiation, Cell migration*	*Applications of growth factors:*	*Chemical and biological properties*	*Differentiation of neuronal stem cells*	*Cardiovascular tissue Engineering*
S-6	SLO-1	*Direct Cell-Cell contact – Cell junctions in tissues*	*Role of VEGF/angiogenesis*	*Elements in contact with the surface of a biomaterial: blood composition, plasma proteins, cells, tissues*	*Types & sources of stem cell with characteristics:*	*Therapeutic applications*
	SLO-2	*Malfunctions in direct cell-cell contact signaling. Response to mechanical stimuli*	*Different approaches for angiogenesis and its importance*	*Role of Scaffolds in tissue engineering*	*Embryonic stem cells and Adult stem cells*	*Introduction to the basic principles for Biofabrication and 3D printing*
S-7	SLO-1	*Extracellular matrix (ECM) component and their regulation of cell behavior*	*Basic properties of the growth factors*	*Biopolymers*	*Comparison between embryonic and adult stem cells*	*Methods and materials, for Biofabrication and 3D printing*

	SLO-2	*Mechanical measurements of the ECM component*	*Cell-Matrix Interactions*	*Modifications of Biomaterials*	*Bone marrow, primordial germ cells*	*Applications of Biofabrication and 3D printing:*
S-8	SLO-1	*Physical properties of the ECM component*	*Cell-Cell Interactions*	*In vitro testing of biomaterials*	*Cancer stem cells*	*Lab-on-chip, Organ-on-chip*
	SLO-2	*Cell-ECM interactions – Binding to the ECM*	*Telomeres and Self-renewal*	*In vivo testing of biomaterials*	*Induced pleuripotent stem cells*	*Prosthetics and Implants*
S-9	SLO-1	*Modifying the ECM*	*Cell migration*	*Role of Nanotechnology*	*Culture of stem cells*	*Innovative bioactive research*
	SLO-2	*Malfunctions in ECM signaling*	*Control of cell migration in tissue engineering*	*Applications of Biomaterials*	*Immunomodulation of mesenchymal stem cell*	*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 (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Dr. Dipak Datta, CDRI, Lucknow, India *e-mail: dipak.datta@cdri.res.in*	*Dr. Rathindranath Baral, CNCI, Kolkata., India* *e-mail: baralrathin@hotmail.com*	*Dr. N. Selvamurugan, SRMIST* *e-mail: selvamurugan.n@ktr.srmuniv.ac.in*

Course Code	18BTE417T	Course Name	BIOREACTORS IN TISSUE ENGINEERING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
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*			
CLR-6:	*Identify the usages of bioreactors and their advantages in tissue engineering*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Apply the basic understanding of large scale production stem cells in bioreactors*	*1*	*85*	*85*
CLO-2 :	*Discuss the 3D- culture systems and artificial organs*	*2*	*80*	*80*
CLO-3 :	*Identify the bioreactor based strategies to generate organoids*	*2*	*85*	*80*
CLO-4 :	*Understand the role of bioreactors in the development of drug development and therapy*	*2*	*80*	*85*
CLO-5 :	*Explain the large scale production of stem cells*	*2*	*80*	*80*
CLO-6 :	*Apply the clinical applications of bioreactors*	*3*	*85*	*85*

Program Learning Outcomes (PLO)														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
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
H	-	-	*H*	-	-	-	*H*	-	-	-	*H*	*H*	*H*	*H*
M	-	-	*M*	-	-	-	*M*	-	-	-	*H*	*H*	*H*	*H*
H	-	-	*M*	-	-	-	*M*	-	-	-	*H*	*H*	*H*	*H*
M	-	-	*M*	-	-	-	*M*	-	-	-	*H*	*H*	*H*	*H*
H	-	-	*H*	-	-	-	*M*	-	-	-	*H*	*H*	*H*	*H*
H	-	-	*H*	-	-	-	*M*	-	-	-	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to tissue engineering – Current scope of development; Cell as therapeutic agents*	*Bioreactors in Tissue Engineering; Tissue formation in Bioreactor systems – Generation of functional tissues*	*Bioreactors- Link between in vitro and in vivo studies*	*Biomaterials: Properties of Biomaterials ,Surface, bulk, mechanical and biological properties*	*Clinical applications - Stem cell therapy, Molecular therapy*
	SLO-2					
S-2	SLO-1	*cell numbers and growth rates, measurement of cell characteristics morphology, cell viability, motility and functions*	*Principles of functional tissue engineering – Functional tissue engineering and role of Biomechanics in a 3D environment*	*Novel approaches in bioreactor systems for stem cell seeding of vascularized bioscaffolds*	*Scaffolds & tissue engineering, Types of Biomaterials, biological and synthetic materials*	*In vitro organogenesis, Neurodegenrative diseases*
	SLO-2					
S-3	SLO-1	*Biochemical Basics for Nutrition and Growth of living Cells - Measurement of tissue characteristics, appearance, tissue types*	*Ex vivo engineering of living tissues – generation of mammalian tissue equivalents in vitro – Bioreactors role in tissue engineering of Cartilage*	*Bioreactor-based strategies with reconstructive applications of (Vascularized composite allotransplantation) VCA*	*Biopolymers, Applications of biomaterials,Modifications of Biomaterials*	*spinal cord injury, heart disease, diabetes, burns and skin ulcers*
	SLO-2					
S-4	SLO-1	*Tissue dynamics and Cell migration cellular component, ECM component, mechanical measurements and physical properties*	*Cardiovascular tissue (Cardiomyocytes, valves), Vascular tissue, musculoskeletal tissue and Skin –Bone*	*Stem cell cultivation in scaffold-bioreactor systems; Physiological biomimicry*	*Role of Nanotechnology. Sensing and Automation in bioreactor systems*	*muscular dystrophy, orthopedic applications*
	SLO-2					
S-5	SLO-1	*Complexity and organization of the Organ system; Bioreactors; History of Bioreactors*	*microfluidic devices and microbioreactors for stem cell micro environment – Perfusion bioreactors for granulocyte progenitor cell growth; Bioreactor stimulation*	*Understanding Mechanical forces on organs and functional aspects*	*Bioreactors in drug discovery and implant testing; Bioreactors in clinics*	*Stem cells and Gene therapy*
	SLO-2					
S-6	SLO-1	*Types of Bioreactors – Perfusion Bioreactors for 3D cultures, Spinner Flask Bioreactor*	*Mechanics and Controlled Parameters of Bioreactors – Temperature, pH, Dissolved oxygen (DO), Oxygen Diffusion*	*Control and Feedback Control in Mechatronics for Mechanical Stimulation; Scaffolds and Constructs for Bioreactor Systems (including adapted Fabrication Techniques)*	*Stem cell cultivation in scaffold-bioreactor systems;*	*Physiological models, tissue engineering therapies, product characterization*
	SLO-2					

S-7	SLO-1 SLO-2	*Rotating Wall Bioreactor, Compression Bioreactor, Strain Bioreactor*	*Nutrient Transport, Waste Removal; Predicting Mechanical Functionality of Engineered Tissues*	*Tissue architecture- Tissue types and Tissue components, Tissue repair*	*Large-scale bioreactor cultivation of pluripotent stem cells*	*components, safety, efficacy. Preservation – freezing and drying*
S-8	SLO-1 SLO-2	*static culture, stem cell cultivation in scaffold Bioreactor systems*	*Engineering stem cell niches in bioreactors- Oxygen tension, Scaffold/substrate cues*	*Basic wound healing events, Applications of growth factors*	*Engineering of functional bone tissue from human stem cells*	*Patent protection and regulation of of tissue-engineered products,ethical issues*
S-9	SLO-1 SLO-2	*Hydrostatic pressure Bioreactor, Flow Perfusion Bioreactor, Combined Bioreactor*	*Decellularized ECMs, Mechanical forces, Electrical stimulation, Flow shear rate, and paracrine and autocrine factors*	*Role of VEGF. Angiogenesis,Basic properties,Cell-Matrix& Cell-Cell Interactions, Control of cell migration in tissue engineering*	*Miniature bioreactors for precise, systematic studies of stem cell environments*	*Emerging trends in clinically relevant bioreactor design and future direction*

Learning Resources	1. *Molecular and cellular tissue engineering (The biomedical hand book, 4th edition), Joseph D. Bronzino and Donald R. Peterson, 2015* 2. *Biomaterials science and Tissue engineering: Principles and methods (Cambridge IISc series) - Bikramjit Basu, 2017* 3. *3D Cell culture: Fundamental and applications in tissue engineering and regenerative medicine, Ranjana C. Dutta and Aroop K Dutta, 2018.* 4. *Raphael Gorodetsky, Richard Schäfer. Cambridge: RSC publishing, c2011.Stem cell based tissue repair.*

SLO – Session Learning Outcome

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Dr. Sudarshan Reddy *Oncosimis Biotech Pvt. Ltd. email: info@oncosimis.com*	*2. Dr. R. Ilangovan , University of Madras* *Ilnagovan2000@yahoo.com*	*2. Dr. R. Satish, SRMIST* *satishr@srmisst.edu.in*

Course Code	18BTE418T	Course Name	DEVELOPMENTAL BIOLOGY IN TISSUE ENGINEERING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Describe the biology of animal embryogenesis and development.*			
CLR-2 :	*Recognize cell-cell interactions from the context of tissue engineering.*			
CLR-3 :	*Analyse the role of stem cells and stem cell niches in organogenesis and tissue regeneration.*			
CLR-4:	*Discuss the biology of organogenesis.*			
CLR-5:	*Summarize the concepts of tissue and organ regeneration.*			
CLR-6:	*Appraise the biology of ageing.*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Interpret the basics of embryology and cell signaling mechanisms.*	*1*	*80*	*70*
CLO-2 :	*Describe the types of cell specification and differentiation.*	*2*	*80*	*75*
CLO-3 :	*Appraise the role of stem cells in organ development.*	*2*	*80*	*70*
CLO-4 :	*Apply the genetics behind organogenesis.*	*2*	*80*	*75*
CLO-5 :	*Identify the developmental biology concepts behind tissue regeneration.*	*2*	*80*	*70*
CLO-6 :	*Analyze the genetics of ageing.*	*2*	*80*	*75*

Program Learning Outcomes (PLO)														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
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
		M	*H*				*M*		*M*		*H*	*H*	*H*	*H*
		M	*H*				*M*		*M*		*H*	*H*	*H*	*H*
		M	*H*				*M*		*M*		*H*	*H*	*H*	*H*
		M	*H*				*M*		*M*		*H*	*H*	*H*	*H*
		M	*H*				*M*		*M*		*H*	*H*	*H*	*H*
		M	*H*				*M*		*M*		*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Differential cell affinity*	*Cell commitment*	*Introduction to germ layers*	*Overview of kidney development*	*Ageing*
	SLO-2	*Cadherins and cell adhesion*	*Levels of cell commitment*	*Ectoderm - Derivatives*	*Development of kidney tissue*	*Genes and ageing*
S-2	SLO-1	*Adhesion dynamics*	*Cell specification*	*Endoderm - Derivatives*	*Overview of reciprocal interactions*	*DNA repair enzymes in ageing*
	SLO-2	*Cell migration*	*Autonomous specification*	*Mesoderm - Derivatives*	*Mechanisms of reciprocal induction*	*Insulin signaling pathway in ageing*
S-3	SLO-1	*Induction and competence*	*Conditional specification*	*Neurulation*	*Lateral plate mesoderm*	*Stem cells and ageing*
	SLO-2	*Cell-cell interactions*	*Morphogen gradients*	*Formation of the neural tube*	*Specification of lateral plate mesoderm*	*Senescence*
S-4	SLO-1	*Paracrine factors*	*Syncytial specification*	*Patterning of neural tube – AP axis*	*Vasculogenesis*	*Epimorphic regeneration in Salamander*
	SLO-2	*Signal transduction cascades*	*Cell fate determination*	*Patterning of neural tube – DV axis*	*Initial formation of blood vessels*	*Blastema formation*
S-5	SLO-1	*The RTK pathway, the Jak-STAT pathway in development*	*The stem cell concept*	*Neural crest cells - Introduction*	*Angiogenesis*	*Morphallactic regeneration in Hydra*
	SLO-2	*The Wnt pathway and TGF-β pathway in development*	*Embryonic stem cells in developmet*	*Regionalization of neural crest cells*	*Sprouting of blood vessels*	*Activation gradients*
S-6	SLO-1	*Juxtacrine signaling in development*	*Adult stem cells in developmet*	*Paraxial mesoderm*	*Hematopoiesis*	*Regeneration in mammalian liver*
	SLO-2	*The Notch pathway in development*	*Stem cell potency*	*Specification of paraxial mesoderm*	*Sites of hematopoiesis*	*Compensatory regeneration*
S-7	SLO-1	*Cell patterning*	*Pluripotent stem cells in development*	*Cell types of somites*	*Hematopoietic stem cells (HSC)*	*Axonal regeneration*
	SLO-2	*Maintenance of differentiated state*	*Multipotent stem cells in development*	*Hox genes and cell fate specificity*	*HSC niche*	*Regeneration of neural tissues*
S-8	SLO-1	*Developmental signals from ECM*	*Stem cell niches*	*Somitogenesis*	*The Digestive tube – Overview*	*Regeneration of zebrafish fin tissue*
	SLO-2	*Integrin signaling in development*	*Regulatory microenvironments*	*Clock and wave front model*	*Specification of gut tissue*	*Molecular control of fin regeneration*
S-9	SLO-1	*Cell-Cell communication in development*	*Mesenchymal stem cells in development*	*Intermediate mesoderm*	*The Respiratory tube – Overview*	*Heart regeneration in zebrafish*
	SLO-2	*Epithelial-mesenchymal transition*	*Organogenesis – An introduction*	*Specification of intermediate mesoderm*	*Formation of respiratory tube*	*Cardiomyocyte plasticity during regeneration*

Learning Resources	1. *Developmental Biology (2016): Scott F. Gilbert and Michael J.F. Barresi, Eleventh 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.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Dr. A. Premkumar, Ph.D., GVK Biosciences, Hyderabad aprem70@yahoo.com*	1. *Dr. K. Subramaniam, Ph.D., IIT Madras, Chennai subbu@iitm.ac.in*	1. *Dr. S. Kirankumar, Ph.D., SRMIST kirankus@srmist.edu.in*
2. *Dr. M.C. Raja, Ph.D., Genotypic Technology, Bangalore genotypic@hotmail.com*	2. *Dr. Naren Ramanan, Ph.D., IISc, Bangalore naren@cns.iisc.ernet.in*	2. *Dr. R. Satish, Ph.D., SRMIST satishr@srmist.edu.in*

Course Code	18BTE419T	Course Name	ADVANCED IMMUNOLOGY AND VASCULAR TISSUE ENGINEERING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
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 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:	*Understanding the potentials of immunotherapy*			
CLR-6:	*Train and develop skills among the students to explore strategies for stem cell therapy*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Acquire knowledge on the latest tools for diagnosis of diseases*	*2*	*80*	*75*
CLO-2 :	*Gain knowledge in molecular and immunological basis of diagnosis*	*2*	*85*	*80*
CLO-3 :	*Able to appreciate the relevance of clinical immunology*	*2*	*80*	*75*
CLO-4 :	*Acquire knowledge on vascular biology and vascular tissue engineering*	*2*	*80*	*75*
CLO-5 :	*Acquire knowledge on host vs Graft rejection and the significance of immune system in this process.*	*2*	*85*	*80*
CLO-6 :	*Understand the challenges behind successful transplantation or grafting and the significance of neovascularization*	*2*	*80*	*75*

Program Learning Outcomes (PLO)														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
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
H	-	*M*	*L*	-	-	-	-	-	*H*	-	*M*	*H*	*H*	*H*
H	-	*M*	*L*	-	-	-	-	-	*H*	-	*H*	*H*	*H*	*H*
H	-	*M*	*L*	-	-	-	*M*	-	*H*	-	*H*	*H*	*H*	*H*
M	-	*M*	*L*	-	-	-	-	-	*H*	-	*M*	*H*	*H*	*H*
H	-	*M*	*L*	-	-	-	-	-	*H*	-	*M*	*H*	*H*	*H*
H	-	*M*	*L*	-	-	-	*H*	-	*H*	-	*M*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Organs and Cells of the Immune System – Primary and Secondary Lymphoid Organs*	*The Complement Cascades*	*Immunobiology of Transplantation*	*Stem cells – types and sources*	*Vascular system*
	SLO-2	*Mucosal and Cutaneous associated lymphoid tissue. (MALT & CALT)*	*The role of Major Histocompatibility Complex in Immune Response*	*Cells and Factors involved in Transplant Acceptance vs. Rejection*	*Stem cells in Regenerative Biology*	*Mechanisms of blood vessel formation*
S-2	SLO-1	*Mucosal Immunity*	*Autoimmune disease*	*Importance of Adaptive immunity functions in Graft Recognition*	*Stem cell Therapy for Skin Burns, Ulcers, Neurodegenerative diseases, Spinal cord injury*	*Hemangiogenesis*
	SLO-2	*Antigens – immunogens, haptens*	*Interpersonal compatibility*	*Importance of Innate immunity functions in Graft Recognition*	*Stem cell Therapy for Ulcers,*	*Lymphangiogenesis*
S-3	SLO-1	*Antibody Structure*	*T lymphocyte recognition restrictions*	*Molecular Aspects of Acute and Chronic Rejection*	*Stem cell Therapy for Neurodegenerative diseases, Spinal cord injury*	*Angiogenic factors and their receptors*
	SLO-2	*Antibody Function*	*Evolutionary diversity*	*The biological basis of Graft Verses Host Disease*	*Immunological considerations and the potential barriers for Stem cell therapy*	*Inflammation*
S-4	SLO-1	*Generation of antibody diversity*	*Basis of self – non-self discrimination and Autoimmune disorders*	*Embryonic stem cells*	*Clinical transplantation, Immune tolerance, Killer Immunoglobulin like receptors in transplantation*	*Angiogenesis*
	SLO-2	*B cell maturation*	*Kinetics of immune response, Hypersensitivity and their types*	*Expression of histocompatibility antigens*	*Immunosuppressive therapy*	*Tissue injury response*
S-5	SLO-1	*B cell activation and differentiation*	*HLA typing*	*T-cell response against u/dhESCs measured by functional assays*	*Significance of acellular grafts in regeneration*	*Importance of Vascularization in Tissue Engineering*
	SLO-2	*T-cell maturation activation and differentiation*	*Immunological considerations for Tissue Engineering*	*Interaction of natural killer cells with hESCs*	*Mast cells in allograft rejection*	*Angiogenesis and Vascular Remodeling*
S-6	SLO-1	*T-cell receptors*	*Stem cell Banking*	*Generation of patient-specific isogenic hESC lines*	*Graft-versus-host disease*	*Organization and Patterning of Endothelial Cells in Engineered Tissues*
	SLO-2	*Functional T Cell Subsets*	*Cell-cell co-operation*	*Immunological Aspects of Allogeneic mesenchymal stem cell therapy*	*Mouse models of graft-versus-host disease*	*Models for studying angiogenesis*

S-7	SLO-1	*Cell-mediated immune responses*	*Hapten-carrier system*	*Autologous Mesenchymal Stem Cell Therapies*	*Cytokines in Graft-versus-Host Disease*	*Blood Capillary analogues*
	SLO-2	*ADCC*	*Types of Tissue injury*	*CML of Haematopoietic stem cells*	*Potential barriers to engraftment of human pluripotent stem cells*	*Role of Vascular endothelial growth factors on Angiogenesis*
S-8	SLO-1	*Cytokines-properties, and receptors*	*Tissue injury and immune responses*	*allogenic transplantation of HSC*	*Cancer Stem Cells in Solid Tumors*	*Signaling pathways of Angiogenesis*
	SLO-2	*Cytokines and therapeutic uses*	*Immunoprophylaxis*	*Graft verses Leukemia*	*Immunologic targeting of cancer stem cell population*	*Micropatterning approaches to microvessel creation*
S-9	SLO-1	*Antigen processing*	*Immunotherapy*	*Targeting Malignant progenitors*	*Opportunities in Engineered tissue grafts*	*Stem cells for vascular regeneration*
	SLO-2	*Antigen presenting cells*	*Current status of Immunotherapy*	*Recent Advances in transplantation*	*Opportunities in Engineered tissue grafts*	*Stem cells and scaffolds for vascular regeneration*

Learning Resources	1. *The Immunological Barriers to Regenerative Medicine. Editors-Paul J. Fairchild, Humana Press 2013* 2. *Stem Cell Transplantation, edited by Carlos López-Larrea, Antonio López Vázquez, Beatriz Suárez Álvarez. Springer 2016* 3. *Vascularization: Regenerative Medicine and Tissue Engineering, edited by Eric M. Brey, CRC Press 2017* 4. *Kuby Immunology. Thomas J. Kindt, Richard A. Goldsby, W.H.Freeman, 2007.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Dr. Gokuladhas Krishnan, Director, Laboratory, World Stem Cell Clinic, Chennai, care@worldstemcellclinic.com	*2. Dr. S. Sittadjody, Research Fellow, Institute for Regenerative Medicine, Winston-Salem, USA. ssdjody@gmail.com*	*2. Dr. R. Satish, SRMIST satishr@srmist.edu.in*

Course Code	18BTE420T	Course Name	HUMAN GENETICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18BTC104T	Co-requisite Courses		Progressive Courses	Nil
Course Offering Department	Biotechnology	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Categorize the pattern of inheritance in humans*			
CLR-2 :	*Analyze human genome structure and organization*			
CLR-3 :	*Use karyotype to analyze human chromosomal aberrations*			
CLR-4:	*Apply different methods for mapping of genes in humans*			
CLR-5:	*Compare genetic variations in human population and prenatal diagnosis*			
CLR-6:	*Illustrate genetic principles in human biology studies*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	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
CLO-1 :	*Describe the human inheritance concepts and associated complications*	*2*	*80*	*70*	*H*	*H*	*H*	*H*		*M*	*L*	*H*	*H*	*H*		*H*	*H*	*H*	*H*
CLO-2 :	*Explain the regulation of human gene expression*	*2*	*80*	*75*	*H*	*H*	*H*	*H*			*M*	*H*	*H*	*H*		*H*	*H*	*H*	*H*
CLO-3 :	*Recognize the nature of human chromosome abnormalities*	*2*	*80*	*70*	*M*	*H*	*M*	*H*		*M*		*H*	*H*	*H*		*H*	*H*	*H*	*H*
CLO-4 :	*Identify the different methods of human disease gene identification*	*2*	*80*	*75*	*H*	*H*	*H*	*H*			*H*	*H*	*H*	*H*		*H*	*H*	*H*	*H*
CLO-5 :	*Discuss the importance of population screening and prenatal diagnosis*	*3*	*85*	*70*	*H*	*H*	*H*	*H*		*M*	*H*	*H*	*H*	*L*		*H*	*H*	*H*	*H*
CLO-6 :	*Appraise the basic concepts of human genetics*	*2*	*80*	*75*	*H*	*H*	*H*	*H*		*H*	*H*	*H*	*H*	*H*		*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Human Genetics – Introduction*	*Human chromosome structure*	*Karyotyping*	*Genetic mapping*	*Genetic testing*
	SLO-2	*Modern Human Genetics*	*Human chromosome organization*	*Chromosome banding*	*Recombination fraction*	*Gene scanning*
S-2	SLO-1	*Monogenic inheritance*	*Mitochondrial genome organization*	*FISH technique*	*Genetic markers*	*Analysing specified sequence changes*
	SLO-2	*Incomplete dominance and Codominance*	*Limited autonomy of mitochondrial genome*	*Chromosome painting*	*Two point mapping*	*MLPA test*
S-3	SLO-1	*Uniparental disomy*	*Protein coding genes*	*Numerical chromosome abnormalities*	*Multipoint mapping*	*DNA profiling*
	SLO-2	*Penetrance, nonpenetrance*	*RNA genes*	*Aneuploidy*	*Fine mapping analysis*	*Applications of DNA profiling*
S-4	SLO-1	*Expressivity*	*microRNAs*	*Structural chromosome abnormalities*	*Segregation analysis*	*Personalized medicine*
	SLO-2	*Mitochondrial inheritance*	*Regulatory RNAs*	*Mosaicism*	*Linkage analysis*	*Drugs for specific genotypes*
S-5	SLO-1	*Late onset diseases*	*Overlapping genes*	*Autosomal abnormalities*	*Association studies*	*Prenatal diagnosis*
	SLO-2	*Disease anticipation, imprinting*	*Genes-within-genes*	*Sex chromosome abnormalities*	*Linkage disequilibrium*	*Cast study: Down syndrome*
S-6	SLO-1	*Heterogeneity, consanguinity*	*Noncoding DNA*	*Human reproductive disorders*	*Positional cloning*	*Population screening*
	SLO-2	*Pleiotropy, mosaicism*	*Satellite DNA*	*Congenital abnormalities*	*Candidate gene testing*	*Ethical implications*
S-7	SLO-1	*Mendelian pedigree patterns*	*Mini- and microsatellite DNA*	*Polyploidy*	*Position independent strategies*	*Pedigree construction*
	SLO-2	*Pedigree analysis*	*Transposon derived repeats*	*Mixoploidy*	*Case studies*	*Proband analysis*
S-8	SLO-1	*Multifactorial inheritance*	*Alternative transcription*	*X-inactivation*	*Duchenne muscular dystrophy*	*Pharmacogenetics*
	SLO-2	*Quantitative traits*	*Long range control of gene expression*	*Mosaicism due to X-inactivation*	*Cystic fibrosis*	*Genetic differences and drug metabolism*
S-9	SLO-1	*Polygenic theory*	*DNA methylation*	*Locus heterogeneity*	*Branchio-oto-renal syndrome*	*Genetic counseling*
	SLO-2	*Gene and genotype frequencies*	*Epigenetics*	*Clinical heterogeneity*	*Crohn disease*	*Importance of genetic counseling*

Learning Resources	1. Strachan, T., Read, A.P., "Human Molecular Genetics", 4th edition – Garland Science, 2012. 2. Jack J. Pasternak, "An introduction to Human Molecular Genetics," 2nd edition – Wiley Liss, 2005.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. A. Premkumar, PhD, GVK Biosciences, Hyderabad *aprem70@yahoo.com*	*Dr. Bibhas Kar, Madras Medical Mission, Chennai, Tamilnadu* *drbibhaskar65@gmail.com*	*Dr. S. Kirankumar, SRMIST*
Dr. M.C. Raja, PhD, Genotypic Technologies, Bangalore *genotypic@hotmail.com*	*Dr. Partha P. Majumder, NIBG, Kalyani, West Bengal* *ppm1@nibmg.ac.in*	*Dr. M. Jeevankumar, SRMIST*

Course Code	18BTE421T	Course Name	HIGH THROUGHPUT TECHNIQUES IN ADVANCED BIOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*List various high throughput techniques in biology and 2. applying these techniques in their own research*			
CLR-2 :	*Describe the basics of genomics and its uses*			
CLR-3 :	*Analyse qualitatively and quantitative the expression of protein*			
CLR-4:	*Compare the differential expression of proteins and interpret it in biological context*			
CLR-5:	*Practice advance high throughput techniques like lipidomics, epigenomics and metabolomics*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Describe the terminology, technology characteristics and stake holder benefits of high throughput technologies*	*1*	*90*	*80*
CLO-2 :	*Investigate genomic data, interpret the data in the population genetics and evolutionary genetic context*	*2*	*80*	*80*
CLO-3 :	*Measure the expression of genes, develop necessary expertise in using different computation tools*	*2*	*85*	*80*
CLO-4 :	*Quantify proteins qualitatively and quantitatively and categorize their interactions and modifications.*	*2*	*80*	*75*
CLO-5 :	*Distinguish Metabolomics, Epigenomics and lipdomics research and interpreting the data generated*	*3*	*75*	*75*
CLO-6 :	*Analyze high throughput data using software*	*3*	*70*	*75*

Program Learning Outcomes (PLO)														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
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
H	*H*	*H*	*H*	*L*	*M*	*L*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
H	*H*	*H*	*H*	*H*	*L*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
M	*H*	*M*	*H*	*L*	*M*	*L*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
H	*H*	*H*	*H*	*H*	*L*	*H*	*L*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
H	*H*	*H*	*H*	*L*	*H*	*H*	*H*	*L*	*L*	*H*	*H*	*H*	*H*	*H*
H	*H*	*L*	*H*	*H*	*L*	*L*	*H*	*M*	*M*	*H*	*H*	*M*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*History of technology advancement in biology*	*Introduction to Genome*	*Browser and databases for transcriptomics*	*Introduction to proteomics*	*Introduction to metabolomics*
	SLO-2	*What is high throughput biology*	*Ultrafine structure of gene*	*Tools for transcriptomics*	*Analytical Techniques in proteomics*	*Secondary metabolites and their role in biology*
S-2	SLO-1	*High content screening and their uses*	*Regulatory Landscapes of Mammalian Genomes*	*Search for transcription factor binding sites*	*Protein information databases*	*Metabolome of plants, animals and microbes*
	SLO-2	*High throughput screening in biology*	*Epigenetic Landscapes of Mammalian Genomes*	*miRNA targets and regulatory motifs*	*SwissPROT and UNIPROT*	*Metabolites and metabolomics*
S-3	SLO-1	*Technology characteristics of high throughput screening*	*Genome sequencing*	*Overview of Non-Coding RNAs*	*Mass spectrometry*	*Target analysis of metabolites*
	SLO-2	*Recent theories on High throughput screening*	*Genome assembly and annotation*	*iCLIP*	*ESI MS-MS*	*Metabolomic finger printing*
S-4	SLO-1	*How high throughput technologies empower the stake holders*	*Application of population genetics in genomics*	*Expressed Sequence Tag(EST) anlysis*	*Mass spectrometry ESI MALDI-TOF*	*Epigenome and Imprinting,*
	SLO-2	*Real world applications*	*Important principles in population genomics*	*Serial Analysis of Gene Expression (SAGE)*	*Peptide mass finger printing database*	*Does epigenetic regulation is an antithesis to Darwin's Theory of evolution?*
S-5	SLO-1	*Scalability of High through put screening*	*Comparative genomics of prokaryotes*	*Ribosome Profiling for ribosome-protected mRNA fragments*	*Targeted Mass spectrometry -Principles*	*Histone modification assay*
	SLO-2	*Evolvabilty of High through put screening*	*Comparative genomics of eukaryotes*	*What are RNA motifs and their relevance*	*Targeted Mass spectrometry - Applications*	*DNA Methylation assay*
S-6	SLO-1	*Exploring and replicating published research work*	*Functional genomics of prokaryotes*	*Experimental techniques 1- Micro array*	*Functional mass spectrometry principles*	*Genome wide assays and their relevance*
	SLO-2	*Reviews and their uses*	*Functional genomics of eukaryotes*	*2. RT-PCR as a validating tool*	*Functional mass spectrometry applications*	*Bisulphate sequencing and Direct detection of methylation*
S-7	SLO-1	*Need of open source research*	*Ecological genomics (Metagenomics) of microbes*	*Importance of reference gene*	*Overview of protein quantitation methods*	*Experimental methods for lipid extraction*

	SLO-2	*Power of open source research*	*Ecological genomics (Metagenomics) higher organisms*	*Analysis of differential gene expression*	*Quantitation of proteins using MS*	*Lipid assays*
S-8	SLO-1	*Comparison of available data quality*	*Pharmacokinetics basics*	*Generation of transcriptional regulatory networks*	*Post translational modification of proteins*	*Lipid detection techniques*
	SLO-2	*Comparison of methods for published data*	*Pharmacogenomics*	*Analysis of transcriptional regulatory networks*	*Analysis of post translational modification of proteins using MS*	*Lipid based imaging techniques*
S-9	SLO-1	*'OMICS' technologies*	*Application of genomics in public health*	*Genetic screens for protein network*	*Protein – Protein interactions*	*Lipid based disorders*
	SLO-2	*Current status of OMICS technologies*	*Application of genomics in industry*	*Understanding signaling pathways*	*Interactomics*	*Lipidomic profiling*

Learning Resources	1. *High-Throughput Next Generation Sequencing Methods and Applications, Kwon, Young Min, Ricke, Steven C. (Eds.), Humana press, 2011, UK* 2. *Proteomics: from protein sequence to function,* Pennington, Stephen R.; Dunn, Michael J. 1st Edition, 2000, *Oxford Publications, UK* 3. *Text /Video: Genomics and Proteomics: Principles, Technologies, and Applications, Devarajan Thangadurai (Editor), Jeyabalan Sangeetha(Editor), 1st edition,2015, Apple academic press, New York, USA.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18BTE422T	Course Name	METABOLIC ENGINEERING OF MICROBES	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	4

Pre-requisite Courses	18BTC103J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Biotechnology	Data Book / Codes/Standards			

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning
CLR-1 :	*Develop metabolically engineered organisms and products*	
CLR-2 :	*Use tools and methods used for metabolic engineering of microbes*	
CLR-3 :	*Analyze regulatory mechanisms in metabolic pathways*	
CLR-4:	*Apply knowledge on design of a metabolic engineering in practice*	
CLR-5:	*Analyze metabolic flux in biochemical pathways*	
CLR-6:	*Study about thermodynamic principles of cellular processes*	

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Discuss regulation of metabolic pathways*	*H*	*80*	*80*
CLO-2 :	*To gain insight into methods used for metabolic engineering*	*H*	*80*	*75*
CLO-3 :	*Develop plan and methods for metabolic engineering*	*H*	*75*	*75*
CLO-4 :	*Apply knowledge on tools and techniques used for metabolic engineering*	*H*	*75*	*75*
CLO-5 :	*To understand the product formation from metabolically engineered microbes*	*H*	*80*	*80*
CLO-6 :	*Design pathway engineering techniques for diverting metabolic flux into product formation*	*H*	*80*	*80*

Program Learning Outcomes (PLO)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	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
CLO-1 :	*M*			*H*				*M*					*H*	*H*	*H*
CLO-2 :	*M*	*H*	*H*	*H*				*H*	*H*				*H*	*H*	*H*
CLO-3 :	*M*	*H*	*H*	*H*	*H*			*H*	*H*				*H*	*H*	*H*
CLO-4 :	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*				*H*	*H*	*H*
CLO-5 :	*M*	*H*	*H*		*M*	*M*	*H*	*H*	*H*				*H*	*H*	*H*
CLO-6 :	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*				*H*	*H*	*H*

Duration (hour)		10	10	10	10	10
S-1	SLO-1	*Basic concepts of metabolic engineering*	*Overview of metabolic pathways in microbes*	*Metabolic engineering for enhancing product formation*	*Tools for metabolic engineering*	*Important aspects of metabolic engineering*
	SLO-2	*Importance of metabolic engineering*	*Regulation of metabolic pathways*	*Acetone production*	*Classical mutagenesis techniques*	*Metabolic pathway analysis*
S-2	SLO-1	*Overview of cellular metabolism*	*Enzyme mediated pathway regulation*	*Amino acid production*	*Methods for screening mutants*	*Metabolic flux analysis*
	SLO-2	*Energy generation pathways in microbes*	*Mechanisms of enzyme action*	*Engineering pentose metabolism*	*Gene shuffling methods*	*Metabolic flux control*
S-3	SLO-1	*Anaplerotic reactions*	*Transcriptional control of enzyme activity*	*Starch and lignin degradation*	*Gene knockout using CRISPR*	*Methods to calculate metabolic flux*
	SLO-2	*Rate constants and reaction equillibrium*	*Enzyme turnover*	*Vitamin production*	*Cloning and expression of gene clusters*	*Metabolic component analysis*
S-4	SLO-1	*Fuelling reactions – glycolysis*	*Enzyme activity by translational control*	*Polyketide biosynthesis*	*Antisense RNA based methods*	*Linear pathway analysis*
	SLO-2	*Fermentation pathways*	*Reversible inhibition*	*Biopolymer production*	*Directed evolution for improving protein function*	*Branched pathway analysis*
S-5	SLO-1	*Catabolism of fats and amino acids*	*Irreversible inhibition*	*Production of novel compounds using metabolic engineering*	*Artificial chromosomes*	*Structure of a metabolic network*
	SLO-2	*Biosynthetic of polymers*	*Global regulation of metabolic pathways*	*Antibiotics and vitamins*	*Chromosomal engineering strategies*	*Flux distribution*
S-6	SLO-1	*Nucleic acid biosynthesis*	*Allosteric enzymes involved in metabolic regulation*	*Production of pigments*	*RNA engineering technologies*	*Flux analysis of metabolic networks*
	SLO-2	*Amino acid biosynthesis*	*Regulation of enzyme activity using feedback mechanism*	*Biopolymer production*	*Improving translational efficiency*	*Determination of Group Control Coefficient*
S-7	SLO-1	*Active transport*	*Sigmoidal kinetics*	*Pesticide degradation*	*Stimulation of product formation using precursor molecules*	*Thermodynamics of cellular processes*
	SLO-2	*Facilitated diffusion*	*Allosteric regulation of enzyme activity*	*Xenobiotic degradation*	*Multifunctional enzyme systems*	*Thermodynamic feasibility*

S-8	SLO-1	*Cellular energetics,*	*Co-operativity of allosteric enzymes*	*Metabolic engineering of mammalian cells*	*Engineering of secretory processing pathway*	*Metabolic models for growth*
	SLO-2	*yield coefficients*	*Examples of enzyme cooperativity*	*Cell cycle engineering*	*Phenotype microarrays*	*Models for product formation*
S-9	SLO-1	*Primary metabolite production*	*Branch point classification*	*Apoptosis control*	*HighThrougput Mutagenesis*	*Genome scale modeling of cellular metabolism*
	SLO-2	*Secondary metabolite production*	*Coupled reactions*	*Inhibition of cell proliferation*	*High Throughput screening*	*Cell free systems for metabolic engineering*

Learning Resources	1. *Gregory N. Stephanopolous, Aristous A. Aristoudou, Jens Neilsen, Metabolic engineering – Principles and methodologies , Academic press, (1998)* 2. *Quiong Chen – Microbial Metabolic Engineering – Methods and protocols – first edition – Humana Press (2011)* 3. *Christina Smoke – Metabolic Engineering Pathway Handbook – 2nd edition, CRC press (2017)*

SLO – Session Learning Outcome

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1 Dr. Rajeev Kumar Sukumaran, NIIST, Trivandrum *rajeevs@niist.res.in*	*1 Dr. Guhan Jayaraman* *IIT, Madras, guhanj@iitm.ac.in*	*1 Dr. K. N. Rajnish* *SRM Inst. of Science & Technology*
2. Dr. N. Ayyadurai, CLRI, Adyar, *ayyadurai@clri.res.in*	*2 Dr. S. Ramalingam,* *Anna University, Chennai rama@bioprocess.edu*	*2 Dr. M.Ramya* *SRM Inst. of Science & Technology*

Course Code	18BTE423T	Course Name	GENETICS OF CROP IMPROVEMENT	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18BTC105J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Genetic Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Identify the important attributes that demonstrate high yield potential*
CLR-2 :	*Understanding the factors that control crop productivity.*
CLR-3 :	*Analyze Biotic and abiotic stress-plant interactions*
CLR-4:	*Explore plant-microbe beneficial interactions*
CLR-5:	*Analyze metabolic pathways for crop value addition*
CLR-6:	*compare, contrast and distinguish the right molecular strategies for crop improvement*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Explain the genetic basis of crop productivity*	*1*	*85*	*75*
CLO-2 :	*Analyze the tools for crop improvement*	*2*	*90*	*80*
CLO-3 :	*Develop tolerance against abiotic stress*	*2*	*75*	*65*
CLO-4 :	*Develop tolerance against biotic stress*	*2*	*75*	*65*
CLO-5 :	*Analyze pathways to engineer value addition*	*3*	*70*	*60*
CLO-6 :	*Develop elite cultivars*	*3*	*70*	*60*

Program Learning Outcomes (PLO)															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
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
	H	*M*	*L*	*M*	*M*	*M*		*M*	*H*		*H*	*H*	*H*	*H*
	H	*M*	*L*	*M*	*M*			*M*	*H*		*H*	*H*	*H*	*H*
	M	*L*	*L*	*L*	*M*	*M*		*M*	*H*		*H*	*H*	*H*	*H*
	M	*L*	*L*	*L*	*M*	*M*		*M*	*H*		*H*	*H*	*H*	*H*
	M	*L*	*L*	*L*	*M*	*M*		*M*	*H*		*H*	*H*	*H*	*H*
	M	*L*	*L*	*H*	*H*	*H*		*M*	*H*		*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Traditional breeding*	*Pest tolerance and agriculture sustainability*	*Abiotic stress and agriculture sustainability*	*Photosynthetic efficiency*	*Plant Metabolic Pathways and products*
	SLO-2	*Methods of breeding*	*Pathogens and insect pests*	*Major abiotic stresses*	*Regulation of photosynthesis*	*Signals cascade*
S-2	SLO-1	*Marker assisted breeding*	*Genetics of host-pathogen interactions*	*Biochemical basis of abiotic stresses*	*C3, C4, and CAM*	*Metabolic engineering for value addition*
	SLO-2	*Methods to generate markers*	*signal transduction*	*signal transduction*	*Molecular control of photosynthesis*	*Methods to modify metabolic pathway*
S-3	SLO-1	*Mutation breeding*	*Virulence- Avirulence in host–pathogens interaction*	*drought, salinity*	*Biological Nitrogen Fixation*	*Sugar metabolism*
	SLO-2	*Steps in mutation breeding*	*Molecular mechanism of virulence*	*Regulation of drought response*	*Molecular regulation of N fixation*	*Amino acid pathway*
S-4	SLO-1	*transgenic technology*	*Molecular strategies of pathogen tolerance*	*Temperature*	*Molecular basis of N fixation*	*Vitamin A and carotenoid pathway*
	SLO-2	*Over expression and knock outs*	*Approaches against fungal pathogens*	*Regulation of temperature respose*	*Enzymes involved in N fixation*	*vitamin A fortified rice*
S-5	SLO-1	*Loss of /Gain of function mutants*	*Approaches against bacterial pathogens*	*Stress signal transduction*	*Hormonal in plant growth and development*	*Fortified edible oil*
	SLO-2	*Genetic screens*	*Insect pest resistance*	*Key transcriptional factors in stress response*	*Plant Growth Promoting bacteria*	*Omega fatty acids*
S-6	SLO-1	*RNAi*	*Molecular strategies of insect pest tolerance*	*Reactive oxygen species*	*Phosphorus Solubilizing/Mobilizing bacteria*	*Secondary metabolites*
	SLO-2	*Genome editing*	*Biological control of insect pests*	*Regulation of ROS*	*Molecular basis of P mobilization*	*Industrially and medicinal metabolites*
S-7	SLO-1	*Zinc finger*	*multi-gene pyramiding*	*Molecular strategies for tolerance against abiotic stress*	*Sucrose as a signaling molecule*	*metabolic engineering to remove antinutritional compounds*
	SLO-2	*TALEN*	*Pathogenesis related proteins*	*calcium, nitric oxide and salicylic acid in plant defence*	*Vesicular Arbuscular Mycorrhiza*	*Phytates*
S-8	SLO-1	*CRISPR/Cas*	*Virus resistance*	*synthesis and functions of proline*	*Microbes that mimics stress response*	*Engineering to improve food digestibility*
	SLO-2	*CRISPR/Cas mechanism*	*Strategies of virus resistance*	*synthesis and functions of glycine betaine in stress tolerance*	*Nutrient translocation*	*Engineering for aesthetic value*
S-9	SLO-1	*GMO*	*Molecular methods to generate virus resistance*	*Role of hormones in stress response*	*Applications of plant – beneficial microbe association*	*Applications of metabolic engineering in crop improvement*
	SLO-2	*Regulation and Monitoring GM*	*Applications of genetic engineering in pest tolerance*	*Applications of genetic engineering in abiotic stress tolerance*	*Genetic engineering approaches to enhance plant growth and development*	*Applications of metabolic engineering in agricultural industry*

Learning Resources	1. *S. Mohan Jain and D.S. Brar Molecular Techniques in Crop Improvement 2nd edition. 2010 Springer. ISBN 978-90-481-2966-9 e-ISBN 978-90-481-2967-6* 2. *Khalid Rehman Hakeem and Parvaiz Ahmad Munir Ozturk. 2013. Springer. Crop Improvement New Approaches and Modern Techniques. ISBN 978-1-4614-7027-4 ISBN 978-1-4614-7028-1*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Dr. N. Ayyadurai, CLRI, Adyar, ayyadurai@clri.res.in	*Dr. Gopalakrishnan, IARI New Delhi – (krish.icar@gmail.com)*	*2 Dr. M.Ramya, SRM Inst. of Science & Technology*

Course Code	18BTE424T	Course Name	MOLECULAR BIOLOGY OF INFECTIOUS DISEASES	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18BTC103J	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:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*State the basics of infectious diseases*			
CLR-2 :	*Discuss molecular pathogenesis of bacterial diseases*			
CLR-3 :	*Discuss molecular pathogenesis of viral diseases*			
CLR-4:	*Explain molecular pathogenesis of parasitic and fungal diseases*			
CLR-5:	*Illustrate the molecular pathogenesis of fungal pathogens*			
CLR-6:	*Recognize defense mechanisms of infectious microbes*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Describe the basics of molecular pathology of various infectious diseases*	*1*	*80*	*75*
CLO-2 :	*Investigate the molecular pathogenesis of bacterial pathogens*	*2*	*80*	*70*
CLO-3 :	*Investigate the molecular pathogenesis of viral pathogens*	*2*	*80*	*75*
CLO-4 :	*Examine the molecular pathogenesis of parasitic diseases*	*2*	*80*	*70*
CLO-5 :	*Explain the molecular pathogenesis of fungal infections*	*2*	*85*	*75*
CLO-6 :	*Recall the defense mechanisms of infectious microbes*	*3*	*90*	*80*

Program Learning Outcomes (PLO)															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
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
M	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*M*	*L*	*L*	*H*	*H*	*H*	*H*
M	*M*	*M*	*M*	*H*	*H*	*H*	*M*	*M*	*L*	*L*	*H*	*H*	*H*	*H*
M	*M*	*M*	*M*	*H*	*H*	*H*	*M*	*M*	*L*	*L*	*H*	*H*	*H*	*H*
M	*M*	*M*	*M*	*H*	*H*	*H*	*M*	*M*	*L*	*L*	*H*	*H*	*H*	*M*
M	*M*	*M*	*M*	*H*	*H*	*H*	*M*	*M*	*L*	*M*	*H*	*H*	*H*	*H*
M	*M*	*M*	*M*	*H*	*H*	*H*	*M*	*M*	*L*	*M*	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	Historical perspective of infectious diseases	Morphology, pathogenicity of Cholera	Morphology, pathogenicity of HIV	Morphology and lifecycle of Malaria	Hide from immune surveillance
	SLO-2	Disease outbreak	Molecular biology of Cholera	Molecular biology of AIDS virus	Molecular biology of Malaria	Microbe escape mechanism
S-2	SLO-1	Microbial Toxins	Morphology, pathogenicity of Tuberculosis	Morphology and lifecycle of Dengue	Morphology and lifecycle of Wuchereria bancrofti	Antibiotic resistance mechanism
	SLO-2	Types of microbial toxins	Molecular biology of Tuberculosis	Molecular biology of Dengue	Molecular biology of Filariasis	Multiple drug resistance
S-3	SLO-1	Toxin assays	Enteric fever causes	Morphology, pathogenicity of Rabies virus	Morphology , transmission, pathogenesis of Leptospirosis	Evasion of phagocytosis
	SLO-2	Toxin genes	Molecular biology of Enteric Fever	Molecular biology of Rabies	Molecular biology of Leptospirosis	Evasion mechanism of phagocytosis
S-4	SLO-1	Water borne pathogens	Morphology and pathogenesis of Shigella	Structure and pathogenesis of Hepatitis virus	Morphology, pathogenicity of Treponema pallidum	Antigen Hyper variability
	SLO-2	Air borne Pathogens	Bacterial signals and cell responses during Shigella entry into epithelial cells	Molecular biology of Hepatitis	Molecular biology of Syphilis	Antigenic shift and drift
S-5	SLO-1	Soil borne pathogens	Insights into biology of Typhoid Toxin	Pathogenesis of papilloma virus	Fungal pathogens	Secreted modulators
	SLO-2	Pathogens transmitted via animals	Serovars of Salmonella	Molecular biology of cervical cancer	Molecular biology of Aspergillosis	Surface modulators
S-6	SLO-1	Mode of Entry of pathogens	Genetic and Molecular aspects of Helicobacter pyroli	Morphology and pathogenesis of Flu virus	Causes of Athletes foot	Interaction with Toll Like receptors
	SLO-2	Initiation of diseases	Molecular biology of Gastric ulcer	Molecular biology of Flu virus	Molecular biology of Athletes foot	Interference with Cytokines
S-7	SLO-1	General disease symptoms - External	Morphology and pathogenesis of botulism	Morphology and pathogenesis of Polio virus	Morphology , transmission, pathogenesis of Trypanosomia	Complement pathway inhibition
	SLO-2	Disease symptoms - Internal	Mode of action of botulism toxin	Molecular biology of Polio virus	Molecular biology of Sleeping sickness	Defense against competition
S-8	SLO-1	Virulence factors – Cell bound	Morphological identification methods	Genetic screens to understand signaling pathways	Molecular biology of Amoebiasis	Interfering with cell signaling
	SLO-2	Virulence factors - secreted	Culture based identification methods	Virus culturing	Molecular biology of Candidiasis	Examples
S-9	SLO-1	Virulence associated Genes	Serologic diagnostic methods of bacterial diseases	Serologic diagnostic methods of viral diseases	Serologic diagnostic methods of parasitic diseases	Pathogen signaling to repress antimicrobial compound synthesis
	SLo-2	Plasmid borne virulence associated genes	Molecular diagnostic methods of bacterial diseases	Molecular diagnostic methods of viral diseases	Molecular diagnostic methods of parasitic diseases	Pathogen structural barriers

Learning Resources	1. *Peter Williams, Julian Ketley & George Salmond, "Methods in Microbiology: Bacterial Pathogenesis, Vol. 27", Academic Press, 1998.* 2. *Rajan.R., "Medical Microbiology", MJP Publishers, 1st edition, 2007.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18BTE425T	Course Name	MOLECULAR DIAGNOSTICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Explain hybridization based methods for diagnosis of genetic diseases*			
CLR-2 :	*Discuss PCR based diagnosis*			
CLR-3 :	*Discuss diagnosis by DNA Sequencing*			
CLR-4:	*Explain about nucleic acid based diagnosis of infectious diseases*			
CLR-5:	*Discuss immunological diagnosis of infectious diseases*			
CLR-6:	*Explain molecular methods for molecular diagnostics*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Employ hybridization based methods for diagnosis of genetic diseases*	*2*	*75*	*70*
CLO-2 :	*Apply PCR based diagnosis*	*3*	*80*	*75*
CLO-3 :	*Design diagnostic method by DNA Sequencing*	*3*	*85*	*80*
CLO-4 :	*Apply nucleic acid based diagnosis of infectious diseases*	*2*	*80*	*75*
CLO-5 :	*Employ immunological diagnosis of infectious diseases*	*3*	*85*	*75*
CLO-6 :	*Analyze genetic and infectious diseases through molecular methods*	*2*	*80*	*75*

Program Learning Outcomes (PLO)														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
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
M	*H*	*H*	*H*	*H*	*H*	*L*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
H	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
M	*H*	*M*	*H*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
H	*H*	*H*	*H*	*H*	*M*	*H*	*L*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
H	*H*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*L*	*H*	*H*	*H*	*H*	*H*
H	*H*	*H*	*H*	*L*	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to FISH*	*Introduction to PCR based diagnostics*	*Basics of DNA sequencing*	*Ribotyping*	*Agglutination test: Principle, method*
	SLO-2	*Types of FISH*	*End-point PCR*	*Mutation detection by sequencing*	*Applications of Ribotyping*	*Application of Agglutination test*
S-2	SLO-1	*Interphase FISH*	*ARMS PCR based diagnostics*	*Genome wide association studies*	*Pulse Field Gel Electrophoresis*	*ELISA's : principle, method and types*
	SLO-2	*Metaphase FISH,*	*Allele specific PCR*	*Application in Health care*	*Application of PFGE*	*Application of ELISA*
S-3	SLO-1	*Principles of Multicolor FISH*	*Restriction fragment length polymorphism (RFLP)*	*Next generation sequencing*	*Multiplex PCR for virulence factor detection*	*Immunofluorescence: Principle, method and types*
	SLO-2	*Multicolor FISH*	*Mutation detection using RFLP*	*Application in disease diagnosis*	*Application and limitations*	*Application of Immunofluorescence*
S-4	SLO-1	*Application of FISH*	*Multiplex PCR*	*Clinical exome sequencing*	*Recombinase polymerase amplification (RPA) assay*	*Western blots: Principle, Method, trouble shoot*
	SLO-2	*Limitations of FISH*	*Applications of multiplex PCR*	*Application in Health care*	*Application and limitations RPA*	*Application of Western blot*
S-5	SLO-1	*Principles of genomic hybridization*	*LAMP PCR*	*Linkage analysis*	*Sequencing for multidrug resistant markers*	*Clinical significance of HIV*
	SLO-2	*Comparative genomic hybridization*	*LAMP PCR for Molecular diagnisis*	*Linkage analysis for disease diagnosis*	*Applications and limitations*	*Case study: HIV detection*
S-6	SLO-1	*Introduction to DNA chips and Micro-arrays*	*Multiplex ligation probe dependent amplification (MLPA)*	*Marfan syndrome: Disease gene identification*	*DNA chips: Principle and method*	*Case study: Tuberculosis*
	SLO-2	*Diagnostics based on DNA chips and Micro-arrays*	*MLPA in disease diagnosis*	*Case study: Marfan syndrome*	*Gene chips for mutation screening in virulence genes*	*Diagnosis and challenges*
S-7	SLO-1	*Down syndrome*	*Real time PCR*	*Cystic fibrosis*	*Case study: MRSA,*	*Case study: Flu virus*

	SLO-2	*Case study: Diagnosis of Down syndrome*	*Application in diagnosis*	*Case study: cystic fibrosis*	*Diagnosis of MRSA*	*Diagnosis of Flu Virus*
S-8	SLO-1	*Digeorge syndrome*	*Sickel cell anaemia*	*Molecular aspects of diabetes*	*Case study: Vibrio cholerae*	*Case study: Dengue*
	SLO-2	*Case study: Diagnosis of Digeorge syndrome*	*Case study: Diagnosis of Sickel cell anaemia*	*Case study: Diagnosis of diabetes*	*Diagnosis of Vibrio cholerae*	*Diagnosis of Dengue virus*
S-9	SLO-1	*Childhood leukemia*	*Duchenne muscular dystrophy*	*Dibetes: Disease gene identification*	*Case study: Acinetobacter boumannii*	*Case study: chikungunya*
	SLO-2	*Case study: Diagnosis of Childhood leukemia*	*Case study: Diagnosis of Duchenne muscular dystrophy*	*Clinical application of dibetes gene identification*	*Diagnosis of Acinetobacter boumannii*	*Diagnosis of chikungunya*

Learning Resources	*1. Gersen, Keagle, " The Principles of Clinical Cytogenetics" 3rd edition - Springer-Verlag, Inc., 2013.* *2. Donnai, Read, "New Clinical Genetics" 3rd edition – Scion, Inc., 2015.* *3. Tang, Statton, "Advanced Techniques in Diagnostic Microbiology" Springer, Inc., 2013*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18BTE426T	Course Name	GENE THERAPY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18BTC105J	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:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Provide basic knowledge on gene therapy and its importance.*			
CLR-2 :	*Identify an interest to know about the different types of gene therapy, its applications for diseases.*			
CLR-3 :	*Develop awareness about the different methods of gene delivery and provide knowledge on vectors.*			
CLR-4:	*Initiate interest on latest techniques in genome editing and understand its applications.*			
CLR-5:	*Develop interest on applications and uses of gene therapy in treatment of disease.*			
CLR-6:	*Prepare engineering students to know the recent advancements in gene therapy.*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Apply knowledge about gene therapy in treating diseases.*	*1*	*80*	*70*
CLO-2 :	*Practice knowledge on different types of gene therapy and its applications.*	*2*	*85*	*75*
CLO-3 :	*Interpret knowledge on construction of viral vectors and usage of non-viral vectors to correct the genetic defect.*	*2*	*80*	*70*
CLO-4 :	*Use molecular aspects involved in genome editing in gene therapy.*	*2*	*80*	*75*
CLO-5 :	*Evaluate treatment of diseases addressed by gene therapy clinical trials.*	*3*	*80*	*70*
CLO-6 :	*Analyze recent advancements in gene therapy.*	*2*	*80*	*70*

		Program Learning Outcomes (PLO)														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		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
CLO-1 :	*Apply knowledge about gene therapy in treating diseases.*	-	-	*H*	*M*	-	-	*M*	*H*	-	*H*	-	*H*	*H*	*H*	*H*
CLO-2 :	*Practice knowledge on different types of gene therapy and its applications.*	-	-	*H*	*M*	-	-	*M*	*H*	-	*H*	-	*H*	*H*	*H*	*H*
CLO-3 :	*Interpret knowledge on construction of viral vectors and usage of non-viral vectors to correct the genetic defect.*	*H*	-	*H*	*M*	-	-	*M*	*H*	-	*H*	-	*H*	*H*	*H*	*H*
CLO-4 :	*Use molecular aspects involved in genome editing in gene therapy.*	*H*	-	*H*	*M*	-	-	*M*	*H*	-	*H*	-	*H*	*H*	*H*	*H*
CLO-5 :	*Evaluate treatment of diseases addressed by gene therapy clinical trials.*	*H*	-	*H*	*M*	-	-	*M*	*H*	-	*H*	-	*H*	*H*	*H*	*H*
CLO-6 :	*Analyze recent advancements in gene therapy.*	*H*	-	*H*	*M*	-	-	*M*	*H*	-	*H*	-	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Gene therapy*	*Embryo somatic gene therapy - Reproductive cloning*	*Gene delivery-An overview*	*Genome editing-Gene Targeting*	*Stem cells in gene therapy-gene therapy of hematopoietic stem cells*
	SLO-2	*Genes as drugs*	*Embryo somatic gene therapy - Therapeutic cloning*	*Methods of gene delivery*	*Genome editing Processes-Double strand break repair*	*Major Applications Procedures for Gene Transfer into Hematopoietic Stem Cells*
S-2	SLO-1	*Gene therapy – overview*	*Preimplantation genetic diagnosis-History, Indications and applications*	*Direct Inoculation of DNAs*	*Engineered Nucleases*	*Treatment of genetic diseases - gene therapy of cancer- Gene Therapy of Cancer Using Suicide Genes*
	SLO-2	*History of Gene Therapy*	*Preimplantation genetic diagnosis – Techniques and ethical issues*	*Direct Inoculation of RNAs*	*Meganucleases*	*Immunotherapy of Cancer*
S-3	SLO-1	*Types of gene therapy-somatic*	*Prenatal/ fetal gene therapy – Concepts and methods*	*Non-viral methods-Physical methods*	*Zinc Finger Nucleases*	*Treatment of genetic diseases - neurodegenerative disorders- Gene Therapy of Alzheimer's Disease*
	SLO-2	*Types of gene therapy- germ line*	*Prenatal/fetal gene therapy with case study –Tay Sach's disease*	*Non-viral methoods-Chenical methods*	*ZNFs as gene editing tools*	*Treatment of genetic diseases - neurodegenerative disorders- Gene Therapy of Parkinson's Disease*
S-4	SLO-1	*Methods of gene therapy-Ex vivo*	*Postnatal somatic gene therapy*	*Viral Vectors - Retroviral vectors-Structure*	*TALENs as gene editing tools*	*Gene Therapy of Huntington's Disease*
	SLO-2	*Methods of gene therapy- In-vivo*	*Germline gene therapy*	*Retroviral vectors- Mechanism and action Adenoviral vectors-Structure, Mechanism*	*CRISPR/Cas9 as gene editing tools-Introduction and Mechanism*	*Gene Therapy of Spinal Muscular Dystrophy*
S-5	SLO-1	*Vectors for gene therapy-viral*	*Methods of Germline gene therapy*	*Adenoviral vectors-Structure, Mechanism*	*CRISPR/Cas9 as gene editing tools-Applications*	*Gene Treatment of genetic diseases - Retinal Photo transduction and the Visual Cycle*
	SLO-2	*Vectors for gene therapy-non-viral*	*Germline gene therapy-Drawbacks*	*Adenoviral vectors- Advantages and disadvantages*	*Precision and efficiency of engineered nucleases*	*Gene Treatment of genetic diseases - Congenital Retinal degenerations*
S-6	SLO-1	*Diseases with dominant heredity*	*Suicide gene therapy – Current strategies*	*Adeno associated viral vectors-Structure, Mechanism*	*Multiplex automated Genome engineering*	*Gene Therapy of Retinal Neovascularization and Retinoblastoma*

	SLO-2	*Diseases with recessive heredity*	*Suicide gene therapy for Cancer*	*Adeno associated viral vectors- Advantages and disadvantages*	*Types of therapeutic genome modifications- Gene disruption*	*Treatment of genetic diseases - cardiovascular disorders-*
S-7	SLO-1	*Ex vivo gene therapy with case study-SCID (Causes)*	*Secretion gene therapy*	*Herpes simplex viral vectors –Structure*	*Types of therapeutic genome modifications- Non homologous end joining - NHEJ gene correction*	*Gene Therapy of Heart Failure*
	SLO-2	*Ex vivo gene therapy with case study-SCID (Treatment)*	*Immunotherapy*	*Herpes simplex viral vectors – Mechanism and Action*	*Types of therapeutic genome modifications- Non homologous end joining - NHEJ gene addiction*	*Therapeutic Angiogenesis*
S-8	SLO-1	*In vivo gene therapy with case study- Cystic fibrosis (Causes)*	*Gene therapy for infectious diseases- Nucleic acid-based gene therapy (Antisense DNA and RNA, Ribozymes, RNA decoys)*	*Envelope protein pseudo typing of viral vectors*	*Types of therapeutic genome modifications - Homology directed repair - HDR gene correction*	*Gene therapy of HIV infection - Natural History of HIV-1 Infection*
	SLO-2	*In vivo gene therapy with case study- Cystic fibrosis (Treatment)*	*Protein- based assays for gene therapy*	*Replication-competent vectors*	*Types of therapeutic genome modifications - Homology directed repair - HDR gene addition*	*General Considerations Gene Therapy of HIV Infection by Intracellular Immunization*
S-9	SLO-1	*Ethical problems in gene therapy*	*Target pathogens for antimicrobial gene therapy*	*Cis and trans-acting elements*	*Applications of Genome editing*	*Therapy of HIV Infection by Immunotherapy*
	SLO-2	*Social problems in gene therapy*	*Examples of clinical trials for infectious diseases*	*Hybrid vectors*	*Prospects and Ilimitations of Genome editing*	*Recent advances in gene therapy*

Learning Resources	*1. Evelyn B. Kelly, "Gene Therapy", Greenwood Press, 2007.* *2. Mauro Giacca, "Gene Therapy", Springer Milan, 2010.* *3. Peter J. Quesenberry, "Stem cell biology and gene therapy", John Wiley & Sons, 2002.*	*4. Roland W. Herzog, "A Guide to Human Gene Therapy", World Scientific Publishing Co Pvt. Ltd. 2010.* *5. David Benjamin Turitz Cox et al "Therapeutic genome editing: prospects and challenges" Nature Medicine, Vol 21(2): 121- 131, 2015.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember / Understand	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply / Analyze	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate / Create	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	*Experts from Higher Technical Institutions*	*Internal Experts*
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Course Code	18BTE427T	Course Name	FUNCTIONAL GENOMICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Analyze the genome structure, organization and function across life.*			
CLR-2 :	*Analyze about the comparative genomics of organelles and nuclear genomes across life*			
CLR-3 :	*Apply different classical methods to study gene expression and whole transcriptome*			
CLR-4:	*Compare various NGS techniques to study genome, exome, and transcriptomes.*			
CLR-5:	*Infer the basics of metabolic pathways, transcription factors and genome editing.*			
CLR-6:	*Analyze the applications of functional genomics in various sectors.*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Describe the basics of genome organization across life and study of gene function*	*1*	*75*	*80*
CLO-2 :	*Describe the genomics of organelle and nuclear genomes across life*	*1*	*75*	*80*
CLO-3 :	*Review the organization of transcriptome and classical methods to study gene expression*	*2*	*70*	*80*
CLO-4 :	*Describe about traditional and Next Generation Sequencing (NGS)platforms for the study of genome, exome and transcriptome*	*2*	*60*	*75*
CLO-5 :	*Describe about genes for metabolic pathways, transcription factors, genome editing.*	*3*	*70*	*80*
CLO-6 :	*Summarize the applications of functional genomics in various sectors.*	*3*	*60*	*80*

Program Learning Outcomes (PLO)															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
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
M	*H*	*H*	*H*	*H*				*H*			*H*	*H*	*H*	*H*
M	*H*	*H*	*H*	*H*				*H*			*H*	*H*	*H*	*H*
M	*H*	*H*	*H*	*H*				*H*			*H*	*H*	*H*	*H*
H	*H*	*H*	*H*	*H*			*H*	*H*		*H*	*H*	*H*	*H*	*H*
M	*H*	*H*	*H*	*H*			*H*	*H*			*H*	*H*	*H*	*H*
M	*H*	*H*	*H*	*H*		*H*	*H*	*H*		*H*	*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Genome organization in Eukaryotes*	*Genome size, gene content*	*Transcriptome from Eukaryotes*	*DNA Sequencing*	*Study of Gene functions*
	SLO-2	*Structural level organization*	*Gene order*	*Transcriptome from prokaryotes*	*Sanger method of DNA Sequencing*	*Metabolic pathways-KEGG*
S-2	SLO-1	*Genome organization in Eukaryotes*	*Orthologs*	*Gene expression studies with mRNA*	*Automated DNA Sequencing*	*Transcription factors*
	SLO-2	*Sequence level organization*	*Paralogs*	*Gene expression studies with other RNAs*	*Next Generation Sequencing (NGS)*	*Signaling cascades controlled by Transcription factors*
S-3	SLO-1	*Genome organization in Prokaryotes*	*Comparative genomics*	*Classical methods to study gene expression*	*Principle and methodology of NGS Platforms*	*Genome editing*
	SLO-2	*Sequence level organization*	*Comparative genomics of bacteria*	*Northern hybridization*	*Principle and methodology of NGS Platforms*	*Targeted genome Editing*
S-4	SLO-1	*Genetic elements and their organization in Eukaryotes*	*Pangenome-metagenomics*	*Differential Display PCR*	*Third Generation Sequencing methods*	*Tools for genome editing*
	SLO-2	*Genetic elements and regulation of gene expression in eukaryotes*	*Microbiome*	*Serial Analysis of Gene Expression (SAGE)*	*Comparison of high-throughput sequencing methods and applications*	*CRISPR/cas9 genome editing*
S-5	SLO-1	*Genetic elements and their organization in prokaryotes*	*Horizontal gene transfer*	*Reverse transcriptase PCR (RT-PCR) to study gene expression*	*Genome sequencing*	*Genetic variations and diseases*
	SLO-2	*Genetic elements and regulation on gene expression in Prokaryotes*	*Organelle genomes*	*Methodology of RT-PCR*	*Genome assembly*	*Tools to study mendelian diseases*
S-6	SLO-1	*Forward genetics*	*Methods to study organelle genomes*	*Quantitative PCR (real time) to study gene expression*	*Gene Prediction*	*Genomics of monogenic disorders*
	SLO-2	*Classical Forward genetics*	*Comparative genomics of mitochondrial genomes*	*Methodology of realtime-PCR*	*High-throughput RNA sequencing*	*Genomics of polygenic disorders*
S-7	SLO-1	*Functional genomic analysis with Forward genetics*	*Comparative genomics of plastid genomes*	*High-throughput methods to study gene expression*	*RNA sequencing to study genome wide gene expression*	*Genomics in Diagnostics*
	SLO-2	*Methods in Forward genetics*	*Nuclear genomes*	*Study of Gene expression using Microarray*	*Differential gene expression analysis with RNAseq*	*Population genetics*

S-8	SLO-1	*Reverse Genetics*	*Comparative genomics of nuclear genomes*	*Principle of Microarray*	*Small RNA sequencing*	*Evolutionary genetics*
	SLO-2	*Functional genomic analysis with reverse genetics*	*Plant genomes*	*Methodology of Microarray*	*Targeted sequencing*	*Applications of functional genomics in agriculture*
S-9	SLO-1	*Classical Methods in Reverse genetics*	*Animal genomes*	*Study of splice variants*	*Exome sequencing*	*Applications of functional genomics in healthcare*
	SLO-2	*Current methods in Forward and reverse genetics*	*Comparison of plant and animal genomes*	*Correlation of mRNA and protein abundance*	*Amplicon sequencing*	*Applications of functional genomics in prokaryotes*

Learning Resources	*1. Pevsner. J., "Bioinformatics and Functional Genomics", 3rd edition, Wiley-Blackwell. 2015.* *2. Mount. D, "Bioinformatics: Sequence and Genome Analysis", 2nd Edition, Cold Spring Harbor Laboratory Press, New York. 2004.* *3. Primrose. S.B., Twayman. R.M., "Principles of Gene Manipulation and Genomics" 7th edition, Blackwell publishing. 2006.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18BTE428T	Course Name	PLANT INTERACTIONS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18BTC108J	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:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Relate the signaling mechanisms in the development of a plant's root, shoot, leaf and flower*			
CLR-2 :	*Discuss the response of plants to physical stimuli and day-night cycle (circadian rhythm)*			
CLR-3 :	*Explain the mechanisms in plant-microbe interaction, biotic and abiotic stresses*			
CLR-4:	*Discuss about hyperaccumulators, heavy metal tolerance and phytoremediation*			
CLR-5:	*Relate the role of phytochemicals in plants behavior and in facilitating plants growth*			
CLR-6:	*Recognize the efforts taken by sessile plants for their survival and avoidance of stress.*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Describe the perception and responses of plants to environmental stimuli and stress cues*	2	85	80
CLO-2 :	*Design transgenic plants (GMOs) for biotic and abiotic stress tolerance*	3	85	80
CLO-3 :	*Exploit light response plasticity for improved productivity*	3	80	75
CLO-4 :	*Demonstrate how plants compete with themselves and other plants for nutrients and sunlight*	2	75	70
CLO-5 :	*Examine the benefits of intercropping and crop rotation*	2	80	75
CLO-6 :	*Recall what a plant does in the course of its lifetime for better growth and productivity*	3	80	75

Program Learning Outcomes (PLO)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	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
CLO-1	M	H		M	M	M	M	H		H	H	H	H	H	H
CLO-2	M	H		H	H	H	H	H	M	H	H	H	H	H	H
CLO-3	M	H	H	H	H	H	H	H		H	H	H	H	H	H
CLO-4	M	H	H	H	H	H	H	H		H	H	H	H	H	H
CLO-5	M	H	H	H	H	H	H	H	M	H	H	H	H	H	H
CLO-6	M	H	H	H	H	H	H	H	M	H	H	H	H	H	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Development biology of plants-an overview*	*Plant response to physical and light stimuli-an overview*	*Plant-microbe interaction-an overview*	*Plant adaptation to abiotic stresses-An overview*	*Plant-plant interactions*
	SLO-2	*Signal transduction using G proteins Calcium, MAPK*	*Response to gravity-gravitropism*	*Plant growth promoting rhizobacterium*	*Physiological and molecular response of plant to drought*	*Plant plasticity*
S-2	SLO-1	*One-component sensor regulatory system*	*Response to touch-thigmotropism*	*Root exudates*	*Physiological response to salinity*	*Allelopathy, secondary metabolites*
	SLO-2	*Two-component sensor regulatory system*	*Thigmotropism in shoots*	*Types of root exudates*	*Molecular mechanisms in salt tolerance*	*Volatiles*
S-3	SLO-1	*Stages of embryogenesis*	*Plant herbivory*	*Microbial secretions*	*Physiological response to cold*	*Plant's competitive behavior*
	SLO-2	*Genes in embryogenesis*	*Chemical and mechanical defenses*	*Microbe secreted plant hormones*	*Molecular mechanisms in cold tolerance*	*Behaviour based on memory*
S-4	SLO-1	*Plant growth hormones-auxin, cytokinin and gibberellin*	*Response to light-Phototropism*	*Quorum sensing*	*Physiological response to water logging*	*Co-operative behavior*
	SLO-2	*Ethylene and abscisic acid*	*Five models of auxin distribution in phototropism*	*Plant-microbe interaction*	*Molecular response to water logging*	*Facilitative behaviour*
S-5	SLO-1	*Anatomy of shoot apical meristem*	*Phytochromes-structure*	*Biofilm formation of PGPR*	*Physiological response to heat*	*Below ground competition*
	SLO-2	*Genes in the development of shoot apical meristem*	*Function of phytochromes*	*Biofilm visualization-confocal imaging*	*Molecular response to heat tolerance*	*Kith and Kin recognition*
S-6	SLO-1	*Structure of root apical meristem*	*Cryptochromes-structure*	*Phytopathogens*	*Physiological response to heavy metals*	*Alien recognition*
	SLO-2	*Genes in the development of root apical meristem*	*Function of cryptochromes*	*Phytopathoges of rice, wheat, tomato, onion, spinach*	*Genes involved in heavy metal accumulation, tolerance and resistance*	*Siblings recognition*
S-7	SLO-1	*Parts of a monoecious and dioecious flower*	*Circadian clock*	*Plant immunity*	*Hyperaccumulators*	*Shoot competition*
	SLO-2	*ABC model for flowering-florigenesis*	*Molecular mechanisms of light perception*	*Physical barriers*	*Phytoremediation*	*Root competition*
S-8	SLO-1	*Natural fertilization*	*TOC1, LHY and CCA genes*	*Systemic acquired resistance (SAR)*	*Phenotypic plasticity*	*Shade avoidance*
	SLO-2	*Artificial fertilization-apomixis and parthenocarpy*	*Model of circadian clock in Arabidopsis*	*Hormones in SAR*	*Root plasticity*	*Effect of phytochromes*

S-9	SLO-1	*Hormones in seed dormancy*	*Short day plants*	*Induced systemic resistance (ISR)*	*Soil physical constraints*	*Neighbor signaling as a warning to biotic stresses*
	SLO-2	*Hormones in seed germination*	*Long day plants*	*Hormones in ISR*	*Plant growth in non-conducive soil*	*Neighbor signaling as a warning to abiotic stresses*

Learning Resources	1. *Plant Environment Interactions, Second edition, by Robert E. Wilkinson., Marcel Dekker, Inc., 2000.* 2. *Principles of plant microbe interactions, by Ben Lugtenberg, Springer, 2015.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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