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:*
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:*	Learning			Program Learning Outcomes (PLO)														
		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 mechanisms of cell to cell communication*	*1*	*80*	*80*	*L*	*H*	*H*	*H*		*M*	*L*	*H*	*H*	*H*	*H*	*H*	*L*	*H*	*H*
CLO-2 :	*Describe the fundamental organization of reproduction and flowering in plants*	*2*	*85*	*75*	*M*	*H*	*H*	*M*			*M*	*H*	*L*	*H*	*H*	*H*	*L*	*H*	*H*
CLO-3 :	*Explain the concepts and experiments in the early development, cleavage and axis formation*	*2*	*75*	*80*	*M*	*H*	*M*	*H*	*M*	*M*		*M*	*H*	*H*	*H*	*H*	*L*	*H*	*H*
CLO-4 :	*Recognize the various pathways of organogenesis*	*2*	*85*	*80*	*L*	*H*	*H*	*H*			*H*	*L*	*L*	*H*	*H*	*H*	*M*	*H*	*H*
CLO-5 :	*Discuss about the various endocrine receptors*	*3*	*85*	*75*	*L*	*H*	*H*	*M*		*M*	*H*	*H*	*H*	*L*	*H*	*H*	*H*	*H*	*H*
CLO-6 :	*Explain the concepts of development in health and diseases*	*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	*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*

Duration (hour)		9	9	9	9	9
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 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. G. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com*	1. *Prof.. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in*	1. *Dr. S.ThyagaRajan, SRMIST*
2. *Dr. Karthik Periyasamy, Scientist I, Aurozymes Unit, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com*	2. *Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	2. *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:*
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:*	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 role of genes in brain development and functions*	*1*	*80*	*80*	*L*	*H*	*H*	*H*		*M*	*L*	*H*	*H*	*H*	*H*	*H*	*L*	*H*	*H*
CLO-2 :	*Describe the fundamental organization of brain and its functions.*	*2*	*85*	*75*	*M*	*H*	*H*	*M*			*M*	*H*	*L*	*H*	*H*	*H*	*L*	*H*	*H*
CLO-3 :	*Explain the concepts and experiments in the ion channels and NEUROTRANSMITTERS*	*2*	*75*	*80*	*M*	*H*	*M*	*H*	*M*	*M*		*M*	*H*	*H*	*H*	*H*	*L*	*H*	*H*
CLO-4 :	*Recognize the various pathways of sensory system*	*2*	*85*	*80*	*L*	*H*	*H*	*H*			*H*	*L*	*L*	*H*	*H*	*H*	*M*	*H*	*H*
CLO-5 :	*Discuss the different methods in the neuroendocrine and immune interactions*	*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	*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*

Duration (hour)		9	9	9	9	9
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
1. Dr. G. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	*1. Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in*	*1. Dr. S.ThyagaRajan, SRMIST*
2. Dr. Karthik Periyasamy, Scientist I, Aurozymes Unit, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*2. Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	*2. 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:*
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			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 metabolic principles*	*2*	*80*	*70*	*L*	*M*	*L*	*H*	*H*	*H*			*H*	*H*	*H*	*H*	*L*	*M*	*L*
CLO-2 :	*able to solve the metabolic problems of specific nutrients*	*2*	*85*	*75*	*L*	*M*	*H*	*H*	*H*	*H*	*M*		*H*	*H*	*H*	*H*	*L*	*M*	*H*
CLO-3 :	*able to apply knowledge in metabolic control*	*2*	*75*	*80*	*L*	*H*	*M*	*H*	*H*	*H*	*L*		*H*	*H*	*H*	*H*	*L*	*H*	*M*
CLO-4 :	*Know the importance of genetics in medicine and in metabolic diseases.*	*2*	*85*	*80*	*L*	*H*	*L*	*H*	*H*	*H*	*H*		*H*	*H*	*H*	*H*	*L*	*H*	*L*
CLO-5 :	*Realize how genetic diseases are common in our society and the reason for it.*	*3*	*85*	*80*	*L*	*M*	*L*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*L*	*M*	*L*
CLO-6 :	*Understand the various treatment strategies of metabolic disorders*	*2*	*80*	*75*	*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*			*Inborn error of lipid metabolism*	*Disorders of Fat soluble vitamins*

Duration (hour)		15	15	15	15	15
	SLO-2		*Carbohydrate metabolic pathways and its associated deficiencies*	*Nitrogen metabolism and its target organs Aminoacid synthesis transport and storage*		
S-13	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 14-15	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					

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	*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. Giridharan Appaswamy, Lifecell International (P) Limited, Chennai, giridharan.a@lifecell.in*	1. *Prof. Karunagaran D, IITM, Chennai, karuna@iitm.ac.in*	1. *Dr. K.M. Ramkumar, SRMIST*
2. *Dr. Karthik Periyasamy, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com*	2. *Dr. Sib Sankar Roy, CSIR-IICB, Kolkatta, sibsankar@iicb.res.in*	2. *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:*
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			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 :	*Demonstrate general understating of the infectious diseases and their causative agents*	*1*	*80*	*80*	*H*	*H*	*H*	*H*		*M*	*L*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-2 :	*Illustrate the bacterial infections and ways to tackle different bacterial diseases.*	*2*	*85*	*75*	*H*	*H*	*H*	*H*			*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-3 :	*Interpret the viral infections, vaccine development and challenges*	*2*	*75*	*80*	*M*	*H*	*M*	*H*	*M*	*M*		*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-4 :	*Discuss about the protozoan and fungal infections and methods to combat them*	*2*	*85*	*80*	*H*	*H*	*H*	*H*			*H*	*L*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-5 :	*Categorize the infectious diseases and their social impact*	*3*	*85*	*75*	*H*	*H*	*H*	*H*		*M*	*H*	*H*	*H*	*L*	*H*	*H*	*H*	*H*	*H*
CLO-6 :	*Analyze the reimmerging infections and their control*	*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	*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*

Duration (hour)		9	9	9	9	9
	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
1. *Dr. G. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com*	1. *Prof. K Subramaniam, IITM, Chennai, suubu@iitm.ac.in*	1. *Dr Suvankar Ghorai*
2. *Dr. Karthik Periyasamy, Scientist I, Aurozymes Unit, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com*	2. *Dr. Saumya Raychaudhuri, IMTECH, Chandigarh Saumya@imtech.res.in*	2. *Dr. Koustav Sarkar*

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:*
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:*	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 role of diet in different forms of cancer*	*1*	*80*	*80*	*L*	*H*	*H*	*H*		*M*	*L*	*H*	*H*	*H*	*H*	*H*	*L*	*H*	*H*
CLO-2 :	*Describe the fundamental assays in hazard identification*	*2*	*85*	*75*	*M*	*H*	*H*	*M*			*M*	*H*	*L*	*H*	*H*	*H*	*L*	*H*	*H*
CLO-3 :	*Explain the concepts and experiments in cancer development*	*2*	*75*	*80*	*M*	*H*	*M*	*H*	*M*	*M*		*M*	*H*	*H*	*H*	*H*	*L*	*H*	*H*
CLO-4 :	*Recognize the various pathways of cancer and pain*	*2*	*85*	*80*	*L*	*H*	*H*	*H*			*H*	*L*	*L*	*H*	*H*	*H*	*M*	*H*	*H*
CLO-5 :	*Discuss the different methods in the neuroendocrine and immune interactions in cancer*	*3*	*85*	*75*	*L*	*H*	*H*	*M*		*M*	*H*	*H*	*H*	*L*	*H*	*H*	*H*	*H*	*H*
CLO-6 :	*Explain the concepts of cancer detection and therapy*	*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	*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*

Duration (hour)		9	9	9	9	9
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 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		
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2. *Dr. Karthik Periyasamy, Scientist I, Aurozymes Unit, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com*	2. *Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	2. *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:	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 role of endocrine and immune system in stress	1	80	80	L	H	H	H		M	L	H	H	H	H	H	L	H	H
CLO-2 :	Describe the role of brain and neurotransmitters in stress	2	85	75	M	H	H	M			M	H	L	H	H	H	L	H	H
CLO-3 :	Explain the concepts and experiments in stress and stressors	2	75	80	M	H	M	H	M	M		M	H	H	H	H	L	H	H
CLO-4 :	Recognize the various pathways of stress related disorders	2	85	80	L	H	H	H			H	L	L	H	H	H	M	H	H
CLO-5 :	Discuss the different methods in the management of stress	3	85	75	L	H	H	M		M	H	H	H	L	H	H	H	H	H
CLO-6 :	Explain the concepts of diet, exercise and life style in managing stress	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	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

Duration (hour)		9	9	9	9	9
	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		
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2. Dr. Karthik Periyasamy, Scientist I, Aurozymes Unit, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*2. Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	*2. 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		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Appraise the changes the drug and human system undergoes when consumed*			
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:*	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 :	*Select appropriate target, drug-like candidates based on desired pharmacokinetic and pharmacodynamic parameters*	*1*	*80*	*80*	*M*	*H*	*L*	*H*			*L*	*H*	*L*	*L*	*L*	*H*	*H*	*H*	*H*
CLO-2 :	*Estimate the dose of drug to be administered for individuals*	*2*	*85*	*75*	*M*	*H*	*L*	*H*			*L*	*H*	*M*	*L*	*H*	*H*	*H*	*H*	
CLO-3 :	*Explain the logical usage of drugs and suggest appropriate treatment*	*2*	*75*	*80*	*L*	*H*	*M*	*H*		*M*		*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-4 :	*Justify the choice of drugs for microbial infection in an individual*	*2*	*85*	*80*	*H*	*H*	*H*	*H*			*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-5 :	*Underline the significance of stringent laws pertaining to manufacturing, distribution and sale of drugs in India*	*3*	*85*	*75*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-6 :	*Illustrate the process of pre-clinical investigation of drug designing*	*2*	*80*	*80*	*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*

Duration (hour)		9	9	9	9	9
	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 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. Karthik Periyasamy, Scientist I, Aurozymes Unit, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com*	2. *Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	2. *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:*
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 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. *Mr. Raghu R.Schrondinger, raghu.rangaswamy@schrodinger.com*	1. *Dr.G. Ramesh kumar, AU-KBC Research Centre, gramesh@au-kbc.org*	1. *Dr. Priya Swaminathan, SRM Institute of Science & Technology, priya.s@ktr.srmuniv.ac.in*
2. *Dr. Karthik Periyasamy, Scientist I, Aurozymes Unit, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com*	2. *Prof. R. B. Narayanan, SVCE,Chennai, rbn@svce.ac.in*	2. *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:*	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 basic concepts of drug design processes for a various number of drug development scenarios.*	*1*	*85*	*80*	*L*	*H*	*H*	*H*	*H*		*M*	*M*	*H*			*H*	*H*	*H*	*H*
CLO-2 :	*Explain the basic concept of target identification and target characterization*	*1*	*85*	*80*	*L*	*H*	*H*	*H*	*H*		*H*		*H*			*H*	*H*	*H*	*H*
CLO-3 :	*Compare the different computational tools for drug designing and the computer software used in the drug designing.*	*2*	*80*	*70*	*M*	*H*	*H*	*H*	*H*		*H*		*H*			*H*	*H*	*H*	*H*
CLO-4 :	*Explain the basic concepts of pharmacophore Model and QSAR.*	*1*	*80*	*70*	*M*	*H*	*H*	*H*	*H*		*H*		*H*			*H*	*H*	*H*	*H*
CLO-5 :	*Summarize the basic concepts of Quantum Mechanics in drug designing and De nova ligand synthesis.*	*1*	*85*	*80*	*M*	*H*	*H*	*H*	*H*		*H*		*H*			*H*	*H*	*H*	*H*
CLO-6 :	*Summarize the basic concepts in the drug design process and the computational techniques used in the drug design process.*	*1*	*80*	*70*	*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*

Duration (hour)		9	9	9	9	9
	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 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. G. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com*	1. *Prof. K Subramaniam, IITM, Chennai, suubu@iitm.ac.in*	1. *Mr. Jaganathan. M. K. SRMIST*
2. *Dr. Karthik Periyasamy, Scientist I, Aurozymes Unit, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com*	2. *Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	2. *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:*
CLR-1 :	*Learn the knowledge of the living and non-living resources.*
CLR-2 :	*Analyze the pharmacological potency of toxins.*
CLR-3 :	*Apply the biopolymers from various sources.*
CLR-4:	*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:*	Learning		
		1	2	3
		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.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Dr. G. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com*	1. *Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in*	1. *Dr.R.A.Nazeer, SRMIST*
2. *Dr. Karthik Periyasamy, Scientist I, Aurozymes Unit, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com*	2. *Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	2. *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			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 :	*Acquire theoretical knowledge on conventional strategies in vaccine production*	*1*	*80*	*80*	*H*	*H*	*H*	*H*		*M*	*L*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-2 :	*Exemplify the students with vaccine production techniques*	*2*	*85*	*75*	*H*	*H*	*H*	*H*	*M*		*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-3 :	*Distinguish various types of vaccine*	*2*	*75*	*80*	*M*	*H*	*M*	*H*	*M*	*M*		*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-4 :	*Devise various methods for vaccine delivery*	*2*	*85*	*80*	*H*	*H*	*H*	*H*	*M*		*H*	*L*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-5 :	*Explain the guidelines for vaccine production and delivery*	*3*	*85*	*75*	*H*	*H*	*H*	*H*		*M*	*H*	*H*	*H*	*L*	*H*	*H*	*H*	*H*	*H*
CLO-6 :	*Illustrate the basic concepts of vaccination and prophylaxis*	*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	*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*

Duration (hour)		9	9	9	9	9
	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.,

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2. *Dr. Karthik Periyasamy, Scientist I, Aurozymes Unit, Aurobindo Pharma Limited, Hyderaba, karthikmpk@gmail.com*	2. *Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	2. *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:*
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:*	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 :	*Summaries about the drug targets and method to clone drug targets.*	*1*	*85*	*80*	*L*	*H*	*H*	*H*	*H*		*M*	*M*	*H*			*H*	*H*	*H*	*H*
CLO-2 :	*Explain about G protein coupled receptors.*	*1*	*80*	*70*	*L*	*H*	*H*	*H*	*H*		*H*		*H*			*H*	*H*	*H*	*H*
CLO-3 :	*Explain about various ion channels.*	*1*	*80*	*75*	*L*	*H*	*H*	*H*	*H*		*H*		*H*			*H*	*H*	*H*	*H*
CLO-4 :	*Explain about various transporters*	*1*	*85*	*80*	*L*	*H*	*H*	*H*	*H*		*H*		*H*			*H*	*H*	*H*	*H*
CLO-5 :	*Discuss how an individual's genetic makeup influences their response to therapeutic drugs.*	*1*	*80*	*70*	*L*	*H*	*H*	*H*	*H*		*H*	*H*	*H*			*H*	*H*	*H*	*H*
CLO-6 :	*Summaries about the drug targets and their role in health and disease.*	*2*	*85*	*80*	*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*

Duration (hour)		9	9	9	9	9
	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.*	3. *Terry Kenakin, "Pharmacology in drug discovery: understanding drug response", Mica Haley, 2016.*
2. *Michael Palmer, Alice Chan, Thorsten Dieckmann, John Honek, "Biochemical Pharmacology", Wiley, 2012.*	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 / 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, Scientist I, Aurozymes Unit, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*2. Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	*2. 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:*
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:*	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 Plant-water relations, uptake and transport*	*1*	*80*	*80*	*M*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-2 :	*Explain the contributions of two different transporters to plant salinity tolerance*	*2*	*85*	*75*	*M*	*M*	*H*	*H*	*-*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-3 :	*Recognize the positive and negative impacts of the use of chemically synthesized fertilizers*	*2*	*75*	*80*	*M*	*-*	*M*	*H*	*M*	*H*	*H*	*-*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-4 :	*Discuss the different ways to calculate Nutrient use efficiency*	*2*	*85*	*80*	*-*	*H*	*H*	*H*	*-*	*H*	*H*	*L*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-5 :	*Explain the important of influx and efflux transporters*	*3*	*85*	*75*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*-*	*H*	*M*	*H*	*H*	*H*	*H*	*H*
CLO-6 :	*Gain knowledge about the biological functions of each of the micronutrients*	*2*	*80*	*80*	*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*

Duration (hour)		9	9	9	9	9
	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
1. Dr. Senthil, EID Parry, Chennai, parrynutraceuticals@parry.murugappa.com	*1. Prof .Usha Vijayraghavan. IISc, Bangalore, uvr@mcbl.iisc.ernet.in*	*1. Dr. R. Pachaiappan, SRMIST*
2. Dr. G. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com	*2. Prof. Akhilesh. S. Raghubanshi, Banaras Hindu University, Varanasi, asr@bhu.ac.in*	*2. 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:*
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:*	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 :	*Gain knowledge on major plant hormones*	*1*	*80*	*80*	*L*	*M*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-2 :	*Explain the history, synthesis, transport and functions of auxin in plant life*	*2*	*85*	*75*	*M*	*M*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*
CLO-3 :	*Describe the cytokinin biosynthetic pathway, two methods of analyzing and protein kinase cascade*	*2*	*75*	*80*	*M*	*M*	*M*	*H*	*M*	*M*	*H*	*M*	*H*	*M*	*H*	*H*	*H*	*H*	*H*
CLO-4 :	*Discuss the processes that control the accumulation of bioactive GAs, role of DELLAs and physiological responses*	*2*	*85*	*80*	*M*	*M*	*H*	*H*	*H*	*M*	*M*	*M*	*H*	*M*	*H*	*H*	*H*	*H*	*H*
CLO-5 :	*Gain knowledge the different physiological responses to ethylene*	*3*	*85*	*75*	*L*	*H*	*M*	*H*	*M*	*M*	*H*	*M*	*H*	*L*	*H*	*H*	*H*	*H*	*H*
CLO-6 :	*Explain the ways that ABA affects development of roots, fruits and seeds*	*2*	*80*	*80*	*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*

Duration (hour)		9	9	9	9	9
	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
1. *Dr. Senthil, EID Parry, Chennai, parrynutraceuticals@parry.murugappa.com*	1. *Prof .Usha Vijayraghavan. IISc, Bangalore, uvr@mcbl.iisc.ernet.in*	1. *Dr. R. Pachaiappan, SRMIST*
2. *Dr. Karthik Periyasamy, Scientist I, Aurozymes Unit, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com*	2. *Prof. Santa Ram Joshi., Department of Biotechnology & Bioinformatics North Eastern Hill University, Shillong-793022, Meghalaya, srjoshi2006@gmail.com*	2. *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:*
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:*	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 three ways that plants defend themselves against pathogens*	*1*	*80*	*80*	*M*	*H*	*H*	*H*	-	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-2 :	*Explain the physiological functions of pathogenesis related proteins in plants*	*2*	*85*	*75*	*M*	-	*H*	*H*	-	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-3 :	*Comprehend the concept of cell wall degrading enzymes produced from plants as a defence*	*2*	*75*	*80*	*H*	*M*	-	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-4 :	*Discuss the different ways of resistance to pathogens at molecular level*	*2*	*85*	*80*	-	*M*	*H*	*H*	-	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-5 :	*Explain the importance of PR-Proteins in agriculture crop development*	*3*	*85*	*75*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	-	*H*	*M*	*H*	*H*	*H*	*H*	*H*
CLO-6 :	*Gain knowledge about the signals, synthesis, binding to the receptor and role during plant – pathogen interactions*	*2*	*80*	*80*	*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*

Duration (hour)		9	9	9	9	9
	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.,

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2. *Dr. G. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com*	2. *Prof. Appa Rao Podile, Central University, Hyderabad, podilerao@gmail.com*	2. *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:*
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:*	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 :	*Define basic concepts of Food and Nutrition*	2	80	70		H	H			H		H	H				H	H	H
CLO-2 :	*Formulate food with daily dietary allowances*	2	80	70		H	H				H						H	H	H
CLO-3 :	*Identify the scope and prospects of food science in food industries*	2	80	70	M	H	H	M	H		M		H		H		H	H	H
CLO-4 :	*Design diet according to energy requirements of the body*	2	80	70	H		H		H		M		H		H		H	H	H
CLO-5 :	*Design diet for different age group and for people under diseased condition*	3	80	70	H	H	H	H	H		M		H		H		H	H	H
CLO-6 :	*Evaluate food constituents and its importance*	2	80	70	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*

Duration (hour)		9	9	9	9	9
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*	*1. Dr. K.A.Athmaselvi, 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.Preetha, SRMIST*

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			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:	*Identify plants and plant parts used as medicine traditionally*	*1*	*80*	*80*	*L*		*M*	*H*		*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-2:	*Apply techniques to screen plants for drugs and medicines*	*2*	*85*	*75*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-3:	*Analyze the secondary metabolic pathways that produce several medicinally important compounds*	*2*	*75*	*80*	*H*	*H*	*M*	*H*	*H*	*M*		*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-4:	*Deduce structure activity relationship*	*3*	*85*	*80*	*H*	*H*	*H*	*H*	*H*		*L*	*L*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-5:	*Predict the metabolic branch points that can be targeted for engineering*	*3*	*85*	*75*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*L*	*H*	*L*	*H*	*H*	*H*	*H*	*H*
CLO-6:	*Explain the mechanism of action of major known pharmaceutically important compounds in therapeutics*	*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	*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*

Duration (hour)		9	9	9	9	9
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 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. G. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com*	1. *Prof.. K Subramaniam, IITM, Chennai, suubu@iitm.ac.in*	1. *Dr. R. Pachaiappan, SRMIST*
2. *Dr. Karthik Periyasamy, Scientist I, Aurozymes Unit, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com*	2. *Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	2. *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			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 about the food safety terms*	*2*	*80*	*70*		*H*				*H*		*H*	*H*				*H*	*H*	*H*
CLO-2 :	*Identify the issues of food safety and quality*	*2*	*80*	*70*		*H*	*H*				*H*						*H*	*H*	*H*
CLO-3 :	*Explain the process of food safety analysis*	*2*	*80*	*70*	*M*	*H*	*H*	*M*	*H*		*H*		*H*		*H*		*H*	*H*	*H*
CLO-4 :	*Describe basic concepts of Food Safety and Quality Management*	*2*	*80*	*70*	*H*		*H*		*H*		*M*		*H*		*H*		*H*	*H*	*H*
CLO-5 :	*Set up and operate HACCP, SOP and ISO 22000 for food industries*	*3*	*80*	*70*	*H*	*H*	*H*	*H*	*H*		*M*		*H*		*H*		*H*	*H*	*H*
CLO-6 :	*Practice quality auditing methods in the food industries*	*2*	*80*	*70*	*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 Barriers to Food Safety Implementation*	*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					
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*

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

Learning Resources		
	1. *Andres Vasconcellos J. 2 nd edition. Quality Assurance for the Food industry - A practical approach. 2005, CRC press.*	3. *Sara Mortimore and Carol Wallace. 3rd edition HACCP - A practical approach.2013, Chapman and Hall, London.*
	2. *Inteaz Alli. 1st edition, Food quality assurance - Principles & practices. 2004, CRC Press. New York.*	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	*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.A.Athmaselvi, 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.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:*
CLR-1 :	*Discuss the basics of enzyme mechanism, classification, and factors affecting enzyme activity*
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:*	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 :	*Recognize the basic nature of enzyme, classification and their mechanism of working*	*1*	*80*	*80*	*H*	*M*	*L*	*H*	*M*		*H*		*H*		*H*		*H*	*H*	*H*
CLO-2 :	*Describe the various kinetic mechanisms and regulation of enzyme actions*	*2*	*85*	*75*	*H*	*H*	*H*	*H*	*H*		*H*		*H*				*H*	*H*	*H*
CLO-3 :	*Formulate the succession of enzyme purification and their characterization*	*2*	*75*	*80*	*M*	*L*	*H*	*H*	*H*		*H*		*H*		*H*		*H*	*H*	*H*
CLO-4 :	*Illustrate the methods of enzyme immobilization and evaluating the effectiveness of immobilization*	*2*	*85*	*80*	*H*	*H*	*H*	*H*	*H*		*H*		*H*		*M*		*H*	*H*	*H*
CLO-5 :	*Assess the extent of enzyme applications in various industries*	*3*	*85*	*75*	*H*	*L*	*H*	*H*	*M*		*H*		*H*		*H*	*H*	*H*	*H*	*H*
CLO-6 :	*Interpret the mechanisms of enzyme action and evaluating their importance in various applications*	*2*	*80*	*80*	*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*

Duration (hour)		9	9	9	9	9
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
1. *Dr. G. N. Ramchand, Saksin Life sciences Pvt Ltd, Chennai, ramchand@saksinlife.com*	1. *Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in*	1. *Dr. V.Vinothkumar, SRMIST, vinothkumar.v@ktr.srmuniv.ac.in*
2. *Dr. Karthik Periyasamy, Scientist I, Aurozymes Unit, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com*	2. *Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	2. *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:*
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:*	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 membranes for bioprocess industries*	*2*	*80*	*90*	*M*	*M*	*H*	*M*	*M*						*H*	*H*	*H*	*H*	*H*
CLO-2 :	*Demonstrate methods of casting membrane*	*2*	*85*	*90*	*M*	*M*	*H*	*M*	*M*						*H*	*H*	*H*	*H*	*H*
CLO-3 :	*Utilize the selection of membranes for micro and Macro molecules separation*	*2*	*75*	*80*	*M*	*M*	*H*	*M*	*L*						*H*	*H*	*H*	*H*	*H*
CLO-4 :	*Apply membrane for dialysis*	*2*	*90*	*85*	*M*	*M*	*H*	*M*	*M*						*H*	*H*	*H*	*H*	*H*
CLO-5 :	*Demonstrate membrane for distillation and production*	*2*	*80*	*80*	*M*	*M*	*H*	*M*	*M*						*H*	*H*	*H*	*H*	*H*
CLO-6 :	*Explain membrane in upstream and downstream process economically*	*2*	*80*	*80*	*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*

Duration (hour)		9	9	9	9	9
	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
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.Venkatesh Prabhu SRM IST*
2. Dr. Karthik Periyasamy, Aurobindo Pharma Limited, Hyderabad, karthikmpk@gmail.com	*2. Prof. R. B. Narayanan, SVCE, Chennai, rbn@svce.ac.in*	*2 .Dr. Y.Ravichandran SRM IST*

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:*	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 :	*Accomplish knowledge on improvement of strain development for primary and secondary metabolites*	*2*	*80*	*70*	*H*	*H*	*H*	*H*			*H*		*H*		*H*	*H*	*H*	*H*	*H*
CLO-2 :	*Explain the upstream and Downstream fermentation process of organic acids and aminoacids*	*2*	*85*	*75*	*H*	*H*	*H*	*H*			*H*		*H*		*H*	*H*	*H*	*H*	*H*
CLO-3 :	*Describe the industrial scale methodologies for Antibiotic and microbial enzyme production*	*3*	*75*	*80*	*H*	*H*	*H*	*M*	*H*		*H*		*H*		*H*	*H*	*H*	*H*	*H*
CLO-4 :	*Understand enzyme biotransformation biostratergies and recombinant protein production with commercial and medical importance*	*3*	*85*	*80*	*H*	*H*	*H*	*H*	*H*		*M*		*H*		*H*	*H*	*H*	*H*	*H*
CLO-5 :	*Apprehend the food fermentation process and its preservants used for improving the shelf period*	*3*	*85*	*80*	*H*	*H*	*H*	*H*	*H*		*M*		*H*		*H*	*H*	*H*	*H*	*H*
CLO-6 :	*Decipher the availability and application of various food colourants, flavourants and SCP*	*2*	*80*	*75*	*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*

Duration (hour)		9	9	9	9	
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.* 3. *Waites M. J., Morgan N.L., Rockey J.S., Higton G., "Industrial Microbiology: An Introduction", Blackwell Science, 2013.*
	4. *Saran S., Babu V., Chuabey A., "High Value Fermentation Products: Human Health", Scrivener Publishing, 2019* 5. *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
1. *Dr. P. BalaKumaran, Proklean Technologies (P) Limited, Chennai, genbalu86@gmail.com*	1. *Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in*	1. *Dr. V. 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. 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			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 :	*Know the basic design of reactor*	*1*	*85*	*80*	*H*	*H*	*H*	*H*	*M*				*H*	*M*	*H*	*H*	*H*	*H*	*H*
CLO-2 :	*Acquire knowledge on air driven reactor*	*2*	*90*	*80*	*H*	*H*	*H*	*H*	*M*				*H*	*M*	*H*	*H*	*H*	*H*	*H*
CLO-3 :	*Know about reactors for solid state fermentation*	*2*	*80*	*80*	*H*	*H*	*H*	*M*	*L*				*H*	*M*	*H*	*H*	*H*	*H*	*H*
CLO-4 :	*Have knowledge on biofilm reactor*	*2*	*80*	*80*	*H*	*H*	*H*	*H*	*M*				*H*	*M*	*H*	*H*	*H*	*H*	*H*
CLO-5 :	*Know about modeling, simulation and control system used in reactor*	*2*	*85*	*80*	*H*	*H*	*H*	*H*	*M*				*H*	*M*	*H*	*H*	*H*	*H*	*H*
CLO-6 :	*Acquire the basic knowledge on design of SMF and SSF and its control*	*2*	*80*	*80*	*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*

Duration (hour)		9	9	9	9	9
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.*	3. *Panda. T., "Bioreactors: Analysis and Design", McGraw Hill Education (India) Private Limited, 2011*
2. *B.Atkinson.,"Biochemical Reactors",Pion limited,London,1974*	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 / 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. P. BalaKumaran, Proklean Technologies (P) Limited, Chennai, genbalu86@gmail.com	*Prof. K Subramaniam, IITM, Chennai, subbu@iitm.ac.in*	*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*	*Dr. Y.Ravichandran SRM IST*

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:*
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			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 and concepts about the mathematical modeling*	*2*	*80*	*70*	*H*	*H*	*H*	*H*			*H*		*H*		*H*	*H*	*H*	*H*	*H*
CLO-2 :	*Explain about the various mathematical models in biochemical engineering systems*	*2*	*85*	*75*	*H*	*H*	*H*	*H*			*H*		*H*		*H*	*H*	*H*	*H*	*H*
CLO-3 :	*Discuss the application of SuperPro Design for analysis of material and energy balance of biochemical reaction*	*3*	*75*	*80*	*H*	*H*	*H*	*M*	*H*		*H*		*H*		*H*	*H*	*H*	*H*	*H*
CLO-4 :	*Explain the basic concepts of MATLAB, data analysis and interpretation of data*	*3*	*85*	*80*	*H*	*H*	*H*	*H*	*H*		*M*		*H*		*H*	*H*	*H*	*H*	*H*
CLO-5 :	*Explain the basic concepts of SIMULINK, data analysis and interpretation of data*	*3*	*85*	*80*	*H*	*H*	*H*	*H*	*H*		*M*		*H*		*H*	*H*	*H*	*H*	*H*
CLO-6 :	*Accomplish knowledge about the fundamentals of modeling and simulations of bioprocess*	*2*	*80*	*75*	*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*

Duration (hour)		9	9	9	9	9
	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.*	5. *Biquette. W.B., "Process Dynamics- Modeling analysis with simulation", Prentice Hall; 1 edition, 1998.*
2. *Burstein L., "Matlab® in Bioscience and Biotechnology, Woodhead Publishing, 2011.*	6. *Beers. K.J., "Numerical Methods for Chemical Engineering Applications in MATLAB®", Massachusetts Institute of Technology, Cambridge University press. 2007. www.intelligen.com/ SuperPro Designer user guide.*
3. *Luben. W.L., "Process Modelling Simulation and Control for Chemical Engineers", McGrawHill, 1990.*	
4. *Franks. R.G.E., "Mathematical Modeling in Chemical Engineering", John Wiley and Sons, Inc., 2004.*	

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. 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	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:*
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			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 :	*Manage Inoculum development and nutritional balance for product conversion.*	*2*	*80*	*70*	*H*	*H*	*H*	*H*			*H*		*H*		*H*	*H*	*H*	*H*	*H*	
CLO-2 :	*learn about the mass and energy balance of bioprocess*	*2*	*85*	*75*	*H*	*H*	*H*	*H*			*H*		*H*		*H*	*H*	*H*	*H*	*H*	
CLO-3 :	*develop and optimize the process parameters for the industries*	*3*	*75*	*80*	*H*	*H*	*H*	*M*	*H*		*H*		*H*		*H*	*H*	*H*	*H*	*H*	
CLO-4 :	*apply design factors for scale up in the industry*	*3*	*85*	*80*	*H*	*H*	*H*	*H*	*H*		*M*		*H*		*H*	*H*	*H*	*H*	*H*	
CLO-5 :	*evaluate the process plant design for regulatory compliance*	*3*	*85*	*80*	*H*	*H*	*H*	*H*	*H*		*M*		*H*		*H*	*H*	*H*	*H*	*H*	
CLO-6 :	*design a plant layout for processing of biological materials*	*2*	*80*	*75*	*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*

Duration (hour)		9	9	9	9	9
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.*	3. *Perry R. H., Green D. W., "Perry's Chemical Engineers' Handbook", 9th Edition, McGraw Hill Book Co., 2018.*
2. *Peters M. S., Timmerhaus. K. D., "Plant Design and Economics for Chemical Engineers", 5th Edition, McGrawHill Book Co., 2003*	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*

Duration (hour)		9	9	9	9	9
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		
		1	2	3
		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:*	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 an insight into the pollution from major industries including the sources and characteristics of pollutants*	*1*	*80*	*70*	*H*	*H*	*M*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*M*	*H*	*M*	*H*	*H*
CLO-2 :	*Analyze the mode of treatment based on waste characteristics*	*2*	*85*	*75*	*H*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*M*	*L*	*H*	*H*	*M*	*H*	*H*
CLO-3 :	*Design of wastewater treatment plants to attain standard limits*	*2*	*75*	*70*	*H*	*H*	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*M*	*H*
CLO-4 :	*Assess the impact of industrial wastes on the environmental compartments (land, water and air)*	*2*	*85*	*80*	*H*	*H*	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*
CLO-5 :	*Analyze and choose approportate strategy to convert waste to economic goods*	*2*	*85*	*75*	*H*	*H*	*M*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-6 :	*Develop knowledge on environmental regulations and legal aspects*	*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	*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*

Duration (hour)		9	9	9	9	9
	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.,

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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		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Identify the potent biomass resources for energy production*			
CLR-2 :	*Identify the applications of energy conversion technology*			
CLR-3 :	*Demonstrate the significance of environmental benefits of bioenergy*			
CLR-4:	*Create insights to the concepts of sustainable and green technologies*			
CLR-5:	*Analyze the important wastes to energy conversion*			
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:*	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 appropriate biofuel production based on available feedstocks*	*1*	*80*	*70*	*H*	*H*	*M*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*M*	*H*	*M*	*H*	*H*
CLO-2 :	*Analyze cell wall components of 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 biomass conversion to produce biofuel*	*2*	*75*	*70*	*H*	*H*	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*M*	*H*
CLO-4 :	*Apply enzymatic process to convert biomass t fuel and value added chemicals*	*2*	*85*	*80*	*H*	*H*	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*
CLO-5 :	*Employ synthetic routes for ease and fast biofuel prouction*	*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)		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
		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*

Duration (hour)		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
		9	9	9	9	9
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.*	3. *A.H.Scragg, "Biofuels, Production, Application and Development", CAB Internaional, 2009*
2. *Roland A. Jansen, "Second Generation Biofuels and Biomass", Wiley – VCH Verlag GmbH Co., 2013.*	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 / 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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Dr. D. Gunaseelan Biocon Limited, guna.sachin@gmail.com	*Dr. Rintu Banerjee IIT Kharagpur, rb@agfe.iitkgp.ernet.in*	*Dr. Samuel Jacob Department of Biotechnology SRM Inst. of Science & Technology, samueljacob.b@ktr.srmuniv.ac.in*
Dr. S. Sam Gunasekar Orchid Pharma Ltd., Chennai	*Dr. Subhabrata Ray IIT Kharagpur, sray@che.iitkgp.ernet.in*	*Dr. K.Ramani Department of Biotechnology SRM Inst. of Science & Technology, ramani.k@ktr.srmuniv.ac.in*

Course Code	18BTE320T	Course Name	ENVIRONMENTAL MICROBIOLOGY AND 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:*
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		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Apply the concepts of microbial diversity and its taxonomic make up.*	*1*	*80*	*80*
CLO-2 :	*Understand the extremophiles and its uses in Biotechnology.*	*2*	*85*	*75*
CLO-3 :	*Apply Metagenomics data to describe 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 :	*Understand the soil microbiome and biofilm organisms in the environmental cleanup*	*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*	*M*	*L*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
H	*H*	*H*	*H*	*M*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
M	*H*	*M*	*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*
H	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*L*	*H*	*H*	*H*	*H*	*H*
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*

Duration (hour)		9	9	9	9	9
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 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. S. Sam Gunasekar, Orchid Chemicals and Pharmaceuticals Ltd., sam@orchidpharma.com	*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:*	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,	Modern Tool Usage	Society & Culture	Environment &	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Apply the concepts of biodiversity and their importance.*	*1*	*80*	*80*	*H*	*H*	*H*	*H*		*M*	*L*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-2 :	*Understand the extremophiles and its applications in environmental remediation.*	*2*	*85*	*75*	*H*	*H*	*H*	*H*			*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
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*	*M*	*H*	*M*	*H*	*M*	*M*		*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*	*L*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-5 :	*Apply next generation sequencing technology.*	*3*	*85*	*75*	*H*	*H*	*H*	*H*		*M*	*H*	*H*	*H*	*L*	*H*	*H*	*H*	*H*	*H*
CLO-6 :	*Analyze the biofilm communities in the soil microbiome and their metagenomic strategies.*	*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	*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*

Duration (hour)		9	9	9	9	9
	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 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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Course Code	18BTE410T	Course Name	ENVIRONMENTAL 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:*	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 :	*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*

Duration (hour)		9	9	9	9	9
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 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 %	

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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:*
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:*	Learning		
		1	2	3
		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*

Duration (hour)		9	9	9	9	9
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	*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. 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
CLO-1 :	*H*	*H*	-	*H*	-	-	-	*M*	-	*H*	-	*H*	*H*	*H*	*H*
CLO-2 :	*M*	*M*	-	*M*	-	-	-	*M*	-	*H*	-	*H*	*H*	*H*	*H*
CLO-3 :	*H*	*M*	-	*M*	-	-	-	*M*	-	*H*	-	*H*	*H*	*H*	*H*
CLO-4 :	*H*	*H*	-	*M*	-	-	-	*M*	-	*H*	-	*H*	*H*	*H*	*H*
CLO-5 :	*M*	*M*	-	*H*	-	-	-	*M*	-	*H*	-	*H*	*H*	*H*	*H*
CLO-6 :	*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*

Duration (hour)		9	9	9	9	9
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
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. 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		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Provide basic knowledge on embryogenesis from the perspective of engineers.*			
CLR-2 :	*Create an interest to know about the different types of stem cells, its isolation, differentiation and transdifferentiation.*			
CLR-3 :	*Develop awareness about cancer stem cells, iPSCs and importance of stem cell niches.*			
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 (%)	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 embryogenesis, stem cells and its characteristics.*	*2*	*80*	*70*	-	-	*H*	*M*	-	-	*M*	*H*	-	*H*	-	*H*	*H*	*H*	*H*
CLO-2 :	*Gain knowledge on different types of stem cells isolation of ESCs, its specialized functions and transdifferentiation.*	*3*	*85*	*70*	-	-	*H*	*M*	-	-	*M*	*H*	-	*H*	-	*H*	*H*	*H*	*H*
CLO-3 :	*Discuss about cancer stem cells, iPSCs and stem cell niches.*	*2*	*80*	*75*	-	-	*H*	*M*	-	-	*M*	*H*	-	*H*	-	*H*	*H*	*H*	*H*
CLO-4 :	*Identify the role of signaling pathways, epigenetics and genome editing in engineering of stem cells.*	*2*	*80*	*70*	-	-	*H*	*M*	-	-	*M*	*H*	-	*H*	-	*H*	*H*	*H*	*H*
CLO-5 :	*Utilize application of stem cells in tissue engineering, treatment of different diseases & ethics and regulations of stem cell research.*	*3*	*80*	*70*	-	-	*H*	*M*	-	-	*M*	*H*	-	*H*	-	*H*	*H*	*H*	*H*
CLO-6 :	*Apply knowledge on CRISPR/Cas9 gene editing system.*	*3*	*80*	*70*	-	-	*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*

Duration (hour)		9	9	9	9	9
	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
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2. Dr. A. Premkumar, Ph.D., GVK Biosciences, Hyderabad aprem70@yahoo.com	*2. Dr.Sudha Warrier, Associate Professor, Manipal University, sudha.warrier@mannipal.edu*	*2. Dr. N.Selvamurugan, SRMIST selvamun@srmist.edu.in*

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 (%)
CLO-1 :	*Explain the basic techniques to manufacture scaffolds from raw biomaterials and explain the different prerequisites for the biomaterials.*	*2*	*80*	*70*
CLO-2 :	*Illustrate the types of biomaterials for biomedical applications.*	2	75	80
CLO-3 :	*Explain the biological problems in tissue engineering that require engineering expertise to solve them.*	2	80	70
CLO-4 :	*Explain the applications of biomaterials for various biomedical applications.*	2	80	75
CLO-5 :	*Explain good manufacturing of biomaterials related their applications.*	3	80	70
CLO-6 :	*Illustrate global marketing of biomaterials for commercialization*	2	85	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*	*M*				*H*		*H*		*H*	*H*	*H*	*H*
CLO-2 :			*M*	*M*				*H*		*H*		*H*	*H*	*H*	*H*
CLO-3 :			*M*	*M*				*H*		*H*		*H*	*H*	*H*	*H*
CLO-4 :			*M*	*M*				*H*		*H*		*H*	*H*	*H*	*H*
CLO-5 :			*M*	*M*				*H*		*H*		*H*	*H*	*H*	*H*
CLO-6 :			*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*

Duration (hour)		9	9	9	9	9
	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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2. Dr. Gokuladhas Krishnan , Director, Laboratory, World Stem Cell Clinic, Chennai, care@worldstemcellclinic.com	*2. N. Srinivasan, Ph. D., Chettinad Health City, Chennai srinivasanibms@gmail.com*	*2. Dr. M. Pandima Devi, SRMIST pandimam@srmist.edu.in*

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
CLO-1 :			*H*	*M*	*M*				*M*	*H*		*H*	*H*	*H*	*H*
CLO-2 :			*H*	*M*	*M*				*M*	*H*		*H*	*H*	*H*	*H*
CLO-3 :			*H*	*M*	*M*				*M*	*H*		*H*	*H*	*H*	*H*
CLO-4 :			*H*	*M*	*M*				*M*	*H*		*H*	*H*	*H*	*H*
CLO-5 :			*H*	*M*	*M*				*M*	*H*		*H*	*H*	*H*	*H*
CLO-6 :			*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*

Duration (hour)		9	9	9	9	9
	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:*
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*

Duration (hour)		9	9	9	9	9
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 / 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. Harikrishna Varma, SCTIMST, Thiruvananthapuram, India *e-mail: head-bmtw@sctimst.ac.in*	*1.Dr. Sourabh Ghosh, IIT Delhi, India* *e-mail: sghosh08@textile.iitd.ac.in*	*1.Dr. Koutsav Sarkar, SRMIST* *e-mail: koustavm@srmist.edu.in*
2. Dr. Dipak Datta, CDRI, Lucknow, India *e-mail: dipak.datta@cdri.res.in*	*2.Dr. Rathindranath Baral, CNCI, Kolkata., India* *e-mail: baralrathin@hotmail.com*	*2. 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
CLO-1 :	*H*	-	-	*H*	-	-	-	*H*	-	-	-	*H*	*H*	*H*	*H*
CLO-2 :	*M*	-	-	*M*	-	-	-	*M*	-	-	-	*H*	*H*	*H*	*H*
CLO-3 :	*H*	-	-	*M*	-	-	-	*M*	-	-	-	*H*	*H*	*H*	*H*
CLO-4 :	*M*	-	-	*M*	-	-	-	*M*	-	-	-	*H*	*H*	*H*	*H*
CLO-5 :	*H*	-	-	*H*	-	-	-	*M*	-	-	-	*H*	*H*	*H*	*H*
CLO-6 :	*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					

Duration (hour)		9	9	9	9	9
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	*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*
	SLO-2					
S-8	SLO-1	*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*
	SLO-2					
S-9	SLO-1	*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*
	SLO-2					

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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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*

Duration (hour)		9	9	9	9	9
	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
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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:*
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
CLO-1 :	*H*	-	*M*	*L*	-	-	-	-	-	*H*	-	*M*	*H*	*H*	*H*
CLO-2 :	*H*	-	*M*	*L*	-	-	-	-	-	*H*	-	*H*	*H*	*H*	*H*
CLO-3 :	*H*	-	*M*	*L*	-	-	-	*M*	-	*H*	-	*H*	*H*	*H*	*H*
CLO-4 :	*M*	-	*M*	*L*	-	-	-	-	-	*H*	-	*M*	*H*	*H*	*H*
CLO-5 :	*H*	-	*M*	*L*	-	-	-	-	-	*H*	-	*M*	*H*	*H*	*H*
CLO-6 :	*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*

Duration (hour)		9	9	9	9	9
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 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	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.,

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Course Code	18BTE421T	Course Name	HIGH THROUGHPUT TECHNOLOGIES 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			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 :	*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:*																		
CLO-1 :	*Describe the terminology, technology characteristics and stake holder benefits of high throughput technologies*	*1*	*90*	*80*	*H*	*H*	*H*	*H*	*L*	*M*	*L*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-2 :	*Investigate genomic data, interpret the data in the population genetics and evolutionary genetic context*	*2*	*80*	*80*	*H*	*H*	*H*	*H*	*H*	*L*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-3 :	*Measure the expression of genes, develop necessary expertise in using different computation tools*	*2*	*85*	*80*	*M*	*H*	*M*	*H*	*L*	*M*	*L*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-4 :	*Quantify proteins qualitatively and quantitatively and categorize their interactions and modifications.*	*2*	*80*	*75*	*H*	*H*	*H*	*H*	*H*	*L*	*H*	*L*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-5 :	*Distinguish Metabolomics, Epigenomics and lipdomics research and interpreting the data generated*	*3*	*75*	*75*	*H*	*H*	*H*	*H*	*L*	*H*	*H*	*H*	*L*	*L*	*H*	*H*	*H*	*H*	*H*
CLO-6 :	*Analyze high throughput data using software*	*3*	*70*	*75*	*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*

Duration (hour)		9	9	9	9	9
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	3

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		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
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:*	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 regulation of metabolic pathways*	*H*	*80*	*80*	*M*			*H*				*M*					*H*	*H*	*H*
CLO-2 :	*To gain insight into methods used for metabolic engineering*	*H*	*80*	*75*	*M*	*H*	*H*	*H*				*H*	*H*				*H*	*H*	*H*
CLO-3 :	*Develop plan and methods for metabolic engineering*	*H*	*75*	*75*	*M*	*H*	*H*	*H*	*H*			*H*	*H*				*H*	*H*	*H*
CLO-4 :	*Apply knowledge on tools and techniques used for metabolic engineering*	*H*	*75*	*75*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*				*H*	*H*	*H*
CLO-5 :	*To understand the product formation from metabolically engineered microbes*	*H*	*80*	*80*	*M*	*H*	*H*		*M*	*M*	*H*	*H*	*H*				*H*	*H*	*H*
CLO-6 :	*Design pathway engineering techniques for diverting metabolic flux into product formation*	*H*	*80*	*80*	*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*

Duration (hour)		10	10	10	10	10
	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
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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:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
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
CLO-1 :	*Explain the genetic basis of crop productivity*		*H*	*M*	*L*	*M*	*M*	*M*		*M*	*H*		*H*	*H*	*H*	*H*
CLO-2 :	*Analyze the tools for crop improvement*		*H*	*M*	*L*	*M*	*M*			*M*	*H*		*H*	*H*	*H*	*H*
CLO-3 :	*Develop tolerance against abiotic stress*		*M*	*L*	*L*	*L*	*M*	*M*		*M*	*H*		*H*	*H*	*H*	*H*
CLO-4 :	*Develop tolerance against biotic stress*		*M*	*L*	*L*	*L*	*M*	*M*		*M*	*H*		*H*	*H*	*H*	*H*
CLO-5 :	*Analyze pathways to engineer value addition*		*M*	*L*	*L*	*L*	*M*	*M*		*M*	*H*		*H*	*H*	*H*	*H*
CLO-6 :	*Develop elite cultivars*		*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*

Duration (hour)		9	9	9	9	9
	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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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:*	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 :	*Describe the basics of molecular pathology of various infectious diseases*	*1*	*80*	*75*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*M*	*L*	*L*	*H*	*H*	*H*	*H*
CLO-2 :	*Investigate the molecular pathogenesis of bacterial pathogens*	*2*	*80*	*70*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*M*	*M*	*L*	*L*	*H*	*H*	*H*	*H*
CLO-3 :	*Investigate the molecular pathogenesis of viral pathogens*	*2*	*80*	*75*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*M*	*M*	*L*	*L*	*H*	*H*	*H*	*H*
CLO-4 :	*Examine the molecular pathogenesis of parasitic diseases*	*2*	*80*	*70*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*M*	*M*	*L*	*L*	*H*	*H*	*H*	*M*
CLO-5 :	*Explain the molecular pathogenesis of fungal infections*	*2*	*85*	*75*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*M*	*M*	*L*	*M*	*H*	*H*	*H*	*H*
CLO-6 :	*Recall the defense mechanisms of infectious microbes*	*3*	*90*	*80*	*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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Shalini M, , Scientist I, ITC Lifescienes PVT LTD Email: shalubioc@gmail.com	*Dr. Nishad Fathima Principal scientist, CSIR-Central Leather Research Institute, Chennai Email: nishad.clri@gmail.com*	*Dr.Rajnish , SRMIST*

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:*	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 :	*Employ hybridization based methods for diagnosis of genetic diseases*	*2*	*75*	*70*	*M*	*H*	*H*	*H*	*H*	*H*	*L*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-2 :	*Apply PCR based diagnosis*	*3*	*80*	*75*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-3 :	*Design diagnostic method by DNA Sequencing*	*3*	*85*	*80*	*M*	*H*	*M*	*H*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-4 :	*Apply nucleic acid based diagnosis of infectious diseases*	*2*	*80*	*75*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*L*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-5 :	*Employ immunological diagnosis of infectious diseases*	*3*	*85*	*75*	*H*	*H*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*L*	*H*	*H*	*H*	*H*	*H*
CLO-6 :	*Analyze genetic and infectious diseases through molecular methods*	*2*	*80*	*75*	*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*

Duration (hour)		9	9	9	9	9
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			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 knowledge about gene therapy in treating diseases.*	*1*	*80*	*70*	-	-	*H*	*M*	-	-	*M*	*H*	-	*H*	-	*H*	*H*	*H*	*H*
CLO-2 :	*Practice knowledge on different types of gene therapy and its applications.*	*2*	*85*	*75*	-	-	*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.*	*2*	*80*	*70*	*H*	-	*H*	*M*	-	-	*M*	*H*	-	*H*	-	*H*	*H*	*H*	*H*
CLO-4 :	*Use molecular aspects involved in genome editing in gene therapy.*	*2*	*80*	*75*	*H*	-	*H*	*M*	-	-	*M*	*H*	-	*H*	-	*H*	*H*	*H*	*H*
CLO-5 :	*Evaluate treatment of diseases addressed by gene therapy clinical trials.*	*3*	*80*	*70*	*H*	-	*H*	*M*	-	-	*M*	*H*	-	*H*	-	*H*	*H*	*H*	*H*
CLO-6 :	*Analyze recent advancements in gene therapy.*	*2*	*80*	*70*	*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*

Duration (hour)		9	9	9	9	9
	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		
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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			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 basics of genome organization across life and study of gene function*	*1*	*75*	*80*	*M*	*H*	*H*	*H*	*H*				*H*			*H*	*H*	*H*	*H*
CLO-2 :	*Describe the genomics of organelle and nuclear genomes across life*	*1*	*75*	*80*	*M*	*H*	*H*	*H*	*H*				*H*			*H*	*H*	*H*	*H*
CLO-3 :	*Review the organization of transcriptome and classical methods to study gene expression*	*2*	*70*	*80*	*M*	*H*	*H*	*H*	*H*				*H*			*H*	*H*	*H*	*H*
CLO-4 :	*Describe about traditional and Next Generation Sequencing (NGS)platforms for the study of genome, exome and transcriptome*	*2*	*60*	*75*	*H*	*H*	*H*	*H*	*H*			*H*	*H*		*H*	*H*	*H*	*H*	*H*
CLO-5 :	*Describe about genes for metabolic pathways, transcription factors, genome editing.*	*3*	*70*	*80*	*M*	*H*	*H*	*H*	*H*			*H*	*H*			*H*	*H*	*H*	*H*
CLO-6 :	*Summarize the applications of functional genomics in various sectors.*	*3*	*60*	*80*	*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:*	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 perception and responses of plants to environmental stimuli and stress cues*	*2*	*85*	*80*	*M*	*H*		*M*	*M*	*M*	*M*	*H*		*H*	*H*	*H*	*H*	*H*	*H*
CLO-2 :	*Design transgenic plants (GMOs) for biotic and abiotic stress tolerance*	*3*	*85*	*80*	*M*	*H*		*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-3 :	*Exploit light response plasticity for improved productivity*	*3*	*80*	*75*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*		*H*	*H*	*H*	*H*	*H*	*H*
CLO-4 :	*Demonstrate how plants compete with themselves and other plants for nutrients and sunlight*	*2*	*75*	*70*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*		*H*	*H*	*H*	*H*	*H*	*H*
CLO-5 :	*Examine the benefits of intercropping and crop rotation*	*2*	*80*	*75*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-6 :	*Recall what a plant does in the course of its lifetime for better growth and productivity*	*3*	*80*	*75*	*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*

Duration (hour)		9	9	9	9	9
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%)#			
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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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