M. Sc. Medical Biotechnology

Syllabus

UNIVERSITY DEPARTMENT

Program Code:

2020 – 2021 onwards

BHARATHIAR UNIVERSITY

(A State University, Accredited with "A" Grade by NAAC,
Ranked 13th among Indian Universities by MHRD-NIRF,
World Ranking: Times -801-1000,Shanghai -901-1000, URAP - 982)

Coimbatore - 641 046, Tamil Nadu, India

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)	
The programme aims to generate highly skilled human resources with the ability to comprehend and analyze biological problems paramount to human health and contribute to the development of updated, contemporary and appropriate solutions. The specific programme objectives are to develop post-graduates with the following competencies,	
PEO1	Contribute to problem identification and development and offering of solutions relevant and pertaining to human health by associating with biomedical industries, laboratories, non-profit organizations or in pursuit of doctoral studies at National/International level
PEO2	Effectively communicate the technical developments in biotechnology in order to become a successful entrepreneur in one's own caliber and expertise
PEO3	Develop their knowledge and skills throughout their careers as an ongoing and ever-growing enterprise

PROGRAMME OUTCOMES (POs)	
On completion of the M. Sc. Medical Biotechnology programme, the students will be able to,	
PO1	Demonstrate a broad understanding of biotechnology
PO2	Employ computational and other next generation tools to understand and resolve biological problems.
PO3	Independently carry out research to identify, formulate and solve problems in biotechnology in general and medical biotechnology in particular
PO4	Demonstrate ethical behaviour and biosafety norms
PO5	Articulate facts and ideas through professional communication in the form of reports and documents
PO6	Apply advanced knowledge of science and technology for societal impact
PO7	Adapt to work in inter and transdisciplinary teams
PO8	Exhibit knowledge of contemporary developments and sustainable systems
PO9	Expound ability to learn new developments as per professional requirements
PO10	Plan, articulate, implement and manage the projects independently

PROGRAMME SPECIFIC OUTCOMES (PSOs)	
The specific outcomes that the students will demonstrate at the exit point of the programme are,	
PSO1	An ability to analyze and formulate solutions to existing and emerging issues related to human health
PSO2	An ability to effectively use computational biology and other advanced techniques in order to understand the intricacies of the life process and functions at systems level and to design & develop therapeutics and diagnostics which have immense relevance in human healthcare
PSO3	An ability to contribute in an interdisciplinary team to develop and offer solutions to complex human health problems

BHARATHIAR UNIVERSITY : : COIMBATORE 641 046
DBT Supported M. Sc. Medical Biotechnology Curriculum
(University Department)
(For the students admitted during the academic year 2020 - 21 onwards)

Scheme of Examination

Course Code	Title of the Course	Credits	Hours		Maximum Marks		
			Theory	Lab	CIA	ESE	Total
SEMESTER ONE							
20MB1C01	Biochemistry	4	4	-	25	75	100
20MB1C02	Cell and Molecular Biology	4	4	-	25	75	100
20MB1C03	Genetics	4	4	-	25	75	100
20MB1C04	Developmental Biology and Human Physiology	4	4	-	25	75	100
20MB1C05	Biostatistics	4	4	-	25	75	100
20MB1P01	**Lab: 1** Cell Biology, Microscopy, Biochemistry and Analytical Techniques	5	-	6	40	60	100
TOTAL		**25**	**20**	**6**	**165**	**435**	**600**
SEMESTER TWO							
20MB1C06	Immunology and Immunotechnology	4	4	-	25	75	100
20MB1C07	Biophysical Principles and Analytical Techniques	4	4	-	25	75	100
20MB1C08	Medical Microbiology and Infection Biology	4	4	-	25	75	100
20MB1C09	Bioinformatics	4	4	-	25	75	100
20MB1C10	OMICS: Genomics, Transcriptomics, Proteomics and Metabolomics	4	4	-	25	75	100
20MB1P02	**Lab: 2** Immunotechnology& Molecular Diagnostics, Microbiology and Molecular Biology	5	-	6	40	60	100
20MB1E1A	**Elective: 1A** Plant Molecular Pharming	2	2	-	12	38	50
20MB1E1B	**Elective: 1B** Indian Systems of Medicine						
TOTAL		**27**	**22**	**6**	**177**	**473**	**650**
SEMESTER THREE							
20MB1C11	Clinical Biochemistry and Disease Metabolism	4	4	-	25	75	100
20MB1C12	Tissue Engineering and Stem Cell Technology	4	4	-	25	75	100
20MB1C13	Molecular Diagnostics and Therapeutics	4	4	-	25	75	100
20MB1C14	Genetic Engineering and Genome Editing Technologies	4	4	-	25	75	100
20MB1P03	**Lab: 3** Clinical Biochemistry and Disease Metabolism and Animal Cell culture	5	-	6	40	60	100
20MB1PR1	Project Proposal Preparation and Defense	3	-	2	75	-	75

20MB1C15	Medical Devices	2	2	-	12	38	50
20MB1C16	Intellectual Property Rights, Biosafety and Bioethics	2	2	-	12	38	50
TOTAL		**28**	**20**	**8**	**239**	**436**	**675**
SEMESTER FOUR							
20MB1PR2	Inhouse Project jointly with other Department(s) / Industries	8	-	26	225	50	275
20MB1E2A	**Elective: 2A**Nanobiotechnology	2	2	-	12	38	50
20MB1E2B	**Elective: 2B** Pharmacogenomics						
TOTAL		**10**	**2**	**26**	**237**	**88**	**325**
GRAND TOTAL		**90 + 12***	**64**	**46**	**818**	**1432**	**2250**

Extra Credit Courses

Course Code	Title of the Course	Credits	Hours		Maximum Marks		
			Theory	Lab	CIA	ESE	Total
SEMESTER ONE							
20MB1V01	**Value added course: 1** Seminar and Communication Skills	2	2	-	50	-	50
SEMESTER TWO							
20MB1V02	**Value added course: 2** Journal Club and Communication Skills	2	2	-	50	-	50
20MB1O01	Online self-study course in GLP/GMP/Drug regulations]- SWAYAM Platform	2	2	-	-	-	-
20MB1SI	One Month Summer Internship in Hospital or Biomedical Industries	2	-	-	-	-	-
SEMESTER THREE							
20MB1JO1	**Job Oriented Certificate Course: 1** Lead Molecule Discovery and Preclinical Development	4	2	2	100	-	100
SEMESTER FOUR							
20MB1JO2	**Job Oriented Certificate Course: 2** Clinical Trials Management	4	2	2	100	-	100

Programme Summary

Core Credit Courses			Extra Credit Courses	
Total Courses	**Total Credits**	**Total Marks**	**Total Courses**	**Total Credits**
23	90	2250	6	16

For final grading and ranking, only the scholastic courses scores are counted, however for the award of the degree, completion of the co-scholastic courses is mandatory

First Semester

SEMESTER ONE

Biochemistry **Credits** 4

Course Code	20MB1C01	Course Type	Core	L	T	P	C	Syllabus version	2020-2021
				3	1	-	4		
Pre-requisite	A basic knowledge on biomolecules and metabolic pathways								

Course Objectives:

1. To obtain fundamental understanding of cell biology research and its importance in human diseases
2. To provide an overview about morphological features of cells and relate them in the context of healthy and diseased human body
3. To develop knowledge about advanced microscopy including live cell imaging, correlative light and electron microscopy, confocal microscopy and underlying biophysics. Obtain operational skills to handle few of them

Expected Course Outcomes:

CO1	Learn in detail about structural properties of proteins that are building blocks of life. Clear understanding about factors that determine the structure and functions of a protein by equipping them to apply the knowledge in biopharmaceutical industry.	**K4**
CO2	Obtain a comprehensive knowledge about enzymes as modulators of biochemical reactions. Enable students to apply their critical thinking to evaluate applications of enzymes in therapeutics and commercial applications.	**K5**
CO3	Understand the biochemical events that lead to production of energy and the functional importance of energy reserves of the body. Improve their ability to understand the direct relationship between physiology and metabolism.	**K2**
CO4	Understand the central dogma of molecular biology. Develop insights into the structural importance of DNA in health and disease. Strong basics will be very useful for developing clinical tests involving biomolecules.	**K6**
CO5	Acquire strong theoretical knowledge about bioenergetics and pathways that tightly regulate energy metabolism. Detailed understanding of various signaling pathways involved, will be helpful in understanding the pathological importance of these pathways in disease biology.	**K4**
K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 - Create		

Unit I

Protein Structure

Chemical basis of life: Miller-Urey experiment, abiotic formation of amino acid oligomers, composition of living

14 Lectures	matter; Water – properties of water, essential role of water for life on earth, pH, buffer, maintenance of blood pH and pH of gastric juice, pH optima of different enzymes (pepsin, trypsin and alkaline phosphatase), ionization and hydrophobicity, emergent properties of biomolecules in water, biomolecular hierarchy, macromolecules, molecular assemblies; Structure-function relationships: amino acids – structure and functional group properties, peptides and covalent structure of proteins, elucidation of primary and higher order structures, Ramachandran plot, evolution of protein structure, protein degradation and introduction to molecular pathways controlling protein degradation, basic principles of protein purification; tools to characterize expressed proteins; Protein folding: Anfinsen's Dogma, Levinthal paradox, cooperativity in protein folding, free energy landscape of protein folding and pathways of protein folding, molten globule state, chaperons, diseases associated with protein folding, introduction to molecular dynamic simulation. *Self-learning*: structure-function relationships in model proteins like ribonuclease A, myoglobin, hemoglobin, chymotrypsin, etc.
Unit II **Enzyme Kinetics** **12 Lectures**	Enzyme catalysis – general principles of catalysis; quantitation of enzyme activity and efficiency; relevance of enzymes in metabolic regulation, activation, inhibition and covalent modification; single substrate enzymes; concept of catalytic antibodies; catalytic strategies with specific examples of proteases, carbonic anhydrases, restriction enzymes and nucleoside monophosphate kinase; isozymes; role of covalent modification in enzymatic activity; zymogens. *Self-learning*: Enzyme characterization and Michaelis-Menten kinetics
Unit III **Glycobiology** **8 Lectures**	Sugars-mono, di, polysaccharides and complex carbohydrates with specific reference to glycogen, amylose and cellulose, glycosylation of other biomolecules-glycoproteins and glycolipids; lipids- structure and properties of important members of storage and membrane lipids; lipoproteins.
Unit IV **Structure and functions of DNA & RNA** **8 Lectures**	Nucleosides, nucleotides, nucleic acids - structure, a historical perspective leading up to the proposition of DNA double helical structure; difference in RNA and DNA structure, importance of DNA as the genetic material in evolution of disease diagnosis
Unit Va **Bio-energetics**	Bioenergetics-basic principles; equilibria and concept of free energy; coupled interconnecting reactions in metabolism;

14 Lectures	oxidation of carbon fuels; Introduction to GPCR, *myo*-Inositol containing phospholipids/DAG//PKC and Ca++ signaling pathways; reciprocal regulations and non-carbohydrate sources of glucose; citric acid cycle as a source of biosynthetic precursors; Oxidative phosphorylation; importance of electron transfer in oxidative phosphorylation; F_1-F_0 ATP Synthase; shuttles across mitochondria; regulation of oxidative phosphorylation; *Self-learning:* Glycolysis, Gluconeogenesis, Citric acid cycle, entry to citric acid cycle, Photosynthesis – chloroplasts and two photosystems; proton gradient across thylakoid membrane.
Unit Vb **Role of Vitamins & Cofactors in Metabolism** **12 Lectures**	Roles of epinephrine and glucagon and insulin in glycogen metabolism; protein turnover and amino acid catabolism; nucleotide biosynthesis; biosynthesis of membrane lipids and sterols with specific emphasis on cholesterol metabolism and mevalonate pathway; elucidation of metabolic pathways; logic and integration of central metabolism; entry/ exit of various biomolecules from central pathways; principles of metabolic regulation; steps for regulation; TOR (target of rapamycin) & autophagy regulation in relation to C & N metabolism *Self-learning:* Calvin cycle and pentose phosphate pathway; glycogen metabolism, reciprocal control of glycogen synthesis and breakdown, Fatty acid metabolism, starvation responses and insulin signaling.
Unit VI **Contemporary issues** **2 Lectures**	Guest lectures by academic/industry experts, online seminars - webinars
Total Lectures – 70	

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	-	M	-	S	-	-	S	L	L
CO2	-	M	-	L	-	-	M	-	-	-
CO3	M	L	L	-	M	M	-	-	M	-
CO4	-	-	-	-	-	-	-	M	L	-
CO5	L	-	M	-	S	-	M	L	-	M

*S-Strong; M-Medium; L-Low

Recommended Textbooks and References:

1. Stryer,L. (2015). *Biochemistry*. (8thEd.) New York: Freeman.
2. Lehninger,A.L. (2012). *Principles of Biochemistry* (6thEd.). New York, NY :Worth.
3. Voet, D., &Voet, J. G. (2016). *Biochemistry* (5thEd.). Hoboken, NJ: J. Wiley & Sons.
4. Dobson, C. M. (2003). *Protein Folding and Misfolding*. Nature, 426(6968),884-890. doi:10.1038/nature02261.
5. Richards, F. M. (1991). *The Protein Folding Problem*. Scientific American, 264(1), 54-63.doi:10.1038/scientificamerican0191-54

Related Online Contents:

1. https://onlinecourses.swayam2.ac.in/cec20_bt12/preview
2. https://nptel.ac.in/courses/104/105/104105076/

Course adapted from DBT curriculum and handled by Dept. of Biotechnology	**Dr. V. Thirunavukkuarasu, Associate Professor**

SEMESTER ONE

Cell and Molecular Biology — Credits 4

Course Code	20MB1C02	Course Type	Core	L	T	P	C	Syllabus version	2020-2021
				3	1	-	4		
Pre-requisite	A basic knowledge in cell and molecular biology								

Course Objectives:

1. The aim of this course is to obtain and understand fundamental knowledge of molecular and cellular processes:
2. To familiarize the student in various aspects of cell and molecular biology streams including cellular organization and their interactions in DNA replication, and protein biosynthesis and translational regulation
3. To impart the molecular biology knowledge in applications of various aspects of human health care

Expected Course Outcomes:

CO1	Understand and apply the principles and techniques of molecular biology which prepares students for further education and/or employment in teaching, basic research, or the health professions.	**K1**
CO2	To obtain strong knowledge base in cell and molecular biology in biomedical sciences	**K2**
CO3	Advanced laboratory practices in cell and molecular biology will make the students choose their career in molecular biology research and further will help them to get job opportunities	**K3**
CO4	To conduct independent work in a laboratory with basis of cell biology	**K4**
CO5	The theoretical knowledge gained from this paper will help the student to apply these concepts in their future research	**K5, K6**
K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 - Create		

Unit I **Endo-membrane system, cellular cytoskeleton and motility** **14 Lectures**	Structure and function of biological membranes: Structural models; Composition and dynamics; Transport of ions and macromolecules; Pumps, carriers and channels; Endo and Exocytosis; Cellular junctions and adhesions; Structure and functional significance of plasmodesmata; Mechanism of cellular recognition and communication. Overview of cellular cytoskeleton: Organization and role of microtubules and microfilaments; Intermediate filaments; Muscle organization and function; Cellular motility; Molecular motors
Unit II **Molecular Structure and**	Nucleus: structure and function of nuclear envelope, lamina and nucleolus; Macromolecular trafficking; Chromatin organization

Functions of Cell and Organelles **14 Lectures**	and packaging; Cell cycle and control mechanisms; Mitochondria: structure, origin and evolution, organization of respiratory chain complexes, Structure-function relationship; structure and function of peroxisome; mitochondrial genome; Structure and function of microbodies, Golgi apparatus, lysosomes and endoplasmic reticulum; Protein processing, sorting; vesicle transport, secretion.
Unit III **DNA Structure, Organization and Functions** **12 Lectures**	Structure of DNA- A,B, Z and triplex DNA; Central dogma, DNA as genetic material; Organization of bacterial genome; Structure of eukaryotic chromosomes: DNA compaction, nucleosome, 10nm "beads-on-a-string" fibre, 30nm chromatin fibre and metaphase chromosome; Nuclear matrix in chromosome organization and function; Heterochromatin and Euchromatin; DNA melting and buoyant density; Tm; DNA reassociation kinetics (Cot curve analysis); Repetitive and unique sequences; Satellite DNA; DNase I hypersensitive regions; DNA methylation & epigenetic effects. Replication: initiation, elongation and termination in prokaryotes and eukaryotes; Enzymes and accessory proteins and mechanisms; Fidelity; Replication of single stranded circular DNA; link with cell cycle
Unit IV **RNA transcription, RNA processing and regulation in prokaryotes** **12 Lectures**	Structure and function of prokaryotic mRNA, tRNA (including initiator tRNA) and rRNA (and ribosomes); Prokaryotic Transcription -RNA polymerase and sigma factors, Transcription unit, Promoters, Promoter recognition, Initiation, Elongation and Termination (intrinsic, Rho and Mfd dependent); Processing of mRNA, rRNA and tRNA transcripts; Gene regulation: Repressors, activators, positive and negative regulation, Constitutive and Inducible, small molecule regulators, operon concept: *lac, trp, his* operons. Cell signalling – types of cell signalling - G protein mediated, Tyrosine kinase mediated signalling. MAP Kinases mediated cell signalling. Transposable elements. Transposable elements.
Unit V **RNA transcription, RNA processing and regulation in eukaryotes** **18 Lectures**	Structure and function of eukaryotic mRNA, tRNA (including initiator tRNA) and rRNA (and ribosomes). Eukaryotic transcription - RNA polymerase I, II and III mediated transcription: RNA polymerase enzymes, eukaryotic promoters and enhancers, General Transcription factors; TATA binding proteins (TBP) and TBP associated factors (TAF); assembly of pre-initiation complex for nuclear enzymes, interaction of transcription factors with the basal transcription machinery and with other regulatory proteins, mediator, TAFs; Processing of hnRNA, tRNA, rRNA; 5'-Cap formation; 3'-end processing of RNAs and polyadenylation; loop model of translation; Splicing

	of tRNA and hnRNA; snRNPs and snoRNPs in RNA processing; Regulation of RNA processing: capping, splicing, polyadenylation; mRNA stability and degradation: degradation and surveillance pathways. Families of DNA binding transcription factors: Helix-turn-helix, helix-loop-helix, homeodomain; 2C 2H zinc finger, multi cysteine zinc finger, basic DNA binding domains (leucine zipper, helix-loop-helix). Translational machinery; Mechanism of Translation in prokaryotes and eukaryotes; Co- and Post-translational modifications of proteins *Self-learning:* An overview of microscopy techniques – Bright field phase contrast, dark field, differential interference (DIC), Fluorescence, Confocal, Electron (TEM and SEM), Electron tunneling and Atomic Force Microscopy; Cell fractionation, differential centrifugation. Structural models of macromolecular assembly; Composition and dynamics; Ribosomes; Composition and assembly; universal genetic code; Genetic code in mitochondria; Degeneracy of codons; Termination codons; Wobble hypothesis.
Unit VI **Contemporary issues** **2 Lectures**	Guest lectures by academic/industry experts, online seminars - webinars
Total Lectures – 72	

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	L	-	M	-	-	-	-	-	M	-
CO2	-	M	-	L	-	-	-	-	-	-
CO3	S	-	L		M		L	-	-	-
CO4	-	-	-	-	L	M	-	-	-	L
CO5	-	-	L	-	-	L	-	L	-	-
*S-Strong; M-Medium; L-Low										

Recommended Textbooks and References:

1. Molecular cell Biology, by Darnell, Lodish, Baltimore, Scientific American Books, Inc., 1994
2. Karp's Cell and Molecular Biology: Concepts and Experiments, 8th Edition. Gerald Karp, Janet Iwasa Wallace Marshall.2015
3. Cell biology by D. E. Sadava, CBS Publishers & Distributors, 2009

4. Molecular and cellular Biology, Stephen L.Wolfe, Wadsworth Publishing Company, 1993
5. Molecular Biology LabFax, T.A. Brown (Ed.), Bios Scientific Publishers Ltd., Oxford, 1991

Related Online Contents:

1. Swayam- Molecular biology course by Dr. Nayan K. Jain
2. Swayam- Cell Biology by Dr. K. Sanatombi
3. NPTEL - Molecular Cell Biology by Prof. D. Karunagaran – IIT Madras

Course adapted from DBT curriculum and handled by Dept. of Biotechnology	**Dr. S. Girija, Associate Professor**

SEMESTER ONE

Genetics **Credits** 4

Course Code	20MB1C03	Course Type	Core	L	T	P	C	Syllabus version	2020-2021
				3	1	-	4		
Pre-requisite	A basic knowledge in genetics								

Course objectives:

1. The course offers basic knowledge of genetics encompassing prokaryotic/phage genetics, and higher eukaryotic domains and over all concepts of Mendelian genetics.
2. It makes the students understand the relationship between phenotype and genotype in human genetic traits
3. It also imparts knowledge of basics of human genetics and disease gene mapping.
4. Students gain knowledge of the aims and outcome of the human genome project

Expected Course Outcomes:

CO1	Students will gain knowledge about the genetics of prokaryotic and phage genetics	**K1, K2**
CO2	Gain knowledge on Drosophila genetics	**K1, K2**
CO3	The students will understand the inheritance of genes and the diseases in the Human	**K2, K3, K5**
CO4	The students learn various techniques related to cytogenetics and molecular and immunogenetics for disease diagnosis	**K2, K3**
CO5	Students understand the concept of genetic variation, epigenetics and Transgenerational epigenetics	**K4, K5**
K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 - Create		

Unit I **Genetics of bacteria and bacteriophage** **12 Lectures**	Concept of a gene in pre-DNAera ; mapping of genes in bacterial and phage chromosomes by classical genetic crosses; fine structure analysis of a gene; genetic complementation and other genetic crosses using phenotypic markers; phenotype to genotype connectivity prior to DNA-based understanding of a gene; Restriction modification systems – history, types of systems and their characteristics, applications of RM systems, methylation-dependent restriction enzymes, transposable elements – types, properties and applications.
Unit II **Drosophila genetics as a model of higher eukaryotes**	Monohybrid &dihybrid crosses, back-crosses, test-crosses, analyses of autosomal and sex linkages, screening of mutations based on phenotypes and mapping the same, hypomorphy, genetic mosaics, genetic epistasis in the context of developmental mechanisms; Testing gene mutations for

12 Lectures	allelism: complementation test, intragenic complementation, pleiotropy.
Unit III **Human Genetics** **16 Lectures**	History of human genetics, Pedigrees- gathering family history, pedigree symbols, construction of pedigrees, presentation of molecular genetic data in pedigrees, Monogenic traits, Autosomal inheritance-dominant, recessive Sex-linked inheritance, Sex-limited and sex-influenced traits, Mitochondrial inheritance, OMIM number, Complications to the basic pedigree patterns- non-penetrance, variable, expressivity, pleiotropy, late onset, dominance problems, anticipation, genetic heterogeneity, genomic imprinting and uniparentaldisomy, spontaneous mutations, mosaicism and chimerism, malelethality, X- inactivation; Approaches to analysis of complex traits- 'Nature nurture' concept, role of Family and shared environment, monozygotic and dizygotic twins and adoption studies, Polygenic inheritance of continuous (quantitative)traits, normal growth charts, Polygenic inheritance of discontinuous (dichotomous) traits- threshold model, liability and recurrence risk, Genetic susceptibility in multifactorial disorders (alcoholism, diabetes mellitus, obesity),Estimation of genetic components of multifactorial traits: empiric risk, heritability, coefficient of relationship.
Unit IV **Cytogenetics, Developmental Genetics and Immunogenetics** **14 Lectures**	Cytogenetics: Techniques in human chromosome analysis, Human karyotype: banding, nomenclature of banding, Pathology of human chromosomes, Nomenclature of aberrant karyotypes, Common syndromes due to numerical chromosome changes, Common syndromes due to structural alterations (translocations, duplications, deletions, microdeletion, fragile sites) Common chromosome abnormalities in cancer, Genetics of fetal wastage Disorders of sex chromosomes and autosomes; Molecular cytogenetics– Fluorescence In situ Hybridization (FISH); Comparative Genomic Hybridization (CGH); Developmental genetics: Genes in early development; Maternal effect genes; Pattern formation genes; Homeotic genes; Signaling and adhesion molecules; Immunogenetics: Major histocompatibility complex; Immunoglobulin genes-tissue antigen and organ transplantation; Single gene disorders of immune system
Unit V **Epigenetics** **12 Lectures**	Mutations; kinds of mutation; agents of mutation; genome polymorphism; uses of polymorphism; The epigenome, epigenetic modifications: DNA methylation, histone modification, chromatin remodeling and non-coding RNAs; cellular maintenance of the epigenome; epigenetic control of gene expression, and epigenetics and development.

	Transgenerational epigenetic inheritance.
Unit VI **Contemporary issues** **2 Lectures**	Guest lectures by academic/industry experts , online seminars - webinars
Total Lectures – 68	

Mapping with Programme Outcome

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	-	-	L	L	L	-	M	S	M	L
CO2	-	L	M	-	-	M	S	-	-	L
CO3	S	-	-	-	L	S	-	-	-	L
CO4	-	M	M	L	M	-	-	-	M	-
CO5	-	-	-	-	L	M	S	M	-	-
*S-Strong; M-Medium; L-Low										

Recommended Textbooks and References:

1. Gardner et al (1991). Principles of Genetics. John Wiley.
2. Hartl. D.L. A Primer of population genetics. III Edition, Sinauer associates inc. Sunderland, 2000
3. Human genetics, A. Gardner, R. T. Howell and T. Davies, Published by VinodVasishtha for Viva Books private limited, 2008.
4. The science of Genetics by Alan G. Atherly, Jack. R, Girton, Jhon. F, Mc Donald. Sounders college publishers.
5. Strachan and Read (2003). Human Molecular Genetics. Wiley.
6. Pasternak (2005). A Introduction to Human Genetics.
7. Prichard &Korf (2004). Medical Genetics at a Glance. Blackwell.
8. Manu L Lothari, Lopa A Mehta, Sadhana S Roy Choudhury (2009). Essential of Human Genetics (Universities Press India ltd)

Related online contents:

1. https://www.classcentral.com/course/swayam-genetics-and-genomics-17623
2. https://nptel.ac.in/courses/102/104/102104052/
3. https://www.coursera.org/learn/genetics-evolution

Course adapted from DBT curriculum and handled by Dept. of Biotechnology	**Dr. V. Vijaya Padma, Professor**

SEMESTER ONE

Developmental Biology and Human Physiology Credits 4

Course Code	20MB1C04	Course Type	Core	L	T	P	C	Syllabus version	2020-2021
				3	1	-	4		
Pre-requisite	Basic understanding of cell development and differentiation								

Course objectives:

1. To learn the basic overview of developmental biology and its key concepts.
2. To enable the students to learn the actual pathway of physiological metabolism of major invertebrates and vertebrates including humans.
3. To understand the mechanism behind functioning and maintenance of various living system

Expected Course Outcomes:

CO1	Learn the importance of embryology (historical review) and more recently developmental biology as an emerging discipline and science.	**K1**
CO2	Identify several unifying themes and differences in developmental biology with respect to anatomy, physiology and evolution in selected Invertebrates and Vertebrates species.	**K5**
CO3	Learn the process and the mechanisms of early embryonic development (fertilization, early cleavage, blastula, gastrula, neurula) in Vertebrates including frog, chicken and mouse and Invertebrates e.g. *Drosophila melanogaster* and Sea Urchin.	**K2**
CO4	Identify the molecular pathways controlling axis formation (anterior-posterior, dorsal-ventral and left-right axes) in amphibians (frog), mammals (mouse, humans) and fly (Drosophila) including the signalling molecules and key gene regulators.	**K4**
CO5	To be able to communicate scientific information about key concepts in developmental biology.	**K3**
CO6	To describe and explain the normal function of the cells, tissues, organs, and organ systems of the human body to help prepare you for a career in your chosen field (e.g. to gain content knowledge and comprehension in Biotechnology and Healthcare).	**K3**
CO7	Describe and apply theory to explain the physiology of: individual systems and/organ integrated system response.	**K2**
K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 - Create		

Unit I **Introduction to**	Defining developmental biology. Structure and function of reproductive system: Male reproductive system, Female reproductive system. Production of gametes: Spermatogenesis,

Developmental biology **12 Lectures**	Oogenesis. Cell surface molecules in sperm - egg recognition in animals; zygote formation, cleavage, blastula formation, gastrulation and formation of germ layers in animals. Early developmental events in vertebrates.
Unit II **Basic concepts of development** **14 Lectures**	Overview of homeotic genes, axis formation in sea urchin, *C. elegans*, *D. melanogaster*, amphibians and mammals; formation of vulva in *C. elegans*; Embryonic fields, potency, commitment, specification, induction, competence, determination and differentiation; morphogenetic gradients; cell fate and cell lineages; genomic equivalence and the cytoplasmic determinants; imprinting. Role of epigenetics in development. Postembryonic development: metamorphosis, regeneration and aging; Developmental constraints on evolution. Developmental defects and disorders.
Unit III **System physiology: digestion and hematology** **12 Lectures**	Homeostasis, nutrition, structure and functions of digestive system. Physiology of digestion. Blood corpuscles, haemopoiesis, plasma function, blood volume, haemostasis. Comparative anatomy of heart structure, myogenic heart, ECG- its principle and significance, cardiac cycle, heart as a pump, blood pressure, neural and chemical regulation of all above.
Unit IV **Respiration and excretion** **14 Lectures**	Comparison of respiration in different species, anatomical considerations, transport of gases, exchange of gases, waste elimination, neural and chemical regulation of respiration. Comparative physiology of excretion, kidney, urine formation, urine concentration, waste elimination, micturition, regulation of water balance, electrolyte balance and acid-base balance.
Unit V **Nervous system** **14 Lectures**	Neurons, action potential, gross neuroanatomy of the brain and spinal cord, central and peripheral nervous system. Types, structure and functions of muscles, Physiology of muscle contraction. Sense organs: vision, hearing and tactile response. Endocrine glands, basic mechanism of hormone action, hormone and diseases; Thermoregulation.
Unit VI **Contemporary issues** **2 Lectures**	Guest lectures by academic/industry experts , online seminars - webinars
Total Lectures – 68	

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	-	-	-	M	-	M	M	S	S
CO2	-	-	S	-	-	-	-	S	-	-
CO3	-	-	M	-	-	-	-	-	M	L
CO4	-	-	-	-	M	L	-	-	-	-
CO5	S	M	-	L	-	-	S	S	S	-
CO6	-	-	S	L	M	S	-	-	-	-
CO7	S	M	-	-	M	M	S	M	S	L
*S-Strong; M-Medium; L-Low										

Recommended Textbooks and References:

1. Developmental biology, (2018), 11th edition by Michael J. F. Barresi, Scott F. Gilbert.
2. Human Embryology & Developmental Biology (2019), 6th edition by Bruce M. Carlson.
3. Principles of Development (2019), 6th edition by Cheryll Tickle; Lewis Wolpert; Alfonso Martinez Arias.
4. Essentials of Animal Physiology (2019) 4th edition by Rastogi.
5. Ganong's Review of Medical Physiology (2019), 26th edition by Kim E. Barrett, Susan M. Barman, Heddwen L. Brooks, Jason Yuan, Scott Boitano.

Related online contents:

1. https://nptel.ac.in/courses/102/106/102106084/
2. https://nptel.ac.in/courses/102/104/102104058/
3. https://onlinecourses.nptel.ac.in/noc20_bt35/preview
4. https://onlinecourses.swayam2.ac.in/cec20_bt19/preview

Course adapted from DBT curriculum and handled by Dept. of Biotechnology	**Dr. P. Ekambaram, Associate Professor**

SEMESTER ONE
Biostatistics

Credits 4

Course Code	20MB1C05	Course Type	Core	L	T	P	C	Syllabus version	2020-2021
				2	1	1	4		
Pre-requisite	Basic understanding on the objectives of statistics and computations								

Course objectives:

1. Introduce the basics of biostatistics
2. Instil knowledge to compute statistical measures for analysing data
3. Instruct the applications of statistical methods for biological problems

Expected Course Outcomes:

CO1	Understand the theory and applications of basic statistics	**K1-K6**
CO2	Compute statistical measures for decision making	**K2-K3**
CO3	Formulate hypotheses and perform statistical analysis for biological problems	**K1-K6**
CO4	Perform analysis of variance for experimental designs	**K1-K6**
CO5	Make interpretations of results from the derived results	**K1-K6**
K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 - Create		

Unit I **Descriptive Statistics** **12 Lectures**	Nature of Biological, Clinical and Experimental Data – Graphical and Diagrammatic Representation of Data – Line Diagram - Box Plots – Histogram - Grouped Data – Frequency Distribution - Frequency Curve. Measures of Location: Mean, Median and Mode. Measures of Spread: Range, Standard Deviation, Quartile Deviation - Coefficient of Variation – Measures of Skewness and Kurtosis.
Unit II **Probability and Probability Distributions** **12 Lectures**	Definition of Probability – Addition and Multiplication Laws of Probability – Conditional Probability – Bayes' Rule and Applications - Random Variables: Discrete and Continuous Random Variables – Probability Function: Mass and density Functions – Permutations and Combinations – Bernoulli, Binomial, Poisson and Normal Probability Distributions – Properties and Problems. Basics of Exact Distributions.
Unit III **Hypothesis Testing: One-sample, Two-sample Multi-sample Inference** **12 Lectures**	Fundamental notions of estimation and hypothesis testing of population parameters - Null and alternative hypothesis, simple and composite hypothesis, critical region, type I and type II errors, level of significance, power function – Confidence interval for population parameters, mean and variance = Parametric Tests: One Sample Tests for the Mean and Variance of a Normal Distribution Based on normal, t and chi-square

	tests - One Sample Inference for the Binomial and Poisson Distributions. Two-sample t – Tests for Independent Samples – Paired t- Tests - Tests for the Equality of Two Variances – Analysis of Variance for One-Way and Two-Way Classified Data – Kruscal – Wallis Test. Nonparametric Tests – Sign, Wilcoxon Signed Rank, Wilcoxon Rank-Sum and Friedman Tests.
Unit IV **Regression and Correlation Methods 12 Lectures**	General Concepts – Fitting Regression Lines: Method of Least Squares – Goodness of Fit - Inferences about Parameters from Regression Lines – Interval Estimation for Linear Regression. Fitting Quadratic and Exponential Functions - Correlation Coefficient – Simple, Partial and Multiple Correlation – Inference for Correlation Coefficients – Rank Correlation.
Unit V **Statistical Computation using R Programming** **12 Lectures**	Computation Of Probability – Permutations – Combinations – Data Visualization – Line Plot, Bar Plot, Pie Chart, Box Plot, Histogram, Scatter Plot – Descriptive Statistics – Sum, Mean, Median, Mode, Range, Standard Deviation, Variation, Coefficient Of Variation – Inferential Statistics Based On Z-Test, T-Test, F-Test, Chi-Square Test, ANOVA, Sign Test, Wilcoxon Signed Rank Test, Wilcoxon Rank Sum Test, Kruskal-Wallis Test and Friedman Test - Fitting of Linear Regression, Quadratic and Exponential Functions – Computation of Simple, Partial And Multiple Correlation and Regression Coefficients.
Unit VI (Co-scholastic Component) **Basic Notions of R Programming** **8 Lectures**	Introduction to R Programming – Features of R – Data Types: Vectors, List, Matrix, Array, Data Frame and Factors – Conditional Structures – Functions: Built-In and User Defined Functions – Data Management – R Packages.
Total Lectures – 68	

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	-	S	S	-	M	S	-	L	L	S
CO2	L	-	-	L	-	-	S	-	-	-
CO3	-	-	-	L	-	-	-	L	-	-
CO4	-	-	-	-	M	-	L	-	-	-
CO5	M	S	M	-	-	S	M	-	M	L

*S-Strong; M-Medium; L-Low

Recommended Textbooks and References:

1. Rosner, B. (2016). Fundamentals of Biostatistics, Eighth Edition, Cengage Learning, Boston, MA, US.
2. Daniel, W. W., and Cross, C. L. (2013). Biostatistics: A Foundation for Analysis in the Health Sciences, Tenth Edition, John Wiley & Sons, Inc., NY, US.
3. Zar, A. H. (2010). Biostatistical Analysis, Fifth Edition, Pearson, London, UJ.
4. Campbell, R. C. (1967): Statistics for Biologists, University Press, Cambridge, UK.
5. Lewis, A. E. (1984). Biostatistics, Van Nostrand Reinhold Publications.
6. Pagano, M., and Gauvrean, K. (2018). Principles of Biostatistics, Second Edition, Chapman and Hall/CRC Press, NY.
7. Crawley, M.J. (2013). The R Book, Second Edition, John Wiley & Sons, Ltd., Chichester, UK
8. Purohit, S. G., Gore, S. D., and Deshmukh, S. R. (2008). Statistics Using R, Narosa Publishing House, New Delhi, India

Related online contents:

1. https://nptel.ac.in/courses/102/106/102106051/
2. https://nptel.ac.in/courses/102/101/102101056/
3. https://cran.r-project.org
4. https://cran.r-project.org/doc/contrib/Seefeld_StatsRBio.pdf

Remarks:

1. This course is designed to provide the theoretical and practical knowledge. The performance of the candidates shall be evaluated on the theory and application of Biostatistics as practical.
2. Continuous internal assessment is for 25 marks and comprehensive external evaluation for 75 marks, which will be split into two sections, namely 60 marks for theory with equal weightage (Unit I-IV) and 15 marks for practical examination (Unit V).
3. The contents in Unit 6 shall be considered as Co-scholastic and there shall be no examination.

Pattern of Question Paper for Biostatistics

(Theory Examination)

Time: 3 Hours **Maximum Marks: 60**

Section A – (8 x 1 = 8 Marks)

Answer *All* the questions

Each question carries *one* mark

Q. No.1. – Q. No. 8 - Objective questions with four multiple choices

Section B – (4 x 5 = 20)

Answer all the questions
Each question carries *five* marks
Q. No. 9 – Q. No. 12 - Questions with internal choices (either (a) or (b) type)

Section C – (4 x 8 = 32)
Answer all the questions
Each question carries *eight* marks
Q. No. 13 – Q. No. 16 - Questions with internal choices (either (a) or (b) type)

Pattern of Question Paper for Biostatistics: (Practical Examination)
Time: 45 Minutes **Maximum Marks: 15**
Answer all the questions
Each question carries *five* marks
Q. No. 1 – Q. No. 3 - Questions with internal choices (either (a) or (b) type

Course adapted and handled by Dept. of Statistics	**Dr. R. Vijayaragavan, Professor** **Dr. R. Jaisankar, Professor** **Dr. R. Muthukrishnan, Professor**

SEMESTER ONE

Laboratory I: Cell Biology, Microscopy, Biochemistry and Analytical Techniques **Credits** 5

Course Code	20MB1P01	Course Type	Core	L	T	P	C	Syllabus version	2020-2021
				-	-	6	5		
Pre-requisite	Fundamental skill-set in handling biological samples								

Course objectives:

1. To obtain fundamental understanding of cell biology research and its importance in human disease.
2. To provide an overview about morphological features of cells and relate them in context of healthy and diseased human body
3. To develop knowledge about advanced microscopy including live cell imaging, correlative light and electron microscopy, confocal microscopy and underlying biophysics. Obtain operational skills to handle few of them.

Expected Course Outcomes:

CO1	Learn the basic principles of microscopy. Develop application knowledge to employ appropriate microscopes for studying complexities of disease biology.	**K4**
CO2	Obtain an overview about the morphological features of animal and plant cell. Develop skills to identify these cells using microscopy and determine the morphological changes that occur during stress or disease.	**K5**
CO3	Develop skills to isolate cells for experiments and determine the viability of isolated cells. Provides hands-on experience that could be applied to handle clinical samples.	**K6**
CO4	Clear understanding and rigorous training to assess the features of cell organelles using staining procedures and monitor their changes during physiological and pathological conditions using microscopy.	**K6**
CO5	Comprehensive practical knowledge about structural components of cell and their importance in cell viability and function. Monitor the behavior of cells using live imaging under normal and distress condition and provide interpretations.	**K6**
K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 - Create		

Experiments

1. Introduction to anatomy, functioning & handling of upright and inverted epifluorescence microscope & confocal microscope.
2. Observation of suitable specimen under bright field, phase contrast, dark field and differential interference contrast (DIC) microscope.

3. Observation of animal/plant cell cultures under microscope. Measurement of cell size by oculometer and stage micrometre.
4. Low speed separation of cells from animal blood or any mammalian cells from a culture.
5. To quantify number of cells, present in given sample and assessment of cell viability.
6. Identification of Barr body by preparing buccal smear.
7. Isolation of lysosomes, nuclei & ER membranes from given samples (i.e. chicken liver) by isotonic sucrose method.
8. To study process of cellular osmosis in guard cells from plant leaves or animal blood.
9. To study cellular distribution of mitochondria by janus green staining.
10. Isolation of mitochondria from given tissue samples.
11. To assay activity of an enzyme in its natural
12. To examine number and morphology of nucleus in given tissue sample by DAPI/PI staining.
13. Analysis of Green Fluorescence Protein (GFP) tagged cells/tissue under fluorescence microscope. Quantifying intensity measurements after setting up thresholds, and improving contrast features.
14. Analysis of F-actin based cellular cytoskeleton by Phalloidin staining to the given tissue sample.
15. Localization of specific protein(s) inside the cells (in situ) by immunohistochemistry. (May be demonstrated to the students).
16. Lecture demonstration of live cell movements, dynamics of cellular organelles in relation to a function by using web-tutorials and online movies.

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	-	-	M	-	-	M	-	M	-	L
CO2	S	-	-	L	-	-	-	-	-	-
CO3	M	L	-	L	-	S	S	M	L	-
CO4	-	S	-	-	-	-	-	-	-	-
CO5	-	-	L	-	S	S	S	L	-	L

*S-Strong; M-Medium; L-Low

Course adapted from DBT curriculum and handled by Dept. of Biotechnology

SEMESTER ONE

Seminar and Communication skills **Credits** 2

Course Code	20MB1V01	Course Type	Value added	L	T	P	C	Syllabus version	2020-2021
				1	1	-	2		
Pre-requisite	Basic communication and presentation skills								

Course objectives:

1. To aid students with a good presentation skill.
2. To enable student's effective communication.

Expected Course Outcomes:

CO1	Scope of the communication skills	**K4**
CO2	Converse in the non-verbal communication	**K5**
CO3	Command over the oral communication skills	**K6**
CO4	Converse in the verbal communication	**K6**
CO5	Command over the presentation skills	**K6**
K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 - Create		

Unit I

Communication: An Introduction

4 Lectures

Definition, Nature and Scope of Communication. Importance and Purpose of Communication. Process of Communication and types of Communication

Unit II

Non-Verbal Communication

2 Lectures

Personal Appearance, Gestures, Postures, Facial Expression, Eye Contacts, Body Language, Time language, Silence and Tips for Improving Non-Verbal Communication

Unit III

Oral Communication Skills

6 Lectures

Asking for and giving information, Offering and responding to offers, Requesting and responding to requests, congratulating people on their success, asking questions and responding politely, Apologizing and forgiving, giving instructions, Seeking and giving permission, expressing opinions (likes and dislikes), Agreeing and disagreeing, demanding explanations, asking for and giving advice and suggestions and Expressing sympathy.

Unit IV

Verbal Communication

6 Lectures

Elements of Effective Writing, The Sentence, Phrases and Clauses , Types of Sentences, Main Forms of Written Communication, Paragraph Writing (Linkage and Cohesion), Letter Writing (formal and informal), Essay writing and Notices

Unit V **Presentation Skills** **4 Lectures**	Preparing a PowerPoint Presentation, Greeting and introducing, presenting a Paper, Group Discussions, preparing for and Facing a Job Interview
Unit VI **Contemporary issues** **2 Lectures**	Guest lectures by academic/industry experts , online seminars - webinars
Total Lectures – 24	

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	L	-	L	-	S	M	L	M	L	S
CO2	-	S	-	S	-	-	-	-	-	-
CO3	-	-	-	-	-	L	L	M	-	S
CO4	-	M	L	-	-	L	-	-	L	-
CO5	L	-	-	L	-	-	L	-	-	-

*S-Strong; M-Medium; L-Low

Recommended Textbooks and References:

1. Wren, P. C., & Martin, W. (2005). High school English grammar and composition. S Chand.
2. Usmanova, M., &Xaydarova, N. (2020). ENGLISH GRAMMAR BASICS. Inter Conf.
3. McCorry, L. K., & Mason, J. (2020). Communication skills for the healthcare professional. JONES & BARTLETT PUB Incorporated.
4. MacDonald-Wicks, L., &Levett-Jones, T. (2012). Effective teaching of communication to health professional undergraduate and postgraduate students: A Systematic Review. JBI Database of Systematic Reviews and Implementation Reports, 10(28), 1-12.

Related online contents:

1. Business English Communication - Dr. AyshaIqbalViswamohan – IIT Madras
2. English Language for Competitive Exams - Dr. AyshaIqbalViswamohan – IIT Madras
3. Communication Skills - Dr. T. Ravichandran – IIT Kanpur

Course adapted from DBT curriculum and handled by Dept. of Biotechnology	**Dr. R. Sathishkumar, Professor**

Second Semester

SEMESTER TWO

Immunology and ImmunotechnologyCredits 4

Course Code	20MB1C06	Course Type	Core	L	T	P	C	Syllabus version	2020-2021
				3	1	-	4		
Pre-requisite	Basic concepts in immune system								

Course objectives:

1. Learn about structural features of components of immune system as well as their function.
2. Emphasis on development of immune system and mechanisms by which our body elicit the immune response.
3. Understand the imperative to think like an immunologist and predict about nature of immune response that develops against bacterial, viral or parasitic infection, and prove it by designing new experiments.

Expected Course Outcomes:

CO1	Evaluate the usefulness of immunology in different pharmaceutical companies.	**K1, K2**
CO2	Acquire knowledge on antibodies and their commercial importance in diagnosis and treatment of human diseases.	**K1, K2**
CO3	Apply their knowledge and design immunological experiments to demonstrate innate, humoral or cytotoxic T lymphocyte responses and figure out the kind of immune responses in the setting of infection (viral or bacterial) by looking at cytokine profile.	**K1, K2**
CO4	Understand the importance of vaccine development and identify the proper research lab working in the area of vaccine production.	**K1, K4**
CO5	Distinguish and characterize the CD4+ and other T helper cell lineages in the regulatory T cell.	**K1, K2**
K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 - Create		

Unit I **Immunology: Fundamental concepts and anatomy of the immune system** **12 Lectures**	Components of innate and acquired immunity; Important organs and cells of immune responses, complement and inflammatory responses; pathogen recognition receptors (PRR) and pathogen associated molecular pattern (PAMP); innate immune response; mucosal immunity; antigens - immunogens, haptens; Major histocompatibility complex (MHC) genes, Role of MHC in infectious diseases and disease susceptibility, HLA typing.
Unit II **Immune responses generated by**	Immunoglobulins-basic structure, classes & subclasses of immunoglobulins, antigenic determinants;

B and T lymphocytes **16 Lectures**	multigeneorganization of immunoglobulin genes; B-cell receptor; Immunoglobulin superfamily; principles of cell signaling; basis of self & non self-discrimination; kinetics of immune response, memory; B cell maturation, activation and differentiation; generation of antibody diversity; T-cell maturation, activation and differentiation and T-cell receptors; functional T Cell subsets; cell-mediated immune responses, ADCC; cytokines-properties, receptors and therapeutic uses; antigen processing and presentation- endogenous antigens, exogenous antigens, non-peptide bacterial antigens and super-antigens; cell-cell co-operation.
Unit III **Antigen-antibody interactions** **14 Lectures**	Precipitation, agglutination and complement mediated immune reactions; advanced immunological techniques - RIA, ELISA, Western blotting, ELISPOT assay, immunofluorescence, flow cytometry and immunoelectron microscopy; surface plasmon resonance, biosensor assays for assessing ligand–receptor interaction, CMI techniques- lymphoproliferation assay, mixed lymphocyte reaction, cell cytotoxicity assays, apoptosis, microarrays, transgenic mice, gene knock outs, Hybridoma and monoclonal antibodies, Applications of monoclonal antibodies.
Unit IV **Vaccinology** **14 Lectures**	Active and passive immunization; live, killed, attenuated, subunit vaccines; vaccine technology- role and properties of adjuvants, recombinant DNA and protein based vaccines, reverse vaccinology; peptide vaccines, conjugate vaccines; antibody genes and antibody engineering- chimeric, hybrid monoclonal antibodies; catalytic antibodies and generation of immunoglobulin gene libraries, idiotypic vaccines and marker vaccines, viral-like particles (VLPs), dendritic cell based vaccines, vaccine against cancer, T cell based vaccine, edible vaccine and therapeutic vaccine; Success stories in vaccinology*e.g.* Hepatitis, Polio, Small pox, DPT.
Unit V **Clinical Immunology** **14 Lectures**	Immunity to infection: bacteria, viral, fungal and parasitic infections (Tuberculosis, HIV/ AIDS, Schistosomiasis, Kala Azar, Chikungunya, Dengue); hypersensitivity reactions – Type I-IV; autoimmunity; types of autoimmune diseases; mechanism and role of CD4+ T cells; MHC and TCR in autoimmunity; transplantation – immunological basis of graft rejection; clinical transplantation and immunosuppressive therapy; tumor immunology – tumor antigens; immune response to tumors and tumor evasion of the immune system, cancer

	immunotherapy; immunodeficiency-primary immune deficiencies, acquired or secondary immune deficiencies, anaphylactic shock.
Unit VI **Contemporary issues** **2 Lectures**	Guest lectures by academic/industry experts , online seminars - webinars
Total Lectures – 72	

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	-	-	-	-	-	L	S	L	-
CO2	-	-	M	-	M	S	L	-	-	S
CO3	-	L	S	-	-	S	-	-	-	M
CO4	-	-	M	-	M	-	S	-	-	-
CO5	-	L	-	-	-	-	-	-	M	-

*S-Strong; M-Medium; L-Low

Recommended Textbooks and References:

1. Parham, P. (2014). The Immune System (4th edition). W. W. Norton & Company.
2. Murphy, K., Travers, P., Walport, M., &Janeway, C. (2012). *Janeway'sImmunobiology.* New York: Garland Science.
3. Paul, W. E. (1993). Fundamental Immunology. New York: Raven Press.
4. Goding, J. W. (1986). Monoclonal Antibodies: Principles and Practice: Production and Application of Monoclonal Antibodies in Cell Biology, Biochemistry, and Immunology. London: Academic Press.
5. Peter J. Delves, Seamus J. Martin, Dennis R. Burton, and Ivan M. Roitt (2017). Essential Immunology (13th edition). USA: John Wiley & Sons Ltd.
6. Kindt, T. J., Goldsby, R. A., Osborne, B. A., &Kuby, J. (2006). Kuby Immunology. New York: W.H. Freeman.

Related online contents:

1. http://epgp.inflibnet.ac.in/
2. http://www.partone.litfl.com/basal_metabolic_rate.html#id
3. https://www.edx.org/course/principles-of-biochemistry

Course adapted from DBT curriculum and handled by Dept. of Biotechnology	**Dr. S. Velayuthaprabhu, Assistant Professor**

SEMESTER TWO

Biophysical Principles and Analytical Techniques

Credits 4

Course Code	20MB1C07	Course Type	Core	L	T	P	C	Syllabus version	2020-2021
				3	1	-	4		
Pre-requisite	Basic principles of analytical techniques and instrumentation								

Course objectives:

1. Provide a broad exposure to all basic techniques (Biochemical and Biophysical) used in contemporary modern biology research.
2. Impart a basic conceptual understanding of principles of these techniques and emphasize on the biochemical utility of the same and underlying biophysics.
3. Impart an understanding of all the analytical techniques such that the barrier to implement the same is abated to a great extent.
4. Transform students to skilled workers for executing research with the aid of modern analytical instruments.

Expected Course Outcomes:

CO1	Learn how to combine previously acquired knowledge of physical chemistry and biochemistry to understand biochemical processes at the molecular level.	**K1, K2**
CO2	Obtain a comprehensive knowledge about electromagnetic radiation and different spectroscopic techniques	**K2, K4**
CO3	Gain an in-depth understanding of various forms of centrifugation techniques, radioactivity, and radio isotopic techniques.	**K2, K4**
CO4	Understand the working principle and application of important separation and identification techniques that are widely applied in the field of molecular biology and chemical biology.	**K2, K3, K4, K5**
CO5	Operate microscopic and spectroscopic devices for advanced research activities.	**K4, K5**
CO6	Ability to make new advanced instruments in the field of biotechnology.	**K6**
K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 - Create		

Unit I **Basics** **10 Lectures**	Units of measurement of solutes in solution; Normality, molality, molarity, millimol and ppm; Water- structure and properties; Principles of glass and reference electrodes, types of electrodes, complications of pH measurement (dependence of pH on ionic strength, pH, pOH, Hendersen-Hasselbach equations, buffers, pH of body fluids, buffers in body fluids, red

	blood cells and tissues. Length scales in biological systems: proteins, multiprotein complexes, organelles & cells; Basic thermodynamics; Basic chemical kinetics & reaction rates: Theory of chemical reactions.
Unit II **Basic Principles of Electromagnetic Radiation and Related Spectroscopic Techniques** **12 Lectures**	Energy, wavelength, wave number and frequency; Absorption and emission spectra, Beer-Lambert's law, light absorption and its transmittance; UV and visible spectrophotometry-principles, instrumentation and applications on enzyme assay and kinetic assays, protein structural studies, nucleic acid structural studies; Basic principles, instrumentation and applications of UV-visible, IR, fluorimetry, atomic absorption and emission spectrophotometry; Basic principles, instrumentation and applications of ESR, NMR; Biochemical applications of fluorescence, emission, Fluorescence life-times, Anisotropy, time-resolved fluorescence methods and their applications, IR-Raman Spectroscopic applications in biology.
Unit III **Hydrodynamic Methods, Radioactivity and Radio isotopic Techniques** **14 Lectures**	Basic principles and types of centrifugation-rotors, boundary, differential, density gradient, zonal isopycnic centrifugation, equilibrium; Sedimentation - sedimentation velocity, preparative and analytical ultracentrifugation techniques: principles & applications in biochemical fractionation methods. Radioactivity, stable and radioactive isotopes, concepts of half-life and decay, principles of scintillation counting, GM counters, applications of isotopes, Isotope dilution technique, autoradiography, turnover studies, precursor-product relationship, production of radio-labelled biomolecules, calculations involving isotopes, radiation hazards and methods for contaminant prevention; Nature of radioactivity, properties of α, β and γ-rays, measurement of radioactivity, use of radioisotopes in research, *In vivo* and *in vitro*labelling techniques, double labelling, quenching, internal standard, channel ratio, external standard ratio, emulsion counting, radioactive decay; Application of radioactive isotopes in biochemical reaction mechanisms.
Unit IV **Electrophoresis, Chromatography, X-Ray Crystallography, Molecular and Chemical Biology** **18 Lectures**	Principles of electrophoretic separation, zonal and continuous electrophoresis, paper, cellulose acetate/nitrate, gel and capillary electrophoresis, use of native and denaturating gels, Protein subunit molecular weight determination using SDS-PAGE, Anomalous protein migration of some proteins in SDS-PAGE, Acid-urea PAGE and their physical basis, Isoelectric focusing and two dimensional gel electrophoresis, electroporation, pulse field gel electrophoresis, gradient gels. Chromatography, principles of adsorption, partition and ion-exchange chromatography, gel permeation chromatography, GC, GC-MS and HPLC; X-ray Crystallography - protein

	crystals, Bragg's law, unit cell, isomorphous replacement, fiber pattern of DNA; Small-angle X-ray diffraction methods: Principles & applications; Basic protein structure prediction methods. DNA cloning; bacterial transformation; transfection; chromosome integration; screening for transformants; Polymerase Chain Reaction; PCR types; Gel electrophoresis; DNA sequencing; Molecular hybridization: Southern blot; Northern blot. Protein analyses: Western blot &Immunoprecipitation; Rewriting DNA: mutations; random mutagenesis; point mutation; Site-specific mutations; Genome Editing Technology; DNA array & protein array; Click-chemistry: Principles & applications; Chemical sensors for in-cell biochemistry**.**
Unit V **Optical Tweezers, Optical Microscopy Methods, and Mass Spectroscopy** **14 Lectures**	Principles & applications; single-molecule measurements, Atomic Force microscopy, Near-field Microscopy: Principles & applications. Force measurements at single molecule to cell level using optical tweezers, mechanobiology. Light Microscopy: lenses and microscopes, resolution: Rayleigh's Approach, Darkfield; Phase Contrast; Differential Interference Contrast; fluorescence and fluorescence microscopy; Confocal microscope: confocal principle, resolution and point spread function; nonlinear microscopy: multiphoton microscopy; principles of two-photon fluorescence, advantages of two-photon excitation, tandem scanning (spinning disk) microscopes, deconvolving confocal images; image processing, three-dimensional reconstruction; Total Internal reflection microscopy, STED microscopy. Ionization techniques; mass analyzers/overview MS; FT-ICR and Orbitrap, fragmentation of peptides; proteomics, nano LC-MS; Phospho proteomics; interaction proteomics, mass spectroscopy in structural biology; imaging mass spectrometry
Unit VI **Contemporary issues** **2 Lectures**	Guest lectures by academic/industry experts, online seminars - webinars
Total Lectures – 70	

Mapping Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	L	-	-	M	S	-	M	L	L
CO2	S	-	-	-	-	-	-	-	-	L
CO3	-	-	-	-	-	-	S	-	-	M
CO4	-	-	S	-	-	-	S	-	M	-
CO5	-	S	-	L	-	-	-	L	-	-
CO6	-	-	-	-	M	S	-	-	S	-

*S-Strong; M-Medium; L-Low

Recommended Textbooks and References:

1. David Friefelder, (1983), Physical Biochemistry, 2nd edition, W.H. Freeman and Co., USA.
2. G.H. Jeffery, J. Bassett. J. Mendham, R.C. Denney, (1991), Vogel's Textbook of Quantitative Chemical Analysis, 5th Edition, ELBS, England.
3. P.W. Atkins, (1996), The Elements of Physical Chemistry, Oxford University Press.
4. Brigal.L. Williams, A biologist guide to principle and techniques of practical biochemistry.
5. K Wilson and J Walker (eds.), (1999). Principles and Techniques of Practical Biochemistry, 4th edition, Cambridge Univ.Press.
6. R.A. Day, A.L. Underwood, Quantitative Analysis, (1999), 6th Edition; Prentice-Hall of India Pvt. Ltd., New Delhi.
7. Plummer, (2002). An Introduction to Practical Biochemistry, 3rd edition, Tata McGraw Hill.
8. Jack A. Tuszynski Michal Kurzynski, Introduction to Molecular Biophysics, CRC Press.
9. Sharma. BK. Instrumental methods of chemical analysis.
10. Upadhyay, Upadhyay and Nath, Biophysical chemistry.
11. Khandpur R.S. Handbook of biomedical instrumentation, Tata McGraw Hill.

Related online contents:

1. https://onlinecourses.swayam2.ac.in/ugc19_bt16/preview
2. https://nptel.ac.in/courses/102/107/102107028/
3. https://nptel.ac.in/courses/102/103/102103044/
4. https://www.slideshare.net/ArunimaSur/analytical-techniques-in-biochemistry-and-biophysics-for-macro-molecules
5. https://www.biophysics.org/education-careers/education-resources/selected-topics-in-biophysics/biophysical-techniques

Course adapted from DBT curriculum and handled by Dept. of Biotechnology	**Dr. M. Arun, Assistant Professor**

SEMESTER TWO

Medical Microbiology and Infection Biology — Credits 4

Course Code	20MB1C08	Course Type	Core	L	T	P	C	Syllabus version	2020-2021
				3	1	-	4		
Pre-requisite	A basic knowledge in microbiology and infectious diseases								

Course objectives:

1. To impart knowledge on Medical Microbiology with special reference to Bacteria, viruses, fungi, protozoan and sexually transmitted diseases.
2. To understand, epidemiology, pathogenesis, prevention and treatment of various diseases.
3. To enlighten on sexually transmitted diseases and congenital diseases.
4. To obtain overall holistic knowledge on host-parasite relationship.

Expected Course Outcomes:

CO1	Learn the importance of microorganisms and their association with human health	**K1, K2**
CO2	Get introduced to clinical terms related to diseases	**K2, K3**
CO3	Obtain knowledge on diseases caused through bacteria, viruses, fungi, protozoan, sexually transmitted and congenital diseases.	**K2, K3, K4**
CO4	Understand on diagnosis and therapy.	**K4, K5**
CO5	Critically think on the role of those in medical profession in combating microbes.	**K5, K6**
CO6	Apply the knowledge towards Molecular Diagnostics	**K6**
CO7	Get holistic picture on Microbes as a whole with Biotechnologist perspective	**K2**
K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 - Create		

Unit I **Bacterial Diseases** **14 Lectures**	Pathogenesis and virulence factors - Koch's postulates, Adherence and invasion, Toxins, Enzymes, Antiphagocytic factors, Antigenic heterogeneity, Iron acquisition; *Bacillus anthracis, Clostridium* spp., *Coryne bacterium diptheriae; E. coli, Vibrio cholerae, Helicobacter pylori, Salmonella typhi and paratyphi, Shigelladysenteriae; Listeria monocytogenes, Mycobacterium* spp., Rickettsial diseases; *Haemophilusinfluenzae, Bordetella pertussis*, Brucellosis, Streptococcal and Staphylococcal infections; Chlamydial infections (*Chlamydia trachomatis*); Antibacterial chemotherapy (with examples of antibiotics) - Inhibition of cell wall synthesis, inhibition of cell membrane function, inhibition of protein and nucleic acid synthesis, antimetabolites
Unit II **Viral and sexually transmitted diseases**	Viral Pathogenesis - Routes of entry, Viral spread (local and systemic infection), Viral persistence (chronic and latent infection); Polio, Chicken pox, Mumps, Measles, Rubella; Viral hemorrhagic fever, viral encephalitis, Dengue and Yellow fever; Influenza virus

14 Lectures	infection (emphasis on Avian and swine flu), Rabies and Prion diseases; Hepatitis and Human Cancer viruses; Emerging viral diseases – Ebola, Marburg, SARS, Hanta, Chikungunya, Zika, Chandipura; Antiviral chemotherapy and Viral vaccines; Nucleotide and nucleoside analogs, Reverse transcriptase inhibitor, protease inhibitor, fusion inhibitor, etc., Interferons, Killed and attenuated vaccines. Sexually transmitted diseases and congenital infections: Syphilis and Gonorrheal infections; AIDS and Lentiviral infection; Herpes infections; Congenital viral infections – Cytomegalovirus, Varicella zoster, HBV, Enterovirus, Parvovirus B19, etc.
Unit III **Fungal and Protozoan Diseases** **14 Lectures**	Types of Mycoses (with specific example of causative fungi) – Superficial, Cutaneous, Sub-cutaneous; Types of Mycoses (with specific example of causative fungi) - Endemic and Opportunistic; Mycotoxins and Antifungal chemotherapy – Mycetismus, Aflatoxins, classes of currently available drugs and new inhibitors in the pipeline; Protozoan diseases - Giardiasis, Amoebiasis; Leishmaniasis, African sleeping sickness; Malaria, Cryptosporidiosis; Infection by Helminths – Nematodes, Trematodes, Cestodes. Mycoplasma and Urea plasma infection; Toxoplasmosis.
Unit IV **Host-pathogen interaction** **14 Lectures**	Intracellular and extracellular pathogens, Principles of microbial pathogenesis, host damage, inflammatory responses, adaptation strategies of pathogen- impact of host and pathogen metabolism on immunity and pathogen survival; Chronic pathogens and mechanisms of persistence; Evasion mechanisms of pathogens; Bacterial – host interaction- *Mycobacterium tuberculosis*, *Borreliaburgdorferi*; Viruses – host interaction: HIV, Influenza; Protozoan – host interaction: *Plasmodium* sp., *Leishmania major*. Drug resistance - origin (genetic and non-genetic), mechanisms, antimicrobial activity *in vitro* and *in vivo*, Multi-drug resistance and its mechanisms *e.g.* MDR-TB; Nosocomial infection
Unit V **Human Microbiome** **12 Lectures**	Normal microflora (microbiome) of human body and its role – Skin, mouth and respiratory tract, intestinal tract, urogenital tract; Beneficial organisms of human microbiome mechanism of action, role in health, Human microbiome project. Prebiotics-Concept, definition, criteria, types and sources of prebiotics, prebiotic and gut microflora, health benefits
Unit VI **Contemporary issues** **2 Lectures**	Guest lectures by academic/industry experts , online seminars - webinars
Total Lectures – 70	
Self-study **AI in Medical**	• Applications of Artificial Intelligence in Clinical Microbiology Diagnostic Testing https://www.sciencedirect.com/science/article/abs/pii/S019643992

Microbiology	0300258 • Artificial intelligence: Applications for the clinical microbiology lab today https://asm.org/Webinars/AI-Webinar • Artificial intelligence in Microbiology for faster actionable results https://www.mlo-online.com/information-technology/artificial-intelligence/article/13009222/artificial-intelligence-in-microbiology-for-faster-actionable-results • Image analysis and artificial intelligence in infectious disease diagnosis,https://www.clinicalmicrobiologyandinfection.com/article/S1198-743X(20)30155-5/abstract • Application of Artificial Intelligence to Predictive Microbiology https://www.researchgate.net/publication/290131735_Application_of_Artificial_Intelligence_to_Predictive_Microbiology

Mapping with Programme Outcomes:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	-	L	-	L	M	S	-	-	-	S
CO2	-	-	-	-	-	-	-	S	S	-
CO3	-	-	S	M	-	-	S	M	-	-
CO4	-	L	-	-	M	-	-	M	-	-
CO5	-	-	-	-	-	-	S	S	-	-
CO6	S	-	-	-	L	S	-	M	S	-
CO7	-	L	S	M	M	-	S	L	-	M

*S-Strong; M-Medium; L-Low

Recommended Textbooks and References:

1. KC Carroll, SA Morse, T Mietzner, S Miller. (2016) Jawetz, Melnick and Adelbergs's*Medical Microbiology* 27th edition, McGraw Hill. W.H. Freeman and Co.
2. IT Kudva, NA. Cornick, PJ Plummer, Q Zhang, TL Nicholson, JP Bannantine and BH Bellaire. *Virulence Mechanisms of Bacterial Pathogens*, (2016) 5th edition, ASM Press.
3. V Kumar, AK Abbas and JC Aster, (2015), *Robbins &Cotran Pathologic Basis of Disease.* 9th Edition, Elsevier.
4. AK Abbas, (2015), *Cellular and Molecular Immunology*. 8th Edition, Elsevier. Ananthanarayan and Paniker, *Textbook of Microbiology*, 8th Edition
5. Baveja CP, (2001) *Textbook of Microbiology.* 5th Ed., Mcgraw Hill Education.
6. J Owen, J Punt and Sharon Stranford, (2012), *Kuby Immunology*; 7th edition.

   K Murphy and K Weaver, (2016), *Janeway'sImmunobiology*, 9th Edition, Garland Science.

Related online contents:

1. https://www.news-medical.net/life-sciences/Human-Microbiome-Project-(HMP).aspx
2. https://www.news-medical.net/life-sciences/Microbiome-and-Disease.aspx
3. https://bio.libretexts.org/Bookshelves/Human_Biology/Book%3A_Human_Biology_(Wakim_and_Grewal)/20%3A_Immune_System/20.7%3A_Human_Microbiome
4. https://kids.frontiersin.org/article/10.3389/frym.2017.00035
5. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6463098
6. https://www.coursera.org/learn/bacterial-infections
7. https://www.coursera.org/learn/parasitology
8. https://www.udemy.com/course/medvirone/
9. https://www.classcentral.com/course/canvas-network-intro-to-medical-microbiology-1-bacteriology-12514

Course adapted from DBT and handled by Dept. of Microbial Biotechnology	**Dr. J. Angayarkanni, Associate Professor** **Dr. BrindhaPriyadarshini, Assistant Professor**

SEMESTER TWO
Bioinformatics **Credits** 4

Course Code	20MB1C09	Course Type	Core	L	T	P	C	Syllabus version	2020-2021
				2	-	2	4		
Pre-requisite	Basic knowledge in Biology								

Course objectives:

1. Make the students understand the both theory and practical aspects of Bioinformatics.
2. Know the computational methods for Sequence Alignment, Multiple Sequence alignment and Evolutionary analysis.
3. Understand the steps in Protein modeling and structure predication
4. Genome sequencing technologies and analysis methods

Expected Course Outcomes:

CO1	Gain working knowledge of these computational tools and methods	**K1**
CO2	Develop an understanding of the basic theory of these computational tools	**K2**
CO3	Interpret the algorithms, scoring functions involved in the sequence alignment.	**K3**
CO4	Evaluate the phylogenetic relationship of an organism from sequences using bioinformatics tools.	**K4**
CO5	Model 2D and 3D structure of a target from the sequence.	**K5**
K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 - Create		

Unit I **Bioinformatics basics** **12 Lectures**	Bioinformatics basics: Computers in biology and medicine; Importance of Unix and Linux systems and its basic commands; Database concepts; Protein and nucleic acid databases; Structural databases; databases and search tools: biological background for sequence analysis; Identification of protein sequence from DNA sequence; searching of databases for similar sequences; NCBI; publicly available tools; resources at EBI; resources on the web; database mining tools.
Unit II **DNA sequence analysis** **14 Lectures**	DNA sequence analysis: gene bank sequence database; submitting DNA sequences to databases and database searching; sequence alignment; pairwise alignment techniques; motif discovery and gene prediction; local structural variants of DNA, their relevance in molecular level processes, and their identification; assembly of data from genome sequencing - Multiple sequence alignment; similarity searching with the FASTA3 programme package; use of CLUSTAL W and

	CLUSTAL X for multiple sequence alignment; methods of phylogenetic analysis
Unit III **Protein modelling** **14 Lectures**	Protein modelling: introduction; force field methods; energy, buried and exposed residues; side chains and neighbours; fixed regions; hydrogen bonds; mapping properties onto surfaces; fitting monomers; RMS fit of conformers; assigning secondary structures; sequence alignment- methods, evaluation, scoring; protein completion: backbone construction and side chain addition; small peptide methodology; software accessibility; building peptides; protein displays; substructure manipulations, annealing
Unit IV **Protein structure prediction and docking** **14 Lectures**	Protein structure prediction: protein folding and model generation; secondary structure prediction; Chou-Fasman, GOR method, Neural Network; analyzing secondary structures; homology modelling: potential applications, description, methodology, homologous sequence identification; align structures, align model sequence; Threading and Fold recognition; RAPTOR; Validation of the Model; Ramachandran Plot; PROCHECK; Elements of *in-silico* drug design; Virtual library; AutoDock; Drug-receptor interaction. Pymol, Rasmol viewer
Unit V **Genome analysis** **14 Lectures**	Genome Projects; Genome sequencing technologies and analysis methods; Microarrays; Next Generation Sequencing; Next Generation Sequencing technologies; Analysis of gene expression data; Function, gene set enrichment and pathway analysis; BiNGO and DAVID tools.
Unit VI **Contemporary issues** **2 Lectures**	Guest lectures by academic/industry experts , online seminars - webinars
Total Lectures – 70	

Mapping Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	-	S	-	-	S	-	L	-	-	L
CO2	M	-	-	L	-	M	-	M	-	M
CO3	L	S	S	-	-	-	S	-	-	-
CO4	-	-	-	-	-	-	L	M	-	-
CO5	-	S	-	-	S	S	L	-	L	-

*S-Strong; M-Medium; L-Low

Recommended Textbooks and References:

1. Lesk, A. M. (2002). Introduction to Bioinformatics. Oxford: Oxford University Press.
2. Mount, D. W. (2001). Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press
3. Bourne, P. E., &Gu, J. (2009). Structural Bioinformatics. Hoboken, NJ: Wiley-Liss.
4. Andrew R. Leach Molecular Modeling: Principles and Applications.
5. Lesk, A. M. (2004). Introduction to Protein Science: Architecture, Function, and Genomics. Oxford: Oxford University Press
6. Genomes T.A Brown, 2001, Taylor and Francis Group.
7. Understanding Bioinformatics, Jeremy O. Baum, Marketa J. Zvelebil. 2007, Garland Science, USA
8. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, Andreas D. Baxevanis, B. F. Francis Ouellette, 1998, Wiley Publishers
9. Textbook of Drug Design and Discovery, KristianStromgaard, PovlKrogsgaard-Larsen, Ulf Madsen, 2009, CRC Press.
10. Comparative Genomics Ann Gibbons, 1998, Science.

Related online contents:

1. SWAYAM - Bio-Informatics: Algorithms and Applications - Prof. M. Michael Gromiha – IIT Madras
2. https://nptel.ac.in/courses/102/103/102103044/

Course adapted from DBT and handled by Dept. of Bioinformatics	**Dr. N. Jeyakumar, Professor**

SEMESTER TWO

OMICS: Genomics, Transcriptomics, Proteomics and Metabolomics — **Credits** 4

Course Code	20MB1C10	Course Type	Core	L	T	P	C	Syllabus version	2020-2021
				3	1	-	4		
Pre-requisite	Basic exposure to OMICS technologies								

Course objectives:

1. To learn about the omics discipline and to be clear about the terminologies.
2. To introduce Genomics and other global Omics technologies, theory, and application aspects of these technologies.
3. The student should be able to gain a working knowledge of these technologies and appreciate their ability to impart a global understanding of biological systems and processes in human health and disease.

Expected Course Outcomes:

CO1	Describes in detail on prokaryotic, eukaryotic genome organization and tools for genome analysis	**K1, K2**
CO2	Elaborate on the microarray technology	**K2, K3**
CO3	A brief explanation of diverse sequencing techniques along with case study.	**K2, K3**
CO4	Explains about proteomics and its techniques	**K3, K4,**
CO5	Discusses the importance of metabolomics and data processing	**K5, K6**
K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 - Create		

Unit I

Introduction to Genomics

16 Lectures

Structure and organization of prokaryotic and eukaryotic genomes- nuclear, mitochondrial and chloroplast genomes; Computational analysis, Databases, Finding genes and regulatory regions; Tools for genome analysis- PCR, RFLP, DNA fingerprinting, RAPD, SNP detection, SSCP, FISH to identify chromosome landmarks; Human Genome Project-landmarks on chromosomes generated by various mapping methods, BAC libraries and shotgun libraries preparation, Physical map, Cytogenetic map, Contig map, Restriction map, UCSC browser.

Unit II

Microarray Technology

12 Lectures

Introduction, Basic principles and design, cDNA and oligonucleotide arrays, DNA microarray, Instrumentation, and structure; Designing a microarray experiment - The basic steps, Types of microarray - expression arrays, protein arrays, Comparative Genomic Hybridization (CGH) arrays, Resequencing arrays; Different platforms (Affymetrix, Agilent,

	etc.); Data Processing and Normalization - Algorithms of data processing and Normalization; Tools used to normalize; Microarray databases- NCBI; GEO (Gene Expression Omnibus), ArrayExpress (EBI); Functional Analysis: Differential gene expression; Gene Ontology functional enrichment tools, Pathway analysis (KEGG Database); Applications of Microarray technology; case studies.
Unit III **Sequencing Technologies** **14 Lectures**	Introduction to sequencing, Maxam and Gilbert method, Sanger Sequencing techniques and applications; Next Generation sequencing (NGS), Introduction to NGS, Experimental protocol (Isolation of DNA/RNA), quality check, Library Preparations, sequencing reaction); Platform overview and comparison (Illumina, 454 (Roche), SOLiD (Life technology), Specific Biosciences, Ion Torrent, Nanopore, PacBio; Types of NGS, DNA-sequencing - Whole genome sequencing, exome sequencing, Deep sequencing, ChIP sequencing, RNA-sequencing and the types (small RNA sequencing, non-coding RNA sequencing), Whole transcriptome sequencing; Data Processing and Analysis: Data Quality Check, filtering and Genome assembly and mapping to reference genomes, mapping tools (bowtie, maq, etc,), Sequence Alignment formats: Sequence Alignment/Map (SAM) format, Binary Alignment/Map (BAM) format, Functional Analysis: Pathway analysis, Gene Ontology analysis; Application of different sequencing technique, methylomics, *in vivo* protein binding, genome wide association studies (GWAS), Histone modification, microbial sequencing, Comparison of Microarray technology and High throughput sequencing technology, case studies.
Unit IV **Proteomics** **14 Lectures**	Overview of protein structure-primary, secondary, tertiary and quaternary structure, Relationship between protein structure and function; Outline of a typical proteomics experiment, Identification and analysis of proteins by 2D analysis, Spot visualization and picking; Tryptic digestion of protein and peptide fingerprinting, Mass spectrometry: ion source (MALDI, spray sources), analyzer (ToF, quadrupole, quadrupole ion trap) and detector; Post-translational Modifications: Quantitative proteomics, clinical proteomics, and disease biomarkers, mass spectral tissue imaging, and profiling; Protein-protein interactions: Surfaceomes and Secretomes, Solid-phase ELISA, pull-down assays (using GST-tagged protein) tandem affinity purification for western analysis, by surface plasmon resonance technique; Yeast two-hybrid system, Phage display, Protein interaction maps, Protein arrays-definition; applications-diagnostics, expression profiling.

Unit V **Metabolomics** **12 Lectures**	Introduction and overview of metabolites, sample collection and processing, Non-tracer and tracer (radiolabeled)- based techniques in metabolomics (HPLC, NMR, LC-MS, and GC-MS); Metabolome data processing derived by various techniques, analysis of databases (MetaboLight, Meta Cyc, MMCD, etc.), Analysis tools, Metabolic pathways, and network analysis Metabolic flux analysis (TCA, Amino acids, fatty acids, intermediary metabolites), Stoichiometric metabolic flux analysis, 13C metabolic flux analysis (MFA), Metabolic control analysis (MCA); Applications of metabolomics; Integration of metabolomics data sets with other data (eg. Transcriptomics, enzyme activity, etc.).
Unit VI **Contemporary issues** **2 Lectures**	Guest lectures by academic/industry experts , online seminars - webinars
Total Lectures – 70	

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	-	L	S	-	M	M	-	S	-	-
CO2	-	-	-	M	-	S	-	-	-	M
CO3	-	-	-	-	-	-	S	-	S	S
CO4	-	S	-	L	-	S	-	-	-	L
CO5	M	-	S	-	-	-	S	S	S	L
*S-Strong; M-Medium; L-Low										

Recommended Textbooks and References:

1. Brown TA (2006) Genomes, 3rd Edition, Garland Science.
2. Campbell AM and Heyer LJ (2007) Discovering Genomics, Proteomics, and Bioinformatics. 2nd Edition. Benjamin Cummings.
3. Primrose S and Twyman R (2006) Principles of Gene Manipulation and Genomics, 7th Edition, Blackwell.
4. Rehm H (2006) Protein Biochemistry and Proteomics, 4th Edition, Academic Press.
5. Twyman RM. (2013) Principles of Proteomics, Second Edition by Garland Science Taylor & Francis Group New York and London.
6. Liebler DC (2002) Introduction to Proteomics: Tools for the New Biology, Humana Press, Totowa NJ. USA.

7. Griffiths WJ, Metabolomics, Metabonomics and Metabolite Profiling, (The Royal Society of Chemistry UK) (2008) ISBN 978-0-85404-299-9
8. Teresa Whei-Mei Fan (Editor), Andrew M. Lane (Editor), Richard M. Higashi (Editor) (2012) The Handbook of Metabolomics, Springer ISBN 978-1-61779-618-0.
9. A.M Lesk (2007) Introduction to Genomics. Oxford University Press. ISBN-10: 0199557489
10. Daniel C. Liebler (2002) Introduction to Proteomics: Tools for the New Biology., Humana Press Inc. ISBN-10: 0896039919
11. David W. Mount (2004) Bioinformatics – Sequence and Genome Analysis –Cold Spring Harbor Laboratory Press, U.S.; 2nd Edition. ISBN-10: 9746520709
12. Xing Xiong (2006) Essential Bioinformatics – Cambridge University Press, New York. ISBN-10: 0521706106
13. Pandey, A., & Mann, M. (2000). Proteomics to study genes and genomes. Nature, 405(6788), 837-846.
14. Stoughton, R. B. (2005). Applications of DNA microarrays in biology. Annu. Rev. Biochem., 74, 53-82.
15. Monti, M., Orru, S., Pagnozzi, D., &Pucci, P. (2005). Functional proteomics. ClinicaChimicaActa, 357(2), 140-150.
16. Han, X., Aslanian, A., & Yates III, J. R. (2008). Mass spectrometry for proteomics. Current opinion in chemical biology, 12(5), 483-490.
17. Furey, T. S. (2012). ChIP–seq and beyond: new and improved methodologies to detect and characterize protein–DNA interactions. Nature Reviews Genetics, 13(12), 840-852.
18. Metzker, M. L. (2010). Sequencing technologies—the next generation. Nature reviews genetics, 11(1), 31-46.
19. Hendry, J. I., Dinh, H. V., Foster, C., Gopalakrishnan, S., Wang, L., &Maranas, C. D. (2020). Metabolic flux analysis reaching genome-wide coverage: lessons learned and future perspectives. Current Opinion in Chemical Engineering, 30, 17-25.

Related online contents:

1. NPTEL - Computational Systems Biology - Prof. Karthik Raman – IIT Madras
2. NPTEL - Introduction to Proteogenomics - Prof. SanjeevaSrivastava – IIT Bombay
3. NPTEL - Applications of interactomics using Genomics and proteomics technologies - Prof. SanjeevaSrivastava – IIT Bombay

Course adapted from DBT and handled by Dept. of Biotechnology	**Dr. R. Sathishkumar, Professor**

SEMESTER TWO

Laboratory II: Immunotechnology, Molecular Diagnostics, Microbiology and Molecular Biology

Credits 5

Course Code	20MB1P02	Course Type	Core	L	T	P	C	Syllabus version	2020-2021
				-	-	6	5		
Pre-requisite	Familiar in basic immunology and molecular biology techniques								

Course objectives:

1. Develop an understanding about practical aspects of components of immune system as well as their function.
2. Familiarize the students with basic as well as advanced methods to detect different antigen and antibody interactions. Provide hands-on for isolation of different lymphocyte cells etc. and how they can be used in respective research work.
3. Provide the students with practical skills on basic microbiological and genetic engineering techniques

Expected Course Outcomes:

CO1	Evaluate the usefulness of immunology in different pharmaceutical companies; Identify proper research lab working in area of their own interests	**K2, K4**
CO2	Apply their knowledge and design immunological experiments to demonstrate innate, humoral or cytotoxic T lymphocyte responses.	**K1, K3, K4**
CO3	Figure out kind of immune responses in setting of infections (viral or bacterial) by looking at cytokine profile.	**K2, K4**
CO4	Get first-hand experience that will coincide with what is taught in the lecture portion of the class.	**K2, K3**
CO5	Acquire basic microbiology techniques and principles. Gain hands-on experience on gene cloning, protein expression and purification.	**K2, K3, K4, K5**
K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 - Create		

Experiments:

Immunotechnology and Molecular Diagnostics

1. Handling of animals like rabbits, mice.
2. Preparation of antigens, immunization and methods of bleeding, serum separation and storage.
3. Antibody titre by ELISA method.
4. Double diffusion, Immunoelectrophoresis and Radial Immuno diffusion.
5. Complement fixation test.

6. Isolation and purification of IgG from serum or IgY from chicken egg.
7. SDS-PAGE, Immunoblotting, Dot blot assays.
8. Blood smear identification of leucocytes by Giemsa stain.
9. Culture of Hela/J774 cells and phagocytosis.
10. Separation of mononuclear cells by Ficoll-Hypaque.
11. Differential leucocyte count under microscope.
12. Cryopreservation of cells.
13. Detection of genetic mutation using PCR.
14. Metabolite profile for biomarker detection in body fluids/tissues under various metabolic disorders by making use of any biochemical methods.
15. Lecture-demonstration of any two inherited diseases for which molecular diagnosis has provided a dramatic improvement of quality of medical care: take through web-tutorial using online content.
16. Lecture demonstration of recognized genetic aberrations in clinical samples from cancer patients and detail a test-case using next-generation sequencing of a patient sample using web-tutorials and online content.

Microbiology and Molecular Biology

1. Pure culture technique, e.g. streaking, colony purification and sub-culturing.
2. Growth curve using viable count; Total cell count by measuring turbidity by spectrophotometer and Petroff-Hausser chamber.
3. Identification of microbes in a local sample (soil/water/skin, etc).
4. Determination of antibiotic sensitivity by Kirby-Bauer method and antibiotic resistance.
5. Isolation of auxotrophs and AMES test using any chemical mutagen and testing the mutagenicity of routine cosmetics and drugs.
6. Replica plate assay
7. Isolation of specific mutants (gain of function & loss of function phenotypes) using UV light, chemical mutagens, etc.
8. Isolation of microbial DNA (e.g. from *E. coli*) and plasmid DNA, purification and quantification by DNA agarose gel, UV-visible spectrophotometer, NanoDrop method.
9. Isolation of total RNA; gel separation of all ribosomal RNA species.
10. Preparation and plaque assay of bacteriophages.
11. Episome transfer using F' plasmid.
12. Detection of restriction and modification enzyme activity. Quantification of specific activity. EcoRI, BamH1, HindIII digestion of DNA, calculation of restriction endo-nuclease activity, ligation, purification of His-tag protein from Ni-NTA column.
13. Gene complementation using gene transfer technique, followed by its cloning in an expression vector.

14. Measurement of gene expression using a reporter assay.
15. Isolation of RNA from *E. coli* and quantitation of RNA by spectrophotometer, PCR, RT-PCR, quantitative real-time PCR, nested PCR, multiplex PCR.
16. RFLP, RAPD, DNA fingerprinting.

Mapping Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	-	S	-	-	-	S	M	S	S
CO2	-	S	-	-	-	S	-	-	-	M
CO3	-	-	-	-	-	-	-	-	-	M
CO4	-	-	-	L	-	-	-	-	-	-
CO5	S	S	M	-	S	M	L	M	-	-

*S-Strong; M-Medium; L-Low

Recommended Textbooks and References:

1. Peter J. Delves, Seamus J. Martin, Dennis R. Burton, and Ivan M. Roitt (2017). Immunological methods and applications (online content). USA: John Wiley & Sons Ltd.
2. Balakrishnan S, Kaliyapermal K, Senbagam D (2017). Practical Immunology: A Laboratory Manual. LAP LAMBERT Academic Publishing.
3. Danillo Lucas Alves Esposito Benedito Antonio Lopes da Fonseca (2017). Sensitivity and detection of chikungunya viral genetic material using several PCR-based approaches. Rev. Soc. Bras. Med. Trop. vol.50
4. Terry L Riss, Richard A Moravec, Andrew L Niles, Helene A Benink , Lisa Minor (2013). Cell Viability Assays manual.
5. Sumitkumarverma, Himanshi Singh, Prakash C Sharma (2017). An improved method suitable for isolation of high-quality metagenomics DNA from diversesoils.3 biotech,7(3):171
6. Peter J. Delves, Seamus J. Martin, Dennis R. Burton, and Ivan M. Roitt (2016). Roitt's Essential Immunology (12th Edition). USA: John Wiley &Sons Ltd.
7. Animal Models for Autoimmune and Inflammatory Disease: Current Protocols in Immunology (2020). John Wiley & Sons, Inc.
8. Sue Carson, Heather Miller, Melissa Srougi, D. Scott Witherow (2019). Molecular Biology Techniques. Academic Press.

Related online contents:

1. www.roitt.com
2. http://epgp.inflibnet.ac.in
3. http://www.protocol-online.org
4. https://www.protocolsonline.com

SEMESTER TWO

Plant Molecular Pharming **Credits** 2

Course Code	20MB1E1A	Course Type	Elective	L	T	P	C	Syllabus version	2020-2021
				1	1	-	2		
Pre-requisite	Basic understanding of plant systems								

Course objectives:

1. To gain basic knowledge on Plant Molecular Farming.
2. To understand the basic techniques in molecular pharming, limitations, and advantages of using plant systems for recombinant protein production, challenges, bio-safety, and public acceptance towards molecular pharming.

Expected Course Outcomes:

CO1	Explains the use of whole plants or *in vitro* cultured plant cells for the synthesis of desirable recombinant proteins	**K1 & K2**
CO2	Discuss the use of plant viral vectors for stable and transient gene expression	**K2& K3**
CO3	Briefly explains about rapid production of biopharmaceuticals and edible vaccines in transgenic plants	**K3& K4**
CO4	Provides a clear vision of the diverse host system and down-stream processing strategies	**K4, K5 & K6**
CO5	Describes biosafety issues governing plant-derived products	**K2**
K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 - Create		

Unit I **Production Technologies** **6 Lectures**	Efficient and reliable production of pharmaceuticals in alfalfa; Foreign protein expression using plant cell suspension and cultures; Novel sprouting technology for recombinant protein production, monocot expression systems for molecular farming
Unit II **Methods of gene delivery into plant cells** **4 Lectures**	Plant viral vectors: history and new developments; Stable and transient expression system; Agroinfiltration technique and its advantages

Unit III **Pharmaceuticals** **6 Lectures**	Production of pharmaceutical proteins in plants and plant cell suspension cultures; chloroplast expression system, biopharmaceuticals, and edible vaccines; production of secretory IgA in transgenic plants.
Unit IV **Production of plant-derived recombinant proteins** **5 Lectures**	Host plants, systems and expression strategies for molecular farming; Downstream processing of plant-derived recombinant therapeutic proteins.
Unit V **IPR issues governing plant-derived products** **2 Lectures**	Biosafety aspects of molecular farming in plants.
Unit VI **Contemporary issues** **2 Lectures**	Guest lectures by academic/industry experts , online seminars - webinars
Total Lectures – 25	

Mapping with Programme Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	S	S		M	S	-	-	-	S
CO2	-	-	-	-	-	-	S	-	S	-
CO3	-	-	-	-	-	-	-	M	-	-
CO4	-	S	-	-	-	S	-	-	S	-
CO5	-	-	L	M	L	-	M	L	L	M

*S-Strong; M-Medium; L-Low

Recommended Textbooks and References:

1. Kimmo, K. (2004) Novel Sprouting Technology for Recombinant Protein Production. Wiley.
2. Abrahamian, P., Hammond, R. W., & Hammond, J. (2020). Plant Virus–Derived Vectors: Applications in Agricultural and Medical Biotechnology. Annual Review of Virology, 7.
3. Reng, Q., Gang, T., &Qike, L. (2009). Transient gene expression mediated by agroinfiltration and its application. Molecular Plant Breeding.
4. Fischer, R., Vaquero- Martin, C., Sack, M., Drossard, J., Emans, N., &Commandeur, U. (1999). Towards molecular farming in the future: transient

protein expression in plants. Biotechnology and applied biochemistry, 30(2), 113-116.

5. Schiermeyer, A., Dorfmuller, S., &Schinkel, H. (2004). Production of pharmaceutical proteins in plants and plant cell suspension cultures. Molecular Farming.
6. Yagi, Y., &Shiina, T. (2014). Recent advances in the study of chloroplast gene expression and its evolution. Frontiers in Plant Science, 5, 61.
7. Chargelegue, D., Drake, P. M., Obregon, P., & Ma, J. K. C. (2004). Production of secretory IgA in transgenic plants. Molecular Farming. Plant-Made Pharmaceuticals and Technical Proteins, 159-169.
8. Twyman, R. M. (2004). Host plants, systems, and expression strategies for molecular farming. Molecular Farming, 191-216.
9. Ahmad, K. (2014). Molecular farming: strategies, expression systems, and bio-safety considerations. Czech Journal of Genetics and Plant Breeding, 50(1), 1-10.
10. Agrawal, V., &Bal, M. (2012). Strategies for rapid production of therapeutic proteins in mammalian cells. Bio Process Int, 10(4), 32-48.
11. Sharma, R., &Sathishkumar, R. (2017). Rapid production of therapeutic proteins using plant systems. Defence Life Science Journal, 2(2), 95-102.
12. Drossard, J. (2004). Downstream processing of plant-derived recombinant therapeutic proteins. Molecular Farming, 217-231.
13. Commandeur, U., &Twyman, R. M. (2004). Biosafety aspects of molecular farming in plants. Molecular Farming.

Related online contents:

1. NPTEL - Downstream Processing - Prof. MukeshDoble – IIT Madras
2. NPTEL - Plant Biotechnology - Dr. RakhiChaturvedi – IIT Guwahati
3. NPTEL - Organic Farming for Sustainable Agricultural Production - Prof. Dilip Kumar Swain – IIT Kharagpur
4. NPTEL - Nutrition, Therapeutics and Health - Dr. V. Vijaya Lakshmi – IIT Kanpur

Course adapted from DBT and handled by Dept. of Biotechnology	**Dr. R. Sathishkumar, Professor**

SEMESTER TWO

Indian Systems of Medicine **Credits** 2

Course Code	20MB1E1B	Course Type	Elective	L	T	P	C	Syllabus version	2020-2021
				1	1	-	2		
Pre-requisite	Basic knowledge on traditional medicines								

Course objectives:

1. Make the students understand thoroughly the principles and concepts of various Indian systems of medicine.
2. Make the students to understand the industrial requirements, good manufacturing practice (GMP), and new drug documentations.
3. Impart knowledge on the guidelines, methods of preparation, and standardization of formulations in various systems of medicines.
4. Impart sufficient information about quality assurance, quality control and expand their understanding towards regulatory aspects.
5. Enrich the students' knowledge with respect to scientific validations of ISM and related examples of case studies.

Expected Course Outcomes:

CO1	Understand the basic principles of various Indian systems of medicine	**K2**
CO2	Know the industrial infrastructural requirements, current good manufacturing practice of Indian systems of medicine, and new drug documentations	**K1**
CO3	Obtain a comprehensive knowledge about quality assurance, quality control, and their regulatory aspects	**K2, K3**
CO4	Know about the detailed insight on drug preparation and standardization of drug formulation	**K2, K6, K5**
CO5	Gain information's on scientific validation of ISM drugs and know about the current studies in the pharmacological and toxicological screening of ISM.	**K1, K2, K4**
K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 - Create		

Unit I **Introduction to Various Indian Systems of Medicine**	History and development of ISM. Fundamental concepts of Ayurveda, Siddha, Unani, Homoeopathy, Naturopathy, Yoga, Aromatherapy, Energy therapy, and Tribal Medicine. Treatment types. Different dosage forms, merits, and demerits of the ISM.

4 Lectures

Unit II

Good Manufacturing Practice, Industrial requirements &Drug documentation

4 Lectures

Components of GMP (schedule T), GAP, GLP, and its objectives. Infrastructural Requirements: working space, storage area, machinery and equipment, standard operating procedures, health and hygiene, documentation, and records. Preparation of documents for new drug application and export registration.

Unit III

Guidelines, Preparations, and Standardization of Drug Formulations

4 Lectures

General guidelines for ISM drug development, Salient features of the techniques for preparation of some of the important class of formulations as per Ayurveda, Siddha, Homeopathy, and Unani Pharmacopoeia. Standardization - Shelf life and Stability studies of ISM formulations. Problems of standardization in ISM.

Unit IV

Quality Control, Quality Assurance, and Regulatory Aspects

5 Lectures

Quality assurance and control in ISM formulation industry. Regulatory aspects. National/Regional Pharmacopoeias. Analysis of formulations and bio-crude drugs with references to Identity, purity, and quality

Unit V

Scientific validations of ISM

5 Lectures

Scientific evidence validating different products and practices of the Indian system of medicine. Case-studies with suitable examples (Pharmacological and toxicological screening of drugs used in the Indian system of medicine).

Unit VI

Contemporary issues

2 Lectures

Guest lectures by academic/industry experts , online seminars - webinars

Total Lectures – 24

Mapping Programme Outcome

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	L	-	S	L	M	S	-	M	-	-
CO2	-	L	-	M	-	-	-	-	S	-
CO3	M	L	-	-	M	-	M	M	-	L
CO4	-	-	-	-	-	-	-	-	-	-
CO5	M	L	S	L	M	S	-	-	-	-

*S-Strong; M-Medium; L-Low

Recommended Textbooks and References:

1. Ayurvedic Pharmacopoeia, The Controller of Publications, Civil Lines, Govt. of India, New Delhi.
2. H. Panda, Hand Book on Ayurvedic Medicines, National Institute of Industrial Research, New Delhi.
3. KavirajNagendranathSengupata, Ayurvedic System of Medicine, Sri Satguru Publications, New Delhi.
4. Pulok K Mukharjee, GMP for Botanicals - Regulatory and Quality issues on Phytomedicine, Business Horizons, New Delhi.
5. Indian System of Medicine and Homeopathy in India, Planning and Evaluation Cell, Govt. of India, New Delhi.
6. Ayurvedic Pharmacopoeia. Formulary of Ayurvedic Medicines, IMCOPS, Chennai.
7. Homeopathic Pharmacopoeia. Formulary of Homeopathic Medicines, IMCOPS, Chennai.

Related online contents:

1. https://www.ayush.gov.in/docs/guideline-drug-development.pdf
2. https://www.slideshare.net/tusharkedar2/indigenous-system-of-medicine
3. https://www.slideshare.net/TriAngels/indian-medicine-by-triangels-medical-group-history-of-medicine
4. https://main.ayush.gov.in/sites/default/files/Introduction_2.pdf
5. https://books.google.co.in/books/about/Ayurveda.html?id=ZFYAAQAACAAJ&redir_esc=y
6. https://nptel.ac.in/courses/121/106/121106003/

Course adapted from DBT and handled by Dept. of Biotechnology	**Dr. M. Arun, Assistant Professor**

SEMESTER TWO

Journal Club and Communication Skills Credits 2

Course Code	20MB1V02	Course Type	Supportive	L	T	P	C	Syllabus version	2020-2021
				1	1	-	2		
Pre-requisite	Basic communication and presentation skills								

Course objectives:

1. To help students in heightening their resume.
2. To educate and expose the students to learn new things and gain knowledge on different things so that most of them become employable and could find a good job in the present scenario.

Expected Course Outcomes:

CO1	Describes in detail on resume making and effective profiling	**K1**
CO2	Elaborate on the basics of business communication	**K1, K2**
CO3	A brief explanation on telephonic skills	**K2, K3**
CO4	Explains about time and stress management	**K4, K5**
CO5	Discusses the importance of leadership quality	**K6**
K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 - Create		

Unit I **Preparing for a career** **5 Lectures**	Identifying job openings, applying for a job, Preparing Cover letters, Preparing a CV/Resume and Effective Profiling.
Unit II **Business communication** **3 Lectures**	Preparing Agenda and Minutes for Meetings, Writing Notices and Memos, Drafting an E-mail and Press Release.
Unit III **Telephone skills** **4 Lectures**	Basics of Telephone communication, How to handle calls-telephone manners, Leaving a message, Greeting and Leave Taking over phone (etiquette).
Unit IV **Time & Stress Management** **4 Lectures**	Identifying Time Wasters, Time Management Tips, Identifying Factors Responsible for Stress, Stress Management Tips and Test Preparation Tips.
Unit V **Soft Skills for Leadership and Team Management**	Qualities of a Good Leader, Leadership Styles, Decision Making, Intrapersonal skills, Interpersonal skills, Problem solving, Critical thinking, and Negotiation skills.

4 Lectures	
Unit VI	
Contemporary issues	Guest lectures by academic/industry experts, online seminars - webinars
2 Lectures	
Total Lectures – 22	

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	-	-	-	-	-	-	L	-	-	M
CO2	-	-	-	L	L	-	M	-	-	M
CO3	-	-	-	-	L	-	L	-	-	L
CO4	-	-	-	-	-	-	M	-	-	S
CO5	-	-	-	-	-	-	M	-	-	S
*S-Strong; M-Medium; L-Low										

Recommended Textbooks and References:

1. Wren, P. C., & Martin, W. (2005). High school English grammar and composition. S Chand.
2. Bovee, C. L., Thill, J. V., &Raina, R. L. (2016). Business communication today. Pearson Education India.
3. Beers, S. (2011). 21st century skills: Preparing students for their future. Diaksesdari http://www.yinghuaacademy.org/wp content/uploads/2014/10/21st_century_skills. pdf.
4. Markaki, E. N., Sakas, D. P., &Chadjipantelis, T. (2013). Communication
5. management in business. The latent power for career development. Procedia-Social and Behavioral Sciences, 73, 319-326.
6. Ren, S., &Chadee, D. (2020). Influence of career identity on ethical leadership: sense-making through communication. Personnel Review.
7. Bridgstock, R. (2009). The graduate attributes we've overlooked: Enhancing graduate employability through career management skills. Higher Education Research & Development, 28(1), 31-44.

Related online contents:

1. NPTEL - Enhancing Soft Skills and Personality – Dr. T. Ravichandran – IIT Kanpur
2. NPTEL - Developing Soft Skills and Personality – Dr. T. Ravichandran – IIT Kanpur

Course adapted from DBT and handled by Dept. of Biotechnology	**Dr. R. Sathishkumar, Professor**

Third Semester

SEMESTER THREE
Clinical Biochemistry and Disease Metabolism

Credits 4

Course Code	20MB1C11	Course Type	Core	L	T	P	C	Syllabus version	2020-2021
				3	1	-	4		
Pre-requisite	Basic biochemistry knowledge								

Course objectives:

1. To build upon previous knowledge of biochemical pathways and immunology to develop an appreciation of applications of this knowledge in clinical diagnostics and treatment.
2. To make students aware about various disease diagnostic techniques
3. To understand disease pathologies and clinical case studies within the context of each topic
4. To get the knowledge on the biochemical parameters on disease biology
5. To know the organ functions and dysfunctions with respect to biochemical changes

Expected Course Outcomes:

CO1	Understand applications of clinical biochemistry in diagnostics	**K1, K2**
CO2	Understand the molecular basis of various pathological conditions from the perspective of biochemical reactions.	**K2, K3**
CO3	Acquire knowledge on marker enzymes in diagnosis and treatment of human diseases.	**K2, K3**
CO4	Understand the importance of metabolism in various disease pathophysiology	**K3, K4,**
CO5	Evaluate the usefulness of cellular mechanism for the diagnosis of diseases	**K5, K6**
K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 - Create		

Unit I

Introduction to Clinical Biochemistry

12 Lectures

Clinical specimen Considerations - Types of Samples, Sample Processing, Sample Variables, Chain of Custody; Infection control, the vascular system, composition and types of blood specimens, venipuncture, pediatric and geriatric venipuncture, capillary specimen collection, capillary puncture procedures. Place and time of sample collection, preservation, influence of nutrition, drugs, posture, etc. Choice and correct use of anticoagulants; Care of the specimens, identification, transport, storage, influence of temperature, freezing/thawing; Laboratory safety and regulations – Safety awareness, safety equipment, biological, chemical, fire and radiation safety; Method evaluation and quality management, Basic concepts, Reference interval study, Diagnostic efficiency, Method evaluation, Quality Control and quality management.

Unit II **Amino acids and Protein Biochemistry** **12 Lectures**	Amino acids - Basic Structure, Metabolism, Essential Amino Acids, Non-essential Amino Acids, Body amino acid pool, Aminoacidopathies, Amino Acid Analysis, glutathione hyperglycinemias, formation of taurine, homocystinuria, cystinuria and cystinosis, phenyl ketonuria and alkaptonuria, albinism, tyrosinemia; Proteins – Importance, Molecular Size, Catabolism and Nitrogen Balance, Structure, Classification, Dynamic state of body proteins; Plasma proteins - Prealbumin (Transthyretin), Albumin, Globulins; Total Protein abnormalities – Hypoproteinemia, Hyperproteinemia; Methods of analysis – Total nitrogen, Total proteins, Fractionation, Identification and Quantification of specific proteins, Serum protein electrophoresis, High-resolution protein electrophoresis, Immunochemical methods; Proteins in other body fluids – Urinary proteins and Cerebrospinal fluid proteins; Non-protein nitrogen compounds (Physiology, clinical application, methods and pathophysiology) – Urea, Uric acid, Creatine, Creatinine, Ammonia, Synthesis of thyroid hormones, Synthesis and catabolism of catecholamines.
Unit III **Clinically Important Enzymes and Related Pathophysiology** **12 Lectures**	Enzymes of clinical significance - Creatine Kinase, Lactate Dehydrogenase, Aspartate Aminotransferase, Alanine Aminotransferase, Alkaline Phosphatase, Acid Phosphatase, Glutamyltransferase, Amylase, Lipase, Glucose-6-Phosphate Dehydrogenase, Drug- Metabolizing Enzymes, Tumour markers, Bone markers, Cardiac markers, liver markers, Inborn errors associated with carbohydrate metabolism; Inborn errors of metabolism- Glycogen storage diseases, Fructosuria, Fructose intolerance, Pentosuria, Galactosuria, Urine screening.
Unit IV **Diagnosis and Treatment of Carbohydrate Disorders** **10 Lectures**	Blood glucose regulation (fasting/pp/random) –hormones influencing carbohydrate utilization, Insulin, glucagon, glucocorticoids, epinephrine, growth hormone. Hyperglycemia, Diabetes Mellitus - Aetiology and pathophysiology of Diabetes Mellitus, Symptoms and complications, Criteria for Testing for Prediabetes diabetes, Criteria for the Diagnosis of Diabetes Mellitus, Criteria for the Testing and Diagnosis of Gestational Diabetes Mellitus, Hypoglycemia - Genetic Defects in Carbohydrate Metabolism.
Unit V **Transport Mechanism and Associated Disorders** **12 Lectures**	Transport of plasma lipids, lipoprotein metabolism, lipid profile and diet, PUFA and dietary fiber, Serum triglycerides; Diagnosis and treatment of lipid disorders –Arteriosclerosis, Hyperlipoproteinemia, Hypercholesterolemia, Hypertriglyceridemia, Combined Hyperlipoproteinemia, Lipoprotein(a) Elevation, Hypolipoproteinemia,

	Hypoalphalipoproteinemia; Lipid and lipoprotein analyses - Lipid Measurement, Cholesterol Measurement, Triglyceride Measurement, Lipoprotein Methods, High- Density Lipoprotein Methods, Low-Density Lipoprotein Methods, Compact Analyzers, Apolipoprotein Methods, Phospholipid Measurement, Fatty Acid Measurement.
Unit VI **Assessment of Organ System Function** **10 Lectures**	Pituitary function - Introduction to Hormones and Pituitary Function - hypophysiotropic or hypothalamic hormones; Anterior pituitary hormones; Pituitary tumors; Growth hormone; Actions of growth hormone; Testing; Acromegaly; Growth hormone deficiency; Prolactin; Prolactinoma; Other causes of hyperprolactinemia; Clinical evaluation of hyperprolactinemia; Management of prolactinoma; Idiopathic galactorrhea; Hypopituitarism - Etiology of hypopituitarism; Treatment of panhypopituitarism; Posterior pituitary hormones – Oxytocin and Vasopressin. Liver Function - Anatomy - Gross Anatomy, Microscopic Anatomy, Biochemical functions - Excretory and Secretory, Synthetic, Detoxification and Drug Metabolism, Liver function alterations during disease – Jaundice, Cirrhosis, Tumors, Reye Syndrome, Drug- and Alcohol-Related Disorders Assessment of liver function/liver - Function tests: Bilirubin, Urobilinogen in Urine and Faeces, Serum Bile Acids, Enzymes, Tests Measuring Hepatic Synthetic Ability, Tests Measuring Nitrogen Metabolism, Hepatitis. Cardiac Function - Anatomy and function of the heart - Anatomy Function, Pathologic conditions of the heart, Cardiovascular Disease, Congenital Cardiovascular Defects, Heart Failure, Acute Coronary Syndromes, Hypertensive Heart Disease, Infective Heart Disease, Diagnosis of heart disease - Laboratory Diagnosis of Myocardial Infarction, Markers of Inflammation and Coagulation Disorders, Markers of Congestive Heart Failure, Patient-Focused Cardiac Tests, Disease. Renal Function - Renal anatomy, Renal physiology - Glomerular Filtration, Tubular Function, Elimination of Nonprotein Nitrogen Compounds, Water, Electrolyte, and Acid-Base Homeostasis, Endocrine Function, 1,25-Dihydroxy Vitamin D3, Analytic procedures, Clearance Measurements, Urine Electrophoresis, 2-Microglobulin, Myoglobin, Microalbumin, Urinalysis, Pathophysiology – Glomerular Diseases, Tubular Diseases, Urinary Tract Infection/Obstruction, Renal Calculi, Renal Failure. Pancreatic Function and Gastrointestinal Function - Physiology of pancreatic function, Diseases of the pancreas, Tests of pancreatic function - Secretin/Cholecystokinin Test, Fecal Fat Analysis, Sweat Electrolyte Determinations, Serum

	Enzymes, Physiology and biochemistry of gastric secretion, Clinical aspects of gastric analysis, tests of gastric function - Measuring Gastric Acid in Basal and Maximal Secretory Tests, Measuring Gastric Acid, Plasma Gastrin, Intestinal physiology, Clinicopathologic aspects of intestinal function, Tests of intestinal function - Lactose Tolerance Test, D-Xylose Absorption Test, Serum Carotenoids, Other Tests of Intestinal Malabsorption.
Total Lectures – 68	

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	L	L	S	L	M	M	L	S	L	L
CO2	S	L	L	M	S	S	M	L	L	M
CO3	M	L	L	S	S	L	S	L	S	S
CO4	L	S	M	L	L	S	L	M	L	L
CO5	M	L	S	L	L	L	S	S	S	L

*S-Strong; M-Medium; L-Low

Recommended Textbooks and References:

1. Michael L. Bishop, Edward P. Fody and Larry E. Schoeff; (2013). Basic Principles and Practice of Clinical Chemistry, (7th Ed). Lippincott Williams and Wilkins.
2. Stryer, L. (2002). Biochemistry, (8th Ed). Freeman.
3. D.M. Vasudevan and Sreekumari, S, (2010). Textbook of Biochemistry for Medical Students, (6th Ed). Jaypee Brothers Medical Publishers, New Delhi.
4. SuchetaDandekar; (2010). Concise Medical Biochemistry, (3rd ed), Elsevier Health.
5. Satyanarayana and Chakrapani, (2013), Biochemistry; (4th Ed). Elsevier.

Related online contents:

1. https://onlinecourses.swayam2.ac.in/cec20_ag01/preview

Course adapted from DBT and handled by Dept. of Biotechnology	**Dr. S. Velayuthaprabhu** **Assistant Professor**

SEMESTER THREE

Tissue Engineering and Stem Cell Technology

Credits 4

Course Code	20MB1C12	Course Type	Core	L	T	P	C	Syllabus version	2020-2021
				3	1	-	4		
Pre-requisite	Basic knowledge in Animal sciences								

Course objectives:

1. To provide students with knowledge of wide-ranging topics related to stem cells, regenerative medicine and tissue engineering.
2. To offer the student state of the art education of stem cells and how the pluripotent and multipotent cells can be used to treat the neurodegenerative disorders, cardiovascular disorders and diabetes.
3. To review the current scenario of tissue engineering applications in bioartificial organs development and transplantation.

Expected Course Outcomes:

CO1	Gain fundamental knowledge instem cell biology and tissue engineering.	K1
CO2	Describe sources, selection, potential manipulations and challenges ofusing stem cells for tissueengineering.	K2
CO3	Explain significance, current statusand future potential of tissueengineering.	K3
CO4	Identify key challenges in tissue engineering of different humantissues.	K4
CO5	Describe design, fabrication and biomaterials selection criteriafor tissue engineeringscaffolds	K5,K6
K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 - Create		

Unit I **Introduction to Stem cells and Basics of Stem cell culture** **12 Lectures**	Introduction to Stem Cells – Definition, Classification, characteristics; Stem cell Vs Somatic cells; Differentiation, dedifferentiation and transdifferentiation. Cellular signaling and maintenance of stem cells. Mechanism of pleuripotency in stem cells. Instrumentations in stem cell culture/research; Basics of animal cells/stem cells culture; Isolation, expansion, genetic manipulation, genetic reprogramming, and cloning of Stem cells. Stem cell markers, role of feeder layer in stem cell culture. Stem Cells cryopreservation.
Unit II **Types of Stem Cells**	Different kinds of stem cells – Embryonic stem cells, Embryonic Germ cells; Stem cell Niche. Adult Stem Cells: heamtopoietic stem cells, neural stem cells, muscle and cardiac stem cells, umbilical cord blood stem cells, cancer

12 Lectures	stem cells, mesenchymal stem cells, induced pluripotent Stem cells.
Unit III **Stem Cell Therapy** **12 Lectures**	Therapeutic applications: stem cells and neurodegenerative disorders, stem cells and diabetes, stem cells and cardiac disorders, Stem cell therapy for kidney failure, liver failure, infertility and cancer. Stem cell banking. Success stories of stem cell therapy. Current status of Stem cell research. National and International Guidelines/Regulations for stem cell research. Ethical considerations in stem cells research.
Unit IV **Introduction to Tissue Engineering, Biomaterials and Scaffolds** **12 Lectures**	Principles of Tissue Engineering – History, importance and scope, Basics/fundamentals of Tissue Engineering, Tissue dynamics/homeostasis. Tissue Engineering triangle, Role of growth factors, Biomaterials and Scaffolds in Tissue Engineering. Requirement of biomaterials as tissue engineering scaffold. properties and types of scaffolds, tissue specific scaffolds; Methods of scaffold design/preparation. Cell-ECM/Scaffold interactions, Animal cell culture on scaffolds. Tissue Engineering Bioreactors.
Unit V **Tissue Engineering Applications** **14 Lectures**	Tissue and organ transplantation. Bio-artificial organs: Skin Tissue engineering, Liver tissue engineering, Bladder reconstruction, Kidney tissue engineering, Muscle tissue engineering, Neural tissue engineering, Bone and cartilage tissue engineering, Cardiovascular tissue engineering. Commercial products from tissue engineering. Ethical issues in tissue engineering.
Unit VI **Contemporary issues** **3 Lectures**	Guest lectures by academic/industry experts, online seminars - webinars
Total Lectures – 65	

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	L	L	L	L	L	L
CO2	S	S	M	M	L	L	L	L	L	M
CO3	S	S	S	S	S	S	L	L	M	L
CO4	S	M	M	M	M	S	L	L	L	M
CO5	S	S	S	S	S	S	L	L	M	M

*S-Strong; M-Medium; L-Low

Recommended Textbooks and References:

1. Ed. Robert Lanza et al.; Principles of Tissue Engineering – 5th Edition (2020); Academic Press
2. Lanza R., Atala A.; Essentials of Stem Cell Biology 3rd Edition (2013); Academic Press
3. Boer JD et al.; Tissue Engineering – 2nd Edition (2014); Academic Press
4. Pallua N, Suschek CV; Tissue Engineering: from Lab to Clinic (2011); Springer
5. Barnes SJ, Harris LP; Tissue Engineering: Roles, Materials and Applications – 1st Edition (2008); Nova Science Publishers Inc
6. Minuth WW. Strehl R. Schumacher K; Tissue Engineering: from Cell Biology to Artificial Organs (2017); Wiley VCH
7. Zhao RC; Stem Cells: Basics and Clinical Translation (Translational Medicine Research) (2015); Springer
8. Knoepfler; Stem Cells: An Insider's Guide (2013); World Scientific Publishing Company
9. Harris J. Quigley M. Chan S.; Stem Cells: New Frontiers in Science & Ethics (2012); World Scientific Publishing Co Pte Ltd
10. Attala & Lana; Methods of Tissue Engineering (2002); Academic Press

Related online contents

1. https://nptel.ac.in/courses/102/106/102106036/
2. https://www.classcentral.com/course/stem-cells-10745
3. https://research.pasteur.fr/en/course/mooc-advances-in-stem-cell-biology/

Course adapted from DBT and handled by Dept. of Biotechnology	**Dr. P. Ekambaram** **Associate Professor**

SEMESTER THREE

Molecular Diagnostics and TherapeuticsCredits 4

Course Code	20MB1C13	Course Type	Core	L	T	P	C	Syllabus version	2020-2021
				1	1	-	2		
Pre-requisite	Basic knowledge in Diagnostics								

Course objectives:

1. Understand the vantages of molecular diagnostics in precision diagnosis and learn about state-of-the-art techniques that are used in clinical diagnosis of diseases
2. Develop skills by understanding technical details of the assays to be applied for developing novel tests for improved diagnosis.
3. Learn about existing examples which promotes critical thinking that can help in developing tests. Comprehensive knowledge about ethical and regulatory aspects of handling and conducting tests in clinical samples.

Expected Course Outcomes:

CO1	Understanding of disease types and their diagnosis. Obtain knowledge about ethical and regulatory aspects of conducting diagnostic tests.	K3
CO2	Learn the technical aspects of various diagnostic methods which will help in application of these techniques to design and develop new clinical tests.	K4
CO3	Obtain comprehensive knowledge about various biotechnological investigations done to monitor changes happening at different molecular levels. Understand the uniqueness and pitfalls of biological assays to analyse and apply them to develop clinical tests.	K5
CO4	Develop skills to interpret the results of molecular techniques when performing them practically.	K6
CO5	Know about how important diseases are diagnosed using molecular diagnostic methods. Learn practical applications of precision diagnostics in disease management.	K4
K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 - Create		

Unit I

Introduction to Molecular Diagnostics

10 Lectures

Definition - History – Diseases- infectious, physiological and metabolic errors, and inherited diseases. Biomarkers- types, potential uses and limitations. Diagnostics – types and importance in clinical decision making. Benefits of molecular diagnostics over conventional diagnostics. Ethical issues related to molecular diagnostics. Clinical specimens: National and International guidelines for Sample collection- method of collection, transport and processing of samples, Personal safety and laboratory safety. GLP for handling highly infectious disease samples and documentation.

Unit II **DNA Based Molecular Techniques for Diagnosis** **10 Lectures**	PCR based assays: Real-time PCR, ARMS, allele specific, multiplex, methylation analysis, MLPA, single-stranded conformational polymorphism analysis, heteroduplex analysis, competitive oligonucleotide priming, DHPLC, DGGE, CSCE. Mutation screening panels (xTAG, Luminex) Micro arrays: SNP chromosomal microarrays,EST, SAGE.
Unit III **Proteomic and Metabolomics Assays for Diagnostics** **10 Lectures**	Diagnostic proteomics: SELDI-TOF MS; LC-MS, MALDI-TOF, Isotope coated affinity tag (ICAT), SILAC, i-TRAQ, Protein microarray. Metabolite profile for biomarker detection in the body fluids/tissues under various metabolic disorders by making use of LCMS & NMR technological platforms.
Unit IV **Applications of Molecular Diagnostics** **12 Lectures**	Major Histocompatibility Complex (MHC), HLA typing-RFLP, PCR based methods, SSO, SSP and SBT methods. Role of Molecular diagnostics in bone marrow transplantation and organ transplantation. Bone marrow transplant engrafment analysis. Diagnosis of inherited diseases- Thalassemia, Cystic Fibrosis. Neonatal and Prenatal disease diagnostics- Prenatal and pre-implantation diagnosis. Noninvasive: Triple test, Ultrasonography (USG), Invasive: Amniocentesis (AC), chorionic villi sampling. Molecular diagnosis for early detection of cerebral palsy, Down syndrome. Fragile X syndrome.
Unit V **Applications In Molecular Oncology And Microbial Diseases** **12 Lectures**	Molecular oncology testing in malignant disease- Acute and Chronic leukemias, Melanoma, colon, lung and breast cancers. Circulating tumour cell testing (CTC). Molecular diagnosis of various viral diseases: Dengue, Chikungunya and SARS. Direct detection & identification of pathogenic-organisms that are slow growing or currently lacking a system of in vitro cultivation as well as genotypic markers of microbial resistance to specific antibiotics- 16s rRNA typing.
Unit VI **Molecular Therapeutics** **11 Lectures**	Gene therapy; Intracellular barriers to gene delivery; Overview of inherited and acquired diseases for gene therapy; Retro and adeno virus mediated gene transfer; Liposome and nanoparticles mediated gene delivery; Clinical applications of recombinant technology; Erythropoietin; Insulin analogs and its role in diabetes; Recombinant human growth hormone; Streptokinase and urokinase in thrombosis; Recombinant coagulation factors; Immunotherapy; Monoclonal antibodies and their role in

	cancer; Role of recombinant interferons; Immunostimulants; Immunosupressors in organ transplants; Role of cytokine therapy in cancers; Types of recombinant vaccines and clinical applications; Gene silencing technology; Antisense therapy; siRNA

Total Lectures – 65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	S	M	L	S	L	S	M	L
CO2	S	S	S	M	S	L	S	S	S	S
CO3	S	S	S	S	S	L	S	S	S	S
CO4	M	S	S	S	S	L	S	M	M	S
CO5	S	M	S	S	M	S	M	S	S	M

*S-Strong; M-Medium; L-Low

Recommended Textbooks and References:

1. Tietz textbook of clinical chemistry and molecular diagnostics. Carl Burtis, Edward Ashwood, David Bruns, Elsevier Press. 5th Edition 2012.
2. Principles and Techniques of Biochemistry and Molecular Biology. Keith Wilson and John Walker. 2010
3. Molecular Diagnostics: Fundamentals, Methods and Clinical Applications. Lela Buckingham and Maribeth L. Flaws. 2011
4. Modern Blood Banking & Transfusion Practices. Denise M. Harmening. 2018
5. Fundamentals of Molecular Diagnostics. David E. Bruns MD (Author), Edward R. Ashwood MD (Author), Carl A. Burtis PhD. 2007
6. Proteomics in Diagnostics. Veenstra, T.D. 2004

Related online contents:

1. Biomolecules: Structure, function in Health and Disease-CEC
2. Fabrication Techniques for MEMs-based sensors : clinical perspective- NPTEL
3. Economics of Health and Healthcare- NPTEL

Course adapted from DBT and handled by Dept. of Biotechnology	**Dr. V. Thirunavukkarasu** **Associate Professor**

SEMESTER THREE

Genetic Engineering and Genome Editing Technologies **Credits** 4

Course Code	20MB1C14	Course Type	Core	L	T	P	C	Syllabus version	2020-2021
				3	1	-	4		
Pre-requisite	A basic knowledge in molecular biology								

Course Objectives:

1. Impart strong theoretical knowledge on these technologies to explore the tools in genetic engineering.
2. Teach various approaches to conduct genetic engineering and its applications in biological research as well as in biotechnologyindustries.
3. Expedite the students to understand the diverse range of PCR techniques and their specialized applications in the field of modern biology.
4. Communicate sufficient information about the different methods to introduce foreign DNA to host cell and to expand their understanding in gene expression profiling studies.
5. Enrich the students' knowledge in recent advancements and applications in gene silencing and genome editing technologies.

Expected Course Outcomes:

CO1	Take up biological research as well as placement inthe relevant biotech industry.	K3, K6
CO2	Understand the importance of tools used in the field of molecular biology and use such acquaintance to carry out gene cloning and library construction.	K2, K3
CO3	Operate PCR and know about its variations and most recent advancements.	K2, K5
CO4	Obtain a comprehensive knowledge of technique involved in introducing foreign DNA into the host cell, construct libraries, and perform hybridization techniques.	K1, K4
CO5	Gain information's about important strategies like gene silencing and genome editing technologies	K6
K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 - Create		

Unit I

Introduction and Tools for Genetic Engineering

12 Lectures

Impact of genetic engineering in modern society. General requirements for performing a genetic engineering experiment - restriction endonucleases and methylases, DNA ligase, Klenow enzyme, T4 DNA polymerase, polynucleotide kinase, alkaline phosphatase. Cohesive and blunt end ligation, linkers, adaptors, homopolymer tailing. Labelling of DNA - nick translation, random priming, radioactive and non-radioactive probes. Hybridization techniques - northern, southern, south-western, far-western, colony hybridization, and fluorescence in situ hybridization.

Unit II **Different Types of Vectors** **12 Lectures**	Plasmids, Bacteriophages, M13mp vectors, pUC19 and pBluescript vectors, phagemids, Lambda vectors, Insertion and Replacement vectors, Cosmids, Artificial chromosome vectors (YACs and BACs). Principles for maximizing gene expression in vectors. pMal, GST, pET-based vectors. Protein purification - His-tag, GST-tag, MBP-tag *etc.*Intein-based vectors. Inclusion bodies, methodologies to reduce formation of inclusion bodies. Mammalian expression and replicating vectors, Baculovirus and *pichia*vectors system, plant-based vectors, Ti and Ri as vectors, yeast vectors, shuttle vectors.
Unit III **Different Types of PCR Techniques** **12 Lectures**	Principles of PCR, primer design, fidelity of thermostable enzymes, DNA polymerases. Types of PCR - multiplex, nested, real time PCR, touchdown PCR, hot start PCR, colony PCR. Cloning of PCR products, T – vectors. Proof reading enzymes. PCR based site specific mutagenesis. PCR in molecular diagnostics, viral and bacterial detection. Sequencing methods - enzymatic DNA sequencing, chemical sequencing of DNA, automated DNA sequencing, RNA sequencing. Chemical synthesis of oligonucleotides. Mutation detection - SSCP, DGGE, RFLP.
Unit IV **cDNA Analysis** **12 Lectures**	Introduction of foreign DNA into host cells - transformation, electroporation, transfection. Construction of genomic and cDNA libraries, phage display. Strategies for library screening - radioactive and non-radioactive probes, hybridization techniques - Northern, Southern, South-western, Far-western, colony hybridization, and fluorescence *in situ* hybridization.
Unit V **Gene Silencing and Genome Editing Technologies** **12 Lectures**	Gene silencing techniques - introduction to siRNA, siRNA technology, Micro RNA, construction of siRNA vectors, principle and application of gene silencing. Gene knockouts and gene therapy. Creation of transgenic plants, debate over GM crops. Genome editing - introduction to genome editing by CRISPR-CAS. Cloning genomic targets into CRISPR/ Cas9 plasmids, electroporation of Cas9 plasmids into cells, purification of DNA from Cas9 treated cells and evaluation of Cas9 gene editing, *in vitro* synthesis of single guide RNA (sgRNA), using Cas9/sgRNA complexes to test for activity on DNA substrates, evaluate Cas9 activity by T7E1 assays and DNA sequence analysis, applications of CRISPR/cas9 technology. *Self-learning*: Introduction to methods of genetic manipulation in different model systems *e.g.* fruit flies *(Drosophila)*, worms *(C. elegans)*, frogs *(Xenopus)*, fish (zebra fish) and chick. Transgenics - gene replacement, gene targeting, creation of transgenic and knock-out mice, disease model. Applications of gene therapy/gene editing - antiviral strategies, cancer immunotherapy, hematologic disorders,

	liver-targeted gene editing, neuromuscular disorders, ocular disorders *etc*.
Unit VI **Contemporary issues** **5 Lectures**	Guest lectures by academic/industry experts, online seminars - webinars
Total Lectures – 65	

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	L	S	L	M	S	S	S	S	S
CO2	S	L	S	M	L	S	S	S	S	M
CO3	S	L	S	L	M	S	S	S	S	M
CO4	S	L	S	S	L	S	S	S	S	S
CO5	S	S	S	S	L	S	S	S	S	M

*S-Strong; M-Medium; L-Low

Recommended Textbooks and References:

1. Old, R. W., Primrose, S. B., &Twyman, R. M. (2001). *Principles of Gene Manipulation and Genomics*, 7thEdition: Oxford: Blackwell Scientific Publications.
2. Green, M. R., &Sambrook, J. (2012). *Molecular Cloning: a Laboratory Manual*. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
3. George M., and church (2018).Genome editing and engineering. Cambridge university press. Edited by KrishnaraoAppasani.
4. Morgan and Mikhails (2008).An introduction to genetic engineering .3rd edition. University of Paisely.
5. Huang, P.C., Kuo, T.T. and Ray wu (2012). Genetic engineering techniques recent development. Academic publishers. ISBN:1299554245 (ISBN13: 9781299554245).
6. Brown, T. A. (2006). *Genomes* (3rded.). New York: Garland Science Pub.
7. Desmond S.T Nicholl (2019). An introduction to genetic engineering (3rd).ISBN-13: 978- 0521615211
8. Anjanabha Bhattacharya,Vilas Parkhi and Bharat Char (2020).CRISPR/Cas genome editing. Strategies And Potential For Crop Improvement. 1stedition. Editors: Bhattacharya, Anjanabha, Parkhi, Vilas, Char, Bharat (Eds.). ISBN 978-3-030-42022-2

Related Online Contents:

1. Doudna, J. A., &Charpentier, E. (2014). *The New Frontier of Genome Engineering with CRISPR-Cas9*. Science, 346(6213), 1258096-1258096. doi:10.1126/ science.1258096.
2. Hala, T.E, Bassyouni, L and Maysoon Ahmed Mohammed (2018).Genome

editing: A Review of literature.Lap Lambert Academic Publishing. ISBN: 9786138387534

3. Maeder, M. L., &Gersbach, C. A. (2016). *Genome-editing Technologies for Gene and Cell Therapy*. Molecular Therapy, 24(3), 430-446. doi:10.1038/mt.2016.10
4. Genome Editing Resource Library (Thermo Fisher) https://www.thermofisher.com/ in/en/home/life-science/genome-editing/genome-editing-learning-center/genome- editing-resource-library.html
5. Cox, D. B., Platt, R. J., & Zhang, F. (2015). *Therapeutic Genome Editing: Prospects and Challenges*. Nature Medicine, 21(2), 121-131. doi:10.1038/nm.3793
6. Sander JD Joung JK. (2014) *CRISPR-Cas Systems for Editing, Regulating and Targeting Genomes*. Nature Biotechnology 32, 347–355 doi:10.1038/nbt.2842
7. Mohinijoshi and Deshpande (2010).Polymerase chain reaction: Methods,principles and application. International Journal of Biomedical Research.5:81-97
8. https://www.wcrj.net/wp-content/uploads/sites/5/2020/03/e1510-A-review-on-genome-editing-by-crispr-cas9-technique-for-cancer-treatment
9. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4343198/
10. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5733845/

Course adapted from DBT curriculum and handled by Dept. of Biotechnology	**Dr. M. Arun** **Assistant Professor**

SEMESTER THREE

Laboratory III: Clinical Biochemistry and Disease Metabolism and Animal Cell culture

Credits 5

Course Code	20MB1P03	Course Type	Core	L	T	P	C	Syllabus version	2020-2021
				-	-	6	5		
Pre-requisite	Basic knowledge in microbiology, molecular biology, biochemistry, and cell culture								

Course objectives:

1. To build upon existing knowledge of biochemical and immunological principles for its application in clinical diagnostics and treatment.
2. The course shall equip students with basic skills in clinical biochemistry.
3. Providing hands-on experience in handling animal cell cultures.
4. To impart important microbiology and advanced molecular biology practical knowledge and related instrumentation.

Expected Course Outcomes:

CO1	Hands-on skills for blood and urine biochemical analysis and applications of clinical biochemistry in diagnostics	**K2, K3**
CO2	Understand the molecular basis of various pathological conditions through practical case studies.	**K2, K5**
CO3	Handle and maintain various animal cell lines.	**K1, K6**
CO4	Toxicity testing using animal cells.	**K1, K4**
CO5	Hands-on experience in microbiological and molecular biology techniques.	**K3, K6**
K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 - Create		

Experiments: Clinical Biochemistry and Disease Metabolism

Blood Practical

1. Kidney Function Test: Urea - Diacetylmonoxime method),Creatinine - Jaffe's Kinetic method)
2. Electrophoresis for Enzymes & activity staining of any clinically relevant enzyme from a patient sample: Activity measurements of Creatinine Kinase, Lactate Dehydrogenase from patient sample.
3. Total lipid profile & CBC. Lipid: Cholesterol – by CHOD-POD Method.
4. Sugar estimation (fasting/post-pradial-random)- Alkaline copper reduction method.
5. Liver Function Test: Bilirubin (total, direct and indirect)-Diazo Method, SGPT, ALP.
6. Body Elements: Calcium – CPC method, Phosphorus-Ammonium phosphomolybdate method

Urine Practical

1. Sugar, Protein, Ketone bodies, Bile salts and Bile acids.

Other Practical

1. Designing guide RNA using bioinformatic tools, and developing knock down construct for CRISPR based genome editing.
2. Bacterial transformation of recombinant vector by $CaCl_2$ mediated heat shock method and antibiotic screening of transformed colonies.
3. Direct PCR analysis for screening of transformed bacterial colonies.

Case Studies

1. **Case history-1: Diabetic Ketoacidosis:** A 32-year-old male with type 1 diabetes since the age of 14 years was taken to the emergency room because of drowsiness, fever, cough, diffuse abdominal pain, and vomiting. Fever and cough started 2 days ago and the patient could not eat or drink water. On examination, he was tachypneic, his temperature was 39° C, pulse rate 104 beats per minute, respiratory rate 24 breaths per minute, supine blood pressure 100/70 mmHg. He was slightly confused. Perform suitable tests in the blood/urine sample provided and give probable diagnosis on the basis of your findings. Interpret the result accordingly.
2. **Case history-2: Nephrotic Syndrome:** A five-year-old child was brought in pediatric OPD with complaints of weakness and polyuria. On physical examination it was observed that he was having periorbitaloedema and swelling over legs. Perform suitable tests in blood/urine sample provided and interpret your findings
3. **Case history-3: Chronic Renal Failure:** A 70 years old man presented in nephro OPD with complaints of weakness, loss of appetite and breathlessness. He was diabetic and taking anti-diabetic drugs since last 15 years. His blood pressure was 140/100 and there was oedema over face. Perform suitable tests on blood sample provided and interpret your findings accordingly.
4. **Case history-4:** Choose a case of a genetic disorder, describe the basics of disease biochemistry, study patient case history to assess the disease phenotype, discuss the available treatment modalities, study the patient case-history after the successful completion of prescribed treatment.

Experiments: Animal Cell Culture

1. Culturing a given cell line (primary or transformed), maintain the same using serial passaging, safety methods employed to minimize contaminations while culturing and maintaining the culture
2. Various cell culture media, culturing methods for adherent and suspension cultures, counting cells, quantifying cell viability in the culture, freeze-storing the cultures
3. Detecting contamination (bacterial/fungal/mycoplasma *etc.*) in animal cell cultures. Cross-contamination of cell-lines.
4. Trypsinizing cells: Trypsinization is a technique that uses the proteolytic enzyme trypsin to detach adherent cells from the surface of a cell culture vessel. This procedure is performed whenever the cells need to be harvested (*e.g.*, for

passaging, counting, or for nucleic acid isolation).

5. Low speed centrifugation of cultured cells, followed by detergent lysis and fractionation of cell lysates into cytoplasmic, nuclear soluble and chromatin fractions. Assessing the purity of cell fractionation by staining with marker-specific Abs using Immunofluorescence or Western blot methods.
6. Assessing culture instability: This is generally overlooked in busy labs, but is a very important facet of cell culturing. The growth rate of cells that have been repeatedly subculture may sometimes unexpectedly decrease, and the cytotoxicity of, for example, a transfection process may unexpectedly increase. This instability can result from variations in cell culture conditions, genomic variation, and selective overgrowth of constituents of the cell population. Importance of using cells with a low passage number (<10 splitting cycles). To safeguard against instability in continuous cell lines, avoid senescence or transformation in finite cell lines, and maintain consistency in transfection experiments, and create cell banks by freezing aliquots of cells to recall into culture if and when necessary.
7. Also important to learn about procedures of sterilizing potentially biohazardous materials (*e.g.*, cells, culture medium, *etc.*) before disposal, and disposed of according to your institution's guidelines

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	L	S	S	S	S	S	S	S	M
CO2	S	L	S	M	S	S	S	S	S	S
CO3	S	L	S	S	L	S	S	S	S	S
CO4	S	L	M	S	S	S	L	L	L	L
CO5	S	L	S	M	M	S	S	S	S	L

*S-Strong; M-Medium; L-Low

Course adapted from DBT curriculum and handled by all the faculty in Dept. of Biotechnology

SEMESTER THREE
Medical Devices **Credits** 2

Course Code	20MB1C15	Course Type	Core	L	T	P	C	Syllabus version	2020-2021
				1	1	-	2		
Pre-requisite	Basic knowledge in health sciences.								

Course objectives:

1. The course aim is to familiarize students with emerging trends in medical devices for early detection and selection of appropriate treatment.
2. The course will also give an insight about monitoring treatment effectiveness and disease surveillance.

Expected Course Outcomes:

CO1	Know about the detailed insights on sensors, transducers, and optical sensors	**KI, K4**
CO2	Understand the concepts related to bio-recognition systems, electrodes and immobilization	**K2, K5**
CO3	Obtain a comprehensive knowledge about fundamentals and applications of microfluidics	**K1, K3**
CO4	Extend principles of engineering to the development of medical devices and design of sensors	**K6**
CO5	Appreciate basic configuration and distinction among biosensor systems	**K5**
K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 - Create		

Unit I **Sensors** **4 Lectures**	Rationale of electronic biosensors; Essence of three types of electronic biosensors (*i.e.*, potentiometric, amperometric, and cantilever-based sensors); Three essential metrics that define modern electronic sensors; detection time, sensitivity, and selectivity; Physics of detection time that allows one to organize every available sensor in a systematic way; Fundamental limits of detection of various classes of sensors; Opportunities and challenges of integrating sensors in a system platform.
Unit II **Transducers** **4 Lectures**	Principles and applications of Calorimetric, Piezoelectric, semiconductor, impedimetric, based transducers; Biochemical Transducers: Electrode theory: electrode-tissue interface, metal-electrolyte interface, electrode-skin interface, electrode impedance, electrical conductivity of electrode jellies and creams.
Unit III	Photo detectors, optical fiber sensors, indicator mediated

Optical sensors **4 Lectures**	transducers; General principles of optical sensing, optical fiber temperature sensors; Pulse sensor: photoelectric pulse transducer, strain gauge pulse transducer.
Unit IV **Bio recognition systems** **4 Lectures**	Enzymes; Oligonucleotides Nucleic Acids; Lipids (Langmuir-Blodgett bilayers, Phospholipids, Liposomes); Membrane receptors and transporters; Immunoreceptors; Chemoreceptors.
Unit V **Electrodes and immobilization** **4 Lectures**	Microelectrodes, body surface electrodes, needle electrodes, pH electrode, specific ion electrodes/ Ion exchange membrane electrodes, enzyme electrodes; Reference electrodes: hydrogen electrodes, silver-silver chloride electrodes, Calomel electrodes; Enzyme immobilization; Peptide immobilization; Antibody immobilization; Oligonucleotides and Nucleic Acid immobilization; Cell immobilization; Mono-enzyme electrodes; Bi-enzyme electrodes: enzyme sequence electrodes and enzyme competition electrodes.
Unit VI **Fundamentals and applications of microfluidics** **4 Lectures**	Capillary flow and electro kinetics; Micro pump, Micro mixers, Micro reactors, Micro droplets, Micro particle separators; Micro fabrication techniques (different types of lithography methods); Application of micro-fluidics (*eg*. Lab-in –Chip).
Unit VII **Applications** **6 Lectures**	Biomarkers: Disease and pathogen specific information, availability by sample type (blood, serum, urine, sputum, saliva, stool, mucus); Specificity, sensitivity, shelf life, portability; Clinical chemistry; Test-strips for glucose monitoring; Urea determination; Implantable Sensors for long-term monitoring; Drug development and detection; Environmental monitoring; Examples of various diseases (Cancer, HIV/AIDS, Tuberculosis, Malaria, Lymphatic Filariasis, Schistosomiasis, Dengue, Chikungunya).
Unit VIII **Contemporary Issues** **5 Lectures**	Guest lectures by academic/industry experts , online seminars - webinars
Total Lectures – 35	

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	L	S	M	L	S	S	S	S	L
CO2	S	S	S	M	L	S	S	M	S	L
CO3	S	L	S	L	L	S	S	S	S	L
CO4	S	M	S	L	L	S	S	S	S	L
CO5	S	L	S	L	L	S	S	S	S	L

*S-Strong; M-Medium; L-Low

Recommended Textbooks and References:

1. Alice Cunningham, (1998), Introduction to Bioanalytical Sensors, John Wiley & Sons.
2. Jiri Janata, (2009), Principles of Chemical Sensors, 2nd Ed., PlenumPress.
3. F. Schellr, F. Schubert, J.Fedrowitz, (1997), Frontiers in Biosensors, Birkhauser.
4. Brian Eggins, (2002), Chemical Sensors and Biosensors, JohnWilley& Sons.
5. Graham Ramsay, (1998), Commercial Biosensors, JohnWiley& Sons.
6. Ursula Spichiger-Keller, (1998), Chemical Sensors and Biosensors for Medical and Biological Applications,Wiley-VCH
7. Berthier Jean, and Silberzan Pascal, (2010), Microfluidics for Biotechnology, 2nd Ed. ArtechHouse.
8. Frank A Gomez, (2008), Biological Applications of Microfluidics,Wiley.
9. JG.Webster, (1998), Encyclopedia of Medical Devices and Instrumentation. VolI, II, III, IV,Wiley-Blackwell.

Related online contents:

1. F.Ligler, C.RoweTaitt, (2002), Optical Biosensors. Present &Future. Elsevier.
2. Gareth Jenkins, ColinD.Mansfield, (2013), Microfluidic Diagnostics: Methods and Protocols, Springer.

Course adapted from DBT and handled by Dept. of Nanoscience and Technology	**Dr. N. Ponpandian, Professor**

SEMESTER THREE

Intellectual Property Rights, Biosafety and Bioethics Credits 2

Course Code	20MB1C16	Course Type	Core	L	T	P	C	Syllabus version	2020-2021
				3	1	-	4		
Pre-requisite	A Basic knowledge on intellectual property rights								

Course objectives:

1. To provide basic knowledge on intellectual property rights and their implications in biological research and product development.
2. To become familiar with India's National IPR Policy
3. To learn biosafety and risk assessment of products derived from biotechnology and regulation of such products.
4. To become familiar with ethical issues in biological research.
5. This course will focus on the consequences of biomedical research technologies such as cloning of whole organisms, genetic modifications, DNA testing

Expected Course Outcomes:

CO1	Understand the rationale for and against IPR and especially patents	**K1, K2**
CO2	Understand why India has adopted National IPR Policy and be familiar with broad outline of patent regulations	**K2, K3**
CO3	Understand different types of intellectual property rights in general and protection of products derived from biotechnology research and issues related to application and obtaining patents	**K2, K3**
CO4	Gain knowledge of biosafety and risk assessment of products derived from recombinant DNA research environment release of genetically modified organisms, national and international regulations	**K3, K4**
CO5	Understand ethical aspects related to biological, biomedical, health care and biotechnology research	**K5, K6**
K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 - Create		

Unit I **Introduction to IPR** **12 Lectures**	Introduction to intellectual property; types of IP: patents, trademarks, copyright & related rights, industrial design, traditional knowledge, geographical indications, protection of new GMOs; International framework for the protection of IP; IP as a factor in R&D; IPs of relevance to biotechnology and few case studies; introduction to history of GATT, WTO, WIPO and TRIPS; plant variety protection and farmers rights act; concept of 'prior art': invention in context of "prior art"; patent databases - country-wise patent searches (USPTO, EPO, India); analysis and report formation.; Review of Government of India's "National Intellectual Property Rights Policy".

Unit II **Patenting** **12 Lectures**	Basics of patents: types of patents; Indian Patent Act 1970; recent amendments; WIPO Treaties; Budapest Treaty; Patent Cooperation Treaty (PCT) and implications; procedure for filing a PCT application; role of a Country Patent Office; filing of a patent application; precautions before patenting-disclosure/non-disclosure - patent application- forms and guidelines including those of National Bio-diversity Authority (NBA) and other regulatory bodies, fee structure, time frames; types of patent applications: provisional and complete specifications; PCT and conventional patent applications; international patenting-requirement, procedures and costs; financial assistance for patenting- introduction to existing schemes; publication of patents-gazette of India, status in Europe and US; patent infringement- meaning, scope, litigation, case studies and examples; commercialization of patented innovations; licensing – outright sale, licensing, royalty; patenting by research students and scientists-university/organizational rules in India and abroad, collaborative research - backward and forward IP; benefit/credit sharing among parties/community, commercial (financial) and non-commercial incentives.
Unit III **Biosafety** **12 Lectures**	Biosafety and Biosecurity - introduction; historical background; introduction to biological safety cabinets; primary containment for biohazards; biosafety levels; GRAS organisms, biosafety levels of specific microorganisms; recommended biosafety levels for infectious agents and infected animals; definition of GMOs & LMOs; principles of safety assessment of transgenic plants – sequential steps in risk assessment; concepts of familiarity and substantial equivalence; risk – environmental risk assessment and food and feed safety assessment; problem formulation – protection goals, compilation of relevant information, risk characterization and development of analysis plan; risk assessment of transgenic crops vscisgenic plants or products derived from RNAi, genome editing tools.
Unit IV **National and International regulations** **12 Lectures**	International regulations – Cartagena protocol, OECD consensus documents and Codex Alimentarius; Indian regulations – EPA act and rules, guidance documents, regulatory framework – RCGM, GEAC, IBSC and other regulatory bodies; Draft bill of Biotechnology Regulatory authority of India - containments – biosafety levels and category of rDNA experiments; field trails – biosafety research trials – standard operating procedures - guidelines of state governments; GM labeling – Food Safety and Standards Authority of India (FSSAI).
Unit V **Bioethics** **12 Lectures**	Introduction, ethical conflicts in biological sciences - interference with nature, bioethics in health care - patient confidentiality, informed consent, euthanasia, artificial

	reproductive technologies, prenatal diagnosis, genetic screening, gene therapy, transplantation. Bioethics in research – cloning and stem cell research, Human and animal experimentation, animal rights/welfare, Agricultural biotechnology - Genetically engineered food, environmental risk, labeling and public opinion. Sharing benefits and protecting future generations - Protection of environment and biodiversity – biopiracy.
Contemporary issues **5 Lectures**	Guest lectures by academic/industry experts , online seminars - webinars
Total Lectures – 65	

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	-	L	S	-	M	M	-	S	-	-
CO2	-	-	-	M	-	S	-	-	-	M
CO3	-	-	-	-	-	-	S	-	S	S
CO4	-	S	-	L	-	S	-	-	-	L
CO5	M	-	S	-	-	-	S	S	S	L

*S-Strong; M-Medium; L-Low

Recommended Textbooks and References:

1. Ganguli, P. (2001). Intellectual Property Rights: Unleashing the Knowledge Economy. New Delhi: Tata McGraw-Hill Pub.
2. National IPR Policy, Department of Industrial Policy & Promotion, Ministry of Commerce, GoI
3. Complete Reference to Intellectual Property Rights Laws. (2007). Snow White Publication Oct.
4. Kuhse, H. (2010). Bioethics: an Anthology. Malden, MA: Blackwell.
5. Office of the Controller General of Patents, Design & Trademarks; Department of Industrial Policy & Promotion; Ministry of Commerce & Industry; Government of India. http://www.ipindia.nic.in/
6. Karen F. Greif and Jon F. Merz, Current Controversies in the Biological Sciences
7. Case Studies of Policy Challenges from New Technologies, MIT Press
8. World Trade Organisation. http://www.wto.org
9. World Intellectual Property Organisation. http://www.wipo.int
10. International Union for the Protection of New Varieties of Plants. http://www.upov.int
11. National Portal of India. http://www.archive.india.gov.in
12. National Biodiversity Authority. http://www.nbaindia.org

13. Recombinant DNA Safety Guidelines, 1990 Department of Biotechnology, Ministry of Science and Technology, Govt. of India. Retrieved from http://www.envfor.nic.in/divisions/csurv/geac/annex-5.pdf

14. Wolt, J. D., Keese, P., Raybould, A., Fitzpatrick, J. W., Burachik, M., Gray, A., Wu, F. (2009). Problem Formulation in the Environmental Risk Assessment for Genetically Modified Plants. Transgenic Research, 19(3), 425-436. doi:10.1007/s11248-009-9321-9

15. Craig, W., Tepfer, M., Degrassi, G., &Ripandelli, D. (2008). An Overview of General Features of Risk Assessments of Genetically Modified Crops. Euphytica, 164(3) 853-880. doi:10.1007/s10681-007-9643-8

16. Guidelines for Safety Assessment of Foods Derived from Genetically Engineered Plants. 2008.

17. Guidelines and Standard Operating Procedures for Confined Field Trials of Regulated Genetically Engineered Plants. 2008. Retrieved from http://www.igmoris. nic.in/guidelines1.asp

19. Alonso, G. M. (2013). Safety Assessment of Food and Feed Derived from GM Crops: Using Problem Formulation to Ensure "Fit for Purpose" Risk Assessments. Retrieved from http://biosafety.icgeb.org/inhousepublications/ collection biosafety reviews.

Related online contents:

1. https://swayam.gov.in/nd1_noc20_hs18/preview
2. https://nptel.ac.in/courses/109/106/109106092/
3. https://onlinecourses.nptel.ac.in/noc20_hs18/preview
4. https://nptel.ac.in/courses/102/104/102104068/
5. https://www.futurelearn.com/courses/biosecurity

Course adapted from DBT and handled by Dept. of Biotechnology	**Dr. S. Velayuthaprabhu Assistant Professor**

SEMESTER THREE

Lead Molecule Discovery and Preclinical Development
(Job Oriented Certificate Course – 1)

Credits 4

Course Code	20MB1J01	Course Type	Inter/Intra Departmental Course	L	T	P	C	Syllabus version	2020 - 2021
				35	10	-	-		

Name of the Department	**Biotechnology**
Name of the Faculty Member i/c With Complete Address with Phone and e-mail	**Dr. R. Sathishkumar,** Professor, Dept. of Biotechnology, Bharathiar University rsathish@buc.edu.in
Duration of the course	4 Months
Eligibility	PG students of Medical Biotechnology, Biotechnology, Microbiology, Biochemistry students
Number of Candidates to be Admitted	Maximum 30
Mode of the Course	Regular / Online
Collaboration if any with Companies (if Yes, Full Address of the Company Address , Name of the Contact Person)	To be decided
Registration Procedure	Through department office (offline/online)
Job Opportunities: Pharma industries and CRO's	

Course objectives:

1. Understand the drug development process both conventional and emerging systems approach
2. Understand the challenges in drug development
3. Understand the significance of translational medicine in drug development
4. Understand the risk and strategy in drug development
5. Understand the studies required to bring a Lead/discovered compound from target identification through preclinical development

Expected Course Outcomes:

CO1	Critically evaluate the drug discovery pipeline	**K1, K2**
CO2	Applying bioinformatics and omics concepts in the drug discovery	**K2, K3**
CO3	Updating the importance of high-throughput-screening in the drug discovery	**K2, K3**
CO4	Understanding the drug safety assessment process	**K3, K4,**
CO5	Studying how drugs are evaluated in pre-clinical trials	**K5, K6**
K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 - Create		

Course Content	Lecture / Practical / Internship
Module 1 **5 hours**	Drug Discovery and Development in Pharmaceutical Industry
Module 2 **5 hours**	Pharmacology, Medicinal Chemistry and Pharmacokinetics
Module 3 **5 hours**	Drug Targets; Lead Identification
Module 4 **5 hours**	Hit-to-Lead; Testing Models
Module 5 **5 hours**	Lead Optimization; Basics of Biologics
Module 6 **5 hours**	Preclinical Development
Module 7 **5 hours**	Case studies
Module 8 **10 hours**	Student Presentations and Group Discussions
Total – 45 hours (As per NAAC requirement inclusive of Evaluation)	

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	L	L	S	L	M	M	L	S	L	L
CO2	L	L	L	M	L	S	L	L	L	M
CO3	L	L	L	L	L	L	S	L	S	S
CO4	L	S	L	L	L	S	L	L	L	L
CO5	M	L	S	L	L	L	S	S	S	L

*S-Strong; M-Medium; L-Low

Recommended Textbooks and References:

Book(s) for Study:

1. Drugs- From Discovery to Approval, Second Edition by Rick Ng. Wiley- Blackwell, 2009
2. Optimizing the "Drug-Like" Properties of Leads in Drug Discovery by Borchardt, R., Kerns, E., Hageman, M., Thakker, D., Stevens, J. (Eds.), Springer Publishers, 2006
3. Hit and Lead Profiling: Identification and Optimization of Drug-like Molecules: 43 (Methods & Principles in Medicinal Chemistry), Bernard F., and Laszlo U. (Eds.), 2009
4. Systems Biology in Drug Discovery and Development, by Daniel L.Y, Seth M, Wiley Publisher, 2011

Book(s) for Reference:

1. Preclinical Drug Development, by Mark R., David R.T., (Eds.), CRC Press, 2010
2. Systems Biology in Drug Discovery and Development by Yan Q., (Ed.), Springer Publishers 2010
3. Drug Discovery and Development E-Book: Technology in Transition, by Raymond G.H, Duncan R (Eds.), Elsevier Press, 2021

Related online contents:

1. https://journals.sagepub.com/doi/abs/10.1177/24725552211000669
2. https://wyss.harvard.edu/technology/using-systems-biology-to-find-and-test-new-drugs-faster/
3. https://www.nature.com/nrd/

Course designed by Dept. of Biotechnology and handled with Relevant Industry	**Dr. R. Sathishkumar, Professor and Industry personnel**

Fourth Semester

SEMESTER FOUR
Nanobiotechnology **Credits** 2

Course Code	20MB1E2A	Course Type	Elective	L	T	P	C	Syllabus version	2020-2021
				1	1	-	2		
Pre-requisite	Basic knowledge in Nanotechnology								

Course objectives:

1. The course aims at providing general and broad introduction to multi-disciplinary field of nanotechnology.
2. It will familiarize students with combination of top-down approach of microelectronics and micro- mechanics with bottom-up approach of chemistry/biochemistry; a development that is creating new and exciting cross-disciplinary research fields and technologies.
3. The course will also give an insight into complete systems where nanotechnology can be used to improve everyday life.

Expected Course Outcomes:

CO1	Describe basic science behind the properties of materials at the nanometre scale, and the principles behind advanced experimental and computational techniques for studying nanomaterials.	**K4, K5**
CO2	Understand the concepts related to nano-films and their characterization.	**K2, K6**
CO3	Obtain a comprehensive knowledge about nanoparticles and its applications.	**K1, K3**
CO4	Know about the detailed insight on nanomaterials	**K2, K3**
CO5	Gain information's about basics of nanotoxicity	**K1**
K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 - Create		

Unit I **Introduction to Nanobiotechnology** **5 Lectures**	Introduction to Nanobiotechnology; Concepts, historical perspective; Different formats of nanomaterials and applications with example for specific cases; Cellular Nanostructures; Nanopores; Biomolecular motors; Bio-inspired Nanostructures, Synthesis and characterization of different nanomaterials.
Unit II **Nano - films** **5 Lectures**	Thinfilms;Colloidalnanostructures;SelfAssembly,Nanovesicles;Nanospheres;Nano-capsules and theircharacterization.
Unit III **Nano-particles** **5 Lectures**	Nanoparticles for drug delivery, concepts, optimization of nanoparticle properties for suitability of administration through various routes of delivery, advantages, strategies for cellular internalization and long

	circulation, strategies for enhanced permeation through various anatomical barriers.
Unit IV **Application of nano-particles** **5 Lectures**	Nanoparticles for diagnostics and imaging (theranostics); concepts of smartstimuli responsive nanoparticles, implications in cancer therapy, nanodevices forbiosensor development.
Unit V **Nano-materials** **5 Lectures**	Nanomaterials for catalysis, development and characterization of nanobiocatalysts, application of nanoscaffolds in synthesis, applications of nanobiocatalysis in the production of drugs and drug intermediates.
Unit VI **Nano-toxicity** **5 Lectures**	Introduction to Safety of nanomaterials, Basics of nanotoxicity, Models and assays for nanotoxicity assessment; Fate of nanomaterials in different state of environment; Eco- toxicity models and assays; Life cycle assessment, containment.
Unit VII **Contemporary Issues** **5 Lectures**	Guest lectures by academic/industry experts , online seminars - webinars
Total Lectures – 35	

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	L	L	S	S	S	S	L
CO2	S	L	L	L	M	S	S	S	S	L
CO3	S	L	S	L	L	S	S	S	S	L
CO4	S	L	L	L	M	S	S	S	S	L
CO5	M	M	L	S	L	L	S	L	L	L

*S-Strong; M-Medium; L-Low

Recommended Textbooks and References:

1. GeroDecher, Joseph B. Schlenoff, (2003); Multilayer Thin Films: Sequential AssemblyofNanocompositeMaterials,Wiley-VCHVerlagGmbH&Co.KGaA
2. DavidS.Goodsell,(2004);Bionanotechnology:LessonsfromNature, Wiley-Liss
3. Neelina H. Malsch, Biomedical Nanotechnology, CRCPress
4. Greg T. Hermanson, (2013); BioconjugateTechniques, (3rdEdition);Elsevier
5. Recent review papers in the area ofNanomedicine.
6. Risalsingh and shipramithalgupta (2016). Introduction to Nanotechnology. First edition. PP:604.ISBN:9780199456789

7. Charles p pool (2020). Introduction to Nanoscienceand Nanotechnology. wiley publisher.PP.508
8. Narendrakumar and sunitakumbhat (2016). Essentials in Nanoscience and Nanotechnology.wiley publisher.PP.465. ISBN: 978-1-119-09611-5
9. Abdel Salam HamdyMakhlouf Ahmed Barhoum (2018). Fundamentals of Nanoparticles.1st Edition. Elsevier. PP.666. Paperback ISBN: 978032351255
10. Deborah M. Kane, Adam MicolichPeter Roger (2016). Nanomaterials Science and Applications.1st Edition Jenny Stanford Publishing, PP.418 .ISBN 9789814669726
11. Kumar V. Guleria P. Shivendu R. Dasgupta N. Lichtfouse, E. (2021). Nanotoxicology and Nanoecotoxicology. Springer International publisher. Vol. 1 .pp:318. ISBN 978 3030632410
12. Alain Nouailhat (2006). An Introduction to Nanoscience and Nanotechnology. France by Hermes Science/Lavoisier. Doi: https://web.pdx.edu/~pmoeck/phy381/intro-nanotech.pdf
13. A.Ranzoni and M.A.Cooper (2017).Chapter One - The Growing Influence of Nanotechnology in Our Lives. Micro and Nanotechnology in Vaccine Development.PP:1-20
14. Aliofkhazraei, Mahmood (Ed.)(2015). Handbook of Nanoparticles.Springer publisher. ISBN: 978 3319153391
15. IbrahimKhan, KhalidSaeed, IdreesKhan(2019). Nanoparticles: Properties, applications and toxicities. The Arabian journal of chemistry.12(7).PP:908-931
16. SusaiRajendran Anita Mukherjee Tuan Nguyen ChandraiahGodugu RiteshShukla (2020). Nanotoxicity. 1st Edition. Elsevier.pp;504 .ISBN: 9780128199442

Related online contents:

1. https://www.slideshare.net/kirtisingh2011/nanotechnology-ppt
2. http://home.iitk.ac.in/~anandh/MSE694/Introduction_to_Nanomaterials-3.pdf
3. https://travelmantratechnologies.blogspot.com/2021/03/nanofilms-ppt-ppt-nanofilm-technology.html
4. https://application.wiley-vch.de/books/sample/3527331972_c01.pdf
5. https://www.slideshare.net/ganapati123/nanoparticle
6. https://www.slideshare.net/ShrihithRao/application-of-nanotechnolog 71235555
7. https://www.eolss.net/Sample-Chapters/C05/E6-152-35-00.pdf
8. https://nptel.ac.in/courses/118/102/118102003/
9. https://ndl.iitkgp.ac.in/homestudy/science

SEMESTER FOUR
Pharmacogenomics Credits 2

Course Code	20MB1E2B	Course Type	Elective	L	T	P	C	Syllabus version	2020-2021
				1	1	-	2		
Pre-requisite	Basic understanding in Pharmaceuticals								

Course objectives:

This course will give a broad perspective on emergence of pharmacogenomics as a new field and provide them with insight into growing importance it will play in clinical therapeutics and future drug design.

Expected Course Outcomes:

CO 1	Students will gain an understanding of how genetic differences between individuals can impact the outcome of drug therapy in a positive and negative way.	K1&K2
CO 2	The course will also help students to understand how drug therapy based on a person's genetic makeup can optimize effectiveness of therapy while reducing unwanted drug effects.	K1&K2& K4
K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 - Create		

Unit I **Pharmacogenomics** **12 lectures**	Pharmacogenomics; Pharmacogenetics; Benefits; Practical applications of pharmacogenomics; The Promise of Pharmacogenomics today leading to personalized medicines; Human genetic variation- examples of CYP gene variations leading to variable metabolism of drugs; Distribution of variation; Mutations & its kind; Natural selection; Variation in ethnic groups, races.
Unit II **Pharmacology** **12 Lectures**	Pharmacology; Clinical pharmacology; Drugs; Drug Legislation & safety; Types of Drugs-examples of latest drugs; Drug potency and Efficacy; ADME of Drug- Drug absorption; Drug distribution; Drug metabolism & Drug Excretion; Drug efficacy & toxicity; drug therapeutic levels; Therapeutic Index; Drug abuse; Drug response in patients by correlating gene expression; Regulation of gene expression; Polymorphism; Alleles; Single nucleotide polymorphism; Genotyping; Personalized medicine, example of TPMT and DPD gene mutation and their impact in treatment strategy.
Unit III **Biomarkers** **11 Lectures**	Genetic markers-Biomarkers in early drug development; Biomarkers in Clinical development; Biomarkers, Case studies
Total Lectures – 35	

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	-	M	-	-	-	-	-	-
CO2	S	S	-	-	L	-	M	-	-	-
CO3	S	S	-	-	-	-	-	-	-	-
CO4	S	S	L	-	-	-	-	L	-	-
CO5	S	S	-	M	-	L	-	-	-	-

*S-Strong; M-Medium; L-Low

Recommended Textbooks and References:

1. Wu R and Lin M, (2008), Statistical & Computational Pharmacogenomics, CRC Press.
2. Yan Q, (2008), Pharmacogenomics in Drug Discovery and Development, Springer-Verlag New York, LLC
3. Meyer UA and Tyndale RF, (2005), Pharmacogenomics, 2nd Edition, CRC Press.
4. Innocenti F, (2005), Pharmacogenomics: Methods and Applications, Springer-Verlag New York, LLC.
5. Rothstein MA and Collins FS, (2003), Pharmacogenomics: Social, Ethical, and Clinical Dimensions, Wiley John & Sons, Inc.

Course adapted from DBT curriculum and handled by Dept. of Biotechnology	**Dr. V. Thirunavukkarasu** **Associate Professor**

SEMESTER FOUR
Clinical Trials Management
(Job Oriented Certificate Course – 2)

Credits 4

Course Code	20MB1J02	Course Type	Inter/Intra Departmental Course	L	T	P	C	Syllabus version	2020 -21
				30	5				

Name of the Department	**Biotechnology**
Name of the Faculty Member i/c With Complete Address with Phone and e-mail	**Dr. V. Thirunavukkarasu,** AssociateProfessor, Dept. of Biotechnology, Bharathiar University thirunavukkarasu@buc.edu.in
Duration of the course	4 Months
Eligibility	PG students of Medical Biotechnology, Biotechnology, Microbiology, Biochemistry students
Number of Candidates to be Admitted	Maximum 30
Mode of the Course	Regular / Online
Collaboration if any with Companies (if Yes, Full Address of the Company Address , Name of the Contact Person)	**Parexel International (India) Pvt. Ltd,** Bldng No.20, 11thFloor, RahejaMindpower IT park, Madhapur, Hyderabad– 500 081.Telengana
Registration Procedure	Through department office (offline/online)
Job Opportunities: Contract Research Organisations and Research and Development of Pharmaceutical Industries	

Course objectives:

1. Gain basic knowledge about drug discovery
2. Understand the workflow of clinical trials and importance of management of clinical data and interpretation.
3. Gain basic knowledge of SAS programming
4. Acquire knowledge about applying SAS programming for CT management
5. Understand CDISC SDTM and ADaM rules for data standardization

Expected Course Outcomes:

CO1	In-depth learning about work flow of new drug discovery	**K1, K2**
CO2	Understanding the importance of clinical research in drug discovery	**K2, K4**
CO3	Learning and understanding the applications of SAS programming for clinical trial data management	**K2, K4**
CO4	Learning SAS programming and applying it using model clinical data	**K3, K4,**
CO5	Understand the needs for data standardization and evaluating its application in CT	**K2, K5**

K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 - Create

Course Content	Lecture / Practical / Internship
Module 1 **4 hours**	Drug development process. History of Drug Development. Types of drugs. Target identification. Drug Discovery – New entities (Chemical, Biological). In Vitro and In vivo studies. Nonclinical studies and IND. Basics of pharmacokinetics and pharmacodynamics
Module 2 **3 hours**	Clinical trials – Terminology, 4 phases and Documentation (SOPs, Protocols and SAPs. CRFs and Annotated CRFs. NDA, BLA). Cross functional teams and roles in clinical trials.
Module 3 **6 hours**	Introduction to SAS. Libraries and Datasets, Variables and Observations. Types of data - raw vs. sas data; numeric vs. character. sas files -. sas, .sas7bdat, .log, .lst. SAS program structure - Data and Proc steps, Keywords, Statements, Global statements. Syntax rules - dataset and variable names and their attributes, semicolon and comments. SAS dates and Global Options
Module 4 **5 hours**	Data step iterative processing. Compilation and execution. Informats and formats. Dataset combining - set and merge. Read and write data. Conditional execution of statements - If-Then-Else. Do loop processing Array processing. SAS functions - character, numeric and date. Assignment, Retain, Sum, Output and Global statements. Automatic variables.
Module 5 **6 hours**	Basic SAS procedures. General - Contents, Sort, Print, Format, Transpose, Import, Export, Compare. Statistical - Freq, Means. Reporting - Report. Graph - Gplot, Gchart. Where, Var, Id and Class Statements. Output Delivery System - Trace, Output, RTF, EXCEL. Debugging SAS programs. Compilation and Execution errors. Data, Syntax and Logic errors.
Module 6 **5 hours**	Macro programming. Advantages of Macro programming. Macro variables - Global and local. Macro routines and macro code. Keyword and positional parameters. Macro debugging. Writing macros with conditional logic. Methods of creating macro variables.
Module 7 **4 hours**	Proc SQL. Creating and modifying datasets. labels and formats. Combining data using union and join statements. Case expression. Sorting - Order by clause. Except and Intersect statements. Separated by and having clauses.
Module 8 **5 hours**	CDISC Standards. Purpose of SDTM and ADaM datasets. SDTM – Introduction, Fundamentals, submitting standard data, Assumptions for domain models, Special purpose domains, General observation classes, Trial design datasets, Representing relationships.
Module 9 **3 hours**	ADaM – Introduction, Fundamentals, Standard ADaM variables – Conventions, Analysis Dataset – Subject Level (ADSL), Basic data structure (BDS) datasets; Occurrence data structures. Common implementation issues and solutions

Module 10 **4 hours**	SAS in the Pharmaceutical Industry. Role of a SAS programmer. Attributes of a good programmer. SOPs, Protocols and SAPs. CRFs and Annotated CRFs. Importing raw clinical data. Edit checks and cleaning clinical data. Transforming data and creating analysis datasets. Continuous vs. categorical data. LOCF, windowing, Transposing data. Dataset specifications and Mock tables. Creating Tables, listing and Graphs.
Total – 45 hours	(As per NAAC requirement inclusive of Evaluation)

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	L	M	S	L	M	M	L	M	L	L
CO2	M	L	L	M	L	S	L	M	L	M
CO3	L	M	L	L	M	L	S	L	S	S
CO4	L	S	L	L	L	S	L	L	L	L
CO5	M	L	S	L	L	L	S	S	S	L

*S-Strong; M-Medium; L-Low

Recommended Textbooks and References:

1. SAS® Certification Prep Guide: Statistical Business Analysis Using SAS®9; Joni N. Shreve, Donna Dea Holland; Publisher: SAS Institute
2. SAS® Certification Prep Guide: Advanced Programming for SAS®9 Second Edition; Publisher: SAS Institute
3. SAS® Programming in the Pharmaceutical Industry, second edition; Jack Shostak; Publisher: SAS Institute
4. Basic Principles of Drug Discovery and Development; Benjamin E. Blass; 2021; Elsevier Science
5. CDISC Implementation Guides and Model documents – SDTM and ADaM; CDISC.

Course designed and handled by Dept. of Biotechnology and Relevant Industry	**Dr. V. Thirunavukkarasu Associate Professor and Industry personnel**

Annexure

M. Sc. MEDICAL BIOTECHNOLOGY PROGRAMME

(DBT, Government of India Supported)

Syllabus

(With effect from 2020-2021)

Program Code :

Department of Biotechnology
BHARATHIAR UNIVERSITY
(A State University, Accredited with "A" Grade by NAAC and 13th Rank among Indian Universities by MHRD-NIRF- 2020)
Coimbatore 641 046
Tamil Nadu, INDIA

BHARATHIAR UNIVERSITY : :
COIMBATORE 641046

DEPARTMENT OF BIOTECHNOLOGY

MISSION

Provide quality education on par with international standards at affordable cost and empower them with innovative thinking to flourish in their prospective careers. The aim is not only to impart domain knowledge and technical skills, but also to mould into an Biotechnology professional with integrity and honour

DBT Sponsored M. Sc. Medical Biotechnology Programme

(2020-2021 onwards)

Total: 20 seats

10 seats through GAT-B
10 seats for Tamil Nadu native students through BU admission norms

ELIGIBILITY CRITERIA

Bachelor's degree in any discipline of Life Sciences/Biological Sciences (Botany, Zoology, Biotechnology, Biochemistry, Microbiology, Genetics, Biomedical Genetics etc.); Bachelor's degree in Technology (Biotechnology/Biomedical Engineering); M.B.B.S./B.D.S./B.V.Sc./B. Pharm. from recognized institutions.

ADMISSION

Ten seats admission is through GAT-B (Graduate Aptitude Test for Biotechnology), conducted by the Regional Centre for Biotechnology, Faridabad, through online test held across the country at various centres. For further details of GAT-B entrance exam visit www.rcb.res.in. Students should apply online to Bharathiar University for admission with GAT-B scores and for details visit www.b-u.ac.in.

Ten seats admission is through Bharathiar University admission norms for Tamil Nadu native students.

DURATION OF THE PROGRAMME

The duration of the M. Sc. Medical Biotechnology programme is two years, which comprises four semesters. A candidate who has been admitted to the course shall appear in all the four semester examinations during the course of study. On successful completion of all the examinations, he/she shall qualify himself/herself for the award of the degree M. Sc. in Medical Biotechnology.

FELLOWSHIP SUPPORT

All the selected students will get a fellowship of Rs. 5000/- per month from DBT, Government of India

NEED FOR THE PROGRAMME

- Indian Biotech industry is growing at the rate of 30% in which healthcare industries including pharma and diagnostics accounts for more than 60%. This is expected to be a $100 bn industry by 2025.

- There are more than 600 core biotechnology companies, about 2600+ biotech start-ups, 41 BIRAC-supported incubators and more than 523 USFDA approved drug manufacturing facilities.
- To cater to this fast growing industry there is not enough skilled manpower and it is the absolute need of the hour to train students so as to be employable in this industry.

ABOUT THE PROGRAMME

DBT sponsored M.Sc. Medical Biotechnology is a unique programme offered at the Department of Biotechnology, Bharathiar University, Coimbatore, Tamil Nadu, India. The University offers an ideal ambience for the students to take-up and undergo highly productive academic activities in its serene campus. This programme has been designed to reduce the gap between the 'knowledge' gained by students and appropriate skill components required for technology development and implementation. To achieve this, Bharathiar University has roped in leading hospitals and biomedical industries as collaborators. The course is intended to provide an in-depth understanding and knowledge of the modern concepts along with the enrichment of practical skills in the field of medical biotechnology, molecular diagnostics and pharmaceutical sectors, etc. The students will be trained to handle sophisticated instruments so as to analyze, evaluate and report the generated data in the arena of the medical biotechnology.

- This curriculum has been designed based on the DBT's remodeled curriculum, framed by panel of eminent scientists that comprises scintillating theory, extensive and exhaustive practical and technology-based electives. Intensive interdisciplinary research project/dissertation will be carried out as joint projects with industries/other participating departments.
- Each course has its own well-tailored learning objectives and student learning outcome with specific course plan (number of lectures per unit) and with appropriately provided resources/reference text books by renowned authors in the relevant areas of the curriculum.
- The theory and practical courses include relevant examples, case studies highlighting current scenarios and tutorials for inculcating critical thinking by introducing the concept of Education 4.0 and 5.0, which will make students ready for Industry 4.0 and 5.0 innovations.
- The curriculum includes specialized course modules, such as,
    - ✓ Developmental Biology and Human Physiology
    - ✓ Biostatistics
    - ✓ Biophysical Principles and Analytical Techniques
    - ✓ Medical Microbiology and Infection Biology
    - ✓ Genetic Engineering and Genome Editing Technologies
    - ✓ OMICS: Genomics, Transcriptomics, Proteomics and Metabolomics

- ✓ Clinical Biochemistry and Disease Metabolism
- ✓ Tissue Engineering and Stem Cell Technology
- ✓ Molecular Diagnostics and Therapeutics
- ✓ Bioinformatics
- ✓ Medical Devices
- ✓ Plant Molecular Pharming
- ✓ Alternative Medicines
- ✓ Nanobiotechnology
- ✓ Pharmacogenomics

for interdisciplinary understanding and subsequent applications of the acquired knowledge and training in modern medical biotechnology by working with the hospitals and biomedical industries.

- Two value added courses has been added in the curriculum as per the newly framed rules of Bharathiar University, which will focus on to improve the oral and written communication skills by inviting external experts and through classroom and journal club seminars.
- Two job-oriented certificate courseswith the industry has been added in the curriculum as per the newly framed rules of Bharathiar University,
  - ✓ Lead Molecule Discovery and Preclinical Development
  - ✓ Clinical Trials Management
- To facilitate the interdisciplinary research, the student projects have to be designed, developed and proposed in collaboration with hospitals or biomedical industries located far and near the institution. Additional weightage has been given to identify and develop a research proposal in the 3rd semester itself in order to inculcate research thinking while undergoing the curriculum, which is also stipulated to carry marks and credits.
- Intellectual Property Rights, Biosafety and Bioethics has been included as a separate course in order to understand and manage the bio-safety issues as per the norms of regulatory bodies including legal, ethical and cultural aspects.

Dispensing diverse knowledge with in-built provision of relevant skill-sets for the current industry needs (4.0 and 5.0), this course will be an ideal platform for the students to kick start their career in biomedical sectors.

UNIVERSITY DEPARTMENTS INVOLVED

Core Department: BIOTECHNOLOGY

S. No.	Faculty Details (Name and Designation)

1.	Dr. V. Vijayapadma, Professor and Head
2.	**Dr. R. Sathishkumar, Professor and Programme Coordinator**
3.	Dr. S. Girija, Associate Professor
4.	Dr. P. Ekambaram, Associate Professor
5.	Dr. S. R. Prabagaran, Associate Professor
6.	Dr. V. Thirunavukkarasu, Associate Professor
7.	Dr. S. Velayuthaprabhu, Assistant Professor
8.	Dr. M. Arun, Assistant Professor

Collaborating Departments

Name of the Department	Head of the Department	Faculty involved
Bioinformatics	Dr. N. Jeyakumar	1. Dr. N. Jeyakumar Professor and Head
		2. Dr. P. Shanmughavel Professor
Microbial Biotechnology	Dr. J. Angayarkanni	3. Dr. J. Angayarkanni Associate Prof. and Head
		4. Dr. V. BrindhaPriyadarshni Assistant Professor
Nanoscience and Technology	Dr. N. Ponpandian	5. Dr. N. Ponpandian Professor and Head
		6. Dr. C. Viswanathan, Associate Professor
Statistics	Dr. R. Vijayaraghavan	7. Dr. R. Vijayaraghavan Professor and Head
		8. Dr. R. Jaisankar Professor
		9. Dr. R. Muthukrishnan Professor

INDUSTRY PARTNERS

Hospitals

Ganga Hospitals, Coimbatore

PSG Hospitals, Coimbatore

KMCH, Coimbatore

Aravind Eye Hospitals, Coimbatore

Biomedical Industries

Bharat Biotech, Hyderabad

GVK Bio Sciences, Hyderabad

Genotypic Technology Pvt Ltd. Bengaluru

Green Chem Herbal Formulations, Bengaluru

String Bio, Bengaluru

Syngenome, Coimbatore

Micro Lab, Coimbatore

Cellzyme Biotech, Coimbatore

AVN Ayurveda Formulations, Madurai

Texcity Biosciences, Coimbatore

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CHOICE BASED CREDIT SYSTEM (CBCS)

The programme will be based on the pattern of Choice Based Credit System (CBCS) with components of continuous internal assessment and comprehensive external assessment. The comprehensive external assessment shall be done at the end of the semester. The odd semester shall begin in July and the even semester shall begin in December. Each candidate should undergo and successfully complete the following courses in order to be qualified for the award of the degree,

No.	Course Type	No. of Courses	Credits/ Course	Total Credits
	Scholastic Courses			
1	Core-Theory	14	4	56
		2	2	4
2	Core-Practical	3	5	15
3	Elective-Theory	2	2	4
4	Core-Project/Dissertation	1	3+8	11
	Total	**22**	**24**	**90**
	Co-Scholastic Courses			
1	Online SWAYAM Course	1	2	2
2	Value Added Courses	2	2	4
3	Job Oriented Certificate Courses	2	4	8
4	Summer Internship	1	2	2
	Total	**6**	**-**	**16**

DISTRIBUTION OF MARKS*

	EXAMINATION	MARKS
A.	**THEORY**	
1.	**Continuous Internal Assessment (CIA)**	**25**
	Internal Test (Average of best two test performance)	15
	Assignment	5
	Seminar	5
2.	**End Semester Examination (ESE)**	**75**
	Minimum marks required to pass in the ESE	37.5
	Minimum marks (CIA + ESE) for earning the credits	50
B.	**PRACTICAL**	
1.	**Continuous Internal Assessment (CIA)**	**40**
	Major Practical	15
	Minor Practical	10
	Spotters	5
	Record and *Viva*	10
2.	**End Semester Examination (ESC)**	**60**
	Major Practical	25
	Minor Practical	15
	Spotters	10
	Record and *Viva*	10
C.	**PROJECT**	
	Continuous Internal Assessment (CIA)	75 + 75
	Evaluation of Project Report by External Examiner and Supervisor	150
	Viva-Voce by External Examiner and Supervisor	50
	Total	**350**

**except for Biostatistics*

PATTERN OF QUESTION PAPER FOR END SEMESTER EXAMINATION *

Duration: 3 Hours; Maximum Marks: 75

PART A – Answer ALL Questions (10 x 1 = 10)
Two multiple choice questions from each unit

PART B – Answer ALL Questions (5 x 5 = 25)
(Internal Choice – either or type)
One set of question from each unit

PART C – Answer any Five Questions (5 x 8 = 40)

Answer any 5 from 8 questions (equal question distribution from all the units)
except for Biostatistics

ADJUDICATION OF RANK HOLDER

A candidate who qualifies the PG Degree Course passing all the Examinations in the first attempt, within the minimum period prescribed for the Course of Study from the date of admission and become a top scorer in Scholastic courses will be adjudicated as rank holder.