M.Sc. Biotechnology

Course Curriculum

Batch: 2022-2023

Academic Year: 2023-24

W.E.F. July 2023

GSFC University, Vigyan Bhavan, P. O. Fertilizernagar, Vadodara - 391750, Gujarat, India

VISION

- GSFCU strives to be the best compact boutique institution with a futuristic approach, encouraging student centric culture and sharpened focus on developing industry ready & employable students with all-round development.

MISSION

- Establish an institution, which promotes creativity and innovation.
- Develop unique quality standards for academic excellence and pedagogical innovations.
- Remain agile through learning ecosystem with flexible processes & systems.
- Holistic growth for industry readiness.

No.	Programme Outcomes (POs)	Blooms' Taxonomy Domain	Blooms' Taxonomy Sub Domain
PO1	To impart knowledge regarding basic concepts of applied biological sciences.	Basic Knowledge	Explain, Describe, Discuss, Recall, Locate
PO2	To explain the relationships between biological sciences, chemical sciences, physical sciences and mathematical sciences.	Interdisciplinary approach	Apply, Practice, Interpret, Select, Correlate
PO3	To perform procedures as per laboratory standards in the areas of Biological Sciences and to think analytically.	Practical learning	Compare, Classify, Select, Investigate
PO4	To communicate effectively in terms of reading, writing, speaking and delivering the view to others.	Effective Communication and social Interaction	Explain, Describe, outline, Predict, Summarize
PO5	To culminate and understand the moral values for any of the subjects with respect to good practices and humanity.	Ethics	Judge, Assess, Estimate, Predict, Argue
PO6	To explain the importance of ecological balance along with conservation of natural resources for human well being.	Environment and Sustainability	Construct, Develop, Produce

No.	Programme Specific Outcomes (PSOs)	Blooms' Taxonomy Domain	Blooms' Taxonomy Sub Domain
PSO1	Understanding of biotechnology related research and industrial applications.	Remembering and Understanding	Explain, Describe, Discuss, Recall, Locate
PSO2	Expertise in interpreting complex data related to biotechnology problems and challenges.	Application and Analysing	Apply, Practice, Interpret, Select, Correlate
PSO3	Expertise in knowledge needed to solve current and emerging technologies.	Analysing	Compare, Classify, Select, Investigate
PSO4	Understanding related to questions they need to ask and in – depth research they need to conduct.	Understanding	Explain, Describe, outline, Predict, Summarize
PSO5	Expertise in communicating issues related to industrial biotechnology to a wide audience.	Evaluating	Judge, Assess, Estimate, Predict, Argue
PSO6	Expertise in solving complex social and ethical problems confronting the industry and the government.	Creating	Construct, Develop, Produce

Mapping of POs & PSOs:

	PO1	PO2	PO3	PO4	PO5	PO6
PSO1	2	2	3	3	3	2
PSO2	3	2	2	2	3	3
PSO3	3	3	3	2	2	1
PSO4	3	3	2	2	2	2
PSO5	2	3	2	3	2	2
PSO6	2	2	2	2	3	2
Avg.	2.5	2.5	2.3	2.3	2.5	2

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); 0 None

Definition of Credit:

1 Hour Lecture (L) per week	1 credit
1 Hour Tutorial (T) per week	1 credit
2 Hours Practical (P) per week	1 credit
1 Hour Practical (P) per week	0.5 credit
3 Hours Experiential learning	1 credit

Course code Definitions:

Lecture	L
Tutorial	T
Practical	P
Basic Science Courses	BSC
Engineering Science Courses	ESC
Humanities and Social Sciences including Management courses	HSMC
Professional core courses /Major (Core)	PCC
Professional Elective courses /Minor Stream	PEC
Open Elective courses	OEC
Laboratory course	LC
Mandatory courses	MC
Non-credit courses	NC
Project (Experiential learning)	PROJ
Experiential learning ex. Internship, Industrial Visit, Field visit, etc,	EL
Multidisciplinary courses	MDC
Ability Enhancement Course	AEC
Skill Enhancement Course	SCE
Value Added Courses	VAC

Structure of Postgraduate Programme:

Sr. No.	Category	Credit Breakup
1	Professional core courses -**Major (Core)**	61
2	Professional Elective courses relevant to chosen specialization/branch - **Minor Stream**	14
3	Project work, seminar and internship in industry or elsewhere	27
4	Mandatory Courses [Environmental Sciences, Induction Programme, Indian Constitution, Essence of Indian Knowledge Tradition]	(non-credit)
	Total	**102**

Table: Minimum Credit Requirement

S.No.	Broad Category of Course	**Minimum Credit Requirement**
		2-year PG
1	**Major (Core) (50% of total credit)**	**61**
2	**Skill Enhancement Courses (SEC) (from major & Minor)**	**12**
3	**Internship and Dissertation**	**27**
	Total	**102**

Category-wise Courses:

Basic Science Course

(i) Number of Basic Science Course:
(ii) Credits:

Sr. No.	Course Code	Course Name	Semester	Teaching Scheme (Hours/week)				Teaching Credit			
				L	P	T	Total	L	P	T	Total
1	MSBO106	Basics Of Mathematics & Statistic	1	2	0	0	2	2	0	0	2

2	MSBO107	Basics Of Chemistry & Physics	1	2	0	0	2	2	0	0	2
		Total									**4**

Note: L = Lecture, P = Practice, T= Tutorial, MS - Mid Semester, CEC - Continuous Evaluation Component, ES - End Semester

Professional Core Courses

(i) Number of Professional Core Courses: 13
(ii) Credits: 39

Sr. No.	Course Code	Course Name	Semester	Teaching Scheme (Hours/week)				Teaching Credit			
				L	P	T	Total	L	P	T	Total
1	MSBO101	Biochemistry	1	3	0	0	3	3	0	0	3
2	MSBO102	Cell & Molecular Biology	1	3	0	0	3	3	0	0	3
3	MSBO103	Plant & Animal Biotechnology	1	3	0	0	3	3	0	0	3
4	MSBO104	Microbiology	1	3	0	0	3	3	0	0	3
5	MSBO105	Genetics	1	3	0	0	3	3	0	0	3
6	MSBO 201	Genetic Engineering	2	3	0	0	3	3	0	0	3
7	MSBO202	Immunology	2	3	0	0	3	3	0	0	3
8	MSBO203	Bioinformatics	2	3	0	0	3	3	0	0	3
9	MSBO204	Bioprocess Engg.&Tech	2	3	0	0	3	3	0	0	3
10	MSBO205	Ipr,Biosafety & Bioethics	2	3	0	0	3	3	0	0	3
11	MSBO301	Genomics & Proteomics	3	3	0	0	3	3	0	0	3
12	MSBO302	Emerging Technologies	3	3	0	0	3	3	0	0	3
13	MSBO305	Molecular Diagnostics	3	3	0	0	3	3	0	0	3
		Total					**39**				**39**

Note: L = Lecture, P = Practice, T= Tutorial, MS - Mid Semester, CEC - Continuous Evaluation Component, ES - End Semester

Elective Courses

(i) Number of Professional Elective Course: 18
(ii) Credits: 48

Sr. No.	Course Code	Course Name		Teaching Scheme (Hours/week)				Teaching Credit			
				L	P	T	Total	L	P	T	Total
1	MSBO106	Basics Of Mathematics & Statistics		2	0	0	2	2	0	0	2
2	MSBO107	Basics Of Chemistry & Physics		2	0	0	2	2	0	0	2
3	MSBO207/212	Microbial Technology/Environment Biotech		2	0	0	2	1	0	0	1
4	MSBO208	GLP and Regulatory compliances		1	0	0	1	0	2	0	2
5	MSBO306	Project Proposal Preparation		2	0	0	2	2	0	0	2
6	MSBO308	Ddd/Vaccine/Nanotechnolog-y		2	0	0	2	2	0	0	2
			TOTAL								10

Note: L = Lecture, P = Practice, T= Tutorial, MS - Mid Semester, CEC - Continuous Evaluation Component, ES - End Semester Internship In Industry Or Elsewhere

(i) Number of Project Work, Seminar And Internship In Industry Or Elsewhere: 4
(ii) Credits: 8

Sr. No.	Course Code	Course Name	Teaching Scheme (Hours/week)				Teaching Credit			
			L	P	T	Total	L	P	T	Total
1	MSBO108	Internship	0	0			0	2	0	2
2	MSBO210	Internship	0	0	0	0	0	2	0	2
3	MSBO311	Internship	0	0	0	0	0	2	0	2
4	MSBO401	Dissertation Viva-Voce	0	0	0	20	0	0	2	20

		Total			**8**					**26**

Note: L = Lecture, P = Practice, T= Tutorial, MS - Mid Semester, CEC - Continuous Evaluation Component, ES - End Semester

About the Programme:

Science is the basic foundation of any technological and engineering creation. In view of the changing scenario at the national and international level in the field of Science and Technology, there is a great demand for basic sciences with considerable knowledge of its applications. GSFC University is committed to high academic standards.

The M..Sc. Biotechnology Program is an Honours Degree which is designed for four Semesters in such a way that a good basic foundation of subjects is laid and applications along with recent developments are covered. Students will also get theoretical and practical knowledge by undergoing industrial internship after every semester.

The more focused specialization course of Microbiology is designed to full fill recent demands of industrial career.

Teaching Scheme
Semester – I M. Sc Biotechnology

Sr. No.	Course Code	Course Name	Teaching Scheme (Hours/week)				Teaching Credit				Evaluation Scheme					
			L	P	T	Total	L	P	T	Total	Theory: MS Marks	Theory: CEC Marks	Theory: ES Marks	Theory Marks	Practical Marks	Total Marks
	Course															
1	MSBO101	Biochemistry	3	0	0	3	3	0	0	3	30	20	50	100		
2	MSBO102	Cell & Molecular Biology	3	0	0	3	3	0	0	3	30	20	50	100		
3	MSBO103	Plant & Animal Biotechnology	3	0	0	3	3	0	0	3	30	20	50	100		
4	MSBO104	Microbiology	3	0	0	3	3	0	0	3	30	20	50	100		
5	MSBO105	Genetics	3	0	0	3	3	0	0	3	30	20	50	100		
6	MSBO106	Basics Of Mathematics & Statistics	2	0	0	2	2	0	0	2				50		
7	MSBO107	Basics Of Chemistry & Physics	2	0	0	2	2	0	0	2				50		
8	MSBO101	Lab1-Biochem & Analytical Tech	0	4			0	2	0	2				50		
9	MSBO104	Lab2-Microbiology	0	4			0	2	0	2				50		
10	MSBO103	Lab3-Plant & Animal Biotech	0	4			0	2	0	2				50		
11	MSBO108	Internship	0	0			0	2	0	2				50		
12	MSBO109	LAB 4-Basics of Computer Applications			1			1		1				50		

13	MSBO110	LAB 5- Intro to basic Programming			1			1		1				50		
		Total	**19**	**0**		**29**										**900**

Note: L = Lecture, P = Practice, T= Tutorial, MS - Mid Semester, CEC - Continuous Evaluation Component, ES - End Semester

PEC/OEC– I

Course Code	Course Name
MSBO101	BIOCHEMISTRY
MSBO102	CELL & MOLECULAR BIOLOGY
MSBO103	PLANT & ANIMAL BIOTECHNOLOGY
MSBO104	MICROBIOLOGY
MSBO105	GENETICS
MSBO106	BASICS OF MATHEMATICS & STATISTICS
MSBO107	BASICS OF CHEMISTRY & PHYSICS
MSBO101	LAB1-BIOCHEM & ANALYTICAL TECH
MSBO104	LAB2-MICROBIOLOGY
MSBO103	LAB3-PLANT & ANIMAL BIOTECH

COURSE CODE MSBO101	COURSE NAME BIOCHEMISTRY	SEMESTER I

Teaching Scheme (Hours)				Teaching Credit			
Lecture	Practical	Tutorial	Total Hours	Lecture	Practical	Tutorial	Total Credit
3	0	0	45	3	0	0	3

Course Prerequisites	Students should have basic knowledge about cell biology
Course Category	Core Professional.
Course focus	Scientific Temperament & Employability
Rationale	By studying the structures and functions of biomolecules - the energetics, interactions, regulation and downstream signalling of biochemical pathways - and comparing pathways from different species and organisms, you will gain an understanding and appreciation of how living systems operate, survive and die.
Course Revision/ Approval Date:	14/03/2020
Course Objectives (As per Blooms' Taxonomy)	**1. Remember** Concepts of basic Biochemistry. **2. Apply** To understand various Biochemical pathways. **3. Analyses** Interactions at cellular and systems level. **4. Create** an understanding how interactions network develops. **5. Understand** applications both scientific and industrial.

Course Content (Theory)	Weigh tage	Contact hours
Unit 1:Chemical basis of life: Miller-Urey experiment, abiotic formation of amino acid oligomers, composition of living 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.	**20%**	**9**

Unit 2: 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, structure-function relationships in model proteins like ribonuclease A, myoglobin, hemoglobin, chymotrypsin etc.; 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. Enzyme catalysis – general principles of catalysis; quantitation of enzyme activity and efficiency; enzyme characterization and Michaelis-Menten kinetics; 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; regulatory strategies with specific example of hemoglobin; isozymes; role of covalent modification in enzymatic activity; zymogens.	**20%**	**9**
Unit 3: Sugars - Mono, di, and polysaccharides 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. Self-assembly of lipids, micelle, biomembrane organization - sidedness and function; membrane bound proteins - structure, properties and function; transport phenomena; nucleosides, nucleotides, nucleic acids - structure, a historical perspective leading up to the proposition of DNA double helical structure; difference in RNA and DNA structure and their importance in evolution of DNA as the genetic material.	**20%**	**9**
Unit 4: Bioenergetics- Basic principles; equilibria and concept of free energy; coupled interconnecting reactions in metabolism; oxidation of carbon fuels; recurring motifs in metabolism; Introduction to GPCR, Inositol/DAG//PKC and Ca++ signaling pathways; glycolysis and gluconeogenesis; reciprocal regulations and non-carbohydrate sources of glucose; Citric acid cycle, entry to citric acid cycle, citric acid cycle as a source of biosynthetic precursors; Oxidative phosphorylation; importance of electron transfer in oxidative phosphorylation; F1-F0 ATP Synthase; shuttles across mitochondria; regulation of oxidative phosphorylation; Photosynthesis – chloroplasts and two photosystems; proton gradient across thylakoid membrane; Calvin cycle and pentose phosphate pathway; glycogen metabolism, reciprocal control of glycogen synthesis and breakdown, roles of epinephrine and glucagon and insulin in glycogen metabolism; Fatty acid 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.	**20%**	**9**

Unit 5: Theory: Calvin cycle and pentose phosphate pathway; glycogen metabolism, reciprocal control of glycogen synthesis and breakdown, roles of epinephrine and glucagon and insulin in glycogen metabolism; Fatty acid 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; target of rapamycin (TOR) & Autophagy regulation in relation to C & N metabolism, starvation responses and insulin signaling.	**20%**	**9**

List of Practical	Weightage	Contact hours
1. Preparing various stock solutions and working solutions that will be needed for the course.	**20%**	**12**
2. To determine an unknown protein concentration by plotting a standard graph of BSA using UV-Vis Spectrophotometer and validating the Beer- Lambert's Law.	**20%**	**12**
3. To prepare an Acetic-Na Acetate Buffer and validate the Henderson-Hasselbach Equation.	**20%**	**12**
4. Purification and characterization of an enzyme from a recombinant source.	**20%**	**12**
5. Titration of Amino Acids and separation of aliphatic, aromatic and polar amino acids by thin layer chromatography.	**20%**	**12**
6. Experimental verification that absorption at OD260 is more for denatured DNA as compared to native double stranded DNA. reversal of the same following DNA renaturation. Kinetics of DNA renaturation as a function of DNA size.	**20%**	**12**
7. Identification of an unknown sample as DNA, RNA or protein using available laboratory tools. (Optional Experiments)	**20%**	**12**
8. Biophysical methods (Circular Dichroism Spectroscopy, Fluorescence Spectroscopy).	**20%**	**12**
9. Determination of mass of small molecules and fragmentation patterns by Mass Spectrometry.	**20%**	**12**

Instructional Method and Pedagogy:

Audio-Visual Lectures, Quizzes, Debates, Project works, Case studies, and Assignments Practical exercises are designed to understand the theory as taught in the classroom. Hands on in practical session.

Course Outcomes:	Blooms' Taxonomy Domain	Blooms' Taxonomy Sub Domain
After successful completion of the above course, students will be able to:		
CO1 The objectives of this course are to build upon undergraduate level knowledge of biochemical principles with specific emphasis on different metabolic pathways.	Remember	Explain, Describe, Discuss, Recall, Locate
CO2 The course shall make the students aware of various disease pathologies within the context of each topic.	Apply	Apply, Practice, Interpret, Select,
CO3 The course will make the students aware of various Biochemical reactions pertaining to human health and apply biochemical knowledge in normal & diseased states.	Analyses and Evaluation	Compare, Classify, Select, Investigate
CO4 To Understand the metabolism of dietary and endogenous carbohydrate, lipid, and protein.	Create	Develop, Produce
CO5 The principles of bioenergetics and enzyme catalysis	Understand	Explain, Describe, outline, Predict, Summarise

Learning Resources	
1.	Textbook & Reference Book 1. Stryer, L. (2015). Biochemistry. (8th ed.) New York: Freeman. 2. Lehninger, A. L. (2012). Principles of Biochemistry (6th ed.). New York, NY: Worth. 3. Voet, D., & Voet, J. G. (2016). Biochemistry (5th ed.). 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 Reference books : Biochemistry By U Satyanarayan
2.	Journals & Periodicals 1. JBC, 2. Science, 3. Plos biology 4. Periodicals: current science
3	Other Electronic resources: 1) MH Education 2) NPTEL

<table>
<tr><th>Evaluation Scheme</th><th>Total Marks</th></tr>
<tr><td>Theory: Mid semester Marks</td><td>30 marks</td></tr>
<tr><td>Theory: End Semester Marks</td><td>50 marks</td></tr>
<tr><td>Theory: Continuous Evaluation Component Marks</td><td>
<table>
<tr><td>Attendance</td><td>05 marks</td></tr>
<tr><td>MCQs</td><td>05 marks</td></tr>
<tr><td>Skill enhancement activities / case study</td><td>05 marks</td></tr>
<tr><td>Presentation/ miscellaneous activities</td><td>05 marks</td></tr>
<tr><td>Total</td><td>20 Marks</td></tr>
</table>
</td></tr>
<tr><td>Practical Marks</td><td>
<table>
<tr><td>Attendance</td><td>05 marks</td></tr>
<tr><td>Practical Exam</td><td>30 marks</td></tr>
<tr><td>Viva</td><td>10 marks</td></tr>
<tr><td>Journal</td><td>5 marks</td></tr>
<tr><td>Total</td><td>50 Marks</td></tr>
</table>
</td></tr>
</table>

Mapping of PSOs and COs

PO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	1	-	2	1	1	-
CO2	1	3	2	2	-	-
CO3	1	-	-	1	2	1
CO4	2	3	2	-	2	2
CO5	2	1	-	1	-	2

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

Mapping of PO and COs

PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	-	2	2	1
CO2	-	1	1	2	-	-
CO3	2	-	-	1	2	1
CO4	2	1	2	3	2	2
CO5	-	1	-	2	-	3

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

COURSE CODE MSBO102	COURSE NAME CELL & MOLECULAR BIOLOGY	SEMESTER I

Teaching Scheme (Hours)				Teaching Credit			
Lecture	**Practical**	**Tutorial**	**Total Hours**	**Lecture**	**Practical**	**Tutorial**	**Total Credit**
3	0	0	45	3	0	0	3

Course Pre-requisites	Students should have basic knowledge about cell biology
Course Category	Core Professional.
Course focus	Scientific Temperament & Employability
Rationale	As we go down the scale of magnitude from cells to organelles to molecules, the understanding of various biological processes becomes deeper and inclusive.
Course Revision/ Approval Date:	14/03/2020
Course Objectives (As per Blooms' Taxonomy)	**1. Remember** To introduce the field of cell and molecular biology. **2. Apply** To understand cellular and molecular functions. **3. Analyses** Underlying mechanisms of disease development **4. Create** Understanding of strategies to develop drugs based on gained knowledge **5. Understand** Drugs discovery and development based on basic cellular functions

Course Content (Theory)	Weightage	Contact hours
Unit 1: Universal features of cells; cell chemistry and biosynthesis: chemical organization of cells; internal organization of the cell- cell membranes: structure of cell membranes and concepts related to compartmentalization in eukaryotic cells; intracellular organelles: endoplasmic reticulum and Golgi apparatus, lysosomes and peroxisomes, ribosomes, cellular cytoskeleton, mitochondria, chloroplasts and cell energetics; nuclear compartment: nucleus, nucleolus and chromosomes	**20%**	**9**

Unit 2: Chromatin organization-histone and DNA interactome: structure and assembly of eukaryotic and prokaryotic DNA polymerases, DNA-replication, repair and recombination; chromatin control: gene transcription and silencing by chromatin Writers,-Readers and –Erasers; Transcriptional control: Structure and assembly of eukaryotic and prokaryotic RNA Polymerases, promoters and enhancers, transcription factors as activators and repressors, transcriptional initiation, elongation and termination; post-transcriptional control: splicing and addition of cap and tail, mRNA flow through nuclear envelope into cytoplasm, breakdown of selective and specific mRNAs through interference by small non-coding RNAs (miRNAs and siRNAs), protein translation machinery, ribosomes-composition and assembly; universal genetic codes, degeneracy of codons,Wobble Hypothesis;Iso-acceptingtRNA;mechanism of initiation,elongation and termination; co- and post-translational modifications, mitochondrial genetic code translation product cleavage, modification and activation.	**20%**	**9**
Unit 3: Molecular mechanisms of membrane transport, nuclear transport, transport across mitochondria and chloroplasts; intracellular vesicular trafficking from endoplasmic reticulum through Golgi apparatus to lysosomes/cell exterior.	**20%**	**9**
Unit 4: **Cellular processes** Cell cycle and its regulation; cell division: mitosis, meiosis and cytokinesis; cell differentiation: stem cells, their differentiation into different cell types and organization into specialized tissues; cell-ECM and cell-cell interactions; cell receptors and transmembrane signalling; cell motility and migration; cell death: different modes of cell death and their regulation.	**20%**	**9**
Unit 5: Mutations, proto-oncogenes, oncogenes and tumour suppressor genes, physical, chemical and biological mutagens; types of mutations; intra-genic and inter-genic suppression; transpositions- transposable genetic elements in prokaryotes and eukaryotes, role of transposons in genome; viral and cellular oncogenes; tumor suppressor genes; structure, function and mechanism of action; activation and suppression of tumor suppressor genes; oncogenes as transcriptional activators.	**20%**	**9**

Instructional Method and Pedagogy:
Audio-Visual Lectures, Quizzes, Debates, Project works, Case studies, and Assignments Practical exercises are designed to understand the theory as taught in classroom. Hands on in practical session.

Course Outcomes:	Blooms' Taxonomy Domain	Blooms' Taxonomy Sub Domain
After successful completion of the above course, students will be able to: **CO1** The structure, function, and biosynthesis of cellular membranes and organelles;	Remember	Explain, Describe, Discuss, Recall,
CO2 Cell growth and oncogenic transformation	Apply	Interpret, Select,
CO3 Cellular transport, receptors, and cell signaling	Analyses and Evaluation	Compare, Classify, Select,
CO4 The cytoskeleton, the extracellular matrix, and cell movements	Create	Construct, Develop,
CO5 Genome organization and central dogma	Understand	Explain, Describe, outline, Predict, Summarise

Learning Resources	
1.	Textbook & Reference Books 1. Alberts, B., Johnson, A., Lewis, J.,Raff, M., Roberts, K., & Walter,P.(2008). Molecular Biology of the Cell (5th Ed.). New York: Garland Science. 2. Lodish, H. F.(2016). Molecular Cell Biology (8thEd.). New York:W.H.Freeman. 3.Krebs,J.E.,Lewin,B.,Kilpatrick,S.T.,& Goldstein,E.S.(2014).Lewin'sGenesXI. Burlington, MA: Jones & Bartlett Learning. 4.Cooper,G.M.,&Hausman,R.E.(2013).TheCell:aMolecularApproach(6thEd.). Washington: ASM ; Sunderland. 5. Hardin, J., Bertoni, G., Kleinsmith, L. J., & Becker, W.M. (2012). Becker's World of the Cell. Boston (8th Ed.). BenjaminCummings. 6. Watson, J. D. (2008). Molecular Biology of the Gene (5th ed.). Menlo Park, CA: Benjamin/Cummings. Reference books 1. Karp, G. Cell and Molecular Biology: Concepts and Experiments. John Wiley & Sons. 2. De Robertis, E.D.P. and De Robertis, E.M.F. Cell and Molecular Biology. VIII Edition. 3. Cooper, G.M. and Hausman, R.E. The Cell: A Molecular Approach. V Edition. ASMPress

2.	Journals & Periodicals Journal https://www.omicsonline.org/cellular-and-molecular-biology.php 1. Resonance 2. Current Science 3. Science Reporter 4. Safari
3	Other Electronic resources: 1) MH Education 2) NPTEL E- Links 1. The Inner Life of the Cell 2. Mitosis World Movies 3. Davidson College Biology Videos 4. Borisy Lab Movie Page 5. The Biology Project Meiosis I and II Movies

Evaluation Scheme	**Total Marks**
Theory: Mid semester Marks	30 marks
Theory: End Semester Marks	50 marks
Theory: Continuous Evaluation Component Marks	Attendance: 05 marks MCQs: 05 marks Skill enhancement activities / case study: 05 marks Presentation/ miscellaneous activities: 05 marks **Total: 20 Marks**
Practical Marks	Attendance: 05 marks Practical Exam: 30 marks Viva: 10 marks Journal: 5 marks **Total: 50 Marks**

Mapping of PSOs and COs

PO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO						
CO1	1	-	2	1	1	-
CO2	1	3	2	2	-	-
CO3	1	-	-	1	2	1
CO4	2	3	2	-	2	2
CO5	2	1	-	1	-	2

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

Mapping of POs and COs

PO	PO1	PO2	PO3	PO4	PO5	PO6
CO						
CO1	3	2	-	2	2	1
CO2	-	1	1	2	-	-
CO3	2	-	-	1	2	1
CO4	2	1	2	3	2	2
CO5	-	1	-	2	-	3

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

COURSE CODE	COURSE NAME	SEMESTER

MSBO103	PLANT & ANIMAL BIOTECHNOLOGY	I

Teaching Scheme (Hours)				Teaching Credit			
Lecture	Practical	Tutorial	Total Hours	Lecture	Practical	Tutorial	Total Credit
45	20	0	65	3	2	0	5

Course Prerequisites	Students should have basic knowledge about Plant & Animal Biotechnology
Course Category	Core Professional.
Course focus	Scientific Temperament & Employability
Rationale	Able to gain fundamental knowledge in animal and plant biotechnology and their applications.Understand the molecular techniques required for animal and plant biotechnologyThe students will be technically and critically trained with good practical exposure to perform both the plant and animal culture, which is the at most required in this field of science, skilled candidates are absorbed in well established and commercial tissue culture unitsThis area can be taken up as a micropropagation business with smaller investment by entrepreneurs. learn molecular techniques.
Course Revision/ Approval Date:	14/03/2020
Course Objectives (As per Blooms' Taxonomy)	1. **Remember** Able to gain fundamental knowledge in animal and plant biotechnology and their applications. 2. **Apply** Understand the molecular techniques required for animal and plant biotechnology 3. **Analyses** This area can be taken up as a micropropagation business with smaller investment by entrepreneurs. 4. **Create** The students will be technically and critically trained with good practical exposure to perform both the plant and animal culture, which is the at most required in this field of science, skilled candidates are absorbed in well established and commercial tissue culture units 5. **Understand** learn molecular techniques.

Course Content (Theory)	Weightage	Contact hours
Unit 1: Plant tissue culture and animal cell culture Theory: Plant tissue culture: historical perspective; totipotency; organogenesis; Somatic embryogenesis; establishment of cultures – callus culture, cell suspension culture, media preparation – nutrients and plant hormones; sterilization techniques; applications of tissue culture - micropropagation; somaclonal variation; androgenesis and its applications in genetics and plant breeding; germplasm conservation and cryopreservation; synthetic seed production; protoplast culture and somatic hybridization - protoplast isolation; culture and usage; somatic hybridization - methods and applications; cybrids and somatic cell genetics; plant cell cultures for secondary metabolite production. Animal cell culture: brief history of animal cell culture; cell culture media and reagents; culture of mammalian cells, tissues and organs; primary culture, secondary culture, continuous cell lines, suspension cultures; application of animal cell culture for virus isolation and *in vitro* testing of drugs, testing of toxicity of environmental pollutants in cell culture, application of cell culture technology in production of human and animal viral vaccines and pharmaceutical proteins.	**20%**	**10+4**
Unit 2: **Plant genetic manipulation** Theory: Genetic engineering: *Agrobacterium*-plant interaction; virulence; Ti and Ri plasmids; opines and their significance; T-DNA transfer; disarmed Ti plasmid; Genetic transformation - *Agrobacterium*-mediated gene delivery; cointegrate and binary vectors and their utility; direct gene transfer - PEG-mediated, electroporation, particle bombardment and alternative methods; screenable and selectable markers; characterization of transgenics; chloroplast transformation; marker-free methodologies; advanced methodologies - cisgenesis, intragenesis and genome editing; molecular pharming - concept of plants as biofactories, production of industrial enzymes and pharmaceutically important compounds.	**20%**	**10+4**
Unit 3: **Structure and functions of DNA & RNA lipids and Glycobiology** Theory: Animal reproductive biotechnology: structure of sperms and ovum; cryopreservation of sperms and ova of livestock; artificial insemination; super ovulation, embryo recovery and *in vitro* fertilization; culture of embryos; cryopreservation of embryos; embryo transfer technology; transgenic manipulation of animal embryos; applications of transgenic animal technology; animal cloning - basic concept, cloning for conservation for conservation endangered species; Vaccinology: history of development of vaccines, introduction to the concept of vaccines, conventional methods of animal vaccine production, recombinant approaches to vaccine production, modern vaccines.	**20%**	**8+4**

Unit 4: **Plant and animal genomics** Theory: Overview of genomics – definition, complexity and classification; need for genomics level analysis; methods of analyzing genome at various levels – DNA, RNA, protein, metabolites and phenotype; genome projects and bioinformatics resources for genome research – databases; overview of forward and reverse genetics for assigning function for genes.	**20%**	**9+4**
Unit 5: Molecular mapping and marker assisted selection Theory: Molecular markers - hybridization and PCR based markers RFLP, RAPD, STS, SSR, AFLP, SNP markers; DNA fingerprinting-principles and applications; introduction to mapping of genes/QTLs; marker-assisted selection - strategies for Introducing genes of biotic and abiotic stress resistance in plants: genetic basis for disease resistance in animals; molecular diagnostics of pathogens in plants and animals; detection of meat adulteration using DNA based methods.	**20%**	**8+4**

List of Practical	Weightage	Contact hours
1. Prepare culture media with various supplements for plant tissue culture. 2. Prepare explants of *Valleriana wallichii* for inoculation under aseptic conditions. 3. Attempt *in vitro* andro and gynogenesis in plants *(Datura stramonium)*. 4. Isolate plant protoplast by enzymatic and mechanical methods and attempt fusion 5. by PEG (available material). 6. Culture *Agrobacterium tumefaciens* and attempt transformation of any dicot species.	**20%**	**12**
1. Generate an RAPD and ISSR profile of *Eremurus persicus* and *Valleriana wallichii*. 2. Prepare karyotypes and study the morphology of somatic chromosomes of *Allium* 3. *cepa, A. sativum, A. tuberosum* and compare them on the basis of karyotypes. 4. Pollen mother cell meiosis and recombination index of select species 5. (one achiasmate, and the other chiasmate) and correlate with generation of variation. 6. Undertake plant genomic DNA isolation by CTAB method and its quantitation byvisual as well as spectrophotometeric methods.	**20%**	**12**

1. Count cells of an animal tissue and check their viability. 2. Prepare culture media with various supplements for plant and animal tissue culture. 3.Prepare single cell suspension from spleen and thymus. 4.Monitor and measure doubling time of animal cells. 5. Chromosome preparations from cultured animal cells.	**20%**	**12**
1. Perform PCR amplification of 'n' number of genotypes of a species for studying the genetic variation among the individuals of a species using random primers. 2. Study genetic fingerprinting profiles of plants and calculate polymorphic information content	**20%**	**12**
1. Isolate DNA from animal tissue by SDS method. 2. Attempt animal cell fusion using PEG.	**20%**	**12**

Instructional Method and Pedagogy:
Audio-Visual Lectures, Quizzes, Debates, Project works, Case studies, and Assignments Practical exercises are designed to understand the theory as taught in the classroom. Hands on in practical session.

Course Outcomes:	Blooms' Taxonomy Domain	Blooms' Taxonomy Sub Domain
After successful completion of the above course, students will be able to		Explain, Describe, Discuss, Recall, Locate
CO1 The objectives of this course are to introduce students to the principles, practices and application of animal biotechnology, animal genomics, genetic transformation and molecular breeding animals.	Remember	
CO2 The objectives of this course are to introduce students to the principles, practices and application of plant biotechnology, plant tissue culture, plant and genomics, genetic transformation and molecular breeding of plants.	Apply	Apply, Practice, Interpret, Select, Correlate
CO3 Intended to introduce the student to the principles and practical considerations of animal cell and tissue culture	Analyses and Evaluation	Compare, Classify, Select, Investigate
CO4 Intended to introduce the student to the principles and practical considerations of plant cell and tissue culture	Create	Construct, Develop, Produce
CO5 The objectives of this course are to introduce students to the cell culture technique enables to understand the structure and functions of cells which is programmed by Genetic Engineering tools and techniques for the production of	Understand	Explain, Describe, outline, Predict, Summarise

vaccines, interferon, clinical substances viz., growth hormones, monoclonal antibody production, stem cells etc			

Learning Resources	
1.	Textbook & Reference Book Reference books : 1.Gordon, I. (2005). Reproductive Techniques in Farm Animals. Oxford: CAB International. 2. Levine, M. M. (2004). New Generation Vaccines. New York: M. Dekker. 3. Pörtner, R. (2007). Animal Cell Biotechnology: Methods and Protocols. Totowa, NJ: Humana Press. Reference books : 1.Gordon, I. (2005). *Reproductive Techniques in Farm Animals*. Oxford: CAB International. 2. Levine, M. M. (2004). *New Generation Vaccines.* New York: M. Dekker. 3. Pörtner, R. (2007). *Animal Cell Biotechnology: Methods and Protocols*. Totowa, NJ: Humana Press.
2.	Journals & Periodicals 1. ISSCR journals and Cell science. 2. Periodicals: Current scienc
3	Other Electronic resources: NPTL and UGC pathsala

Evaluation Scheme	**Total Marks**
Theory: Mid semester Marks	30 marks
Theory: End Semester Marks	50 marks
Theory: Continuous Evaluation Component Marks	

Attendance	05 marks
MCQs	05 marks
Skill enhancement activities / case study	05 marks
Presentation/ miscellaneous activities	05 marks
Total	**20 Marks**

Practical Marks	

Attendance	05 marks
Practical Exam	30 marks
Viva	10 marks
Journal	5 marks
Total	**50 Marks**

Mapping of PSOs and COs

PO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6
CO						
CO 1	1	-	-	-	-	-
CO 2	1	-	-	-	-	-
CO 3	2	3	3	3	2	1
CO 4	2	3	3	2	2	2
CO 5	2	-	1	-	-	-

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

Mapping of POs and COs

PO	PO1	PO2	PO3	PO4	PO5	PO6
CO						
CO1	3	-	-	-	-	-
CO2	3	1	-	-	-	-
CO3	-	2	2	1	1	2
CO4	-	1	3	1	3	2
CO5	1	-	3	1	2	-

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

COURSE CODE MSBO104			COURSE NAME MICROBIOLOGY			SEMESTER I	
Teaching Scheme (Hours)				Teaching Credit			
Lecture	Practical	Tutorial	Total Hours	Lecture	Practical	Tutorial	Total Credit
4	4	0	45+20	3	2	0	5

Course Pre-requisites	Students should have basic knowledge about Microbiology.
Course Category	Core Professional.
Course focus	Employability
Rationale	To have an overview of microbial response and it's components. The subject also explains the structure, function and regulation of Bacterial, Virus, Fungus and their effect on Human, environment.
Course Revision/ Approval Date:	14/03/2020
Course Objectives **(As per Blooms' Taxonomy)**	1. **Remember** To introduce the field of microbiology with special emphasis on microbial diversity. 2. **Apply** To study microbial morphology, physiology and nutrition. 3. **Analyses** To know the methods of culturing microorganisms 4. **Create** To get insights in the methods involved in controlling growth of microbes. 5. **Understand** Host- microbe interactions.

Course Content (Theory)	Weightage	Contact hours
Unit 1: Introduction to microbiology and microbes, history & scope of microbiology, morphology, structure, growth and nutrition of bacteria, bacterial growth curve, bacterial culture methods; bacterial genetics: mutation and recombination in bacteria, plasmids, transformation, transduction and conjugation; antimicrobial resistance.	**20%**	**9+4**

Unit 2: Microbial taxonomy and evolution of diversity, classification of microorganisms, criteria for classification; classification of bacteria; Cyanobacteria, acetic acid bacteria, Pseudomonads, lactic and propionic acid bacteria, endospore forming bacteria, Mycobacteria and Mycoplasma. Archaea: Halophiles, Methanogens, Hyperthermophilic archae, Thermoplasm; eukarya: algae, fungi, slime molds and protozoa; extremophiles and unculturable microbes.	**20%**	**9+4**
Unit 3: Sterilization, disinfection and antisepsis: physical and chemical methods for control of microorganisms, antibiotics, antiviral and antifungal drugs, biological control of microorganisms	**20%**	**9+4**
Unit 4: Virus and bacteriophages, general properties of viruses, viral structure, taxonomy of virus, viral replication, cultivation and identification of viruses; sub-viral particles – viroids and prions.	**20%**	**9+4**
Unit 5: Host-pathogen interaction, ecological impact of microbes; symbiosis (Nitrogen fixation and ruminant symbiosis); microbes and nutrient cycles; microbial communication system; bacterial quorum sensing; microbial fuel cells; prebiotics and probiotics.	**20%**	**9+4**

List Of Practical	Weightage	Contact hours
1: Isolation of bacteria in pure culture by streak plate method. Study of colony and growth characteristics of some common bacteria: Bacillus, E. coli, Staphylococcus, Streptococcus, etc	**20%**	**12**
2: Preparation of bacterial smear and Gram's staining. Enumeration of bacteria: standard plate count Isolation of bacteria from soil/water samples.	**20%**	**12**
3: Study of colony and growth characteristics of some common bacteria: Bacillus, E. coli, Staphylococcus, Streptococcus, etc. Maintenance of stock cultures: slants, stabs and glycerol stock cultures	**20%**	**12**
4: Sterilization, disinfection and safety in microbiological laboratory. Preparation of media for cultivation of bacteria	**20%**	**12**
5: Antimicrobial sensitivity test and demonstration of drug resistance Determination of phenol co-efficient of antimicrobial agents	**20%**	**12**

Instructional Method and Pedagogy:

Audio-Visual Lectures, Quizzes, Debates, Project works, Case studies, and Assignments Practical exercises are designed to understand the theory as taught in classroom. Hands on in practical session.

Course Outcomes:	Blooms' Taxonomy Domain	Blooms' Taxonomy Sub Domain
After successful completion of the above course, students will be able to:		
CO1 To introduce the field of microbiology with special emphasis on microbial diversity.	Remember	Explain, Describe, Discuss, Recall, Locate
CO2 To study microbial morphology, physiology and nutrition.	Apply	Apply, Practice, Interpret, Select, Correlate
CO3 To know the methods of culturing microorganisms	Analyses and Evaluation	Compare, Classify, Select, Investigate
CO4 To get insights in the methods involved in controlling growth of microbes	Create	Construct, Develop, Produce
CO5 Host- microbe interactions	Understand	Explain, Describe, outline, Predict, Summarise

Learning Resources

1.	Reference books: 1. Textbook 1. D.K Maheshwari (1999) A textbook of Microbiology 2. R.Vasanthakumari (2007) Textbook of Microbiology. 3. Pelczar, M. J., Reid, R. D., & Chan, E. C. (2001). Microbiology (5th ed.). New York: McGraw-Hill.. 4. Willey, J. M., Sherwood, L., Woolverton, C. J., Prescott, L. M., & Willey, J. M. (2011). Prescott's Microbiology. New York: McGraw-Hill.. 5. Matthai, W., Berg, C. Y., & Black, J. G. (2005). Microbiology, Principles and Explorations. Boston, MA: John Wiley & Sons. 6
2.	Journals & Periodicals 1. Journal of Microbiology 2. Current Science Journal, Indian journal of Biotechnology 3. Nature Review microbiology 4. Macromolecules
5	Other Electronic resources: 1) MH Education 2) NPTEL

Evaluation Scheme	Total Marks

Theory: Mid semester Marks	30 marks
Theory: End Semester Marks	50 marks
Theory: Continuous Evaluation Component Marks	

Attendance	05 marks
MCQs	05 marks
Skill enhancement activities / case study	05 marks
Presentation/ miscellaneous activities	05 marks
Total	**20 Marks**

Practical Marks

Attendance	05 marks
Practical Exam	30 marks
Viva	10 marks
Journal	5 marks
Total	**50 Marks**

Mapping of PSOs and COs

PO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6
CO						
CO 1	1	-	2	1	1	-
CO 2	1	3	2	2	-	-
CO 3	1	-	-	1	2	1
CO 4	2	3	2	-	2	2
CO 5	2	1	-	1	-	2

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

Mapping of POs and COs

PO	PO1	PO 2	PO3	PO4	PO5	PO6
CO						
CO 1	3	2	-	2	2	1
CO 2	-	1	1	2	-	-
CO 3	2	-	-	1	2	1
CO 4	2	1	2	3	2	2
CO 5	-	1	-	2	-	3

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

COURSE CODE MSBO105	COURSE NAME GENETICS	SEMESTER I

Teaching Scheme (Hours)				Teaching Credit			
Lecture	Practical	Tutorial	Total Hours	Lecture	Practical	Tutorial	Total Credit
3	0	0	45	3	0	0	3

Course Prerequisites	Students should possess basic knowledge about genes, DNA and chromosomes for deep understanding of the subject.
Course Category	Core Professional.
Course focus	Scientific Temperament & Employability
Rationale	Describe the fundamental molecular principles of geneticsUnderstand the relationship between phenotype and genotype in human genetic traits.Describe the basics of genetic mappingUnderstand how gene expression is regulated.Understand how evolution and population genetics go hand in hand.
Course Revision/ Approval Date:	14/03/2020
Course Objectives **(As per Blooms' Taxonomy)**	**1. Remember** Describe the fundamental molecular principles of genetics **2. Understand & Apply** Understand the relationship between phenotype and genotype in human genetic traits **3. Analyse & Create** Describe the basics of genetic mapping **4. Create** Understand how gene expression is regulated. **5. Analyse & Create** Understand how evolution and population genetics go hand in hand

Course Content (Theory)	Weightage	Contact hours
Unit 1: **Genetics of bacteria and bacteriophages** Theory: Concept of a gene in pre-DNA era; mapping of genes in bacterial and phage chromosomes by classical genetic crosses; fine structure analysis of gene; genetic complementation and other genetic crosses using phenotypic markers; phenotype to genotype connectivity prior to DNA-based understanding of gene.	**20%**	**9**
Unit 2: **Yeast genetics** Theory: Meiotic crosses, tetrad analysis, non-Mendelian and Mendelian ratios, gene conversion, models of genetic recombination, yeast mating type switch; dominant and recessive genes/mutations, suppressor or modifier screens, complementation groups, transposon mutagenesis, synthetic lethality, genetic epistasis.	**20%**	**9**
Unit 3: **Drosophila genetics as a model of higher eukaryotes** Theory: 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 context of developmental mechanism	**20%**	**9**
Unit 4: **Plant genetics** Theory: Laws of segregation in plant crosses, inbreeding, selfing, heterosis, maintenance of genetic purity, gene pyramiding.	**15%**	**6**
Unit 5: **Population genetics, evolutionary genetics and Quantitative genetics of complex traits (QTLs)** Theory: Introduction to the elements of population genetics: genetic variation, genetic drift, neutral evolution; mutation selection, balancing selection, Fishers' theorem, Hardy- Weinberg equilibrium, linkage disequilibrium; in-breeding depression & mating systems; population bottlenecks, migrations, Bayesian statistics; adaptive landscape, spatial variation & genetic fitness.Complex traits, mapping QTLs, yeast genomics to understand biology of QTLs	**25%**	**12**

Instructional Method and Pedagogy:

Audio-Visual Lectures, Quizzes, Debates, Project works, Case studies, and Assignments Practical exercises are designed to understand the theory as taught in the classroom. Hands on in practical session.

Course Outcomes:	Blooms' Taxonomy Domain	Blooms' Taxonomy Sub Domain
After successful completion of the above course, students will be able to: **CO1** The objectives of this course are to gain knowledge on basics genetics and classical genetics covering prokaryotic/ phage genetics to yeast and higher eukaryotic domains	Remember	Explain, Describe, Discuss, Recall, Locate
CO2 The course shall make the student to understand additional genetic patterns	Apply	Apply, Practice, Interpret, Select, Correlate
CO3 The course will make the students to understand the the basics of genetic mapping	Analyses and Evaluation	Compare, Classify, Select, Investigate
CO4 To get an exposure to the concepts of population genetics, quantitative genetics encompassing complex traits,	Create	Construct, Develop, Produce
CO5 To gain knowledge on clinical genetics and genetics of evolution.	Understand	Explain, Describe, outline, Predict, Summarise

Learning Resources

1.	Textbook & Reference Book 1. Gardner, E.J., Simmons, M.J., Snustad, D.P. (2006). Principles of Genetics. VIII Edition John Wiley & Sons. 2. Hartl, D. L., & Jones, E. W.(1998). Genetics: Principles and Analysis. Sudbury, MA: Jones and Bartlett. 3. Pierce, B. A.(2005). Genetics: a Conceptual Approach. New York:W.H.Freeman. 4. Tamarin,R. H., & Leavitt, R. W.(1991). Principles of Genetics. Dubuque, IA: Wm. C. Brown. 5. Smith,J.M. (1998). Evolutionary Genetics. Oxford: Oxford University Press

2.	Journals & Periodicals Genetics, Nature Genetics The Scientist
3	Other Electronic resources: https://ghr.nlm.nih.gov/resources#inheritance

Evaluation Scheme	**Total Marks**
Theory: Mid semester Marks	30 marks
Theory: End Semester Marks	50 marks
Theory: Continuous Evaluation Component Marks	Attendance: 05 marks MCQs: 05 marks Skill enhancement activities / case study: 05 marks Presentation/ miscellaneous activities: 05 marks **Total: 20 Marks**
Practical Marks	Attendance: 05 marks Practical Exam: 30 marks Viva: 10 marks Journal: 5 marks **Total: 50 Marks**

Mapping of PSOs and COs

PO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO						
CO1	1	-	-	-	-	-
CO2	1	-	-	-	-	-
CO3	2	3	3	3	1	1
CO4	2	3	3	2	1	2
CO5	2	-	1	-	-	1

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

Mapping of POs and COs

PO	PO1	PO2	PO3	PO4	PO5	PO6
CO						
CO1	3	-	2	1	-	-
CO2	3	-	2	1	-	-
CO3	2	-	2	1	-	-
CO4	2	-	1	1	-	1
CO5	2	3	2	1	2	1

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

COURSE CODE MSBO106	COURSE NAME BASICS OF MATHEMATICS & STATISTICS	SEMESTER I

Teaching Scheme (Hours)				Teaching Credit			
Lecture	Practical	Tutorial	Total Hours	Lecture	Practical	Tutorial	Total Credit
30	0	15	45	2	0	1	3

Course Pre-requisites	Students should have basic knowledge of Mathematics and statistics
Course Category	Core course
Course focus	Skill development
Rationale	In this course students will learn descriptive statistics and its basic applications in real life. Students will also learn different types of tests for Hypothesis testing. Sutdents will understand the concepts of correlation and learn the methods of regression. They will also get an exposure to differntial and integral calculus and learn to solve the system of linear equations.
Course Revision/ Approval Date:	14/7/23
Course Objectives **(As per Blooms' Taxonomy)**	To enable the student to: **1 Remember:** Use mean and variance to visualise the data and making decisions. **2 Apply:** Use the degree and direction of association between two variables, and fit a regression model to the given data **3 Understand, Apply:** Identify the type of statistical situation to which different tests can be applied. **4 Understand:** the fundamental concepts of Derivatives and Integration of functions **5 Understand, Apply:** Explain what is meant by statistical inference and concepts of approximation for system of equations

Course Content (Theory)	Weightage	Contact hours
Unit 1: Measurement of Central tendency and Dispersion Classification of data, Frequency table, inclusive and exclusive class interval, Various measures of central tendency, measures of dispersion.	**20%**	**6**
Unit 2: Correlation and Regression: Skew-ness and Kurtosis, correlation and its types, coefficients of correlation, Rank correlation, Linear regression, regression coefficients and properties.	**20%**	**6**
Unit 3: Statistical Hypothesis and test of significance: Definition, Simple and compound hypothesis, Null and Alternative hypothesis, Errors in sampling, critical region, Level of significance, p-value, Procedure and testing of hypothesis	**20%**	**6**
Unit 4: Fundamentals of Differential Calculus and Integral Calculus	**20%**	**6**
Unit 5: Algebraic equations: Solving and graphing. Solution of system of linear equations using Gauss Elimination, Gauss Jordan method.	**20%**	**6**

List Of Practical Tutorial	Weightage	Contact hours
Unit 1: Practise examples on Unit 1	**20%**	**3**
Unit 2: Practise examples on Unit 2	**20%**	**3**
Unit 3: Practise examples on Unit 3	**20%**	**3**
Unit 4: Practise examples on Unit 4	**20%**	**3**
Unit 5: Practise examples on Unit 5	**20%**	**3**

Instructional Method and Pedagogy: (Max. 100 words) Chalk-board, Presentation, Use of Geogebra. Group Discussion, Case Study, Quizziz application.

-

Course Outcomes:	Blooms' Taxonomy Domain	Blooms' Taxonomy Sub Domain
After successful completion of the above course, students will be able to:		
CO1: **Apply:** Calculate the simple linear regression equation for a set of data and able to solve the system of equations	Apply	Describe, Find
CO2: **Remember, Understand:** Know the practical issues arising in sampling studies	Remember, Understand	Demonstrate & Examine, Find
CO3: **Apply, Analyse:** Appropriately interpret results of analysis of variance tests, would be able to understand the variation in distribution of the data and importance of hypothesis testing using different tests.	Apply, Analyse:	Describe, Demonstrate & Examine, Find
CO4: **Analyse:** Analyse statistical data using MS-Excel.The student would be able to correlate the given data and estimate the value of unknown variable.	Analyse:	Describe, Demonstrate & Examine

Learning Resources	
1.	Reference Books: 1. Probability and Statistics By T K V Iyengar, S chand, 3rd Edition, 2011. 2. Fundamentals of Mathematical Statistics by S C Gupta & V K Kapoor, Sultan Chand & Sons, New Delhi 2009. 3. Higher Engineering Mathematics By Dr. B. S. Grewal, Khanna Publishers 4. Probability and Statistics for Engineers and Scientists by Sheldon M. Ross, Academic Press 5. Probability & Statistics by Miller and freaud, Prentice Hall India, Delhi 7th Edition 2009 6. Differential Calculus, Shanti Narayan, P.K. Mittle, S. Chand, New Delhi 2005 7. Integral Calculus, Shanti Narayan, P.K. Mittle, S. Chand, New Delhi 2005
2.	Journals & Periodicals: Mathematics Open
3.	Other Electronic Resources: Geometry and Algebra: Geogebra.org/Calculator MATLAB : Mathworks.com/ https://www.tutorialspoint.com/matlab/matlab_syntax.htm

<table>
<tr><th>Evaluation Scheme</th><th>Total Marks</th></tr>
<tr><td>Theory: Mid semester Marks</td><td>20 marks</td></tr>
<tr><td>Theory: End Semester Marks</td><td>40 marks</td></tr>
<tr><td>Theory: Continuous Evaluation Component Marks</td><td>
<table>
<tr><td>Attendance</td><td>05 marks</td></tr>
<tr><td>MCQs</td><td>10 marks</td></tr>
<tr><td>Open Book Assignment</td><td>15 marks</td></tr>
<tr><td>Open Book Assignment</td><td>10 marks</td></tr>
<tr><td>Total</td><td>40 Marks</td></tr>
</table>
</td></tr>
<tr><td>Practical Marks</td><td>
<table>
<tr><td>Attendance</td><td>05 marks</td></tr>
<tr><td>Practical Exam</td><td>20 marks</td></tr>
<tr><td>Viva</td><td>10 marks</td></tr>
<tr><td>Journal</td><td>10 marks</td></tr>
<tr><td>Discipline</td><td>05 marks</td></tr>
<tr><td>Total</td><td>50 Marks</td></tr>
</table>
</td></tr>
<tr><td>Project/ Industrial Internship Marks</td><td>
<table>
<tr><td>Quantity of the Project/Industrial in terms of Language, Presentation & format.</td><td>30 marks</td></tr>
<tr><td>Practical understanding of the subject on the Project/Industrial.</td><td>30 marks</td></tr>
<tr><td>Industry/ University mentor's feedback on the Project/ Industrial.</td><td>30 marks</td></tr>
<tr><td>Attendance</td><td>10 marks</td></tr>
<tr><td>Total</td><td>100 Marks</td></tr>
</table>
</td></tr>
</table>

Mapping of PSOs & COs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9
CO1	1	2	0	0	0	1	1		
CO2	1	2	0	0	0	1	1		
CO3	1	2	0	0	0	1	1		
CO4	2	2	1	0	0	1	2		
CO5	2	3	0	1	0	1	2		

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

Mapping of POs & COs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	2	2	1	1	0	0			
CO2	2	2	1	1	0	0			
CO3	1	2	1	1	0	0			
CO4	2	2	2	1	1	0			
CO5	2	2	1	1	1	0			

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

COURSE CODE MSBO107	COURSE NAME BASICS OF CHEMISTRY & PHYSICS	SEMESTER I

Teaching Scheme (Hours)				Teaching Credit			
Lecture	Practical	Tutorial	Total Hours	Lecture	Practical	Tutorial	Total Credit
30	0	0	30	2	0	0	2

Course Prerequisites	Students should have basic knowledge of Physics at 10+2 level
Course Category	Generic Elective
Course focus	Skill development
Rationale	To make students aware of the fundamental notions related to the governing laws of Physical and Chemical Sciences. This will enhance their knowledge and will help them to get fruitful insight to the chemical and physical dynamics within living organisms.
Course Revision/ Approval Date:	
Course Objectives **(As per Blooms' Taxonomy)**	To enable the student to: 1. **Understand** the fundamental laws of Physics & Chemistry. 2. **To Understand** & **apply** the fundamental laws to the biochemical processes in the living organisms. 3. **Understand**, **remember** and **analyse** fundamental concepts & applications of different physio-chemical processes. 4. **Understand** the formation of atoms, molecules and higher order compounds and the underlying reactions at atomic and molecular scale. 5. **Understand** the concepts of thermodynamics and observe its role in physio-chemical processes in living organisms.

Course Content (Theory)	Weightage	Contact hours
Unit 1: Theory: Physical Quantities Interdynamics: definitions and dimensions; vectors & scalars, displacement, velocity, acceleration, kinematic formulas, angular momentum, torque etc.force, power, work, energy (kinetic potential/electric charge separation, electromagnetic spectrum, photons etc.); springs & Hooke's laws; elastic inelastic collisions; Newton's Law of motions (centripetal and centrifugal forces etc.); simple	**20%**	**6**

harmonic motions, mechanical waves, Doppler effect, wave interference, amplitude, period, frequency & wavelength.		
Unit 2: Theory: diffusion, dissipation, random walks, and directed motions in biological systems; low Reynolds number - world of Biology, buoyant forces,Bernoulli's Equation, viscosity, turbulence, surface tension, adhesion; laws of thermodynamics: Maxwell Boltzmann distribution, conduction, convection and radiation, internal energy, entropy, temperature and free energy, Maxwell's demon (entropic forces at work in biology,chemical assemblies, self assembled systems,role of ATP); Coulomb's law, conductors and insulators, electric potential energy of charges, nerve impulses,voltage gated channels, ionic conductance; Ohm's Law (basic electrical quantities: current, voltage & power), electrolyte conductivity, capacitors and capacitance, dielectrics; various machines in biology i.e. enzymes, allostery and molecular motors (molecules to cells and organisms).	**20%**	**6**
Unit 3: Theory: Basic constituents of matter - elements, atoms, isotopes, atomic weights, atomic numbers,basics of mass spectrometry, molecules, Avogadro Number, molarity, gas constant, molecular weights, structural and molecular formulae, ions and polyatomic ions; chemical reactions, reaction stoichiometry, rates of reaction, rate constants, order of reactions, Arrhenious equation, Maxwell Boltzmann distributions, rate- determining steps, catalysis, free-energy, entropy and enthalpy changes during reactions; kinetic versus thermodynamic controls of a reaction, reaction equilibrium (equilibrium constant).	**20%**	**6**
Unit 4: Theory: Light and matter interactions (optical spectroscopy, fluorescence, bioluminescence, paramagnetism and diamagnetism, photoelectron spectroscopy; chemical bonds (ionic, covalent, Van der Waals forces); electronegativity, polarity; VSEPR theory and molecular geometry, dipole moment, orbital hybridizations; states of matter - vapour pressure, phase diagrams, surface tension, boiling and melting points, solubility, capillary action, suspensions, colloids and solutions; acids, bases and pH - Arrhenius theory, pH, ionic product of water, weak acids and bases, conjugate acid-base pairs, buffers and buffering action etc.	**20%**	**6**
Unit 5: Theory: Chemical thermodynamics - internal energy, heat and temperature, enthalpy (bond enthalpy and reaction enthalpy), entropy, Gibbs free energy of ATP driven reactions, spontaneity versus driven reactions in biology;redox reactions and electrochemistry oxidation-reduction reactions, standard cell potentials, Nernst Equation,resting membrane potentials,electron transport chains (ETC)in biology, coupling of oxidative phosphorylations to ETC; theories of ATP production and dissipation across biological membranes; bond rotations and molecular conformations- Newman projections, conformational analysis of alkanes, alkenes and alkynes; functional groups, optically asymmetric carbon centres, amino acids, proteins, rotational freedoms in polypeptide backbone (Ramachandran plot).	**20%**	**6**

Course Outcomes:	Blooms' Taxonomy Domain	Blooms' Taxonomy Sub domain
After successful completion of the above course, students will be able to: **CO1** Students should be able to have a firm foundation in fundamentals of current Physical and Chemical scientific theories.	Remember	Explain, Describe, Discuss, Recall, Locate
CO2 Students will be able to relate the biochemical application in research behind several biological discovery	Apply	Apply, Practice, Interpret, Select, Correlate
CO3 Students will be able to relate the biochemical application in research behind several biological discovery	Analyses and Evaluation	Compare, Classify, Select, Investigate
CO4 Students will be able to develop good reasoning and numerical problem-solving skills in Physics and Chemistry	Create	Construct, Develop, Produce
CO5 Students will be able to develop a life-long learning attitude towards physical and chemical aspects of their projects.	Understand	Explain, Describe, outline, Predict, Summarise

Learning Resources	
1.	**Textbooks:** 1. Halliday, D., Resnick, R., & Walker, J. (1993). Fundamentals of Physics. New York: Wiley. 2. Ebbing, D. D., & Wrighton, M. S. (1990). General Chemistry. Boston: Houghton Mifflin. 5. Averill, B., & Eldredge, P.(2007). 3. Cantor,C. R., & Schimmel, P.R. (2004). Biophysical Chemistry. San Francisco: W.H. Freeman. 4. Matthews, C. P.,& Shearer,J. S. (1897). Problems and Questions in Physics. New York: Macmillan Company. 5. Chemistry: Principles, Patterns, and Applications. San Francisco: BenjaminCummings. 6. Baaquie,B.E.(2000). Laws of Physics: a Primer. Singapore: National University of Singapore. 7. Mahan, B. H.(1965).University Chemistry. Reading, MA: Addison-WesleyPub.

2.	Journals & Periodicals: 1. Journal of Undergraduate Reports in Physics (JURP) 2. Journal of Young Investigators (JYI) 3. Columbia Undergraduate Science Journal (CUSI)
3.	Other Electronic Resources: 1. Student Journal of Physics 2. Indian Journal of Physics Feynman Lectures in Physics: https://www.feynmanlectures.caltech.edu/

<table>
<tr><th>Evaluation Scheme</th><th>Total Marks</th></tr>
<tr><td>Theory: End Semester Marks</td><td>40 marks</td></tr>
<tr><td>Theory: Continuous Evaluation Component Marks</td><td>
<table>
<tr><td>Attendance</td><td>05 marks</td></tr>
<tr><td>MCQs</td><td>10 marks</td></tr>
<tr><td>Open Book Assignment</td><td>15 marks</td></tr>
<tr><td>Open Book Assignment</td><td>10 marks</td></tr>
<tr><td>Total</td><td>40 Marks</td></tr>
</table>
</td></tr>
<tr><td>Practical Marks</td><td>
<table>
<tr><td>Attendance</td><td>05 marks</td></tr>
<tr><td>Practical Exam</td><td>20 marks</td></tr>
<tr><td>Viva</td><td>10 marks</td></tr>
<tr><td>Journal</td><td>10 marks</td></tr>
<tr><td>Discipline</td><td>05 marks</td></tr>
<tr><td>Total</td><td>50 Marks</td></tr>
</table>
</td></tr>
<tr><td>Project/ Industrial Internship Marks</td><td>
<table>
<tr><td>Quantity of the Project/Industrial in terms of Language, Presentation & format.</td><td>30 marks</td></tr>
<tr><td>Practical understanding of the subject on the Project/Industrial.</td><td>30 marks</td></tr>
<tr><td>Industry/ University mentor's feedback on the Project/ Industrial.</td><td>30 marks</td></tr>
<tr><td>Attendance</td><td>10 marks</td></tr>
<tr><td>Total</td><td>100 Marks</td></tr>
</table>
</td></tr>
</table>

Mapping of PSOs & COs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	2	2	1	-	-	-	2
CO2	2	2	1	1	-	-	2
CO3	2	2	1	2	1	1	2
CO4	2	3	1	2	1	-	2
CO5	2	2	1	1	-	1	2

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

Mapping of POs & COs

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	-	-	-	-
CO2	3	1	2	-	2	1
CO3	2	1	2	1	2	-
CO4	2	1	-	-	-	1
CO5	2	3	-	2	2	1

1: Slight (low); 2: Moderate (Medium

Teaching Scheme
Semester – II M. Sc Biotechnology

Sr. No.	Course Code	Course Name	Teaching Scheme (Hours/week)				Teaching Credit				Evaluation Scheme					
			L	P	T	Total	L	P	T	Total	Theory: MS Marks	Theory: CEC Marks	Theory: ES Marks	Theory Marks	Practical Marks	Total Marks
	Course															
1	MSBO 201	Genetic Engineering	3	0	0	3	3	0	0	3	30	20	50	100		100
2	MSBO202	Immunology	3	0	0	3	3	0	0	3	30	20	50	100		100
3	MSBO203	Bioinformatics	3	0	0	3	3	0	0	3	30	20	50	100		100
4	MSBO204	Bioprocess Engg.& Tech	3	0	0	3	3	0	0	3	30	20	50	100		100
5	MSBO205	Ipr,Biosafety & Bioethics	3	0	0	3	3	0	0	3	30	20	50	100		100
6	MSBO206	Research Methodology	3	0	0	3	3	0	0	3	30	20	50	100		100
7	MSBO207/ 212	Elective : Microbial Technology/Environment Biotech	2	0	0	2	1	0	0	1				50		50
8	MSBO208	GLP and Regulatory compliances	1	0	0	1	0	2	0	2				50		50
9	MSBO209	Lab4-Molecular Bio. & Genetic Eng.	0	2	0	2	0	2	0	2					50	50
10	MSBO210	Lab5-Immunology	0	2	0	2	0	2	0	2					50	50
11	MSBO212	Lab6 Bioinformatics I	0	2	0	2	0	2	0	2					50	50

	MSBO210	Internship	0	0			0	2	0	2					50	50
						27				27						**900**

Note: L = Lecture, P = Practice, T= Tutorial, MS - Mid Semester, CEC - Continuous Evaluation Component, ES - End Semester

COURSE CODE MSBO201	COURSE NAME GENETIC ENGINEERING	SEMESTER II

Teaching Scheme (Hours)				Teaching Credit			
Lecture	**Practical**	**Tutorial**	**Total Hours**	**Lecture**	**Practical**	**Tutorial**	**Total Credit**
3	0	0	45	3	0	0	3

Course Pre-requisites	Basic Understanding of Science and Communication.
Course Category	Core.
Course focus	Scientific Temperament & Employability
Rationale	Students learn how engineers apply their understanding of DNA to manipulate specific genes to produce desired traits, and how engineers have used this practice to address current problems facing humanity. They learn what genetic engineering means and examples of its applications, as well as moral and ethical problems related to its implementation.
Course Revision/ Approval Date:	14/03/2020
Course Objectives (As per Blooms' Taxonomy)	**1. Remember:** Basics of DNA structure and Molecular MEchanisms **2. Apply:** Basic Molecular biology understanding to understand genetic engineering tools **3. Analyses:** How basic cellular principles guide development of new technologies in biotech. **4. Create:** genetic engineering models and field of applications **5. Understand:** technology can be developed for both good and bad. The ethics related to genetic tampering.

Course Content (Theory)	Weightage	Contact hours
Unit 1: **Theory:** **Introduction and tools for genetic Engineering** 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; homopolymeric tailing; labelling of DNA: nick translation, random priming, radioactive and non-radioactive probes, hybridization techniques: northern, southern, south-western and far-western and colony hybridization, fluorescence in situ hybridization.	**20%**	**9**
Unit 2: **Theory:** **Different types of vectors** Plasmids;Bacteriophages;M13mpvectors;PUC19andBluescriptvectors,hage mids; Lambda vectors; Insertion and Replacement vectors; Cosmids; Artificial chromosome vectors(YACs;BACs);Principlesformaximizinggeneexpressionexpressionvec tors; 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 Ria vectors,yeast vectors,shuttle vectors.	**20%**	**9**
Unit 3: **Theory:** **Different types of PCR techniques** Principles of PCR:primer design;fidelity of thermostable enzymes;DNApolymerases; types of PCR–multiplex,nested;reverse-transcriptionPCR,realtimePCR,touchdown PCR, hot start PCR, colony PCR, asymmetric PCR, cloning of PCR products; T-vectors; proofreading enzymes; PCR based site specific mutagenesis; PCR in molecular diagnostics; viral and bacterial detection; sequencing methods; enzymatic DNAsequencing;chemical sequencing of DNA;automated DNA sequencing;RNA sequencing; chemical synthesis of oligonucleotides; mutation detection: SSCP, DGGE, RFLP.	**20%**	**9**

Unit 4: **Theory:** **Gene manipulation and protein-DNA interaction** Insertion of foreign DNA into host cells; transformation, electroporation, transfection; construction of libraries; isolation of mRNA and total RNA; reverse transcriptase and cDNA synthesis; cDNA and genomic libraries; construction of microarrays –genomic arrays, cDNA arrays and oligo arrays; study of protein-DNA interactions: electrophoretic mobility shift assay; DNase footprinting; methyl interference assay, chromatin immunoprecipitation; protein-protein interactions using yeast two-hybrid system; phage display.	**20%**	**9**
Unit 5: **Theory:** **Gene silencing and genome editing technologies** Gene silencing techniques; introduction to siRNA; siRNA technology; Micro RNA; construction of siRNA vectors; principle and application of gene silencing; gene knockout and gene therapy;creation transgenic plants;debateoverGMcrops; introductiontomethodsofgeneticmanipulationindifferentmodelsystemse.g.fruitflies (Drosophila), worms (C. elegans), frogs (Xenopus), fish (zebra fish) and chick; Transgenics -genereplacement;gene targeting;creation transgenic and knock-out mice;disease model; introduction to genome editing by CRISPR-CAS with specific emphasis on Chinese and American clinical trials.	**20%**	**9**

Instructional Method and Pedagogy:
Audio-Visual Lectures, Quizzes, Debates, Project works, Case studies, and Assignments Practical exercises are designed to understand the theory as taught in the classroom. Hands on in a practical session.

Course Outcomes:	Blooms' Taxonomy Domain	Blooms' Taxonomy Subdomain
After successful completion of the above course, students will be able to:	Remember	Explain, Describe, Discuss, Recall, Locate
CO1 The objectives of this course are to teach students with various approaches to conducting genetic engineering		
CO2 To introduce the Tools of Genetic Engineering	Apply	Apply, Practice, Interpret, Select, Correlate
CO3 Applications of Genetic Engineering	Analyses and Evaluation	Compare, Classify, Select, Investigate
CO4 New technologies in Genetic Engineering	Create	Construct, Develop,

CO5 Ethical Concerns surrounding Genetic Engineering	Understand	Produce Explain, Describe, outline, Predict, Summarise

Learning Resources	
1.	Textbook & Reference Books 1. Old,R.W.,Primrose,S.B.,& Twyman,R.M.(2001).PrinciplesofGene Manipulation: An Introduction to Genetic Engineering. Oxford: Blackwell Scientific Publications. 2. Green, M. R., & Sambrook, J. (2012). Molecular Cloning: a Laboratory Manual. ColdSpring Harbor,NY:Cold Spring Harbor Laboratory Press. 3. Brown, T.A. (2006). Genomes(3rd ed.). New York:Garland Science Pub. 4. Selected papers from scientific journals, particularly Nature & Science. 5. Technical Literature from Stratagene, Promega, Novagen, NewEngland Biolab etc.
2.	Journal Journal of Biotechnology Nature Biotechnology Biotechnology Advances Biotechnology and Bioengineering Periodicals/Magazines 1. Resonance 2. Current Science 3. Science Reporter 4. Safari
5	Other Electronic resources: https://opentextbc.ca/biology/chapter/10-1-cloning-and-genetic-engineering/ http://www.hoajonline.com/molbiolgeneteng https://www.yourgenome.org/facts/what-is-genetic-engineering

Evaluation Scheme	Total Marks
Theory: Mid semester Marks	30 marks
Theory: End Semester Marks	50 marks

Theory: Continuous Evaluation Component Marks	

Attendance	05 marks
MCQs	05 marks
Skill enhancement activities / case study	05 marks
Presentation/ miscellaneous activities	05 marks
Total	**20 Marks**

Practical Marks	

Attendance	5 marks
Practical Exam	20 marks
Viva	10 marks
Journal	5 marks
Discipline	5 marks
Total	**50 Marks**

Mapping of PSOs and COs

PO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6
CO						
CO 1	2	-	2	1	1	-
CO 2	1	-	2	2	-	-
CO 3	-	-	-	1	2	1
CO 4	1	3	2	-	2	1
CO 5	2	1	-	1	-	2

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

Mapping of PO and COs

PO	PO1	PO2	PO3	PO4	PO5	PO6
CO						
CO1	-	2	-	2	2	1
CO2	1	2	1	2	-	-
CO3	2	-	-	1	-	1
CO4	1	1	2	-	2	2
CO5	-	1	-	2	-	-

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

COURSE CODE MSBO202	COURSE NAME IMMUNOLOGY	SEMESTER II

Teaching Scheme (Hours)				Teaching Credit			
Lecture	**Practical**	**Tutorial**	**Total Hours**	**Lecture**	**Practical**	**Tutorial**	**Total Credit**
3	0	0	45	3	0	0	3

Course Pre-requisites	Basic Understanding of Science and Communication.
Course Category	Core.
Course focus	Employability
Rationale	Immunology seeks to unravel the complexities of the immune system, which is responsible for defending the body against pathogens and maintaining overall health. By studying immunology, we gain insights into how our bodies protect against infections, recognize and eliminate cancer cells, and regulate immune responses.
Course Revision/ Approval Date:	14/03/2020
Course Objectives (As per Blooms' Taxonomy)	**1. Remember:** To learn about structural features of components of immune system as well as their function **2. Apply:** To gain knowledge on development of the immune system **3. Analyses:** To predict about nature of immune response that develops against bacterial, viral or parasitic infection **4. Create:** To understand the mechanisms by which our body elicits immune response **5. Understand** To understand basic immunological methods involved in research and clinical/applied science

Course Content (Theory)	Weightage	Contact hours
Unit 1: **Immunology: fundamental concepts and overview of the immune system** Components of innate and acquired immunity; phagocytosis; 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, MHC and immune responsiveness and disease susceptibility, human major histocompatibility complex (MHC), Organs of immune system, primary and secondary lymphoid organs.	**20%**	**9**

Unit 2: **Immune responses generated by B and T lymphocytes** Immunoglobulins - basic structure, classes & subclasses of immunoglobulins, antigenic determinants; multigene organization of immunoglobulin genes; genetics of human immunoglobulin, B-cell receptor; Immunoglobulin superfamily; principles of cell signaling; basis of self & non-self discrimination; kinetics of immune response, memory; B cell maturation, activation and differentiation; generation of antibody diversity; T-cell maturation, activation and differentiation and T-cell receptors; functional T Cell subsets; cell-mediated immune responses, ADCC; cytokines: properties, receptors and therapeutic uses; antigen processing and presentation- endogenous antigens, exogenous antigens, non-peptide bacterial antigens and super-antigens; cell-cell co-operation, Hapten-carrier system.	**20%**	**9**
Unit 3: **Antigen-antibody interactions** Precipitation, agglutination and complement mediated immune reactions; advanced immunological techniques: RIA, ELISA, Western blotting, ELISPOT assay, immunofluorescence microscopy, 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 knockouts	**20%**	**9**
Unit 4: **Vaccinology** Active and passive immunization; live, killed, attenuated, subunit vaccines; vaccine technology: role and properties of adjuvants, recombinant DNA and protein based vaccines, plant-based vaccines, reverse vaccinology; peptide vaccines, conjugate vaccines; antibody genes and antibody engineering: chimeric, generation of monoclonal antibodies, hybrid monoclonal antibodies; catalytic antibodies and generation of immunoglobulin gene libraries, idiotypic vaccines and marker vaccines, virus-like particles (VLPs), dendritic cells vaccines, vaccine against cancer, T Cell Based Vaccine, edible vaccine and therapeutic vaccine.	**20%**	**9**

Unit 5: **Clinical Immunology** Immunity to infection : bacteria, viral, fungal and parasitic infections (with examples from each group); hypersensitivity: Type I-IV; autoimmunity; types of autoimmune diseases; mechanism and role of CD4+T Cells; MHC and TCR in autoimmunity; treatment of autoimmune diseases; Major Histocompatibility complex genes and their role in autoimmune and infectious diseases, transplantation: immunological basis of graft rejection; HLA typing, clinical transplantation and immunosuppressive therapy; tumor immunology: tumor antigens; immune response to tumors and tumor evasion of the immune system, cancer immunotherapy; immunodeficiency: primary immunodeficiencies, acquired or secondary immunodeficiencies, autoimmune disorder, anaphylactic shock, immunosenescence, immune exhaustion in chronic viral infection, immune tolerance, NK cells in chronic viral infection and malignancy. Complement genes of the human major histocompatibility complex: implication for linkage disequilibrium and disease associations, genetic studies of rheumatoid arthritis, systemic lupus erythematosus and multiple sclerosis, immunogenetics of spontaneous control of HIV,KIR complex.	**20%**	**9**

Instructional Method and Pedagogy:
Audio-Visual Lectures, Quizzes, Debates, Project works, Case studies, and Assignments Practical exercises are designed to understand the theory as taught in classroom. Hands on in practical session.

Course Outcomes:	Blooms' Taxonomy Domain	Blooms' Taxonomy Sub Domain
After successful completion of the above course, students will be able to:		Explain, Describe, Discuss, Recall, Locate
CO1 To learn about structural features of components of immune system as well as their function	Remember	
CO2 To gain knowledge on development of the immune system	Apply	Apply, Practice, Interpret, Select, Correlate
CO3 To predict about nature of immune response that develops against bacterial, viral or parasitic infection	Analyses and Evaluation	Compare, Classify, Select, Investigate
CO4 To understand the mechanisms by which our body elicits	Create	Construct,

immune response **CO5** To understand basic immunological methods involved in research and clinical/applied science	Understand	Develop, Produce Explain, Describe, outline, Predict, Summarize

Learning Resources	
1.	Goldsby RA, Kindt TJ, Osborne BA. (2007). Kuby's Immunology. 6th edition W.H. Freeman and Company, New York.
2.	Reference books : 1. Brostoff, J., Seaddin, J.K., Male, D.,& Roitt, I. M. (2002). Clinical Immunology. London: Gower Medical Pub. 2. Murphy, K., Travers, P., Walport, M., & Janeway,C. (2012). Janeway's Immunobiology. New York: GarlandScience. 3. Paul, W.E. (2012). Fundamental Immunology. New York:Raven Press. 4. Goding, J. W. (1996). Monoclonal Antibodies: Principles and Practice: Production and Application of Monoclonal Antibodiesin Cell Biology, Biochemistry, and Immunology. London: Academic Press. 5. Parham, P.(2005). The Immune System. New York:Garland Science.
3. 4. 5.	Journals: 1. Journal of Immunology 2. Molecular Immunology 3. Nature Review immunology Periodicals: The scientist Other Electronic resources: h**ttps://www.immunology.org/**

Evaluation Scheme	**Total Marks**
Theory: Mid semester Marks	30 marks
Theory: End Semester Marks	50 marks
Theory: Continuous Evaluation Component Marks	

Attendance	05 marks
MCQs	05 marks
Skill enhancement activities / case study	05 marks
Presentation/ miscellaneous activities	05 marks
Total	**20 Marks**

Practical Marks	

Attendance	05 marks
Practical Exam	30 marks
Viva	10 marks
Journal	05 marks
Total	**50 Marks**

Mapping of PSOs and COs

PO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO						
CO1	1	3	1	2	3	-
CO2	2	2	2	2	-	-
CO3	1	1	-	1	1	-
CO4	-	1	1	-	2	1
CO5	-	-	1	1	-	1

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

Mapping of PO and COs

PO	PO1	PO2	PO3	PO4	PO5	PO6
CO	3	1	-	2	2	3
CO1	2	-	3	2	2	2
CO2	3	1	3	3	3	3
CO3	2	2	1	-	2	2
CO4	3	1	-	-	2	3
CO5	3	1	-	2	2	3

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

COURSE CODE MSBO203			COURSE NAME BIOINFORMATICS			SEMESTER II	
Teaching Scheme (Hours)				Teaching Credit			
Lecture	Practical	Tutorial	Total Hours	Lecture	Practical	Tutorial	Total Credit
3	0	0	45	3	0	0	3

Course Pre-requisites	Basic Understanding of Science and Communication.
Course Category	Core.
Course focus	Employability
Rationale	Bioinformatics employs computational algorithms and statistical models to predict biological phenomena, such as protein structure and function, gene expression patterns, and disease outcomes, aiding in hypothesis generation and experimental design. By comparing biological sequences, structures, and genomes across different species, bioinformatics helps identify evolutionary relationships, conserved motifs, and functional elements, providing insights into the underlying mechanisms of biological processes.
Course Revision/ Approval Date:	14/03/2020
Course Objectives (As per Blooms' Taxonomy)	**1.Remember:** The objectives of this course are to provide theory and practical experience. **2.Apply:** Provide experience of the use of common computational tool **3.Analyses**: To interpret the results accurately and meaningfully **4.Create:** Deals with designing of molecular docking **5.Understand:** Gives knowledge of databases which facilitate investigation of molecular biology and evolution-related concepts

Course Content (Theory)	Weightage	Contact hours
Unit 1: **Bioinformatics basics** Bioinformatics basics: Computers in biology and medicine; Introduction to Unix and Linux systems and basic commands; Database concepts; Protein and nucleic acid databases; Structural databases; Biological XMLDTD's; pattern matching algorithm basics; databases and search tools: biological background for sequence analysis; Identification of protein sequence from DNA sequence; searching of databases similar sequence; NCBI; publicly available tools; resources at EBI; resources on web; database mining tools.	**20%**	**9**

Unit 2: **DNA sequence analysis** DNA sequence analysis:genebank 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,the irrelevance In molecular level processes, and their identification; assembly of data from genome sequencing	**20%**	**9**
Unit 3: **Multiple sequence analysis** Multiple sequence analysis;multiple sequence alignment;flexible sequence similarity searching with the FASTA program package; use of CLUSTALW and CLUSTALX for multiple sequence alignment; submitting DNA protein sequence to databases: where and how to submit, SEQUIN, genome centres; submitting aligned sets of sequences,updating	**20%**	**9**
Unit 4: **Protein modelling** 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; submitted sequences, methods of phylogenetic analysis. 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	**20%**	**9**
Unit 5: **Protein structure prediction and virtual library** Protein structure prediction: protein folding and model generation;secondary structure prediction; analyzing secondary structures; protein loop searching; loop generating methods; homology modelling: potential applications, description, methodology, homologous sequence identification; align structures, align model sequence; construction of variable and conserved regions; threading techniques; topology fingerprint approach for prediction; evaluation of alternate models; structure prediction on a mystery sequence; structure aided sequence techniques of structure prediction; structural profiles, Alignment algorithms,mutationtables,prediction,validation,sequence based methods of structure prediction, prediction using inverse folding, fold prediction; significance analysis, scoring techniques, sequence-sequence scoring; protein function prediction; elements of in silico drug design;Virtual library: Searching PubMed, current content, science citation index and current awareness services, electronic journals, grants and funding information.	**20%**	**9**

Instructional Method and Pedagogy:
Audio-Visual Lectures, Quizzes, Debates, Project works, Case studies, and Assignments Practical exercises are designed to understand the theory as taught in classroom. Hands on in practical session.

Course Outcomes:	Blooms' Taxonomy Domain	Blooms' Taxonomy Sub Domain
After successful completion of the above course, students will be able to:		Explain, Describe,
CO1 The objectives of this course are to provide theory and practical experience.	Remember	Discuss, Recall, Locate
CO2 Provide experience of the use of common computational tool	Apply	Apply, Practice, Interpret, Select, Correlate
CO3 To interpret the results accurately and meaningfully	Analyses and Evaluation	Compare, Classify, Select, Investigate
CO4 Deals with designing of molecular docking	Create	Construct, Develop, Produce
CO5 Gives knowledge of databases which facilitate investigation of molecular biology and evolution-related concepts	Understand	Explain, Describe, outline, Predict, Summarize

Learning Resources	
1.	Textbook: 1. Bourne,P.E.,&Gu,J.(2009). Structural Bioinformatics. Hoboken, NJ:WileyLiss. 2. Lesk, A. M. (2004). Introduction to Protein Science: Architecture, Function, and Genomics. Oxford: Oxford University Press
2.	Reference books : 1.Lesk,A.M.(2002).IntroductiontoBioinformatics.Oxford:OxfordUniversityPr ess. 2. Mount, D. W.(2001). Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press. 3. Baxevanis, A. D.,& Ouellette, B. F.(2001). Bioinformatics: a Practical Guide to the Analysis of Genes and Proteins. New York:Wiley-Interscience. 4. Pevsner,J.(2015). Bioinformatics and Functional Genomics. Hoboken, NJ.: Wiley-Blackwel
3. 4. 5.	Journal : Journal of Bioinformatics and Computational Biology Periodicals: BMC bioinformatics Other Electronic resources: https://www.rcsb.org/

<table>
<tr><th>Evaluation Scheme</th><th>Total Marks</th></tr>
<tr><td>Theory: Mid semester Marks</td><td>30 marks</td></tr>
<tr><td>Theory: End Semester Marks</td><td>50 marks</td></tr>
<tr><td>Theory: Continuous Evaluation Component Marks</td><td>
<table>
<tr><td>Attendance</td><td>05 marks</td></tr>
<tr><td>MCQs</td><td>05 marks</td></tr>
<tr><td>Skill enhancement activities / case study</td><td>05 marks</td></tr>
<tr><td>Presentation/ miscellaneous activities</td><td>05 marks</td></tr>
<tr><td>Total</td><td>20 Marks</td></tr>
</table>
</td></tr>
<tr><td>Practical Marks</td><td>
<table>
<tr><td>Attendance</td><td>05 marks</td></tr>
<tr><td>Practical Exam</td><td>30 marks</td></tr>
<tr><td>Viva</td><td>10 marks</td></tr>
<tr><td>Journal</td><td>05 marks</td></tr>
<tr><td>Total</td><td>50 Marks</td></tr>
</table>
</td></tr>
</table>

Mapping of PSOs and COs

PO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO						
CO1	-	2	1	1	-	-
CO2	3	1	1	1	-	3
CO3	2	1	2	1	1	2
CO4	1	-	-	-	-	1
CO5	2	-	-	-	-	-

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

Mapping of POs and COs

PO	PO1	PO2	PO3	PO4	PO5	PO6
CO						
CO1	3	-	-	-	-	-
CO2	1	2	-	1	1	-
CO3	-	1	2	1	-	-
CO4	-	1	2	1	1	-
CO5	-	-	2	-	-	-

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

COURSE CODE MSBO204	COURSE NAME BIOPROCESS ENG &TECH	SEMESTER II

Teaching Scheme (Hours)				Teaching Credit			
Lecture	**Practical**	**Tutorial**	**Total Hours**	**Lecture**	**Practical**	**Tutorial**	**Total Credit**
3	0	0	45	3	0	0	3

Course Pre-requisites	Basic Understanding of Microbes and environment
Course Category	Core.
Course focus	Scientific Temperament & Employability
Rationale	Bioprocess engineering is an ever growing field since it is a combination of natural resources, Science and technology. The basic science provides us with the knowledge about the living organisms such as plants, animals, bacteria and fungi but the bioprocess engineering helps in development of the essential skills required to utilise the living organisms for the betterment of the human beings and the nature itself.
Course Revision/ Approval Date:	14/03/2020
Course Objectives (As per Blooms' Taxonomy)	1. **Remember:** Basics of Microbiology 2. **Apply:** The basic concepts to industrial applications 3. **Analyses:** Integration of science with technology. 4. **Create:** Models of Industrial designs and applications 5. **Understand:** How living organisms can be used for value creation, product manufacturing and societal development.

Course Content (Theory)	Weightage	Contact hours
Unit 1: **Theory:** Isolation, screening and maintenance of industrially important microbes; microbial growth and death kinetics (an example from each group, particularly with reference to industrially useful microorganisms); strain improvement for increased yield and other desirable characteristics. Elemental balance equations; metabolic coupling – ATP and NAD+; yield coefficients; unstructured models of microbial growth; structured models of microbial growth.	**20%**	**9**
Unit 2: **Theory:** Batch and continuous fermenters; modifying batch and continuous reactors: chemostat with recycle, multistage chemostat systems, fed-batch operations; conventional fermentation v/s biotransformation; immobilized cell systems; large scale animal and plant cell cultivation; fermentation economics; upstream processing: media formulation and optimization; sterilization; aeration, agitation and heat transfer in bioprocess; scale up and scale down; measurement and control of bioprocess parameters.	**20%**	**9**
Unit 3: Theory: Separation of insoluble products - filtration, centrifugation, sedimentation, flocculation; Cell disruption; separation of soluble products: liquid-liquid extraction, precipitation, chromatographic techniques, reverse osmosis, ultra and micro filtration, electrophoresis; final purification: drying; crystallization; storage and packaging.	**20%**	**9**
Unit 4: Theory: Isolation of micro-organisms of potential industrial interest; strain improvement; market analysis; equipment and plant costs; media; sterilization, heating and cooling; aeration and agitation; bath-process cycle times and continuous cultures; recovery costs; water usage and recycling; effluent treatment and disposal. Mechanism of enzyme function and reactions in process techniques; enzymatic bioconversions e.g. starch and sugar conversion processes; high-fructose corn syrup; interesterified fat; hydrolyzed protein etc. and their downstream processing; baking by amylases, deoxygenation and desugaring by glucoses oxidase, beer mashing and chill proofing; cheese making by proteases and various other enzyme catalytic actions in food processing.	**20%**	**9**

Unit 5: Theory: Fermented foods and beverages; food ingredients and additives prepared by fermentation and their purification; fermentation as a method of preparing and preserving foods; microbes and their use in pickling, producing colours and flavours, alcoholic beverages and other products; process wastes-whey, molasses, starch substrates and other food wastes for bioconversion to useful products; bacteriocins from lactic acid bacteria – production and applications in food preservation; biofuels and biorefinery	**20%**	**9**

Course Outcomes:	**Blooms' Taxonomy Domain**	**Blooms' Taxonomy Sub Domain**
After successful completion of the above course, students will be able to:		Explain, Describe, Discuss, Recall, Locate
CO1 To educate students about the fundamental concepts of bioprocess technology	Remember	
CO2 To know the relevance of microorganisms from industrial context	Apply	Apply, Practice, Interpret, Select, Correlate
CO3 To know the importance of design and operations of various industrial fermenters	Analyses and Evaluation	Compare, Classify, Select, Investigate
CO4 To get a know how of basic methods involved in production of biobased products	Create	Construct, Develop, Produce
CO5 To meet the challenges of the new and emerging areas of biotechnology industry	Understand	Explain, Describe, outline, Predict, Summarise
Learning Resources		

1.	Textbook: 1. Bailey, J. E., & Ollis, D. F. (1986). Biochemical Engineering Fundamentals. New York: McGraw-Hill. 2. El-Mansi, M., & Bryce, C. F. (2007). Fermentation Microbiology and Biotechnology. Boca Raton: CRC/Taylor & Francis. Reference books 1. Shuler, M. L., & Kargi, F. (2002). Bioprocess Engineering: Basic Concepts. Upper Saddle River, NJ: Prentice Hall. 2. Stanbury, P. F., & Whitaker, A. (2010). Principles of Fermentation Technology. Oxford: Pergamon Press. 3. Blanch, H. W., & Clark, D. S. (1997). Biochemical Engineering. New York: M. Dekker.
2.	7. Periodicals: Science Daily 8. Journal: Current Science, Biotechnology and Bioprocess Engineering
3	Other Electronic resources: 1) NPTEL 2) SWAYAM 3) UGC - epathshala 4) indiabioscience.org

Evaluation Scheme	**Total Marks**
Theory: Mid semester Marks	30 marks
Theory: End Semester Marks	50 marks
Theory: Continuous Evaluation Component Marks	

Attendance	05 marks
MCQs	05 marks
Skill enhancement activities / case study	05 marks
Presentation/ miscellaneous activities	05 marks
Total	**20 Marks**

Practical Marks	

Attendance	5 marks
Practical Exam	20 marks
Viva	10 marks
Journal	10 marks
Discipline	5 marks
Total	**50 Marks**

Mapping of PSOs and COs

PO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO						
CO1	2	-	2	1	1	-
CO2	1	-	2	2	-	-
CO3	-	-	-	1	2	1
CO4	1	3	2	-	2	1
CO5	2	1	-	1	-	2

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

Mapping of POs and COs

PO	PO1	PO2	PO3	PO4	PO5	PO6
CO						
CO1	-	2	-	2	2	1
CO2	1	2	1	2	-	-
CO3	2	-	-	1	-	1
CO4	1	1	2	-	2	2
CO5	-	1	-	2	-	-

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

COURSE CODE MSBO205	COURSE NAME INTELLECTUAL PROPERTY RIGHTS, BIOSAFETY AND BIOETHICS	SEMESTER II

Teaching Scheme (Hours)				Teaching Credit			
Lecture	**Practical**	**Tutorial**	**Total Hours**	**Lecture**	**Practical**	**Tutorial**	**Total Credit**
3	0	0	45	3	0	0	3

Course Pre-requisites	Students should have basic knowledge of research
Course Category	Core.
Course focus	Employability
Rationale	To have an overview of knowledge on intellectual property rights and their implications in biological research and product development and their effects.
Course Revision/ Approval Date:	14/03/2019
Course Objectives (As per Blooms' Taxonomy)	**1. Remember** To become familiar with India's IPR Policy. **2. Apply** To provide basic knowledge on intellectual property rights and their implications in biological research and product development. **3. Analyses** To learn biosafety and risk assessment of biotechnology products **4. Create** To become familiar with regulations of products derived from biotechnology **5. Understand**vTo learn risk assessment on biotechnology and microbiology, become familiar with ethical issues in biological research.

Course Content (Theory)	Weightage	Contact hours
Unit 1: Theory: Introduction to IPR 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 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.	**20%**	**9**

Unit 2: Theory: Patenting: 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 patents applications: provisional and complete specifications; PC 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.	**20%**	**9**
Unit 3: Theory: Biosafety 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 feed safety assessment; problem formulation–protection goals, compilation of relevant information, risk characterization and development of analysis plan; risk assessment of transgenic crops vs cisgenic plants or products derived from RNAi, genome editing tools.	**20%**	**9**
Unit 4: Theory: National and international regulations: International Regulations – Cartagena Protocol, OECD consensus documents and Codex Alimentarius; India 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 labelling–Food Safety and Standards Authority of India (FSSAI).	**20%**	**9**
Unit 5: Theory: Bioethics: 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.	**20%**	**9**

Instructional Method and Pedagogy:
Audio-Visual Lectures, Quizzes, Debates, Project works, Case studies, and Assignments Practical exercises are designed to understand the theory as taught in the classroom. Hands on in a practical session.

Course Objectives:	Blooms' Taxonomy Domain	Blooms' Taxonomy Sub Domain
After successful completion of the above course, students will be able to:		Explain, Describe, Discuss, Recall, Locate
CO1 To become familiar with India's IPR Policy	Remember	
CO2 To provide basic knowledge on intellectual property rights and their implications in biological research and product development	Apply	Apply, Practice, Interpret, Select, Correlate
CO3 To learn biosafety and risk assessment of biotechnology products	Analyses and Evaluation	Compare, Classify, Select, Investigate
CO4 To become familiar with regulations of products derived from biotechnology	Create	Construct, Develop, Produce
CO5 To learn risk assessment on biotechnology and microbiology, become familiar with ethical issues in biological research.	Understand	Explain, Describe, outline, Predict, Summarize
Learning Resources		

1.	Reference books: 1. Ganguli,P.(2001).Intellectual Property Rights: Unleashing The Knowledge Economy. New Delhi: Tata McGraw-Hill Pub 2. National IPR Policy, Department ofIndustrial Policy & Promotion, Ministry of Commerce, GoI 3. Complete Reference to Intellectual Property Rights Laws. (2007). Snow White PublicationOct. 4. Kuhse, H. (2010). Bioethics: an Anthology. Malden, MA: Blackwell. 5. Karen F.Greif and Jon F. Merz, Current Controversies in the Biological Sciences - Case Studies of Policy Challenges from New Technologies, MIT Press. 6. 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 7. 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 8. Guidelines for Safety Assessment of Foods Derived from Genetically Engineered Plants. 2008. 9. Guidelines and Standard Operating Procedures for Confined Field Trials of Regulated Genetically Engineered Plants. 2008. Retrieved from http://www.igmoris.nic.in/guidelines1.asp 10. Alonso, G.M. (2013). Safety Assessment of Food and Feed Derived from GM Crops: Using Problem Formulation Ensure“Fit for Purpose”Risk Assessments. Retrieved from http://biosafety.icgeb.org/in house publications collection biosafety reviews.
2.	Journals & Periodicals 1. The WIPO Journal
	Periodicals: WIPO magazine, Intellectual Property Magazine
5	Other Electronic resources: 1. Office the Controller General Patents, Designs & Trademarks; Department Of Industrial Policy & Promotion; Ministry of Commerce & Industry; Government of India. http://www.ipindia.nic.in/ 2. World Intellectual Property Organisation. http://www.wipo.int 3. International Union for the Protection of New Varieties of Plants. http://www.upov.int 4. World Trade Organisation. http://www.wto.org 5. National Portal of India. http://www.archive.india.gov.in 6. National Biodiversity Authority. http://www.nbaindia.org 7. 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

Evaluation Scheme	Total Marks
Theory: Mid semester Marks	30 marks

<table>
<tr><td>Theory: End Semester Marks</td><td>50 marks</td></tr>
<tr><td>Theory: Continuous Evaluation Component Marks</td><td>
<table>
<tr><td>Attendance</td><td>05 marks</td></tr>
<tr><td>MCQs</td><td>05 marks</td></tr>
<tr><td>Skill enhancement activities / case study</td><td>05 marks</td></tr>
<tr><td>Presentation/ miscellaneous activities</td><td>05 marks</td></tr>
<tr><td>Total</td><td>20 Marks</td></tr>
</table>
</td></tr>
<tr><td>Practical Marks</td><td>
<table>
<tr><td>Attendance</td><td>0 marks</td></tr>
<tr><td>Practical Exam</td><td>0 marks</td></tr>
<tr><td>Viva</td><td>0 marks</td></tr>
<tr><td>Journal</td><td>0 marks</td></tr>
<tr><td>Discipline</td><td>5 marks</td></tr>
<tr><td>Total</td><td>0 Marks</td></tr>
</table>
</td></tr>
</table>

Mapping of PSOs and COs

PO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO						
CO1	1	-	-	2	1	-
CO2	1	-	-	2	2	1
CO3	1	2	1	-	-	1
CO4	1	2	2	-	-	2
CO5	1	-	2-	-	3	2

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

Mapping of POs and COs

PO	PO1	PO2	PO3	PO4	PO5	PO6
CO						
CO1	2	-	-	-	1	-
CO2	2	-	-	2	1	1
CO3	-	2	3	-	2	1
CO4	-	1	1	2	-	3
CO5	-	-	-	-	3	-

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

COURSE CODE MSBO206	COURSE NAME RESEARCH METHODOLOGY AND SCIENTIFIC COMMUNICATION SKILLS	SEMESTER II

Teaching Scheme (Hours)				Teaching Credit			
Lecture	**Practical**	**Tutorial**	**Total Hours**	**Lecture**	**Practical**	**Tutorial**	**Total Credit**
3	0	0	45	3	0	0	3

Course Pre-requisites	Basic Understanding of Science and Communication.
Course Category	Core.
Course focus	Employability
Rationale	To have an idea how research methodology lies in its ability to provide a systematic approach to investigating and answering research questions. It serves as a roadmap for researchers, helping them design and conduct their studies effectively and ensure the validity and reliability of their findings. Here are a few key points that highlight the rationale behind research methodology
Course Revision/ Approval Date:	14/03/2020
Course Objectives **(As per Blooms' Taxonomy)**	1. **Remember:** To give background on history of science, emphasizing methodologies used to do research. 2. **Apply:** To introduce the framework of research methodologies for understanding effective lab practices and scientific communication 3. **Analyses:** To inculcate scientific and professional ethics 4. **Create:** To impart skills related to various media for scientific communication 5. **Understand:** To impart basic knowledge of modern good laboratory practices specially to develop interpersonal and communication skills including communicating in small groups, taking research notes, and working effectively with peers

Course Content (Theory)	Weightage	Contact hours
Unit 1: Theory: Empirical science; scientific method; manipulative experiments and controls; deductive and inductive reasoning; descriptive science; reductionist vs holistic biology. Choosing a mentor, lab and research question; maintaining a lab notebook.	**20%**	**9**

Unit 2: Theory: Concept of effective communication - setting clear goals for communication; determining outcomes and results; initiating communication; avoiding breakdowns while communicating; creating value in conversation; barriers to effective communication; non-verbal communicationinterpreting non-verbal cues; importance of body language, power of effective listening; recognizing cultural differences	**20%**	**9**
Unit 3: Theory: Presentation skills - formal presentation skills; preparing and presenting using overhead projector, PowerPoint; defending interrogation; scientific poster preparation & presentation; participating in group discussions; Computing skills for scientific research - web browsing for information search; search engines andher mechanism of searching; hidden Web and its importance scientific research; internet as medium of interaction between scientists; effective email strategy using the right tone and conciseness.	**20%**	**9**
Unit 4: Theory: Technical writing skills - types of reports; layout of a formal report; scientific writing skills importance of communicating science; problems while writing scientific document; plagiarism, software for plagiarism; scientific publication writing: elements of a scientific paper including abstract, introduction, materials & methods, results, discussion, references; drafting titles and framing abstracts	**20%**	**9**
Unit 5: Theory: Publishing scientific papers - peer review process and problems, recent developments such as open access and non- blind review; plagiarism; characteristics of effective technical communication; scientific presentations; ethical issues; scientific misconduct.	**20%**	**9**

Instructional Method and Pedagogy:

Audio-Visual Lectures, Quizzes, Debates, Project works, Case studies, and Assignments Practical exercises are designed to understand the theory as taught in classroom. Hands on in practical session.

Course Outcomes:	Blooms' Taxonomy Domain	Blooms' Taxonomy Sub Domain
After successful completion of the above course, students will be able to:		
CO1 To give background on history of science, emphasizing methodologies used to do research	Remember	Explain, Describe, Discuss, Recall, Locate
CO2 To introduce the framework of research methodologies for understanding effective lab practices and scientific communication	Apply	Apply, Practice, Interpret, Select, Correlate
CO3 To inculcate scientific and professional ethics	Analyses and Evaluation	Compare, Classify, Select, Investigate
CO4 To impart skills related to various media for scientific communication	Create	Construct, Develop, Produce
CO5 To impart basic knowledge of modern good laboratory practices specially to develop interpersonal and communication skills including communicating in small groups, taking research notes, and working effectively with peers	Understand	Explain, Describe, outline, Predict, Summarize

Learning Resources	
1.	1. On Being a Scientist: a Guide to Responsible Conduct Research. (2009). Washington, D.C.: National Academies Press. 2. Gopen, G. D., & Smith, J.A. The Science of Scientific Writing. American Scientist, 78 (Nov-Dec 1990), 550-558. 3. Valiela, I. (2001). Doing Science: Design, Analysis, and Communication of Scientific Research. Oxford: Oxford University Press. 4. Mohan, K., & Singh, N. P. (2010). Speaking English Effectively. Delhi: Macmillan India.
2.	Journals & Periodicals 1. International Journal of Research Methodology 2. International Journal of Science and Research Methodology Periodicals: Journal of Research Practice
5	Other Electronic resources: Movies: Naturally Obsessed, The Making of a Scientist

Evaluation Scheme	Total Marks

Theory: Mid semester Marks	30 marks
Theory: End Semester Marks	50 marks
Theory: Continuous Evaluation Component Marks	

Attendance	05 marks
MCQs	05 marks
Skill enhancement activities / case study	05 marks
Presentation/ miscellaneous activities	05 marks
Total	**20 Marks**

Practical Marks	

Attendance	0 marks
Practical Exam	0 marks
Viva	0 marks
Journal	0 marks
Discipline	0 marks
Total	**0 Marks**

Mapping of PSOs and COs

PO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO						
CO1	2	-	2	1	1	-
CO2	1	-	2	2	-	-
CO3	-	-	-	1	2	1
CO4	1	3	2	-	2	1
CO5	2	1	-	1	-	2

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

Mapping of POs and COs

PO	PO1	PO2	PO3	PO4	PO5	PO6
CO						
CO1	-	2	-	2	2	1
CO2	1	2	1	2	-	-
CO3	2	-	-	1	-	1
CO4	1	1	2	-	2	2
CO5	-	1	-	2	-	-

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

COURSE CODE MSBO207			COURSE NAME MICROBIAL TECHNOLOGY			SEMESTER II	
Teaching Scheme (Hours)				Teaching Credit			
Lecture	Practical	Tutorial	Total Hours	Lecture	Practical	Tutorial	Total Credit
2	0	0	30	2	0	0	2

Course Pre-requisites	Basic Understanding of Science and Communication.
Course Category	Elective.
Course focus	Employability
Rationale	To develop a deeper understanding of microbial technology and application of microbial technology. Also apply subject knowledge to the industrial practice and get familiar with industrial scale microbial practice. Acquire knowledge about industrially important microbial products.
Course Revision/ Approval Date:	14/03/2020

Course Objectives (As per Blooms' Taxonomy)	1. **Remember**: To give background on history of science, emphasizing methodologies used to do research. to introduce students to developments made in field of microbial technology for use in human welfare and solving problems of the society. 2. **Apply**: To introduce the framework of research methodologies for understanding effective lab practices and scientific communication to introduce students to advances made in field of microbial technology for use in human welfare and solving problems of the society. 3. **Analyses**: To inculcate scientific and professional ethics The course will cover the concept of microbial growth, metabolism. 4. **Create**: To impart skills related to various media for scientific communication The course will cover the concept of applications of microbial technology in varied fields. 5. **Understand**: To impart basic knowledge of modern good laboratory practices specially to develop interpersonal and communication skills including communicating in small groups, taking research notes, and working effectively with peers provide a strong understanding of applied microbiology and will help the students to explore work opportunities in Biotechnology Companies and Industries as well.

Course Content (Theory)	Weightage	Contact hours
Unit 1: Introduction to microbial technology Theory: Microbial technology in human welfare; Isolation and screening of microbes important for industry – advances in methodology and its application; Advanced genome and epigenome editing tools (e.g., engineered zinc finger proteins, TALEs/TALENs, and the CRISPR/Cas9 System S nucleases for genome editing, transcription factors for epigenome editing, and other emerging tools) for manipulation of useful microbes/strains and their applications; Strain improvement to increase yield of selected molecules, e.g., antibiotics, enzymes, biofuels.	**20%**	**6**

Unit 2: Environmental applications of microbial technology Theory: Environmental application of microbes; Or leaching; Biodegradation-biomass recycle and removal; Bioremediation-toxic waste removal and soil remediation; Global Bio geochemical cycles; Environment sensing (sensor organisms/ biological sensors); International and National guidelines regarding use of genetically modified organisms in environment, food and pharmaceuticals.	**20%**	**6**
Unit 3: Pharmaceutical applications of microbial technology Recombinant protein and pharmaceuticals production in microbes – common bottlenecks and issues (technical/operational, commercial and ethical); Attributes required in industrial microbes (Streptomyces sp., Yeast) to be used as efficient cloning and expression hosts (biological production); Generating diversity and introduction of desirable properties in industrially important microbes (Streptomyces/Yeast); Microbial cell factories; Downstream processing approaches used in industrial production process (Streptomyces sp.,Yeast).	**20%**	**6**
Unit 4: Food applications of microbial technology Theory: Application of microbes and microbial processes in food and health care industries-food processing and food preservation, antibiotics and enzymes production, microbes in targeted delivery application – drugs and vaccines (bacterial and viral vectors); Nonrecombinant ways of introducing desirable properties in Generally recognized as safe (GRAS) microbes to be used in food (e.g., Yeast)- exploiting the existing natural diversity or the artificially introduced diversity through conventional acceptable techniques (mutagenesis, protoplast fusion, breeding, genome shuffling, directed evolution etc.).	**20%**	**6**
Unit 5: Advances in microbial technology Theory: Microbial genomics for discovery of novel enzymes, drugs/antibiotics; Limits Of microbial genomics with respect to use inhuman welfare; Metagenomics and meta transcriptomics–their potential, methods to study and applications/use (animal and plant health, environmental clean-up, global nutrient cycles & global sustainability, understanding evolution), Global metagenomics initiative - surveys/projects and outcome, metagenomic library construction and functional screening in suitable hosts– tools and techniques for discovery/identification of novel enzymes, drugs (e.g., protease, antibiotic) etc.	**20%**	**6**

Instructional Method and Pedagogy:
Audio-Visual Lectures, Quizzes, Debates, Project works, Case studies, and Assignments Practical exercises are designed to understand the theory as taught in classroom. Hands on in practical session.

Course Outcomes:	Blooms' Taxonomy Domain	Blooms' Taxonomy Sub Domain
After successful completion of the above course, students will be able to:		Explain, Describe, Discuss, Recall, Locate
CO1 To introduce students to developments made in field of microbial technology for use in human welfare and solving problems of the society.	Remember	
CO2 To introduce students to advances made in field of microbial technology for use in human welfare and solving problems of the society.	Apply	Apply, Practice, Interpret, Select, Correlate
CO3 The course will cover the concept of microbial growth, metabolism.	Analyses and Evaluation	Compare, Classify, Select, Investigate
CO4 The course will cover the concept of applications of microbial technology in varied fields.	Create	Construct, Develop, Produce
CO5 This course will provide a strong understanding of applied microbiology and will help the students to explore work opportunities in Biotechnology Companies and Industries as well.	Understand	Explain, Describe, outline, Predict, Summarize

Learning Resources	
	1. Textbook: 1. Lee, Y. K. (2013). Microbial Biotechnology: Principles and Applications. Hackensa ck, NJ: World Scientific. 2. Moo-Young, M. (2011). Comprehensive Biotechnology. Amsterdam: Elsevier. 3. Nelson,K.E.(2015). Encyclopedia of Metagenomics.Genes, Genomes and Metagenomes: Basics, Methods, Databases and Tools. Boston, MA: Springer US.
	2. Reference Book 1.The New Science of Metagenomics Revealing the Secrets of Our Microbial Planet. (2007). Washington, D.C.: National Academies Press. 3. Journal: (a)Nature, (b)Nature Biotechnology, (c)Applied microbiology and biotechnology, (d) Trends in Biotechnology, (e) Trends in Microbiology, (f) Current opinion in Microbiology, (g) Biotechnology Advances, (h) Genome Research 4. Periodicals: Microbiology today 5. Other Electronic resources: Websites: http://jgi.doe.gov/our-science/

Evaluation Scheme	Total Marks
Theory: Mid semester Marks	15 marks
Theory: End Semester Marks	25 marks
Theory: Continuous Evaluation Component Marks	

Attendance	2.5 marks
MCQs/Quiz	2.5 marks
Skill enhancement activities / case study	2.5 marks
Presentation/ miscellaneous activities	2.5 marks
Total	**10 Marks**

Mapping of PSOs and COs

PO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO						
CO1	2	-	2	1	1	-
CO2	1	-	2	2	-	-
CO3	-	-	-	1	2	1
CO4	1	3	2	-	2	1
CO5	2	1	-	1	-	2

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

Mapping of POs and COs

PO	PO1	PO2	PO3	PO4	PO5	PO6
CO						
CO1	-	2	-	2	2	1
CO2	1	2	1	2	-	-
CO3	2	-	-	1	-	1
CO4	1	1	2	-	2	2
CO5	-	1	-	2	-	-

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

COURSE CODE MSBO208	COURSE NAME GLP AND REGULATORY COMPLIANCES	SEMESTER II

Teaching Scheme (Hours)				Teaching Credit			
Lecture	Practical	Tutorial	Total Hours	Lecture	Practical	Tutorial	Total Credit
2	0	0	45	2			3

Course Pre-requisites	**Basic Understanding of Science and Communication.**
Course Category	**Core Professional**
Course focus	**Employability**
Rationale	To introduce fundamentals of Environmental Biotechnology and introduce major groups of microorganisms- tools in biotechnology and their most important environmental applications. The environmental applications of biotechnology will be presented in detail and will be supported by examples from the national and international literature. To acquire an awareness of and sensitivity to the total environment and its allied problems. To understand how biotechnology can useful to solve environmental problems
Course Revision/ Approval Date:	14/03/2020
Course Objectives (As per Blooms' Taxonomy)	1. Remember: This course is designed to impart fundamental knowledge on various Good Regulatory Practices viz., cGMP, GLP, GALP and GDP for Pharmaceuticals. 2. Understand: This course is designed to impart fundamental knowledge on various Good Regulatory Practices viz., Cosmetics, Food & Nutraceuticals, Medical devices, In-vitro Diagnostic 3.Analyse and Apply: To understand the rationale behind these requirements and will propose ways and means of complying with them.

Course Content (Theory)	Weightage	Contact hours
Unit 1:Current Good Manufacturing Practices Introduction, US Cgmp Part 210 and Part 211.EC Principles of GMP (Directive 91/356/EEC) Article 6 to Article 14 and WHO cGMP guidelines GAMP-5; Medical device and IVDs Global Harmonization Task Force (GHTF) Guidance docs.	**20%**	**9**
Unit 2: Good Laboratory Practices: Introduction, USFDA GLP Regulations (Subpart A to Subpart K), Controlling the GLP inspection process, Documentation, Audit, goals of Laboratory Quality Audit, Audit tools, Future of GLP regulations, relevant ISO and Quality Council of India (QCI) Standards	**20%**	**9**
Unit 3: Good Automated Laboratory Practices: Introduction to GALP, Principles of GALP, GALP Requirements, SOPs of GALP, Training Documentation,21 CFR Part 11, General check list of 21CFR Part 11, Software Evaluation checklist, relevant ISO and QCI Standards.	**20%**	**9**
Unit 4: Good Distribution Practices: Introduction to GDP, Legal GDP requirements put worldwide, Principles, Personnel, Documentation, Premises and Equipment, Deliveries to Customers, Returns, Self- Inspection, Provision of information, Stability testing principles, WHO GDP, USP GDP (Supply chain integrity), elevant CDSCO guidance and ISO standard**s**	**20%**	**9**
Unit 5:Quality management systems: Concept of Quality, Total Quality Management, Quality by design, Six Sigma concept, Out of Specifications (OOS), Change control. Validation: Types of Validation, Types of Qualification, Validation master plan (VMP), Analytical Method Validation. Validation of utilities, [Compressed air, steam, water systems, Heat Ventilation and Air conditioning (HVAC)]and Cleaning Validation. The International Conference on Harmonization (ICH) process, ICH guidelines to establish quality, safety and efficacy of drug substances and products, ISO 13485, Sch MIII and other relevant CDSCO regulatory guidance documents.	**20%**	**9**

Instructional Method and Pedagogy:
Audio-Visual Lectures, Quizzes, Debates, Project works, Case studies, and Assignments Practical exercises are designed to understand the theory as taught in classroom. Hands on in practical session.

Course Outcomes:	Blooms' Taxonomy Domain	Blooms' Taxonomy Sub Domain
After successful completion of the above course, students will be able to:		Explain, Describe, Discuss, Recall, Locate
CO1 The key regulatory and compliance elements with respect to Good Manufacturing Practices, Good Laboratory Practices, Good Automated Laboratory Practices and Good Documentation Practices.	Remember	
CO2 Prepare and implement the check lists and SOPs for various Good Regulatory Practices	Apply	Apply, Practice, Interpret, Select, Correlate
CO3 Implement Good Regulatory Practices in the Healthcare and related Industries	Analyses and Evaluation	Compare, Classify, Select, Investigate
CO4 Prepare for the readiness and conduct of audits and inspections.	Create	Construct, Develop, Produce
CO5 To maintain risk free environment in the Laboratory for experiments.	Understand	Explain, Describe, outline, Predict, Summarize

Learning Resources	
1.	Textbook: 1. Good Laboratory Practice Regulations, by Sandy Weinberg, Fourth Edition Drugs and the Pharmaceutical Sciences, Vol.168 2. Good Pharmaceutical Manufacturing practice, Rational and compliance by John Sharp, CRC Press 3. Establishing a cGMP Laboratory Audit System, A practical Guide by David M.Bleisner, Wiley Publication.

2.	Reference Book 1. How to practice GLP by PP Sharma, Vandana Publications. 2. Laboratory Auditing for Quality and Regulatory compliance bu Donald C.Singer, Drugs and the Pharmaceutical Sciences, Vol.150. 3. Drugs & Cosmetics Act, Rules & Amendments.
3.	Journal: Handbook: Good laboratory practice
4.	Other Electronic resources: 1. NPTEL

Evaluation Scheme	**Total Marks**
Theory: Mid semester Marks	**30 marks**
Theory: End Semester Marks	**50 marks**
Theory: Continuous Evaluation Component Marks	

Attendance	**5 marks**
MCQs/Quiz	**5 marks**
Skill enhancement activities / case study	**5 marks**
Presentation/ miscellaneous activities	**5 marks**
Total	**20 Marks**

Mapping of PSOs and COs

PO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO						
CO1	2	-	2	1	1	-
CO2	1	-	2	2	-	-
CO3	-	-	-	1	2	1
CO4	1	3	2	-	2	1
CO5	2	1	-	1	-	2

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

Mapping of POs and COs

PO	PO1	PO2	PO3	PO4	PO5	PO6
CO						
CO1	-	2	-	2	2	1
CO2	1	2	1	2	-	-
CO3	2	-	-	1	-	1
CO4	1	1	2	-	2	2
CO5	-	1	-	2	-	-

1: Slight (low) 2: Moderate (Medium); 3: Substantial (High); 0 None

COURSE CODE MSBO2012			COURSE NAME ENVIRONMENTAL BIOTECHNOLOGY			SEMESTER II
Teaching Scheme (Hours)				Teaching Credit		
Lecture	Practical	Tutorial	Total Hours	Lecture	Practical	Tutorial
2	0	0	30	2	0	0

Course Pre-requisites	Basic Understanding of Science and Communication.
Course Category	Elective
Course focus	Employability
Rationale	To introduce fundamentals of Environmental Biotechnology and introduce major groups of microorganisms- tools in biotechnology and their most important environmental applications. The environmental applications of biotechnology will be presented in detail and will be supported by examples from the national and international literature. To acquire an awareness of and sensitivity to the total environment and its allied problems. To understand how biotechnology can useful to solve environmental problems
Course Revision/ Approval Date:	14/03/2020
Course Objectives (As per Blooms' Taxonomy)	1. **Remember**: This course aims to introduce fundamentals of Environmental Biotechnology. 2. **Apply**: The course will introduce major groups of microorganisms- tools in biotechnology and their most important environmental applications 3. **Analyses**: To inculcate scientific and professional ethics The course will cover the concept of microbial growth, metabolism. 4. **Analyse:** The environmental applications of biotechnology will be presented in detail and will be supported by examples from the national and international literature 5. **Create**: To acquire an awareness of and sensitivity to the total environment and its allied problems 6. **Understand**: To understand how biotechnology can useful to solve environmental problems

Course Content (Theory)	Weightage	Contact hours
Unit 1: Introduction to environment Theory: pollution and its control; pollution indicators; waste management: domestic, industrial, solid and hazardous wastes; strain improvement; Biodiversity and its conservation; Role of microorganisms in geochemical cycles; microbial energy metabolism, microbial growth kinetics and elementary chemostat theory, relevant microbiological processes, microbial ecology Practical: (Give the list of Experiments)	**20%**	**6**
Unit 2: Bioremediation: Theory: Bioremediation: Fundamentals, methods and strategies of application (biostimulation, bioaugmentation) – examples, bioremediation of metals (Cr, As, Se, Hg), radionuclides (U, Te), organic pollutants (PAHs, PCBs, Pesticides, TNT etc.), technological aspects of bioremediation (in situ, ex situ).	**20%**	**6**
Unit 3: Role of microorganisms in bioremediation: Application of bacteria and fungi in bioremediation: White rot fungi vs specialized degrading bacteria: examples, uses and advantages vs disadvantages; Phytoremediation: Fundamentals and description of major methods of application (phytoaccumulation, phytovolatilization, rhizofiltration, Phyto stabilization)	**20%**	**6**
Unit 4: Biotechnology and agriculture: Theory: Bioinsecticides: Bacillus thuringiensis, Baculoviruses, uses, genetic modifications and aspects of safety in their use; Bio fungicides: Description of mode of actions and mechanisms (e.g. Trichoderma, Pseudomonas fluorescens); Biofertilizers: Symbiotic systems between plants – microorganisms (nitrogen fixing symbiosis, mycorrhiza fungi symbiosis), Plant growth promoting rhizobacteria (PGPR) – uses, practical aspects and problems in application	**20%**	**6**

Unit 5: Biofuels Theory: Environmental Biotechnology and biofuels: biogas; bioethanol; biodiesel; biohydrogen; Description of the industrial processes involved, microorganisms and biotechnological interventions for optimization of production; Microbiologically enhanced oil recovery (MEOR); Bioleaching of metals; Production of bioplastics; Production of biosurfactants: bioemulsifiers; Paper production: use of xylanases and white rot fungi.	**20%**	**6**

Instructional Method and Pedagogy:
Audio-Visual Lectures, Quizzes, Debates, Project works, Case studies, and Assignments Practical exercises are designed to understand the theory as taught in classroom. Hands on in practical session.

Course Outcomes:	Blooms' Taxonomy Domain	Blooms' Taxonomy Sub Domain
After successful completion of the above course, students will be able to:		Explain, Describe, Discuss, Recall, Locate
CO1 To This course aims to introduce fundamentals of Environmental Biotechnology	Remember	
CO2 The course will introduce major groups of microorganisms-tools in biotechnology and their most important environmental applications	Apply	Apply, Practice, Interpret, Select, Correlate
CO3 The environmental applications of biotechnology will be presented in detail and will be supported by examples from the national and international literature	Analyses and Evaluation	Compare, Classify, Select, Investigate
CO4 To acquire an awareness of and sensitivity to the total environment and its allied problems	Create	Construct, Develop, Produce
CO5 To understand how biotechnology can useful to solve environmental problems	Understand	Explain, Describe, outline, Predict, Summarize
Learning Resources		

1.	Textbook: 1. G.M. Evans and J.C. Furlong (2003), Environmental Biotechnology: Theory and Applications, Wiley Publishers. 2. B. Ritmann and P.L. McCarty, (2000), Environmental Biotechnology: Principle & Applications, 2nd Ed., McGraw Hill Science. 3. P. K. Mohapatra (2006) Textbook of Environmental Biotechnology, IK International 4. Indu Shekhar Thakur (2011) Environmental Biotechnology: Basic Concepts and Applications, I K International Publishing House 5. Hans-Joachim Jördening, Josef Winter (2005) Environmental Biotechnology: Concept and applications. Wiley VCH A. K. Chatterji (2010) Introduction to Environmental Biotechnology PHI Learning Limited New Delhi 6. T. Srinivas (2008) Environmental Biotechnology, New Age International 7. PK Gupta (2005)Elements of Biotechnology 8. Lawrence K. Wang, Volodymyr Ivanov, Joo-Hwa Tay, Yung-Tse Hung (2010) Environmental Biotechnology, Humana Press 9. S. K. Agarwal (2005) Advanced Environmental Biotechnology APH Publishing Corporation New Delhi

	2.	Reference Book 1. Scragg A., (2005) Environmental Biotechnology. Pearson Education Limited. 2. J. S. Devinny, M. A. Deshusses and T. S. Webster, (1998), Biofiltration for Air Pollution Control, CRC Press. 3. H. J. Rehm and G. Reed, (2001), Biotechnology – A Multi-volume Comprehensive Treatise, Vol. 11, 2nd Ed., VCH Publishers Inc. 4. H. S. Peavy, D. R. Rowe and G. Tchobanoglous, (2013), Environmental Engineering, McGraw-Hill Inc. Daniel A. Vallero (2010) Environmental Biotechnology: A Biosystems Approach. Elsevier Journal: 1. Annual Review of Environment and Resources 2. Biocontrol 3. Biocontrol Science and Technology 4. Biofuels 5. Biofuels, Bioproducts and Biorefining 6. Biological control 7. Bioremediation Journal 8. Bioresource Technology 9. Biotechnology Advances 10. Biotechnology Letters 11. Clean Air Journal 12. Critical reviews in biotechnology 13. Emerging Contaminants 14. Environment International 15. Environment: Science and Policy for Sustainable Development 16. Environmental Health 17. Environmental Pollutants and Bioavailability 18. Journal of Petroleum and Environmental biotechnology 19. Nature Biotechnology 20. Renewable & Sustainable Energy Reviews 21. Renewable Energy 22. Reviews in Environmental Science and Bio/Technology 23. Trends in Biotechnology 24. Water, air and soil pollution Periodicals: 1.The Environmental Magazine 2.Natural History (magazine) 3.Environment News Service 4.The Environmentalist 5. Green Builder Media Other Electronic resources: Environmental biotechnology latest research and news

<table>
<tr><th>Evaluation Scheme</th><th>Total Marks</th></tr>
<tr><td>Theory: Mid semester Marks</td><td>15 marks</td></tr>
<tr><td>Theory: End Semester Marks</td><td>25 marks</td></tr>
<tr><td>Theory: Continuous Evaluation Component Marks</td><td>
<table>
<tr><td>Attendance</td><td>2.5 marks</td></tr>
<tr><td>MCQs/Quiz</td><td>2.5 marks</td></tr>
<tr><td>Skill enhancement activities / case study</td><td>2.5 marks</td></tr>
<tr><td>Presentation/ miscellaneous activities</td><td>2.5 marks</td></tr>
<tr><td>Total</td><td>10 Marks</td></tr>
</table>
</td></tr>
<tr><td>Practical Marks</td><td>
<table>
<tr><td>Attendance</td><td>0 marks</td></tr>
<tr><td>Practical Exam</td><td>0 marks</td></tr>
<tr><td>Viva</td><td>0 marks</td></tr>
<tr><td>Journal</td><td>0 marks</td></tr>
<tr><td>Discipline</td><td>0 marks</td></tr>
<tr><td>Total</td><td>0 Marks</td></tr>
</table>
</td></tr>
</table>

Mapping of PSOs and COs

PO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO						
CO1	2	-	2	1	1	-
CO2	1	-	2	2	-	-
CO3	-	-	-	1	2	1
CO4	1	3	2	-	2	1
CO5	2	1	-	1	-	2

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

Mapping of POs and COs

PO	PO1	PO2	PO3	PO4	PO5	PO6
CO						
CO1	-	2	-	2	2	1
CO2	1	2	1	2	-	-
CO3	2	-	-	1	-	1
CO4	1	1	2	-	2	2
CO5	-	1	-	2	-	-

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

Teaching Scheme

Semester – III M. Sc Biotechnology

Sr. No.	Course Code	Course Name	Teaching Scheme (Hours/week)				Teaching Credit				Evaluation Scheme					
			L	P	T	Total	L	P	T	Total	Theory: MS Marks	Theory: CEC Marks	Theory: ES Marks	Theory Marks	Practical Marks	Total Marks
1	MSBO301	GENOMICS & PROTEOMICS	3	0	0	3	3	0	0	3	30	20	50	100		100
2	MSBO302	EMERGING TECHNOLOGIES	3	0	0	3	3	0	0	3	30	20	50	100		100
3	MSBO303	COMPUTATIONAL BIOLOGY	3	0	0	3	3	0	0	3	30	20	50	100		100
4	MSBO304	BIOENTREPRENEURSHIP	3	0	0	3	3	0	0	3	30	20	50	100		100
5	MSBO305	MOLECULAR DIAGNOSTICS	3	0	0	3	3	0	0	3	30	20	50	100		100
6	MSBO306	PROJECT PROPOSAL PREPARATION	2	0	0	2	2	2	0	2	0	0	0	50		50
7	MSBO307	SEMINAR	1	0	0	1	2	2	0	1	0	0	0	50	0	50
8	MSBO308	ELECT: DDD/Vaccine/nanotechnology	2	0	0	2	2	2	0	2	30	20	50	100		100
		Total	10	8		21	10	6	0	20						800

COURSE CODE MSBO301	COURSE NAME GENOMICS & ; PROTEOMICS	SEMESTER III

Teaching Scheme (Hours)				Teaching Credit			
Lecture	Practical	Tutorial	Total Hours	Lecture	Practical	Tutorial	Total Credit
4	4	0	8	4	2	0	6

Course Pre-requisites	B.Sc in life sciences
Course Category	Core course
Course focus	To understands genes and proteins
Rationale	To understands genes and proteins
Course Revision/ Approval Date:	14/03/2020
Course Objectives (As per Blooms' Taxonomy)	**1.** To provide introductory knowledge concerning genomics **2.** To introduce various cytogenetic techniques **3.** To provide introductory knowledge in proteomics **4.** To introduce functional genomics **5.** To know Applications of genomics and proteomics .

Course Content (Theory)	Weightage	Contact hours
Unit 1: Brief overview of prokaryotic and eukaryotic genome organization; extra-chromosomal DNA: bacterial plasmids, mitochondria and chloroplast. Genetic and physical maps; markers for genetic mapping; methods and techniques used for gene mapping, physical mapping, linkage analysis	**20%**	**09**
Unit 2: Theory: Cytogenetic techniques, FISH technique in gene mapping, somatic cell hybridization, radiation hybrid maps, in situ hybridization, comparative gene mapping. Human Genome Project, genome sequencing projects for microbes, plants and animals, accessing and retrieving genome project information from the web.	**20%**	**09**
Unit 3: Theory: Identification and classification of organisms using molecular markers-16S rRNA typing/sequencing, SNPs; use of genomes to understand evolution of eukaryotes, track emerging diseases and design new drugs; determining gene location in genome sequence	**20%**	**09**

Unit 4: Theory: Aims, strategies and challenges in proteomics; proteomics technologies: 2D-PAGE, isoelectric focusing, mass spectrometry, MALDI-TOF, yeast 2-hybrid system, proteome databases. Transcriptome analysis for identification and functional annotation of gene	**20%**	**09**
Unit 5: Theory:Contig assembly, chromosome walking and characterization of chromosomes, mining functional genes in genome, gene function- forward and reverse genetics, gene ethics; protein-protein and protein-DNA interactions; protein chips and functional proteomics; clinical and biomedical applications of proteomics; introduction to metabolomics, lipidomics, metagenomics and systems biology.	**20%**	**09**

Instructional Method and Pedagogy:
Audio-Visual Lectures, Quizzes, Debates, Project works, Case studies, and Assignments Practical exercises are designed to understand the theory as taught in classroom. Hands on in practical session.

Course Outcomes:	Blooms' Taxonomy Domain	Blooms' Taxonomy Sub Domain
After successful completion of the above course, students will be able to:		
CO1 Fundamentals of genomics and proteomics	Apply	Explain, Describe, Discuss, Recall, Locate
CO2 How genomes are mapped and introduction to various genome sequencing projects	Analyses and Evaluation	Apply, Practice, Interpret, Select, Correlate
CO3 Using various molecular markers for identification and Comparison of genomes	Analyses and Evaluation	Compare, Classify, Select, Investigate
CO4 Transcriptomics and metabolomics	Analyses and Evaluation	Construct, Develop, Produce
CO5 The applications of Genomics and Proteomics	Understand	Explain, Describe, outline, Predict, Summarize

Learning Resources	
1	Textbook 1. Ruthvik Chadwick (2015) Genomics and Society Ethical, Legal, Cultural and Socioeconomic Implications 2. Nawin C. Mishra, Günter Blobel (2011) Introduction to Proteomics Principles and Applications 3. Richard Twyman (2004) Principles of Proteomics 4. N Saraswathy, P Ramalingam (2011) Concepts and Techniques in Genomics and Proteomics
2	Reference books: 1. Primrose, S. B., Twyman, R. M., Primrose, S. B., & Primrose, S. B. (2006). Principles of Gene Manipulation and Genomics. Malden, MA: Blackwell Pub. 2. Liebler, D. C. (2002). Introduction to Proteomics: Tools for the New Biology. Totowa, NJ: Humana Press. 3. Campbell, A. M., & Heyer, L. J. (2003). Discovering Genomics, Proteomics, and Bioinformatics. San Francisco: Benjamin Cummings.
3	Journal: 1. Current Science, 2. Indian Journal of Biotechnology and other international biotechnology journals 3. BMC Genomics 4. Proteomics 5. Journal of proteomics
5	Periodicals: 1. Science Daily 2. Everyman's Science
6	Other Electronic resources: 1) MH Education 2) NPTEL 3) SWAYAM

Evaluation Scheme	Total Marks
Theory: Mid semester Marks	20 marks

Theory: End Semester Marks	40 marks
Theory: Continuous Evaluation Component Marks	

Attendance	05 marks
MCQs	10 marks
Open Book Assignment	15 marks
Article Review	10 marks
Total	**40 Marks**

Practical Marks

Attendance	05 marks
Practical Exam	20 marks
Viva	10 marks
Journal	10 marks
Discipline	05 marks
Total	**50 Marks**

Mapping of PSOs and COs

PO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO						
CO1	0	0	2	0	0	0
CO2	1	2	0	0	2	0
CO3	1	0	2	2	0	1
CO4	0	1	2	0	0	2
CO5	0	0	0	1	2	0

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

Mapping of POs and COs

PO	PO1	PO2	PO3	PO4	PO5	PO6
CO						
CO1	3	1	0	1	3	0
CO2	3	1	2	1	2	0
CO3	2	0	2	0	0	0
CO4	1	0	1	2	1	1
CO5	1	1	0	0	0	0

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

COURSE CODE MSBO302			COURSE NAME EMERGING TECHNOLOGIES			SEMESTER III	
Teaching Scheme (Hours)				Teaching Credit			
Lecture	Practical	Tutorial	Total Hours	Lecture	Practical	Tutorial	Total Credit
3	0	0	45	3	0	0	3

Course Prerequisites	Students should have basic knowledge about Microbiology
Course Category	Core Professional.
Course focus	Scientific Temperament & Employability
Rationale	Broad-based in nature encompassing several new technologies that current experimental researchers are employing to probe complex system biology questions in life-sciences.
Course Revision/ Approval Date:	14/03/2020
Course Objectives **(As per Blooms' Taxonomy)**	1. **Remember** Concepts of new technologies 2. **Apply** understanding Experimental approches 3. **Analyses** appreciate current-day research tool-kit. 4. **Create** an understanding how interactions network develops 5. **Understand** applications both scientific and industrial

Course Content (Theory)	Weightage	Contact hours
Unit 1: Microscopy Theory: **Optical microscopy methods** Basic Microscopy: Light Microscopy: lenses and microscopes, resolution: Rayleigh's Approach,Darkfield;PhaseContrast;DifferentialInterferenceContrast;fluorescence and fluorescence microscopy: what is fluorescence, what makes a molecule fluorescent, fluorescence microscope; optical arrangement, light source; filter sets: excitation filter, dichroic mirror, and barrier, optical layout for image capture; CCD cameras; back illumination, binning; recording colour; three CCD elements with dichroic beams platters, boosting the signal. **Advanced Microscopy:** Confocal microscope: scanning optical microscope, confocal principle, resolution and point spread function, light source: gas lasers &solid-state, primary beam splitter; beam scanning, pinhole and signal channel configurations, detectors; pixels and voxels; contrast, spatial sampling: temporal sampling: signal-to noise ratio, multichannel images. nonlinear microscopy: multiphoton microscopy; principles of two-photon fluorescence, advantages two-photon excitation, tandem scanning (spinning disk) microscopes, deconvolving confocal images; image processing, three-dimensional reconstruction; advanced fluorescence techniques: FLIM, FRET, and FCS, Fluorescence Lifetime, Fluorescence Resonant Energy Transfer (FRET), Fluorescence Correlation Spectroscopy (FCS), Evanescent Wave Microscopy; Near-Field and Evanescent Waves, Total Internal Reflection Microscopy; Near-Field Microscopy; BeyondtheDiffractionLimit:StimulatedEmissionDepletion(STED),Super-Resolution Summary, Super-Resolution Imaging with Stochastic Optical Reconstruction Microscopy (STORM) and Photoactivated Localization Microscopy (PALM)	**20%**	**9**
Unit 2: Mass spectroscopy Theory: **Mass spectroscopy** Ionization techniques; mass analysers/overview MS; FT-ICR and Orbitrap, fragmentation of peptides; proteomics, nano LC-MS; Phosphor proteomics; interaction proteomics, mass spectroscopy in structural biology; imaging mass spectrometry.	**20%**	**9**

Unit 3: System & Structural Biology Theory: **Systems biology** High throughput screens in cellular systems, target identification, validation of experimental methods to generate the omics data, bioinformatics analyses, mathematical modelling and designing testable predictions. **Structural biology** X-ray diffraction methods, solution &solid-state NMR, cryo-electron microscopy, small angle X-ray scattering, atomic force microscopy.	**20%**	**9**
Unit 4: CRISPR technology Theory: **CRISPR-CAS** History of its discovery, elucidation of the mechanism including introduction to all the molecular players, development of applications for in vivo genome engineering for genetic studies, promise of the technology as a next generation therapeutic method.	**20%**	**9**
Unit 5: NANOBODIES Theory: **NANOBODIES** Introduction to nanobodies, combining nanobody with phage-display method for development of antibody against native proteins, nanobody as a tool for protein structure-function studies, use of nanobodies for molecular imaging, catabolic antibodies using nanobodies.	**20%**	**9**

Instructional Method and Pedagogy:

Audio-Visual Lectures, Quizzes, Debates, Project works, Case studies, and Assignments Practical exercises are designed to understand the theory as taught in the classroom. Hands on in practical session.

Course Outcomes:	Blooms' Taxonomy Domain	Blooms' Taxonomy Sub Domain
After successful completion of the above course, students will be able to:		Explain, Describe, Discuss, Recall, Locate
CO1 This course is broad-based in nature encompassing several new technologies that current experimental researchers are employing to probe complex system biology questions in life-sciences.	Remember	
CO2 The objectives of this course are to teach basics of the new principles to students so as to appreciate current-day research tool-kit better.	Apply	Apply, Practice, Interpret, Select, Correlate
CO3 Understanding the need for Technologies	Analyses and	Compare,

	Evaluation	Classify, Select, Investigate
CO4 Understanding the advanced technologies.	Create	Construct, Develop, Produce
CO5 Applications of Emerging Technologies	Understand	Explain, Describe, outline, Predict, Summarise
Learning Resources		

1.	**Textbook & Reference Books** 1. Campbell, I.D. (2012). Biophysical Techniques. Oxford: Oxford University Press. 2. Serdyuk, I. N., Zaccai, N. R., & Zaccai, G. (2007). Methods in Molecular Biophysics: Structure, Dynamics, Function. Cambridge: Cambridge University Press. 3. Phillips, R., Kondev, J., & Theriot, J.(2009). Physical Biology of the Cell. New York: Garland Science. 4. Nelson, P.C., Radosavljević, M.,&Bromberg, S.(2004). Biological Physics: Energy, Information, Life. New York: W.H.Freeman. 5. Huang, B., Bates, M., & Zhuang, X. (2009). Super-Resolution Fluorescence Microscopy. Annual Review of Biochemistry, 78(1),993-1016.doi:10.1146/annurev. biochem.77.061906.092014. 6. Mohanraju, P.,Makarova, K. S., Zetsche, B., Zhang, F.,Koonin, E. V.,& Oost, J. V. (2016).Diverse Evolutionary Roots and Mechanistic Variations of the CRISPR-Cas Systems. Science, 353(6299). doi:10.1126/science.aad5147. 7. Lander, E.(2016).The Heroes of CRISPR. Cell, 164(1-2), 18-28.doi:10.1016/j. cell.2015.12.041. 8.Ledford, H.(2016).TheUnsungHeroesofCRISPR.Nature,535(7612),342-344. doi:10.1038/535342a. 9. Jinek,M., Chylinski, K., Fonfara,I., Hauer,M.,Doudna,J.A., &Charpentier,E. (2012). A Programmable Dual-RNA-Guided DNA Endonuclease in Adaptive Bacterial Immunity. Science, 337(6096), 816-821.doi:10.1126/science.1225829. 10.Hamers-Casterman,C.,Atarhouch,T.,Muyldermans,S.,Robinson,G.,Hammers, C., Songa, E. B., Hammers, R. (1993). Naturally Occurring Antibodies Devoid of Light Chains. Nature, 363(6428), 446-448.doi:10.1038/363446a0. 11. Sidhu, S. S., & Koide, S. (2007). Phage Display for Engineering and Analysing Protein Interaction Interfaces. Current Opinion in Structural Biology, 17(4), 481-487. doi:10.1016/j.sbi.2007.08.007. 12. Steyaert, J., & Kobilka, B. K.(2011). Nanobody Stabilization of G Protein-Coupled Receptor Conformational States. Current Opinionin Structural Biology, 21(4), 567-572. doi:10.1016/j.sbi.2011.06.011. 13. Vincke, C., & Muyldermans, S. (2012). Introduction to Heavy Chain Antibodies and Derived Nanobodies. Single Domain Antibodies, 15-26. doi:10.1007/978-1-61779- 968-6_2. 14. Verheesen, P.,& Laeremans, T.(2012). Selection by Phage Display of Single Domain Antibodies Specific to Antigens in their Native Conformation. Single Domain Antibodies, 81-104.doi:10.1007/978-1-61779-968-6_6. 15. Li,J.,Xia,L.,Su,Y.,Liu,H.,Xia,X.,Lu,Q.Reheman,K.(2012).Molecular Imprint of Enzyme Active Site by Camel Nanobodies. Journal of Biological Chemistry J. Biol. Chem., 287(17), 13713-13721.doi:10.1074/jbc.m111.336370. 16.Sohier,J.,Laurent,C.,Chevigné,A.,Pardon,E.,Srinivasan,V.,Wernery,U.Galleni, M. (2013). Allosteric Inhibition of VIM Metallo-β-Lactamases by a Camelid Nanobody. Biochemical Journal, 450(3), 477-486. doi:10.1042/bj20121305. 17. Chakravarty, R., Goel, S., & Cai, W.(2014). Nanobody: The "Magic Bullet" for Molecular Imaging?Theranostics,4(4),386-398.doi:10.7150/thno.8006.
2.	Journals & Periodicals 1. JBC, 2. Science, 3. Plos biology 4. Periodicals: current science

3	Other Electronic resources: 1) MH Education 2) NPTEL

Evaluation Scheme	Total Marks
Theory: Mid semester Marks	30 marks
Theory: End Semester Marks	50 marks
Theory: Continuous Evaluation Component Marks	

Attendance	05 marks
MCQs	05 marks
Skill enhancement activities / case study	05 marks
Presentation/ miscellaneous activities	05 marks
Total	**20 Marks**

Practical Marks

Attendance	05 marks
Practical Exam	30 marks
Viva	10 marks
Journal	5 marks
Total	**50 Marks**

Mapping of PSOs and COs

PO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO						
CO1	1	-	2	1	1	-
CO2	1	3	2	2	-	-
CO3	1	-	-	1	2	1
CO4	2	3	2	-	2	2
CO5	2	1	-	1	-	2

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

Mapping of PO and COs

PO	PO1	PO2	PO3	PO4	PO5	PO6
CO						
CO1	3	2	-	2	2	1
CO2	-	1	1	2	-	-
CO3	2	-	-	1	2	1
CO4	2	1	2	3	2	2
CO5	-	1	-	2	-	3

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

COURSE CODE MSBO303	COURSE NAME COMPUTATIONAL BIOLOGY	SEMESTER III

Teaching Scheme (Hours)				Teaching Credit			
Lecture	Practical	Tutorial	Total Hours	Lecture	Practical	Tutorial	Total Credit
4	4	0	8	4	2	0	6

Course Pre-requisites	Students should contain basic knowledge about computer system, software etc.
Course Category	Core
Course focus	Computational biology
Rationale	To understand use of computational biology
Course Revision/ Approval Date:	20/03/2020
Course Objectives (As per Blooms' Taxonomy)	1 The objective of this course is to provide students with theory essentials to aid computer technology. 3 The objective of this course is to provide students with theory essentials to aid for metabolomics courses. 4 The objective of this course is to provide students with theory essentials to aid for drug design program. 5 This course will pave a way for technological insite.

Course Content (Theory)	Weightage	Contact hours
Unit 1 and 2: Introduction to computational biology basics and biological databases and pairwise and multiple sequence alignments. Computers in biology and medicine; Overview of biological databases, nucleic acid & protein databases, primary, secondary, functional, composite, structural classification database, Sequence formats & storage, Access databases, Extract and create sub databases, limitations of existing databases. Local alignment, Global alignment, Scoring matrices-PAM, BLOSUM, Gapsand penalties, Dotplots. Dynamic programming approach: Needleman and Wunsch Algorithm, Smith and Waterman Algorithm, Hidden Markov Model: Viterbi Algorithm. Heuristic approach: BLAST, FASTA.Building Profiles, Profile based functional identification.	**40%**	**20**
Unit 3 : Genome analysis Organization And Structure Of Genome:Eukaryotic Genome (Nucleosomes, Histones, Chromatids, Centomeres, Telomeres), C Value Paradox. Repetitvie Content Of Eukaryotic Genomes, Chromatin Modification And Genome Expression. Histone Modification (Acetylation, Deacetylation, Phosphorylation). Nucleosome Re-modeling. Genome Silencing B Y DNA Methylation. Imprinting, Prokaryote Genomes (Organiza-tion Of Genes, Operons). Polymorphisms in DNA sequence, Introduction to Next Generation Sequencing technologies, Whole Genome Assembly and challenges, Sequencing and analysis of large genomes, Gene prediction, Functional annotation, Comparative genomics, Probabilistic functional gene networks, Human genome project, Genomics and crop improvement.Study available GWAS, ENCODE, HUGO projects, extract and build sub databases; Visualization tools including Artemis and Vista for genome comparison; Functional genomics case studies.	**15%**	**5**
Unit 4: Structure visualization Retrieving and drawing structures, Macromolecule viewing platforms, Structure validation and correction, Structure optimization, Analysis of ligand-protein interactions; Tools such as PyMol or VMD.	**15%**	**10**

Unit 5 and 6: Molecular modeling and Structure-based drug development Significance and need, force field methods, energy, buried and exposed residues; sidechains and neighbours; fixed regions; hydrogen bonds; mapping properties onto surfaces; RMS fit of conformers and protein chains, assigning secondary structures; sequence alignment: methods, evaluation, scoring; protein curation: backbone construction and side chain addition; different types of protein chain modelling: ab initio, homology, hybrid, loop; Template recognition and alignments; Modelling parameters and considerations; Model analysis and validation; Model optimization; Substructure manipulations, annealing, protein folding and model generation; loop generating methods; loop analysis; Analysis of active sites using different methods in studying protein–protein interactions.Molecular docking: Types and principles, Semi-flexible docking, Flexible docking; Ligand and protein preparation, Macromolecule and ligand optimization, Ligand conformations, Clustering, Analysis of docking results and validation with known information. Extra precision docking platforms, Use of Small-molecule libraries, Natural compound libraries for virtual high through put screenings.	**15%**	**08**
Unit 7: Ligand-based drug development Quantitative structure activity relationships; Introduction to chemical descriptors like 2D, 3D and Group-based; Radar plots and contribution plots and Activity predictions, Pharmacophore modeling, Pharmacophore-based screenings of compound library, analysis and experimental validation.	**15%**	**02**

Instructional Method and Pedagogy:
Audio-Visual Lectures, Quizzes, Debates, Project works, Case studies, and Assignments Practical exercises are designed to understand the theory as taught in classroom. Hands on in practical session.

Course Outcomes:	Blooms' Taxonomy Domain	Blooms' Taxonomy Sub Domain
After successful completion of the above course, students will be able to: **CO1** Develop an understanding of the basic theory of these computational tools; **CO2** Develop required database extraction, integration, coding for computational tools and methods necessary for all Omics; **CO3** Create hypothesis for investigating specific contemporary biological questions	Understand, Remember& apply Understand, Remember& apply Apply	Explain, Describe, Discuss, Recall, Locate Apply, Practice, Interpret, Select, Correlate Compare, Classify, Select,

CO4 Critically analyze and interpret results of their study with respect to whole systems.	Apply	Investigate Construct, Develop, Produce
CO5 Provide help to experiment with or develop appropriate tools;	Understand, Remember& apply	Explain, Describe, outline, Predict, Summarize

Learning Resources	
1	Textbook: 1. Mount, D. W. (2001). *Bioinformatics: Sequence and Genome Analysis*. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press. 2. Bourne, P.E., & Gu, J. (2009). *Structural Bioinformatics*. Hoboken, NJ: Wiley-Liss. 3. Lesk, A. M. (2004). *Introduction to Protein Science: Architecture, Function, and Genomics*. Oxford: Oxford University Press.
2	Reference books : 1. Campbell, M & Heyer, L. J. (2006), *Discovering Genomics, Proteomics and Bioinformatics*, Pearson Education. 2. Oprea, T. (2005). C*hemo informatics in Drug Discovery,* Volume 23. Wiley Online Library. 3. Gasteiger, J.& Engel, T. (2003), *Chemo informatics: a Textbook*, Wiley Online Library.
3	Journal: Bioinformatics and Biology Insights
5	Periodicals: BMC Bioinformatics
6	OtherElectronicresources: https://iop.vast.ac.vn/theor/conferences/smp/1st/kaminuma/SWISSPROT/index.html

Evaluation Scheme	**Total Marks**
Theory: Mid semester Marks	20 marks
Theory: End Semester Marks	40 marks

Theory: Continuous Evaluation Component Marks	

Attendance	05 marks
MCQs	10 marks
Open Book Assignment	15 marks
Article Review	10 marks
Total	**40 Marks**

Practical Marks	

Attendance	05 marks
Practical Exam	20 marks
Viva	10 marks
Journal	10 marks
Discipline	05 marks
Total	**50 Marks**

Mapping of PSOs and COs

PO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO						
CO1	2	-	-	-	2	-
CO2	2	-	3	-	-	-
CO3	1	-	1	-	-	3
CO4	-	1	-	1	-	3
CO5						

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

Mapping of PO and COs

PO	PO1	PO2	PO3	PO4	PO5	PO6
CO						
CO1	3	-	-	-	2	-
CO2	1	1	2	-	-	-
CO3	-	3	2	-	-	-
CO4	-	-	-	1	-	-
CO5						

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

COURSE CODE MSBO304	COURSE NAME BIOENTREPRENEURSHIP	SEMESTER III

Teaching Scheme (Hours)				Teaching Credit			
Lecture	Practical	Tutorial	Total Hours	Lecture	Practical	Tutorial	Total Credit
4	4	0	8	4	2	0	6

Course Pre-requisites	Students should contain basic knowledge about entrepreneurship.
Course Category	Core
Course focus	Employability
Rationale	Bioentrepreneurship is at the intersection of science and business. This course aims to bridge the gap between scientific knowledge and commercial applications, equipping students with the skills to translate innovative research and discoveries into successful biotech ventures.
Course Revision/ Approval Date:	14th March 2019
Course Objectives **(As per Blooms' Taxonomy)**	**1** To get knowledge about concepts of entrepreneurship **2** To gain knowledge on identifying a winning business opportunity **3** To apply their knowledge on gathering funds and launching a busi **4** To grow and nurture the organization and harvest the rewards. **5** To gain knowledge on for technology management and transfer

Course Content (Theory)	Weightage	Contact hours
Unit 1: **Theory: Innovation and entrepreneurship in bio-business** Introduction and scope in Bio-entrepreneurship, Types of bio-industries and competitive dynamics between the sub-industries of the bio-sector (e.g. pharmaceuticals vs. Industrial biotech), Strategy and operations of bio-sector firms: Factors shaping opportunities for innovation and entrepreneurship in bio-sectors, and the business implications of those opportunities, Alternatives faced by emerging bio-firms and the relevant tools for strategic decision	**20%**	**06**
Unit 2: **Theory: Bio markets - business strategy and marketing** Negotiating road from lab to the market (strategies and processes of negotiation with financiers, government and regulatory authorities), Pricing strategy, Challenges in marketing in bio business (market conditions & segments; developing distribution channels, the nature, analysis and management of customer needs), Basic contract principles, different types of agreement and contract terms typically found in joint venture and development agreements, Dispute resolution skills.	**20%**	**06**
Unit 3: **Theory: Finance and accounting:** Business plan preparation including statutory and legal requirements, Business feasibility study,financial management issues of procurement capital and management costs, Collaborations & partnership, Information technology.	**20%**	**06**
Unit 4: **Theory: Technology management:** Technology – assessment, development & upgradation, Managing technology transfer, Quality control & transfer of foreign technologies, Knowledge centers and Technology transfer agencies	**20%**	**06**
Unit 5: **Theory: Entrepreneurship Development programs**: Entrepreneurship development programs of public and private agencies (MSME, DBT,BIRAC, Make In India), strategic dimensions of patenting & commercialization strategies. Understanding of regulatory compliances and procedures (CDSCO, NBA, GCP, GLA, GMP)	**20%**	**06**

Instructional Method and Pedagogy:

Audio-Visual Lectures, Quizzes, Debates, Project works, Case studies, and Assignments Practical exercises are designed to understand the theory as taught in classroom. Hands on in practical session.

Course Outcomes:	Blooms' Taxonomy Domain	Blooms' Taxonomy Sub Domain
After successful completion of the above course, students will be able to:		
CO1 Gain entrepreneurial skills, understand the various operations involved in venture creation	Understand, Remember& apply	Explain, Describe, Discuss, Recall, Locate
CO2 Identify scope for entrepreneurship in biosciences	Apply	Apply, Practice, Interpret, Select, Correlate
CO3 Utilize the schemes promoted through knowledge centres and various agencies	Evaoluate	Compare, Classify, Select, Investigate
CO4 Build up a strong network within the industry.	Apply	Construct, Develop, Produce
CO5 Develop and refine strategy in today's fast-changing, dynamic markets	Understand, Remember& apply	Explain, Describe, outline, Predict, Summarize

Learning Resources	
1	Textbook: 1. Adams, D.J.,& Sparrow,J.C. (2008). Enterprise for Life Scientists: Developing Innovation and Entrepreneurship in the Biosciences.Bloxham: Scion.
2	Reference books : 2. Shimasaki, C. D.(2014). Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies.Amsterdam:Elsevier.AcademicPress is an imprint of Elsevier. 30 3. Onetti, A., & Zucchella, A. Business Modeling for Life Science and Biotech Companies: Creating Value and Competitive Advantage with the Milestone Bridge. Routledge. 4. Jordan, J. F.(2014). Innovation, Commercialization, and Start-Ups in Life Sciences. London: CRC Press. 5. Desai, V.(2009).The Dynamics of Entrepreneurial Development and Management. New Delhi: Himalaya Pub.House
3	Journal : Bioentrepreneur-Nature, Journal of Bioentrepreneurship
5	Periodicals: Harward Buisness Review, Entrepreneur
6	Other Electronic resources: 1. https://online.stanford.edu/courses/xmse100-introduction-innovation-and-entrepreneurship 2. https://ocw.mit.edu/courses/entrepreneurship/

Evaluation Scheme	Total Marks
Theory: Mid semester Marks	20 marks
Theory: End Semester Marks	40 marks
Theory: Continuous Evaluation Component Marks	

Attendance	05 marks
MCQs	10 marks
Open Book Assignment	15 marks
Article Review	10 marks
Total	**40 Marks**

Practical Marks

Attendance	05 marks
Practical Exam	20 marks
Viva	10 marks
Journal	10 marks
Discipline	05 marks
Total	**50 Marks**

Mapping of PSOs and COs

PO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO						
CO1	1	-	-	-	2	-
CO2	-	-	-	-	-	-
CO3	-	-	-	-	-	1
CO4	-	3	-	-	-	2
CO5	-	-	1	-	1	2

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

Mapping of PO and COs

PO	PO1	PO2	PO3	PO4	PO5	PO6
CO						
CO1	3	1	-	1	2	-
CO2	1	-	-	-	2	-
CO3	-	-	-	-	-	-
CO4	-		-	2	-	-
CO5	-	1	-	1	-	1

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

COURSE CODE MSBO305	COURSE NAME MOLECULAR DIAGNOSTICS	SEMESTER III

Teaching Scheme (Hours)				Teaching Credit			
Lecture	Practical	Tutorial	Total Hours	Lecture	Practical	Tutorial	Total Credit
4	4	0	8	4	2	0	6

Course Pre-requisites	Bachelor Degree in Life sciences
Course Category	**Professional Core Professional**
Course focus	
Rationale	
Course Revision/ Approval Date:	14/03/2020
Course Objectives (As per Blooms' Taxonomy)	1. The objectives of this course are to sensitize students about recent advances in diagnostics and various facets of molecular medicine which has potential to profoundly alter many aspects of modern medicine including preor post-natal analysis of genetic diseases and identification of individuals predisposed to disease ranging from common cold to cancer 2. Adequate knowledge about recent advances and technological developments in the field of diagnostics 3. Selection of an appropriate diagnostic method/tool for a particular disease condition and sample type. 4. Expertise to perform any diagnostic test with an ability to troubleshoot. 5. The objectives of this course are to sensitize students about recent advances in molecular biology.

Course Content (Theory)	Weightage	Contact hours
Unit 1: Genome biology in health, disease, resolution, detection & analysis Theory: DNA, RNA, Protein: An overview; chromosomal structure & mutations; DNA polymorphism: human identity; clinical variability and genetically determined adverse reactions to drugs. PCR: Real-time; ARMS; Multiplex; ISH; FISH; ISA; RFLP; DHPLC; DGGE; CSCE; SSCP; Nucleic acid sequencing: new generations of automated sequencers; Microarray chips; EST; SAGE; microarray data normalization & analysis; molecular markers: 16S rRNA typing; Diagnostic proteomics: SELDI-TOFMS; Bioinformatics data acquisition & analysis.	**20%**	**10**
Unit 2: Diagnostic metabolomics Theory: Metabolite profile for biomarker detection of the body fluids/tissues in various metabolic disorders by making using LCMS & NMR technological platforms.	**20%**	**10**
Unit 3: Detection and identity of microbial diseases and inherited diseases Theory: Direct detection and identification of pathogenicorganisms that are slow growing or currently lacking a system of in vitro cultivation as well as genotypic markers of microbial resistance to specific antibiotics. Exemplified by two inherited diseases for which molecular diagnosis has provided a dramatic improvement of quality of medical care: Fragile X Syndrome: Paradigm of new mutational mechanism of unstable triplet repeats, von-Hippel Lindau disease: recent acquisition in growing number of familial cancer syndromes.	**20%**	**10**
Unit 4: Molecular oncology Theory: Detection of recognized genetic aberrations in clinical samples from cancer patients; types of cancer-causing alterations revealed by next-generation sequencing of clinical isolates; predictive biomarkers for personalized onco-therapy of human diseases such as chronic myeloid leukemia, colon, breast, lung cancer and melanoma as well as matching targeted therapies with patients and preventing toxicity of standard systemic therapies.	**20%**	**10**
Unit 5: Quality assurance and control Theory: Quality oversight; regulations and approved testing.	**20%**	**05**

Instructional Method and Pedagogy: Audio-Visual Lectures, Quizzes, Debates, Project works, Case studies, and Assignments Practical exercises are designed to understand the theory as taught in classroom. Hands on in practical session.

Course Outcomes:	Blooms' Taxonomy	Blooms' Taxonomy Sub

	Domain	Domain
After successful completion of the above course, students will be able to:		Explain, Describe,
CO1 Able to understand various facets of molecular procedures and basics of genomics, proteomics and metabolomics that could be employed in early diagnosis and prognosis of human diseases	Understand, Remember& apply	Discuss, Recall, Locate
CO2 Acquire knowledge of various diagnostic tools used in healthcare, industry and research	Apply	Apply, Practice, Interpret, Select, Correlate
CO3 Identify the role and importance of molecular diagnostics such as real-time PCR, epidemiological genotyping, microfluidics, bio-imaging and sequencing technologies	Evaoluate	Compare, Classify, Select, Investigate
CO4 Students will be able to Incorporate both in silico and lab based techniques as part of a combined molecular diagnostics strategy.	Apply	Construct, Develop, Produce
CO5 Perform selected laboratory techniques, interpret results and prepare reports	Understand, Remember& apply	Explain, Describe, outline, Predict, Summarize

Learning Resources	
1	Textbook 1. Campbell, A. M., & Heyer, L. J. (2006). Discovering Genomics, Proteomics, and Bioinformatics. San Francisco: Benjamin Cummings. 2. Brooker, R. J. (2009). Genetics: Analysis & Principles. New York, NY: McGraw-Hill. 3. Glick, B. R., Pasternak, J. J., & Patten, C. L. (2010). Molecular Biotechnology: Principles and Applications of Recombinant DNA. Washington, DC: ASM Press. 4. Coleman, W. B., & Tsongalis, G. J. (2010). Molecular Diagnostics: for the Clinical Laboratorian. Totowa, NJ: Humana Press.
2	Reference book : Molecular Diagnostics, 3rd Edition Editors: George P. Patrinos Wilhelm Ansorge Phillip B. Danielson. Hardcover ISBN: 9780128029718. eBook ISBN: 9780128029886
3	Journal : Journal of Molecular Diagnostics, Nature reviews
5	Periodicals: Current science
6	Other Electronic resources: NPTL and UGC pathsala lectures

Evaluation Scheme	**Total Marks**
Theory: Mid semester Marks	20 marks

Theory: End Semester Marks	40 marks
Theory: Continuous Evaluation Component Marks	

Attendance	05 marks
MCQs	10 marks
Open Book Assignment	15 marks
Article Review	10 marks
Total	**40 Marks**

Practical Marks

Attendance	05 marks
Practical Exam	20 marks
Viva	10 marks
Journal	10 marks
Discipline	05 marks
Total	**50 Marks**

Mapping of PSOs and COs

PO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO						
CO1	3	3	1	2	0	3
CO2	2	2	3	2	1	2
CO3	3	2	3	2	2	2
CO4	2	3	2	2	1	1
CO5	3	2	2	1	2	0

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

Mapping of POs and COs

PO	PO1	PO2	PO3	PO4	PO5	PO6
CO						
CO1	3	2	0	0	2	0
CO2	3	2	3	1	2	2
CO3	2	3	3	1	2	2
CO4	1	3	2	1	3	3
CO5	2	2	3	2	3	0

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

COURSE CODE MSBO306	COURSE NAME PROJECT PROPOSAL PREPARATION	SEMESTER III

Teaching Scheme (Hours)				Teaching Credit			
Lecture	Practical	Tutorial	Total Hours	Lecture	Practical	Tutorial	Total Credit
4	4	0	8	4	2	0	6

Course Pre-requisites	Bachelor Degree in Life sciences
Course Category	**Professional Core Professional**
Course focus	
Rationale	
Course Revision/ Approval Date:	14/03/2020
Course Objectives (As per Blooms' Taxonomy)	1 To help students organize ideas, material and objectives for their d 2 The purpose of this course is to prepare the students to present thei importance to their fellow classmates and teachers. 3 To understand how the papers are refereed 4 To know how papers published 5 To learn skills required for power point and poster presentations.

Course Content (Theory)	Weightage	Contact hours
Unit 1: Selection of research lab and research topic: Students should first select a lab wherein they would like to pursue their dissertation. The supervisor or senior researchers should be able to help the students to read papers in the areas of interest of the lab and help them select a topic for their project. The topic of the research should be hypothesis driven.	**20%**	**06**
Unit 2: Review of literature: Students should engage in systematic and critical review of appropriate and relevant information sources and appropriately apply qualitative and/or quantitative evaluation processes to original data; keeping in mind ethical standards of conduct in the collection and evaluation of data and other resources.	**20%**	**06**
Unit 3: Writing Research Proposal: With the help of the senior researchers, students should be able to discuss the research questions, goals, approach, methodology, data collection, etc. Students should be able to construct a logical outline for the project including analysis steps and expected outcomes and prepare a complete proposal in scientific proposal format for dissertation	**20%**	**06**

Unit 4: Poster Presentation: Students will have to present the topic of their project proposal after few months of their selection of the topic. They should be able to explain the novelty and importance of their research topic	**20%**	**06**
Unit 5: Oral Presentation: At the end of their project, a presentation will have to be given by the students to explain work done by them in detail. Along with summarizing their findings they should also be able to discuss the future expected outcome of their work.	**20%**	**06**

Instructional Method and Pedagogy: Audio-Visual Lectures, Quizzes, Debates, Project works, Case studies, and Assignments Practical exercises are designed to understand the theory as taught in classroom. Hands on in practical session.

Course Outcomes:	Blooms' Taxonomy Domain	Blooms' Taxonomy Sub Domain
After successful completion of the above course, students will be able to:	Understand, Remember& apply	Explain, Describe, Discuss, Recall, Locate
CO1 Formulate a scientific question		
CO2 Present scientific approach to solve the problem	Apply	Apply, Practice, Interpret, Select, Correlate
CO3 Interpret, discuss and communicate scientific results in written form	Evaoluate	Compare, Classify, Select, Investigate
CO4 Gain experience in writing a scientific proposaldiagnostics strategy.	Apply	Construct, Develop, Produce
CO5 Learn how to present and explain their research findings to the audience effectively	Understand, Remember& apply	Explain, Describe, outline, Predict, Summarize

Learning Resources

1	Textbook 1. Nicholas Rowe (2017) Academic & Scientific Poster Presentation : A Modern Comprehensive Guide 2. Kelly Coleman,Kathleen Petelinsek (2014) Choose It! Finding the Right Research Topic 3. Ralph Berry (2000) The Research Project: How to write it 4. Alexei Kapterev (2011) Presentation secrets, Do What You Never Thought Possible with Your Presentations, John Wiley & Sons 5. Writing Scientific Research Articles (2nd Edition) By Margaret Cargill, Patrick O'Connor (2013) 6. Scientific Writing: Easy When You Know How By Jennifer Peat, Elizabeth Elliott, Louise Baur, Victoria Keena (2013) 7. How to Write a Paper (5th Edition) Edited by George M. Hall (2012) 8. How to Write a Great Research Paper By Book Builders, Beverly Chin, (2004) 9. Research Papers for Dummies By Geraldine Woods (2002) 10. Nicholas Rowe (2017) Academic & Scientific Poster Presentation : A Modern Comprehensive Guide 11. Kelly Coleman,Kathleen Petelinsek (2014) Choose It! Finding the Right Research Topic 12. Ralph Berry (2000) The Research Project: How to write it 13. Alexei Kapterev (2011) Presentation secrets, Do What You Never Thought Possible with Your Presentations, John Wiley & Sons 14. Writing Scientific Research Articles (2nd Edition) By Margaret Cargill, Patrick O'Connor (2013) 15. Scientific Writing: Easy When You Know How By Jennifer Peat, Elizabeth Elliott, Louise Baur, Victoria Keena (2013) 16. How to Write a Paper (5th Edition) Edited by George M. Hall (2012) 17. How to Write a Great Research Paper By Book Builders, Beverly Chin, (2004) 18. Research Papers for Dummies By Geraldine Woods (2002)

2	Other Electronic resources 1. Springer® Journal author tutorials now with interactive courses: Free online course and tutorial. 2. Elsevier® Researcher Academy Researcher Academy provides free access to countless e-learning resources designed to support researchers on every step of their research journey. 3. Wiley Author Webinars 4. Writing Scientific Papers Scitable by Nature Education 5. How to Write a World Class Paper From title to references From submission to revision 6. Duke Graduate School Scientific Writing Resource 7. Writing scientific papers: 8 Improving the English 8. How to write a Great Research Paper, and Get it Accepted by a Good Journal. 9. How to Publish Without Perishing: Finding the Time to Write 10. Article Introductions: More Important Than You Thought! 11. 5 Tips for Writing Better Science Papers 12. What Makes a Good Abstract? 13. Biotechnology news 14. Science Daily 15. Nature News 16. Science News 17. Retraction watch (Information about Scientific Misconduct) 18. COPE: Publishing ethics (Website contains information about publication ethics and practical resources)
3	
5	
6	

Evaluation Scheme	**Total Marks**
Theory: Mid semester Marks	20 marks
Theory: End Semester Marks	40 marks
Theory: Continuous Evaluation Component Marks	

Attendance	05 marks
MCQs	10 marks
Open Book Assignment	15 marks
Article Review	10 marks
Total	**40 Marks**

Practical Marks

Attendance	05 marks
Practical Exam	20 marks
Viva	10 marks
Journal	10 marks
Discipline	05 marks
Total	**50 Marks**

Mapping of PSOs and COs

PO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO						
CO1	3	3	1	2	0	3
CO2	2	2	3	2	1	2
CO3	3	2	3	2	2	2
CO4	2	3	2	2	1	1
CO5	3	2	2	1	2	0

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

Mapping of POs and COs

PO	PO1	PO2	PO3	PO4	PO5	PO6
CO						
CO1	2	-	2	-	-	1
CO2	-	2	2	-	1	-
CO3	2	-	-	-	2	-
CO4	1	-	-	3	-	-
CO5	-	-	-	2	-	-

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

COURSE CODE MSBO308	COURSE NAME VACCINES	SEMESTER III

Teaching Scheme (Hours)				Teaching Credit			
Lecture	Practical	Tutorial	Total Hours	Lecture	Practical	Tutorial	Total Credit
4	4	0	8	4	2	0	6

Course Pre-requisites	10+2+B.Sc. Life science/Biotechnology
Course Category	Elective
Course focus	Employability
Rationale	Vaccines are among the most effective public health interventions for preventing infectious diseases. The course rationale highlights that this course aims to educate students about the importance of vaccines in reducing morbidity and mortality worldwide.
Course Revision/ Approval Date:	14/03/2020
Course Objectives (As per Blooms' Taxonomy)	1 This course will provide students with an overview of current developments in different areas of vaccines. 2 Describe the basic principles of vaccination 3 Explain how the public are less tolerant of the risks 4 Describe the importance of post marketing vaccine safety surveillance 5 Identify some vaccines that have been associated with adverse vaccine reactions.

Course Content (Theory)	Weightage	Contact hours
Unit 1: **Fundamentals of immune system** Overview of Immune system; Human Immune system: Effectors of immune system; Innate & Adaptive Immunity; Activation of the Innate Immunity; Adaptive Immunity;T and B cells in adaptive immunity;Immune response in infection;.Correlates of protection.	**20%**	**06**

Unit 2: **Immune response to infection** Protective immune response in bacterial; viral and parasitic infections;Primary and Secondary immune responses during infection; Antigen presentation and Role of Antigen presenting cells: Dendritic cells in immune response; Innate immune response; Humoral (antibody mediated)responses;Cell mediated responses:role ofCD4+ and CD8+ T cells; Memory responses: Memory and effector T and B cells, Generation and Maintenance of memory T and B cells.	**20%**	**06**
Unit 3: **Immune response to vaccination** Vaccination and immune response; Adjuvants in Vaccination; Modulation of immune responses: Induction of Th1 and Th2 responses by using appropriate adjuvants and antigen delivery systems - Microbial adjuvants, Liposomal and Microparticles as delivery systems; Chemokines and cytokines; Role of soluble mediators.	**20%**	**06**
Unit 4: **Vaccine types & design** History of vaccines, Conventional vaccines; Bacterial vaccines; Viral Vaccines; Vaccines based on routes of administration: parenteral, oral, mucosal; Live attenuated and inactivated vaccine; Subunit Vaccines and Toxoids; Peptide Vaccine.	**20%**	**06**
Unit 5: **Vaccine technologies** New Vaccine Technologies;Rationally designed Vaccines;DNA Vaccination; Mucosal vaccination; New approaches for vaccine delivery; Engineering virus vectors for vaccination; Vaccines for targeted delivery (Vaccine Delivery systems); Disease specific vaccine design: Tuberculosis Vaccine; Malaria Vaccine; HIV/AIDS vaccine; New emerging diseases and vaccine needs (Ebola, Zika).	**20%**	**06**

Instructional Method and Pedagogy:
Audio-Visual Lectures, Quizzes, Debates, Project works, Case studies, and Assignments Practicalexercises are designed to understand the theory as taught in classroom. Hands on in practical session.

Course Outcomes:	Blooms' Taxonomy Domain	Blooms' Taxonomy Sub Domain
After successful completion of the above course, students will be able to:	Understand,	Explain, Describe,

CO1 Understand fundamental concepts Of human immune system and basic immunology	Remember& apply	Discuss, Recall, Locate
CO2 Differentiate and understand immune responses in relation to infection and vaccination;	Understand, Remember& apply	Apply, Practice, Interpret, Select, Correlate
CO3 Understand requirement and designing of different types of vaccines	Analyses	Compare, Classify, Select, Investigate
CO4 Understand the importance of conventional and emerging vaccine technologies.	Understand, Remember	Construct, Develop, Produce
CO5 To understand importance of vaccine designing and development during pandemic	Understand, Remember& apply	Explain, Describe, outline, Predict, Summarize

Learning Resources	
1	Textbook:Vaccines for Biodefense and Emerging and Neglected Diseases 1st Edition, by Alan D.T. Barrett (Author), Lawrence R. Stanberry (Author)
2	Reference books : 1. Janeway, C. A., Travers,P.,Walport, M., & Shlomchik, M. J.(2005). *Immuno Biology:* *the Immune System in Health and Disease*. USA: Garland Science Pub. 2. Kindt, T.J., Osborne, B. A., Goldsby,R. A., & Kuby,J.(2013). *Kuby Immunology*. New York: W.H.Freeman. 3. Kaufmann, S. H. (2004).*Novel VaccinationStrategies*.Weinheim:Wiley-VCH.
3	Journal : Annual Review of Immunology, Annual Review of Microbiology, Current Opinion in Immunology, Nature Immunology, Expert review of vaccines.
5	Periodicals: https://www.cdc.gov/vaccines/pubs/pinkbook/index.html
6	Other Electronic resources: https://www.hhs.gov/vaccines/about/resources/smart-vaccine-tool/index.html

Evaluation Scheme	**Total Marks**
Theory: Mid semester Marks	20 marks
Theory: End Semester Marks	40 marks

Theory: Continuous Evaluation Component Marks	

Attendance	05 marks
MCQs	10 marks
Open Book Assignment	15 marks
Article Review	10 marks
Total	**40 Marks**

Practical Marks	

Attendance	05 marks
Practical Exam	20 marks
Viva	10 marks
Journal	10 marks
Discipline	05 marks
Total	**50 Marks**

Mapping of PSOs and COs

PO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO						
CO1	2	-	-	-	2	-
CO2	1	-	-	-	2	-
CO3	-	-	1	-	-	-
CO4	-	2	2	-	2	-
CO5	2	-	-	-	2	-

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

Mapping of PO and COs

PO	PO1	PO2	PO3	PO4	PO5	PO6
CO						
CO1	3	2	-	-	2	-
CO2	1	-	-	-	2	-
CO3	1	-	-	-	2	1
CO4	-	-	1	-	2	1
CO5	3	2	-	-	2	-

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

COURSE CODE MSBO308	COURSE NAME DRUG DISCOVERY AND DEVELOPMENT	SEMESTER III

Teaching Scheme (Hours)				Teaching Credit			
Lecture	**Practical**	**Tutorial**	**Total Hours**	**Lecture**	**Practical**	**Tutorial**	**Total Credit**
4	4	0	8	4	2	0	6

Course Pre-requisites	10+2 examination in science
Course Category	Discipline specific elective
Course focus	Employability
Rationale	The course rationale acknowledges that drug discovery and development are critical in addressing global health challenges, including infectious diseases, cancer, neurodegenerative disorders, and other prevalent health conditions.
Course Revision/ Approval Date:	14/03/2020
Course Objectives (As per Blooms' Taxonomy)	1 This course will give a broad overview of research and developmen setup towards drug discovery. 2 It will present drug development as a process involving target sel computer-based methods and combinatorial chemistry/high-throughp 3 Safety evaluation, bioavailability, clinical trials, and the essentials c discussed. 4 Along the way you will learn about molecular recognition, comput toxicology as applied to the development of new medicines. 5 This course develops the key themes in the drug discovery and highlights the multidisciplinary nature of the research and developme

Course Content (Theory)	Weightage	Contact hours
UUnit 1: Target identification and molecular modelling: Identification of target or drug leads associated with a particular disease by a number of different techniques including combinations of molecular modeling, combinatorial libraries and high-throughput screening (HTS); Conceptualizing the automation of the HTS process and the importance of bioinformatics and data processing in identification of lead compounds; Rational drug design, based on understanding the three dimensional structures and physicochemical properties of drugs and receptors; Modelling drug/ receptor interactions with the emphasis on molecular mechanisms, molecular dynamics simulations and homology modelling; Conformational sampling, macromolecular folding, structural bioinformatics, receptor-based and ligand-based design and docking methods, in silico screening of libraries, semi-empirical and ab-initio methods, QSAR methods, molecular diversity, design of combinatorial libraries of drug-like molecules, macromolecular and chemical databases.	**20%**	**06**
Unit 2: Lead optimization: Identification of relevant groups on a molecule that interact with a receptor and are responsible for biological activity; Understanding structure activity relationship; Structure modification to increase potency and therapeutic index; Concept of quantitative drug design using Quantitative structure–activity relationship models (QSAR models) based on the fact that the biological properties of a compound are a Function of its physicochemical parameters such as solubility, lipophilicity, electronic effects, ionization, stereochemistry, etc.; Bioanalytical assay development in support of in vitro and in vivo studies (LC/MS/MS, GC/MS and ELISA).	**20%**	**06**
Unit 3: Preclinical development: Principles of drug absorption, drug metabolism and distribution - intestinal absorption, Metabolic stability, drug-drug interactions, plasma protein binding assays, metabolite profile studies, Principles of toxicology, Experimental design for preclinical and clinical PK/PD/TK studies, Selection of animal model; Regulatory guidelines for preclinical PK/ PD/TK studies; Scope of GLP, SOP for conduct of clinical & non clinical testing, control on animal house, report preparation and documentation Integration of non-clinical and preclinical data to aid design of clinical studies.	**20%**	**06**
Unit 4: Drug Manufacturing: Requirements of GMP implementation, Documentation of GMP practices, CoA, Regulatory certification of GMP, Quality control and Quality assurance, concept and philosophy of TQM, ICH and ISO 9000; ICH guidelines for Manufacturing, Understanding Impurity Qualification Data, Stability Studies.	**20%**	**06**

Unit 5: Clinical trial design: Objectives of Phase I, II, III and IV clinical studies, Clinical study design, enrollment, sites and documentation, Clinical safety studies: Adverse events and adverse drug reactions, Clinical PK, pharmacology, drug-drug interaction studies, Statistical analysis and documentation. **Unit 6: Fundamentals of regulatory affairs and bioethics:** Global Regulatory Affairs and different steps involved, Regulatory Objectives, Regulatory Agencies; FDA guidelines on IND and NDA submissions, Studies required for IND and NDA submissions for oncology, HIV, cardiovascular indications, On-label vs. off-label drug use GCP and Requirements of GCP Compliance, Ethical issues and Compliance To current ethical guidelines, Ethical Committees and their setup, Animal Ethical issues and compliance.	**20%**	**06**

Instructional Method and Pedagogy:
Audio-Visual Lectures, Quizzes, Debates, Project works, Case studies, and Assignments Practical exercises are designed to understand the theory as taught in classroom. Hands on in practical session.

Course Outcomes:	Blooms' Taxonomy Domain	Blooms' Taxonomy Sub Domain
After successful completion of the above course, students will be able to:		
CO1 On completion of this course, students should be able to understand the basics of R&D in drug discovery and should be able to apply knowledge gained in respective fields of pharmaceutical industry.	Understand, Remember& apply	Explain, Describe, Discuss, Recall, Locate
CO2 Demonstrate an understanding of the steps involved in the drug discovery and design process.	Remember	Apply, Practice, Interpret, Select, Correlate
CO3 Demonstrate an awareness of the important contributions the different discipline areas make to the drug discovery and development process	Remember	Compare, Classify, Select, Investigate
CO4 Critically analyse biological pathways for their potential as drug targets for a given disease..	Analyses	Construct, Develop, Produce
CO5 Demonstrate the ability to use evidence-based approaches to guide decision making during the drug discovery and development process.	Understand, Remember& apply	Explain, Describe, outline, Predict, Summarize

Learning Resources	
1	Textbook: 1. Drug Discovery and Development; Technology in Transition. HP Rang. Elsevier Ltd 1 st edition 2006. 2. Pharmacology in Drug Discovery. T. P. Kenakin. Elsevier, 1st Edition 2012. 3. An introduction to medicinal chemistry. G. L. Patrick. 5 th Edition Oxford UK, Oxford University Press, 2013.
2	Reference books **6.** Krogsgaard-Larsen et al. Textbook of Drug Design and Discovery. 4th Edition. CRC Press. **7.** Kuhse, H. (2010). Bioethics: an Anthology. Malden, MA: Blackwell. **8.** Nally, J. D. (2006) GMP for Pharmaceuticals. 6th edition. CRC Press **9.** Brody, T. (2016) Clinical Trials: Study Design, Endpoints and Biomarkers, Drug Safety, and FDA and ICH Guidelines. Academic Press.
3	Journal :Drug Discovery Today. 9. Natures Review Drug Discovery. 10. Drug, Discovery, Development and Therapy.
5	Periodicals: **1.** SLAS Discovery. **2.** Marine Drugs.
6	Other Electronic resources: NCBI, ENSEMBL, VISTA, UCSC etc

Evaluation Scheme	Total Marks
Theory: Mid semester Marks	20 marks
Theory: End Semester Marks	40 marks
Theory: Continuous Evaluation Component Marks	

Attendance	05 marks
MCQs	10 marks
Open Book Assignment	15 marks
Article Review	10 marks
Total	**40 Marks**

Practical Marks

Attendance	05 marks
Practical Exam	20 marks
Viva	10 marks
Journal	10 marks
Discipline	05 marks
Total	**50 Marks**

Mapping of PSOs and COs

PO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO						
CO1	2	-	-	-	3	-
CO2	1	-	-	2	3	-
CO3	-	2	3	2	-	3
CO4	-	3	3	-	-	3
CO5	-	-	3	2	-	3

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

Mapping of POs and COs

PO	PO1	PO2	PO3	PO4	PO5	PO6
CO						
CO1	3	3	-	-	3	3
CO2	2	1	3	2	-	-
CO3	3	-	3	2	-	3
CO4	-	-	3	-	2	3
CO5	-	-	3	-	-	2

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

COURSE CODE MSBO308	COURSE NAME DRUG DISCOVERY AND DEVELOPMENT	SEMESTER III

Teaching Scheme (Hours)				Teaching Credit			
Lecture	**Practical**	**Tutorial**	**Total Hours**	**Lecture**	**Practical**	**Tutorial**	**Total Credit**
4	4	0	8	4	2	0	6

Course Pre-requisites	10+2 examination in science
Course Category	Discipline specific elective
Course focus	Employability
Rationale	The course rationale acknowledges that drug discovery and development are critical in addressing global health challenges, including infectious diseases, cancer, neurodegenerative disorders, and other prevalent health conditions.
Course Revision/ Approval Date:	14/03/2020
Course Objectives (As per Blooms' Taxonomy)	1 This course will give a broad overview of research and developmen setup towards drug discovery. 2 It will present drug development as a process involving target sel computer-based methods and combinatorial chemistry/high-throughp 3 Safety evaluation, bioavailability, clinical trials, and the essentials c discussed. 4 Along the way you will learn about molecular recognition, comput toxicology as applied to the development of new medicines. 5 This course develops the key themes in the drug discovery and highlights the multidisciplinary nature of the research and developme

Course Content (Theory)	Weightage	Contact hours
Unit 1: Target identification and molecular modelling: Identification of target or drug leads associated with a particular disease by a number of different techniques including combinations of molecular modeling, combinatorial libraries and high-throughput screening (HTS); Conceptualizing the automation of the HTS process and the importance of bioinformatics and data processing in identification of lead compounds; Rational drug design, based on understanding the three dimensional structures and physicochemical properties of drugs and receptors; Modelling drug/ receptor interactions with the emphasis on molecular mechanisms, molecular dynamics simulations and homology modelling; Conformational sampling, macromolecular folding, structural bioinformatics, receptor-based and ligand-based design and docking methods, in silico screening of libraries, semi-empirical and ab-initio methods, QSAR methods, molecular diversity, design of combinatorial libraries of drug-like molecules, macromolecular and chemical databases.	**20%**	**06**
Unit 2: Lead optimization: Identification of relevant groups on a molecule that interact with a receptor and are responsible for biological activity; Understanding structure activity relationship; Structure modification to increase potency and therapeutic index; Concept of quantitative drug design using Quantitative structure–activity relationship models (QSAR models) based on the fact that the biological properties of a compound are a Function of its physicochemical parameters such as solubility, lipophilicity, electronic effects, ionization, stereochemistry, etc.; Bioanalytical assay development in support of in vitro and in vivo studies (LC/MS/MS, GC/MS and ELISA).	**20%**	**06**
Unit 3: Preclinical development: Principles of drug absorption, drug metabolism and distribution - intestinal absorption, Metabolic stability, drug-drug interactions, plasma protein binding assays, metabolite profile studies, Principles of toxicology, Experimental design for preclinical and clinical PK/PD/TK studies, Selection of animal model; Regulatory guidelines for preclinical PK/ PD/TK studies; Scope of GLP, SOP for conduct of clinical & non clinical testing, control on animal house, report preparation and documentation Integration of non-clinical and preclinical data to aid design of clinical studies.	**20%**	**06**
Unit 4: Drug Manufacturing: Requirements of GMP implementation, Documentation of GMP practices, CoA, Regulatory certification of GMP, Quality control and Quality assurance, concept and philosophy of TQM, ICH and ISO 9000; ICH guidelines for Manufacturing, Understanding Impurity Qualification Data, Stability Studies.	**20%**	**06**

Unit 5: Clinical trial design: Objectives of Phase I, II, III and IV clinical studies, Clinical study design, enrollment, sites and documentation, Clinical safety studies: Adverse events and adverse drug reactions, Clinical PK, pharmacology, drug-drug interaction studies, Statistical analysis and documentation.	**20%**	**06**
Unit 6: Fundamentals of regulatory affairs and bioethics: Global Regulatory Affairs and different steps involved, Regulatory Objectives, Regulatory Agencies; FDA guidelines on IND and NDA submissions, Studies required for IND and NDA submissions for oncology, HIV, cardiovascular indications, On-label vs. off-label drug use GCP and Requirements of GCP Compliance, Ethical issues and Compliance To current ethical guidelines, Ethical Committees and their setup, Animal Ethical issues and compliance.		

Instructional Method and Pedagogy: Audio-Visual Lectures, Quizzes, Debates, Project works, Case studies, and Assignments Practical exercises are designed to understand the theory as taught in classroom. Hands on in practical session.

Course Outcomes:	Blooms' Taxonomy Domain	Blooms' Taxonomy Sub Domain
After successful completion of the above course, students will be able to:		
CO1 On completion of this course, students should be able to understand the basics of R&D in drug discovery and should be able to apply knowledge gained in respective fields of pharmaceutical industry.	Understand, Remember& apply	Explain, Describe, Discuss, Recall, Locate
CO2 Demonstrate an understanding of the steps involved in the drug discovery and design process.	Remember	Apply, Practice, Interpret, Select, Correlate
CO3 Demonstrate an awareness of the important contributions the different discipline areas make to the drug discovery and development process.	Remember	Compare, Classify, Select, Investigate
CO4 Critically analyse biological pathways for their potential as drug targets for a given disease.	Analyses	Construct, Develop, Produce
CO5 Demonstrate the ability to use evidence-based approaches to guide decision making during the drug discovery and development process.	Understand, Remember& apply	Explain, Describe, outline, Predict, Summarize

Learning Resources	
1	Textbook: Drug Discovery and Development; Technology in Transition. HP Rang. Elsevier Ltd 1 st edition 2006. Pharmacology in Drug Discovery. T. P. Kenakin. Elsevier, 1st Edition 2012. An introduction to medicinal chemistry. G. L. Patrick. 5 th Edition Oxford UK, Oxford University Press, 2013.
2	Reference books Krogsgaard-Larsen et al. Textbook of Drug Design and Discovery. 4th Edition. CRC Press. Kuhse, H. (2010). Bioethics: an Anthology. Malden, MA: Blackwell. Nally, J. D. (2006) GMP for Pharmaceuticals. 6th edition. CRC Press Brody, T. (2016) Clinical Trials: Study Design, Endpoints and Biomarkers, Drug Safety, and FDA and ICH Guidelines. Academic Press.
3	Journal :Drug Discovery Today. Natures Review Drug Discovery. Drug, Discovery, Development and Therapy.
4	Periodicals: SLAS Discovery. Marine Drugs.
5	Other Electronic resources: NCBI, ENSEMBL, VISTA, UCSC etc

Evaluation Scheme	Total Marks
Theory: Mid semester Marks	20 marks
Theory: End Semester Marks	40 marks
Theory: Continuous Evaluation Component Marks	

Attendance	05 marks
MCQs	10 marks
Open Book Assignment	15 marks
Article Review	10 marks
Total	**40 Marks**

Practical Marks

Attendance	05 marks
Practical Exam	20 marks
Viva	10 marks
Journal	10 marks
Discipline	05 marks
Total	**50 Marks**

Mapping of PSOs and COs

PO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO						
CO1	2	-	-	-	3	-
CO2	1	-	-	2	3	-
CO3	-	2	3	2	-	3
CO4	-	3	3	-	-	3
CO5	-	-	3	2	-	3

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

Mapping of PO and COs

PO	PO1	PO2	PO3	PO4	PO5	PO6
CO						
CO1	3	3	-	-	3	3
CO2	2	1	3	2	-	-
CO3	3	-	3	2	-	3
CO4	-	-	3	-	2	3
CO5	-	-	3	-	-	2

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None