Scheme of Teaching

&

Detailed Syllabus

For

Master of Science

M.Sc. (Biotechnology)

(Two Year Program)

(w.e.f. Academic Session 2021–22)

School of Basic & Applied Sciences

Shobhit Institute of Engineering & Technology

(Deemed to-be University)

NH-58, Modipuram, Meerut (U.P.) – 250110

Website: www.shobhituniversity.ac.in

Registrar
Shobhit Institute of Engg. & Tech.
(Deemed to-Be University)
NH-58, Modipuram, Meerut-250110

Program Educational Objectives (PEOs):

PEO1. Apply basic knowledge of Cell and Molecular Biology, Microbial Diversity, Biophysical Techniques, Gentics, Genetic Engineering, Biostatistics and interdisciplinary engineering concepts to solve problems related to field of Biotechnology**.**

PEO2. Demonstrate the application of biotechnology practices and engineering principles through development of innovative products that are of beneficial for the human welfare and the nation.

PEO3. Exhibit skills of designing and production of different products based on biotechnology engineering.

PEO4. Exhibit strong, independent learning, analytical and problem solving skills with special emphasis on design, communication, and ability to work in teams.

PEO5. Pursue higher education and research in reputed institute at national and international level.

Program Outcomes (POs):

PO 1. Graduates will gain and apply knowledge of Biotechnology, Science and Engineering concepts to solve problems related to field of Biotechnology.

PO 2. Graduates will be able to identify, analyze and understand problems related to biotechnology Engineering and finding valid conclusions with basic knowledge in biotechnology Engineering.

PO 3. Graduates will be able to design and develop solution to Biotechnology Engineering problems by applying appropriate tools while keeping in mind safety factor for environmental & society.

PO 4. Graduates will be able design, perform experiments, analyze and interpret data for investigating complex problems in biotechnology Engineering and related fields.

PO 5. Graduates will be able to decide and apply appropriate tools and techniques in biotechnological manipulation.

PO6. Graduates will be able to justify societal, health, safety and legal issues and understand his responsibilities in biotechnological engineering practices

PO7 . Graduates will be able to understand the need and impact of biotechnological solutions on environment and societal context keeping in view need for sustainable solution.

PO 8. Use the techniques, skills, and modern engineering tools necessary for engineering practice.

PO 9. Design system, components or processes to meet realistic needs of society, environment, health and safety, and sustainability.

PO 10. Recognize the need for, and an ability to engage in life-long learning.

PO 11. Acquire knowledge of contemporary issues.

PO 12. Graduates will be able to demonstrate knowledge of project and finance management when dealing with Biotechnology Engineering problems.

Program Specific Outcomes (PSOs):

PSO1: Able to apply fundamental knowledge of basic Interdisciplinary content ((Physical andMathematical)alongwithappliedbiosciencecoursestoapply the knowledgeinfollowingstate of art subjects Bioinformatics and Computational Biology, Structural biology, Drug de-signing,GenomicsandProteomics.

PSO2: Able to apply basic knowledge and skills of various aspects of biotechnology to address the problems of food security, healthy food production, diseases etiology and environment.

PSO3: Able to pursue research in industry and institutions related animal, plant ,environmentbiotechnology or to be able to pursue higher studies in diverse fields of biotechnology andinterdisciplinary programs by applying principles of management, environmental, ethical, andsocialissues.

PSO4: Able to apply principles of soft computing skills, problem solving, creative thinking,group dynamics, team building,leadership skills, decision making skills, contributing tooverallpersonality,careerdevelopmentandinnovation.

SCHEME OF TEACHING – M.Sc. (Biotechnology)
FIRST YEAR

SEMESTER-I

Course Code	Course / Title	L	T	P	Credit
MSBT-101	Biochemistry	3	0	0	3
MSBT-102	Microbial Diversity	4	0	0	4
MSBT-103	Biophysical Techniques	3	0	0	3
MSBT-104	Genetics	4	0	0	4
MSBT-105	Cell and Molecular Biology	4	0	0	4
MSBT-151	Biochemistry Lab.	0	0	4	2
MSBT-152	Microbial Diversity Lab.	0	0	4	2
MSBT-153	Biophysical Techniques Lab.	0	0	4	2
Total		**18**	**0**	**12**	**24**

SEMESTER-II

Course Code	Course / Title	L	T	P	Credit
MSBT-201	Genetic Engineering	4	0	0	4
MSBT-202	Immunotechnology	3	0	0	3
MSBT-203	Bioinformatics	3	0	0	3
MSBT-204	Genomics and Proteomics	4	0	0	4
MSBT-205/ MSBT-206/ MSBT-207	**Elective-I**	4	0	0	4
MSBT-251	Genetic Engineering Lab.	0	0	4	2
MSBT- 252	Immunotechnology Lab.	0	0	4	2
MSBT- 253	Bioinformatics Lab.	0	0	4	2
Total		**18**	**0**	**12**	**24**

SECOND YEAR

SEMESTER-III

Course Code	Course / Title	L	T	P	Credit
MSBT-301	Plant Biotechnology	4	0	0	4
MSBT-302	Biostatistics	3	0	0	3
MSBT-303	Animal Biotechnology	4	0	0	4
MSBT-304	Intellectual Property Rights, Biosafety and Bioethics	3	0	0	3
MSBT-305/ MSBT-306/ MSBT-307	**Elective -II**	4	0	0	4
MSBT-351	Plant Biotechnology Lab	0	0	4	2
MSBT-353	Animal Biotechnology Lab	0	0	4	2
MSBT-381	Seminar	0	0	4	2
Total		**18**	**0**	**12**	**24**

SEMESTER-IV

Course Code	Course / Title	L	T	P	Credit
MSBT-481	Seminar	0	0	04	2
MSBT-491	Dissertation	0	0	24	12
	Total	**0**	**0**	**28**	**14**

Elective-I – MSBT -205Drug Discovery and Development
MSBT -206 Environmental Biotechnology
MSBT -207 Microbial Technology

Elective-II - MSBT -305 Bioprocessing Technology
MSBT -306 Nanobiotechnology
MSBT S-307 Vaccines

SEMESTER-I

Course code	**MSBT-101**				
Category	**Applied Sciences**				
Course title	**Biochemistry**				
Scheme and Credits	**CR**	**L**	**T**	**P**	
	3	3	0	0	
Pre-requisites (if any)	Nil				
Objectives	Theobjectivesofthiscoursearetobilduponundergraduatelevelknowledgeof biochemical principles with specificemphasis ondifferentmetabolicpathways.The course shall make the students awareof various disease pathologies within thecontextofeachtopic.				
Outcomes	On completion of this course,studentsshouldbeableto: 1.Gain fundamental knowledgeinbiochemistry; 2.Understandthemolecularbasis of various pathological 3. Conditions from the perspectiveofbiochemicalreactions.				
S. No.	**Unit details**				**Time Allotted**
Unit-1	**Chemical basis of life:** Miller-Urey experiment, abiotic formation of amino acidoligomers,compositionoflivingmatter;Water–propertiesofwater,essentialrole ofwaterforlifeonearthpH,buffer,maintenanceofbloodpHandpHofgastricjuice,pH optima of different enzymes (pepsin, trypsin and alkaline phosphatase), ionizationand hydrophobicity, emergent properties of biomolecules in water, biomolecularhierarchy,macromolecules,molecularassemblies.				**8Hrs**
Unit-2	**Proteinstructure-** Structure-function relationships: amino acids – structure and functional groupproperties, peptides and covalent structure of proteins, elucidation of primary andhigher order structures,Ramachandranplot,evolutionofproteinstructure,proteindegra				**8Hrs**

	dationandintroductiontomolecularpathwayscontrollingproteindegradation,structure-function.	
Unit-3	**Enzyme Kinetics-**Enzyme catalysis – general principles of catalysis; quantitation of enzyme activity andefficiency; enzyme characterization and Michaelis-Menten kinetics; relevance ofenzymes in metabolic regulation, activation, inhibition and covalent modification;single substrate enzymes; concept of catalytic antibodies; catalytic strategies withspecificexamplesofproteases,carbonicanhydrases,restrictionenzymesandnucleosidemonophosphate kinase; regulatory strategies with specific example of hemoglobin;isozymes;roleofcovalentmodificationinenzymaticactivity;zymogens.	**9Hrs**
Unit-4	**Glycobiology-**Sugars-mono,di,andpolysaccharideswithspecificreferencetoglycogen,amylosea nd cellulose, glycosylation of other biomolecules - glycoproteins and glycolipids;lipids -structure andpropertiesofimportantmembersofstorageandmembranelipids;lipoproteins.	**8Hrs**
Unit-5	**Role of Vitamins and cofactors-** Calvincycleandpentosephosphatepathway;glycogenmetabolism,reciprocalcontrolof glycogen synthesis and breakdown, roles of epinephrine and glucagon and insulinin glycogen metabolism; Fatty acid metabolism; protein turnover and amino acidcatabolism; nucleotide biosynthesis; biosynthesis of membrane lipids and sterols withspecific emphasis on cholesterol metabolism and mevalonate pathway.	**9Hrs**

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	1	2	3	1	1	1	1	2	2	2	1	1	1	1
CO 2	1	2	2	-	2	1	2	2	2	-	2	2	2	2	2
CO 3	3	1	2	1	2	2	2	1	3	2	2	2	1	2	2
CO 4	3	1	-	1	2	2	1	1	3	2	2	-	2	2	2
Average	**1.8**	**1.0**	**1.0**	**0.5**	**1.5**	**1.3**	**1.3**	**1.0**	**2.0**	**1.0**	**1.5**	**1.0**	**1.3**	**1.5**	**1.5**

References	1. Stryer,L.(2015).Biochemistry.(8th ed.)NewYork:Freeman. 2. Lehninger, A.L. (2012).Principles ofBiochemistry(6th ed.). NewYork, NY:Worth.

	3. Voet, D.,&Voet,J.G.(2016).Biochemistry(5th ed.).Hoboken,NJ: J.Wiley&Sons. 4. Dobson,C.M.(2003).ProteinFoldingandMisfolding.Nature,426(6968), 884-890.doi:10.1038/nature02261. 5. Richards,F.M.(1991).TheProteinFoldingProblem.ScientificAmerican,264(1),54-63.doi:10.1038/scientific American 0191-54.

Course code	**MSBT-102**				
Category	**Applied Sciences**				
Course title	**Microbial Diversity**				
Scheme and Credits	**CR**	**L**	**T**	**P**	
	3	3	0	0	
Pre-requisites (if any)	Nil				
Objectives	Theobjectivesofthiscoursearetobuildknowledgeofprokaryotic and eukaryotic diversity with specificemphasisonmechanisms behind it.The course shall make the students awareof various microbial communities and within thecontextofeachtopic.				
Outcomes	a. Describe common groups of bacteria and archaea in different ecosystems, and their role in biogeochemical key processes in these environments. b. Describe for cultivation-independent methods for studies of the composition of microbial communities and for the function and occurrence of individual groups. c. Describe genomic-based methods to study microbial diversity in nature and for the mechanisms behind it. d. Describe important interactions within microbial communities and between microorganisms and plants and animals. e. Evaluate, synthesize and present scientific studies of genetic and functional microbial diversity in different ecosystems				
S. No.	**Unit details**				**Time Allotted**

Unit-1	**Archaea**: Systematics, and occurrence, diversity, characteristic features, significance and potential applications (eg. biochips, methane generation, ultrafiltation membranes, production of PHB and PHA, desulphurization of coal and crude oil, bioleaching of metals, enzymes, compatible solutes and others) of different groups of archaebacteria (Crenarchaeota, Euarchaeota, Korarchaeota, Nanoarchaeota).	**8 Hrs**
Unit-2	**Bacteria**: Conventional and molecular systematics, and general discussion on the occurrence, diversity, characteristic features, significance and potential applications of various groups of bacteria according to Bergey's Manual of Systematic Bacteriology.	**8 Hrs**
Unit-3	**Fungal Systematics and diversity**: Fungal endophytes of tropical plants and their applications: Endophytic fungi, colonization and adaptation of endophytes. Endophytes as latent pathogens and biocontrol agents. Mycorrhizal fungi: Diversity of endo and ectomycorrhizal fungi. Biology of arbuscularmycorrhizal fungi: signaling, penetration and colonization inside roots, culturing and benefits, recent advances in the field of mycorrhiza.	**8 Hrs**
Unit-4	**Agriculturally important toxigenic fungi**: Biodiversity, Chemical and biological characterization of toxic metabolites, toxigenic fungi in sustainable agriculture with special emphasis on biopesticides. Secondary metabolites from fungi: Terpenes, Non-ribosomal peptides, hydrophobins, peptaibols, indole alkaloids, detailed emphasis on polyketides.	**8 Hrs**
Unit-5	**Biodiversity of yeast and Algae**: Mycocinogeny and diversity of mycogenic yeast strains, characteristics of mycocins, mode of action, genetic basis of mycocinogeny, important mycocins, applications of antagonistic yeasts. Biotechnological applications of yeasts. Algal diversity from morphology to molecules: Importance of algae in production of algal pigments, biofuels, hydrogen production.	**8 Hrs**

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO 1	2	1	2	3	1	1	1	1	2	2	2	1	1	1	1

CO 2	1	2	2	-	2	1	2	2	2	-	2	2	2	2	2
CO 3	3	1	2	1	2	2	2	1	2	2	2	2	1	2	2
CO 4	3	1	-	1	2	2	1	1	3	2	2	-	2	2	2
CO 5	2	1	2	3	1	1	1	1	1	2	2	1	1	1	1
Average	**2**	**1.2**	**1.6**	**1.6**	**1.6**	**1.4**	**1.4**	**1.2**	**2**	**1.6**	**2**	**1.2**	**1.4**	**1.6**	**1.6**

References	1.The Prokaryotes. A handbook on the biology of bacteria: ecophysiology, isolation, identification, applications. Volumes I-IV by Balows, A., Trüper, H. G., Dworkin, M., Harder, W., Schleifer, K. H. Springer-Verlag, New York; 1992 2. Bacterial Systematics, by Logan, A., Niall A. Logan, Wiley-blackwell; 1994 3. Principles of Microbiology by R.M. Atlas, Mosby publishers, St. Louis; 1995 10 4. Brock Biology of Microorganisms (12th edition) by Madigan and John M. Martinko, Paul V. Dunlap, David P. Clark Benjamin Cummings; 2008. 5. Microbiology: An Introduction by Gerard J Tortora, Berdell R Funke, Christine L Case Benjamin- Cummings Publishing Company; 2008. 6. Fundamentals of the fungi by Elizabeth Moore, Fourth edition, Benjamin Cummings; Landecker; 1996. 7. Mycotechnology: Present status and future prospects. Edited by Mahendra Rai. I.K., International Publishing House Pvt. Ltd.; 2007. 8. The Yeast Handbook: Biodiversity and Ecophysiology of yeasts by Carlos A. Rosa and Gabor Peter. Springer- Verlag Berlin Heidelberg; 2006. 9. Algae: Anatomy, Biochemistry and Biotechnology by Laura Barsanti and Paolo Gualtieri. Taylor and Francis Group, LLC; 2006.

Course code	**MSBT -103**				
Category	**Applied Sciences**				
Course title	**Biophysical Techniques**				
Scheme and Credits	**CR**	**L**	**T**	**P**	
	4	4	0	0	
Pre-requisites (if any)	Nil				
Objectives	The objectives of this course is to teach students to differentiate between the various techniques for measurement of parameters used in biological sciences. The course is designed to teach students the utility of set of experimental methods in biological research in a problem-				

	oriented manner.
Outcomes	On completion of this course, students should be able to: a. Explain principles of electrophoresis and immunochemical techniques and discuss how these techniques can be used in molecular medicine. b. Explain basic principles for chromatographic separation techniques. c. To familiarize with basic Laboratory techniques and understand the principle of measurements using those techniques.

S. No.	**Unit details**	**Time Allotted**
Unit-1	**Electrophoresis&Blotting:**Agarose and polyacrylamide gel electrophoresis (native and denaturing), Immuno-electrophoresis, Isoelectric Focusing, Capillary electrophoresis. Southern blotting, northern blotting, western blotting, South western blotting.	**8Hrs**
Unit-2	**Chromatography**: Planner chromatography and column chromatography (ion exchange, gel permeation, affinity), GLC and HPLC.	**8 Hrs**
Unit-3	**Spectroscopy and X –ray crystallography**: Principles of colorimetry and UV-Vis spectrophotometry, Mass spectrometry, MALDI, X-Ray Crystallography, SPR.	**8 Hrs**
Unit-4	**Microscopy** -Principle, working, sample preparation and biological applications of different microscopes light microscope (bright field and dark field, phase contrast, polarization, differential interference contrast), electron microscope (TEM, SEM), fluorescence microscope (simple and confocal) and atomic force microscope.	**9Hrs**
Unit-5	**Centrifugation**: Principle, construction, working of centrifugation and concept of RCF, types of instruments and rotors used in centrifugation, types of centrifugations-preparative, differential density gradient centrifugation and analytical ultracentrifuge.	**9 Hrs**

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**

CO 1	2	1	2	3	1	1	1	1	2	2	2	1	1	1	1
CO 2	3	1	-	1	2	2	1	1	3	2	2	-	2	2	2
CO 3	2	1	2	3	1	1	1	1	1	2	2	1	1	1	1
Average	**2.3**	**1.0**	**1.3**	**2.3**	**1.3**	**1.3**	**1.0**	**1.0**	**2.0**	**2.0**	**2.0**	**0.7**	**1.3**	**1.3**	**1.3**

References	1. Wilson, K. and Walker, J. 1994. Principles and Techniques Practical Biochemistry, Cambridge University Press, Cambridge. 2. Willard, H.H., Meritt, L.L., Dean, J.A. and Settle, F.A. 1986. Instrumental method of analysis (7th eds.). Wadsworth Pub. Co., USA. 3. Rana, S.V.S. 2006 and 07. Biotechniques– Theory and Practice (2nd eds.). Rastogi Publications. 4. Chatwal, G.R. and Anand, S.K. 2008. Instrumental methods of chemical analysis (5th eds.). Himalaya Publishing House. 5. Skoog, D.A., Holler, F.J. and Crouch, S.R. 2007. Instrumental analysis. Brooks/Cole Cengage Learning. 6. Upadhayay, A. and Upadhayay, K. 2008. Biophysical chemistry (4th eds.). Himalaya Publishing House.

Course code	**MSBT -104**				
Category	**Applied Sciences**				
Course title	**Genetics**				
Scheme and Credits	**CR**	**L**	**T**	**P**	
	4	4	0	0	
Pre-requisites (if any)	Nil				
Objectives	The objectives of this course are to takestudents through basics of genetics andclassical genetics covering prokaryotic/phage genetics to yeast and highereukaryotic domains. On covering allclassicalconceptsofMendeliangeneticsacrosstheselife-forms,studentswillbe exposed to concepts of populationgenetics, quantitative geneticsencompassingcomplextraits,clinicalgeneticsandgeneticsofevolution.				
Outcomes	Onsuccessfulcompletionofthiscourse,studentwillbeable: 1. Describefundamentalmolecularprinciplesofgenetics;				

	2. Understand relationship betweenphenotypeandgenotypeinhumangenetictraits; 3. Describethebasicsofgeneticmapping; 4. Understandhowgeneexpressionisregulated.

S. No.	Unit details	Time Allotted
Unit-1	History of Genetics, Mitosis and Meiosis, Cell Cycle regulation, Mendel's laws of Inheritance, Codominance, Lethal GeneLinkage- types of linkage and estimation of linkage	**8Hrs**
Unit-2	Ultrastructureofcellandcellorganellesandtheirfunctions, Cytoplasmic inheritance, Chromosome structure, morphology, number and types-karyotype and ideogram, Structure of chromosomal aberrations.	**9Hrs**
Unit-3	Mutations-Germinal and Somatic Mutations, Types of mutations, Molecular bases of mutation, Methods of inducing mutation and C/B technique, quantitative traits-qualitative traits and differences between them.	**8Hrs**
Unit-4	Multiple factor hypothesis, Alleles, Multiple alleles in Plants, Types of gene action	**7Hrs**
Unit-5	Regulation of gene expression, DNA and its structure, function, types, mode of replication and repair, lac operon and fine structure of gene: Classification of gene.	**8Hrs**

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO 1	2	1	2	3	1	1	1	1	2	2	2	1	1	1	1
CO 2	3	1	-	1	2	2	1	1	3	2	2	-	2	2	2
CO 3	2	1	2	3	1	1	1	1	2	2	2	1	1	1	1
CO 4	2	1	2	3	1	1	1	1	1	2	2	1	1	1	1
Average	**2.3**	**1.0**	**1.5**	**2.5**	**1.3**	**1.3**	**1.0**	**1.0**	**2.0**	**2.0**	**2.0**	**0.8**	**1.3**	**1.3**	**1.3**

References

1. Hartl,D.L.,&Jones,E.W.(1998).Genetics:PrinciplesandAnalysis.Sudbury,MA:JonesandBartlett.
2. Pierce,B.A.(2005).Genetics:aConceptualApproach.NewYork:W.H.Freeman.
3. Tamarin,R.H.,&Leavitt,R.W.(1991).PrinciplesofGenetics.Dubuque,IA:Wm. C.Brown.Smith,J.M.(1998).*EvolutionaryGenetics*.Oxford:OxfordUniversityPress

Course code	**MSBT -105**				
Category	**Applied Sciences**				
Course title	**Cell and Molecular Biology**				
Scheme and Credits	**CR**	**L**	**T**	**P**	
	4	4	0	0	
Pre-requisites (if any)	Nil				
Objectives	The objectives of this course are tosensitize the students to the fact thataswegodownthescaleofmagnitudefromcellstoorganellestomolecules, the understanding of various biologicalprocessesbecomesdeeperandinclusive.				
Outcomes	Studentshouldbeequippedtounderstandthree fundamental aspects in biologicalphenomenon: a) what to seek; b) how toseek;c)whytoseek?				

S. No.	**Unit details**	**Time Allotted**
Unit-1	**Cell organelles-** Internal organization of the cell - cell membranes: structure of cell membranesand concepts related to compartmentalization in eukaryotic cells; intracellularorganelles: endoplasmic reticulum and Golgi apparatus, lysosomes and peroxisomes,ribosomes,cellularcytoskeleton,mitochondria,chloroplastsandcellenergetics;nuclearcompartment:nucleus,nucleolusandchromosomes.	**8Hrs**
Unit-2	**Cellularsignalling,transportandtrafficking-**Molecular mechanisms of membrane transport, nuclear transport, transport acrossmitochondriaandchloroplasts;intracellularvesiculartraffickingfromendoplasmicreticulumthroughGolgiapparatustolysosomes/cellexterior.	**8Hrs**
Unit-3	**Cellular Processes-**Cell cycle and its regulation; cell division: mitosis, meiosis and cytokinesis; celldifferentiation: stem cells, their differentiation into different cell types and organizationinto specialized tissues; cell-cell interactions; cell receptors and trans-membranesignalling;cellmotilityandmigration;celldeath:differentmo	**9Hrs**

	desofcelldeathandtheirregulation.	
Unit-4	**Manipulating and studying cells-** Isolationofcellsandbasicsofcellculture;observingcellsunderamicroscope,differenttypesofmicroscopy;analyzingandmanipulatingDNA,RNAandproteins.	**8Hrs**
Unit-5	**Genome instability and cell transformation-**Mutations,proto-oncogenes,oncogenesandtumoursuppressorgenes,physical,chemicaland biological mutagens; types of mutations;transpositions-transposable genetic elements in prokaryotes and eukaryotes, role oftransposons in genome; viral and cellular oncogenes; tumor suppressor genes; structure,functionandmechanismofaction.	**8Hrs**

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO 1	2	1	2	3	1	1	1	1	2	2	2	1	1	1	1
Average	**2**	**1**	**2**	**3**	**1**	**1**	**1**	**1**	**2**	**2**	**2**	**1**	**1**	**1**	**1**

References

1. Alberts,B.,Johnson,A.,Lewis,J.,Raff,M.,Roberts,K.,&Walter,P.(2008).*Molecular Biology of the Cell* (5thEd.). New York: Garland Science.
2. Lodish, H. F.(2016). *Molecular CellBiology*(8thEd.). NewYork: W.H. Freeman.
3. Krebs,J.E.,Lewin,B.,Kilpatrick,S.T.,&Goldstein,E.S.(2014).*Lewin'sGenesXI*.Burlington,MA:Jones&BartlettLearning.
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 WorldoftheCell*.Boston(8thEd.).BenjaminCummings.
6. Watson,J.D.(2008).*MolecularBiologyoftheGene*(5thd.).MenloPark,CA:Benjamin/Cummings.

Course code	**MSBT-151**
Category	**Applied Sciences**
Course	**Biochemistry Lab.**

title					
Scheme and Credits	**CR**	**L**	**T**	**P**	
	2	0	0	4	
Pre-requisites (if any)	Nil				
Objectives	Theobjectiveofthislaboratorycourseistointroducestudentstoexperimentsinbiochemistry.Thecourseisdesignedto teach students the utility of set ofexperimentalmethodsinbiochemistryinaproblemorientedmanner.				
Outcomes	On completion of this course, studentsshouldbeableto: 1. Toelaborateconceptsofbiochemistrywitheasytorunexperiments; 2. To familiarize with basic laboratoryinstrumentsandunderstandandtheprinciple of measurements usingthoseinstrumentswithexperimentsinbiochemistry.				

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO 1	2	1	2	2	1	1	1	1	2	2	3	1	1	1	2
CO 2	2	2	2	2	1	1	1	1	1	2	2	1	1	2	1
Average	**2**	**1.5**	**2**	**2**	**1**	**1**	**1**	**1**	**1.5**	**2**	**2.5**	**1**	**1**	**1.5**	**1.5**

Experiment details

1. Preparingvariousstocksolutionsandworkingsolutionsthatwillbeneededfort hecourse
2. TopreparеanAcetic-NaAcetateBufferandvalidatetheHenderson-Hasselbachequation.
3. TodetermineanunknownproteinconcentrationbyplottingastandardgraphofBSA usingUV-VisSpectrophotometerandvalidatingtheBeer-Lambert'sLaw.
4. Titration of Amino Acids and separation of aliphatic, aromatic and polar aminoacidsbythinlayerchromatography.
5. Purification and characterization of an enzyme from a recombinant source(suchasAlkalinePhosphataseorLactateDehydrogenaseoranyenzym eoftheinstitution'schoice).

a) Preparationofcell-freelysates
b) AmmoniumSulfateprecipitation
c) Ion-exchangeChromatography
d) GelFiltration
e) AffinityChromatography
f) Dialysisofthepurifiedproteinsolutionagainst60%glycerolasademonstr

ationofstoragemethod

g) Generating a Purification Table (protein concentration, amount of totalprotein; Computing specific activity of the enzyme preparation at eachstageofpurification)

h) AssessingpurityofsamplesfromeachstepofpurificationbySDS-PAGEGelElectrophoresis

i) EnzymeKineticParameters:Km,VmaxandKcat.

Course code	**MSBT-152**				
Category	**Applied Sciences**				
Course title	**Microbial Diversity Lab.**				
Scheme and Credits	**CR**	**L**	**T**	**P**	
	2	0	0	4	
Pre-requisites (if any)	Nil				
Objectives	Theobjectiveofthislaboratorycourseis to provide practical skills on basicmicrobiologicaltechniques				
Outcomes	Studentsshouldbeableto: 1. Isolate,characterizeandidentifycommonbacterialorganisms; 2. Determinebacterialloadofdifferentsamples; 3. Performantimicrobialsensitivitytests; 4. Preservebacterialcultures.				

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO 1	2	1	2	2	1	1	1	1	2	2	3	1	1	1	3
CO 2	2	-	2	2	1	1	1	1	1	2	-	1	1	3	1
CO 3	2	1	2	-	1	1	1	-	2	2	3	1	3	1	2
CO 4	2	2	2	2	1	1	1	1	1	2	2	1	1	2	1
Average	**2.0**	**1.0**	**2.0**	**1.5**	**1.0**	**1.0**	**1.0**	**0.8**	**1.5**	**2.0**	**2.0**	**1.0**	**1.5**	**1.8**	**1.8**

Experiment details

1. Sterilization,disinfectionandsafetyinmicrobiologicallaboratory.
2. Preparationofmediaforcultivationofbacteria.
3. Isolationofbacteriainpureculturebystreakplatemethod.
4. Studyofcolonyandgrowthcharacteristicsofsomecommonbacteria:
5. *Bacillus,E.coli,Staphylococcus,Streptococcus,etc.*
6. PreparationofbacterialsmearandGram'sstaining.
7. Enumerationofbacteria:standardplatecount.
8. Antimicrobialsensitivitytestanddemonstrationofdrugresistance.
9. Maintenanceofstockcultures:slants,stabsandglycerolstockcultures
10. Determinationofphenolco-efficientofantimicrobialagents.
11. DeterminationofMinimumInhibitoryConcentration(MIC)

Course code	**MSBT -153**				
Category	**Applied Sciences**				
Course title	**Biophysical Techniques Lab**				
Scheme and Credits	**CR**	**L**	**T**	**P**	
	2	0	0	4	
Pre-requisites (if any)	Nil				
Objectives	Theobjectiveofthislaboratorycourseistointroducestudentstoexperimentsin Biophysical techniques. Thecourseisdesignedto teach students the utility of set ofexperimentalmethodsinaproblemorientedmanner.				
Outcomes	On completion of this course, studentsshouldbeableto: 1. Toelaborateconceptsofbiophysicaltechniqieswitheasytorunexperiments; 2. To familiarize with basic laboratoryinstrumentsandunderstandandtheprinciple of measurements usingthoseinstrumentswithexperimentsinbiochemistry, microbiology and bimolecules.				

	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PSO	PSO	PSO

	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	2	1	2	2	1	1	1	1	2	2	2	1	1	1	2
CO 2	2	2	2	2	1	1	1	1	1	2	1	1	1	3	1
Average	**2**	**1.5**	**2**	**2**	**1**	**1**	**1**	**1**	**1.5**	**2**	**1.5**	**1**	**1**	**2**	**1.5**

Experiment details

1. ExperimentalverificationthatabsorptionatOD_{260}ismorefordenaturedDNA ascomparedtonativedoublestrandedDNA.reversalofthesamefollowingDNA renaturation.KineticsofDNArenaturationasafunctionofDNAsize.
2. IdentificationofanunknownsampleasDNA,RNAorproteinusingavailable laboratorytools.(OptionalExperiments)
3. Biophysicalmethods(CircularDichroismSpectroscopy,FluorescenceSpectroscopy).
4. DeterminationofmassofsmallmoleculesandfragmentationpatternsbyMas sSpectrometry.
5. As per syllabus

SEMESTER-II

Course code	**MSBT -201**				
Category	**Applied Sciences**				
Course title	**Genetic Engineering**				
Scheme and Credits	**CR**	**L**	**T**	**P**	
	4	4	0	0	
Pre-requisites (if any)	Nil				
Objectives	The objectives of this course are to teach students with various approaches to conducting genetic engineering and their applications in biological research as well as in biotechnology industries. Genetic engineering is a technology that has been developed based on our fundamental understanding of the principles of molecular biology and this is reflected in the contents of this course.				
Outcomes	On completion of this course,studentsshouldbeableto: 1.Endowed with strong theoretical knowledge of this technology. 2.Acquainted with tools of RDT like enzymes, vectors and hosts. 3.Apply RDT in different domains of life science, medical, agriculture, forensic and allied fields for the welfare of living beings.				
S. No.	**Unit details**				**Time Allotted**
Unit-1	**Introduction and tools for genetic engineering:**Impactof 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-				**6Hrs**

	western and colony hybridization, fluorescence in situ hybridization.	
Unit-2	**Different types of vectors:**Plasmids; Bacteriophages; M13 mp vectors; PUC19 and Bluescript vectors, hagemids; Lambda vectors; Insertion and Replacement vectors; Cosmids; Artificial chromosome vectors (YACs; BACs); Principles for maximizing gene expression expression vectors; pMal; GST; pET-based vectors; Protein purification; His-tag; GST-tag; MBP-tag *etc*.; Intein-based vectors; Inclusion bodies; methodologies to reduce formation of inclusion bodies; mammalian expression and replicating vectors; Baculovirus and *Pichia*vectors system, plant based vectors, Ti and Ri as vectors, yeast vectors, shuttle vectors.	**7Hrs**
Unit-3	**Different types of PCR techniques:** Principles of PCR: primer design; fidelity of thermostable enzymes; DNA polymerases; types of PCR – multiplex, nested; reverse-transcription PCR, real time PCR, touchdown PCR, hot start PCR, colony PCR, asymmetric PCR, cloning of PCR products; T-vectors; proof reading enzymes; PCR based site specific mutagenesis; PCR in molecular diagnostics; viral and bacterial detection; sequencing methods; enzymatic DNA sequencing; chemical sequencing of DNA; automated DNA sequencing; RNA sequencing; chemical synthesis of oligonucleotides; mutation detection: SSCP, DGGE, RFLP.	**7Hrs**
Unit-4	**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; DNasefootprinting; methyl interference assay, chromatin immunoprecipitation; protein-protein interactions using yeast two-hybrid system; phage display.	**7Hrs**

Unit-5	**Gene silencingand genome editing technologies:** Gene silencing techniques; introduction to siRNA; siRNA technology; Micro RNA; construction of siRNA vectors; principle and application of gene silencing; gene knockouts and gene therapy; creation of transgenic plants; debate over GM crops; introduction to methods of genetic manipulation in different model systems *e.g.* fruit flies(*Drosophila*), worms (*C. elegans*), frogs (*Xenopus*), fish (zebra fish) and chick; Transgenics- gene replacement; gene targeting; creation of transgenic and knock-outmice; disease model; introduction to genome editing by CRISPR-CAS with specific emphasis on Chinese and American clinical trials.	**13Hrs**

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO 1	2	2	2	2	1	-	1	1	1	2	-	1	1	3	2
CO 2	2	1	2	-	1	1	1	3	2	2	2	1	3	1	2
CO 3	2	2	2	2	1	1	1	1	1	2	2	1	1	2	1
Average	**2.0**	**1.7**	**2.0**	**1.3**	**1.0**	**0.7**	**1.0**	**1.7**	**1.3**	**2.0**	**1.3**	**1.0**	**1.7**	**2.0**	**1.7**

References	1. Old, R. W., Primrose, S. B., &Twyman, R. M. (2001). Principles of Gene Manipulation: an Introduction to Genetic Engineering. Oxford: Blackwell Scientific Publications. 2. Green, M. R., & Sambrook, J. (2012). Molecular Cloning: a Laboratory Manual. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press. 3. 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, New England Biolab etc.

Course code	**MSBT -202**				
Category	**Applied Sciences**				
Course title	**Immunotechnology**				
Scheme and Credits	**CR**	**L**	**T**	**P**	
	3	3	0	0	
Pre-requisites (if any)	Nil				
Objectives	The objectives of this course are to learn about structural features of components of immune system as well as their function. The major				

	emphasis of this course will be on development of immune system and mechanisms by which our body elicits immune response. This will be imperative for students as it will help them to predict about nature of immune response that develops against bacterial, viral or parasitic infection, and prove it by designing new experiments.	
Outcomes	On completion of this course, students should be able to: 1. Evaluate usefulness of immunologyin different pharmaceutical companies; 2. Identify proper research lab working in area of their own interests; 3. Apply their knowledge and design immunological experiments to demonstrate innate, humoral or cytotoxic T lymphocyte responses and figure out kind of immune responses in the setting of infection (viral or bacterial).	
S. No.	**Unit details**	**Time Allotted**
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, Organs of immune system, primary and secondary lymphoid organs.	**5Hrs**
Unit-2	**Immune responses generated by B and T lymphocytes:**Immunoglobulins - basic structure, classes & subclasses of immunoglobulins, antigenic determinants; multigene organization of immunoglobulin genes; B-cell receptor; Immunoglobulin superfamily; principles of cell signaling; basis of self & non-self discrimination; kinetics of immune response, memory; B cell maturation, activation and differentiation; generation of antibody diversity; T-cell maturation, activation and differentiation and T-cell receptors; functional T Cell subsets; cell-mediated immune responses, ADCC; cytokines: properties, receptors and therapeutic uses; antigen processing and presentation-endogenous antigens, exogenous antigens, non-peptide bacterial antigens and super-antigens; cell-cell co-operation,	**8Hrs**

	Hapten-carrier system.	
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 knock outs.	**6Hrs**
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, viral-like particles (VLPs), dendritic cell based vaccines, vaccine against cancer, T cell based vaccine, edible vaccine and therapeutic vaccine.	**8Hrs**
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; transplantation: immunological basis of graft rejection; clinical transplantation and immunosuppressive therapy; tumor immunology: tumor antigens; immune response to tumors and tumor evasion of the immunesystem, 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.	**8Hrs**
Unit-6	**Immunogenetics:** Major histocompatibility complex genes and their role in autoimmune and infectious diseases, HLA typing, human major histocompatibility complex (MHC), 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, genetics of human immunoglobulin, immunogenetics of spontaneous	**5Hrs**

	control of HIV, KIR complex.	

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	1	2	-	1	1	1	3	2	2	2	1	3	1	2
CO 2	2	1	1	3	2	1	2	1	3	1	1	2	2	1	1
CO 3	2	2	2	2	1	1	1	1	1	2	2	1	1	2	1
Average	**2.0**	**1.3**	**1.7**	**1.7**	**1.3**	**1.0**	**1.3**	**1.7**	**2.0**	**1.7**	**1.7**	**1.3**	**2.0**	**1.3**	**1.3**

References

1. Kindt, T. J., Goldsby, R. A., Osborne, B. A., &Kuby, J. (2006). Kuby Immunology. New York: W.H. Freeman.
2. Brostoff, J., Seaddin, J. K., Male, D., &Roitt, I. M. (2002). Clinical Immunology. London: Gower Medical Pub.
3. Murphy, K., Travers, P., Walport, M., &Janeway, C. (2012). Janeway's Immunobiology. New York: Garland Science.
4. Paul, W. E. (2012). Fundamental Immunology. New York: Raven Press.
5. Goding, J. W. (1996). Monoclonal Antibodies: Principles and Practice: Production and Application of Monoclonal Antibodies in Cell Biology, Biochemistry, and Immunology. London: Academic Press.
6. Parham, P. (2005). The Immune System. New York: Garland Science.

Course code	**MSBT -203**				
Category	**Applied Sciences**				
Course title	**Bioinformatics**				
Scheme and Credits	**CR**	**L**	**T**	**P**	
	3	3	0	0	
Pre-requisites (if any)	Nil				
Objectives	The objectives of this course are to provide theory and practical experience of theuse of common computational tools and databases which facilitate investigation of molecular biology and evolution-related concepts.				
Outcomes	On completion of this course,studentsshouldbeableto: 1. Develop an understanding of basic theory of these computational tools; 2. Gain working knowledge of these computational tools and methods; 3. Appreciate their relevance for investigating specific contemporary biological questions; 4. Critically analyse and interpret results of their study.				

S. No.	Unit details	Time Allotted
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 XML DTD'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.	**5Hrs**
Unit-2	**DNA sequence analysis:**DNA sequence analysis: gene bank sequence database; submitting DNA sequences to databases and database searching; sequence alignment; pairwise alignment techniques; motif discovery and gene prediction; local structural variants of DNA, their relevance in molecular level processes, and their identification; assembly of data from genome sequencing.	**5Hrs**
Unit-3	**Multiple sequence analysis:** Multiple sequence analysis; multiple sequence alignment; flexible sequence similarity searching with the FASTA3 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 submitted sequences, methods of phylogenetic analysis.	**5Hrs**
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; sequence alignment- methods, evaluation, scoring; protein completion: backbone construction and side chain addition; small peptide methodology; software accessibility; building peptides;	**5Hrs**

	protein displays; substructure manipulations, annealing.	
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, mutation tables, 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.	**6Hrs**

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO 1	2	1	2	1	1	1	1	3	2	2	2	1	3	1	2
CO 2	3	1	1	-	2	3	2	1	3	-	1	2	2	-	1
CO 3	1	2	1	2	1	1	1	1	1	1	-	1	1	2	1
CO 4	2	2	2	2	1	1	1	1	1	2	2	1	1	2	1
Average	**2.0**	**1.5**	**1.5**	**1.3**	**1.3**	**1.5**	**1.3**	**1.5**	**1.8**	**1.3**	**1.3**	**1.3**	**1.8**	**1.3**	**1.3**

References

1. Lesk, A. M. (2002). Introduction to Bioinformatics. Oxford: Oxford University Press.
2. Mount, D. W. (2001). Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
3. 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-Blackwell.
5. Bourne, P. E., &Gu, J. (2009). Structural Bioinformatics. Hoboken, NJ: Wiley-Liss.
6. Lesk, A. M. (2004). Introduction to Protein Science: Architecture, Function, and Genomics. Oxford: Oxford University Press.

Course code	**MSBT -204**				
Category	**Applied Sciences**				
Course title	**Genomics and Proteomics**				
Scheme and Credits	**CR**	**L**	**T**	**P**	
	4	4	0	0	
Pre-requisites (if any)	Nil				
Objectives	The objective of this course is to provide introductory knowledge concerning genomics, proteomics and their applications.				
Outcomes	On completion of this course,studentsshouldbeableto: 1. Acquire knowledge and understanding offundamentals of genomics and proteomics, transcriptomics and metabolomics and their applications in various applied areas of biology.				

S. No.	**Unit details**	**Time Allotted**
Unit-1	**Basics of genomics and proteomics:**Brief overview of prokaryotic and eukaryotic genome organization; extra-chromosomal DNA: bacterial plasmids, mitochondria and chloroplast.	**3Hrs**
Unit-2	**Genome mapping:**Genetic and physical maps; markers for genetic mapping; methods and techniques used for gene mapping, physical mapping, linkage analysis, cytogenetic techniques, FISH technique in gene mapping, somatic cell hybridization, radiation hybrid maps, *in situ* hybridization, comparative gene mapping.	**4Hrs**
Unit-3	**Genome sequencing projects:** Human Genome Project, genome sequencing projects for microbes, plants and animals, accessing and retrieving genome project information from the web.	**3Hrs**
Unit-4	**Comparative genomics:** 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.	**5Hrs**
Unit-5	**Proteomics:** Aims, strategies and challenges in proteomics; proteomics technologies: 2D-PAGE, isoelectric focusing, mass spectrometry, MALDI-TOF,	**5Hrs**

	yeast 2-hybrid system, proteome databases.	
Unit-6	**Functional genomics and proteomics:** Transcriptome analysis for identification and functional annotation of gene, 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.	**8Hrs**

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO 1	2	1	2	1	1	1	1	3	2	2	2	1	3	1	2
Average	2	1	2	1	1	1	1	3	2	2	2	1	3	1	2

References

1. Primrose, S. B., Twyman, R. M., Primrose, S. B., & Primrose, S. B. (2006).
2. Principles of Gene Manipulation and Genomics. Malden, MA: Blackwell Pub.
3. Liebler, D. C. (2002). Introduction to Proteomics: Tools for the New Biology.Totowa, NJ: Humana Press.
4. Campbell, A. M., &Heyer, L. J. (2003). Discovering Genomics, Proteomics, and Bioinformatics. San Francisco: Benjamin Cummings.

Course code	**MSBT -205**				
Category	**Applied Sciences**				
Course title	**Drug Discovery and Development**				
Scheme and Credits	**CR**	**L**	**T**	**P**	
	4	4	0	0	
Pre-requisites (if any)	Nil				
Objectives	This course will give a broad overview of research and development carried out in industrial setup towards drug discovery.				
Outcomes	On completion of this course,studentsshouldbeableto: 1. Understand basics of R&D in drug discovery and should be able to apply knowledge gained in respective fields of pharmaceutical industry. 2. Critically analyse and interpret results of their study.				
S. No.	**Unit details**				**Time Allotted**

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 theHTS process and the importance of bioinformatics and data processing in identification of lead compounds; Rational drug design, based on understanding the three-dimensionalstructures 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.	**7Hrs**
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).	**5Hrs**
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 documentationIntegration of non-clinical andpreclinical	**5Hrs**

	data to aid design of clinical studies.	
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.	**4Hrs**
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.	**4Hrs**
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 Complianceto current ethical guidelines, Ethical Committees and their set up, Animal Ethical issues and compliance.	**4Hrs**

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO 1	2	1	2	1	1	1	1	3	2	2	2	1	2	1	2
CO 2	2	2	1	3	1	2	2	2	1	1	2	1	2	1	1
Average	**2**	**1.5**	**1.5**	**2**	**1**	**1.5**	**1.5**	**2.5**	**1.5**	**1.5**	**2**	**1**	**2**	**1**	**1.5**

References

1. Krogsgaard-Larsen et al. Textbook of Drug Design and Discovery. 4th Edition. CRC Press.
2. Kuhse, H. (2010). Bioethics: an Anthology. Malden, MA: Blackwell.
3. Nally, J. D. (2006) GMP for Pharmaceuticals. 6th edition. CRC Press
4. Brody, T. (2016) Clinical Trials: Study Design, Endpoints and Biomarkers, Drug Safety, and FDA and ICH Guidelines. Academic Press.

Course code	**MSBT -206**				
Category	**Applied Sciences**				
Course title	**Environmental Biotechnology**				
Scheme and Credits	**CR**	**L**	**T**	**P**	
	4	4	0	0	
Pre-requisites	Nil				

(if any)	
Objectives	This course aims to introduce fundamentals of Environmental Biotechnology. The course will 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.
Outcomes	On completion of this course,studentsshouldbeableto: 1. Understand use of basicmicrobiological, molecular and analytical methods, which are extensively used in environmental biotechnology.

S. No.	**Unit details**	**Time Allotted**
Unit-1	**Introduction to environment:**Introduction to environment; 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.	**6Hrs**
Unit-2	**Bioremediation:**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*).	**6 Hrs**
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, rhizofiltrationphytostabilization).	**6 Hrs**
Unit-4	**Biotechnology and agriculture:** Bioinsecticides: Bacillus thuringiensis, Baculoviruses, uses, genetic modifications and aspects of safety in their use; Biofungicides: Description of mode of actions and mechanisms (e.g. Trichoderma, Pseudomonas fluorescens); Biofertilizers: Symbiotic systems	**11 Hrs**

	between plants – microorganisms (nitrogen fixing symbiosis, mycorrhiza fungi symbiosis), Plant growth promoting rhizobacteria (PGPR) – use, practical aspects and problems in application.	
Unit-5	**Biofuels:** 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.	**11 Hrs**

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO 1	2	2	1	3	1	2	2	2	1	1	2	1	2	1	1
Average	**2**	**2**	**1**	**3**	**1**	**2**	**2**	**2**	**1**	**1**	**2**	**1**	**2**	**1**	**1**

References

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. Scragg A., (2005) Environmental Biotechnology. Pearson Education Limited.
4. J. S. Devinny, M. A. Deshusses and T. S. Webster, (1998), Biofiltration for Air Pollution Control, CRC Press.
5. H. J. Rehm and G. Reed, (2001), Biotechnology – A Multi-volume Comprehensive Treatise, Vol. 11, 2nd Ed., VCH Publishers Inc.

Course code	**MSBT -207**				
Category	**Applied Sciences**				
Course title	**Microbial Technology**				
Scheme and Credits	**CR**	**L**	**T**	**P**	
	4	4	0	0	
Pre-requisites (if any)	Nil				
Objectives	The objectives of this course are to introduce students to developments/ advances made in field of microbial technology for use in human welfare and solving problems of the society.				
Outcomes	On completion of this course,studentsshouldbeableto: 1. Develop deeper understanding of the microbial technology and its applications.				
S. No.	**Unit details**				**Time**

		Allotted
Unit-1	**Introduction to microbial technology:**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 as 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.	**8Hrs**
Unit-2	**Environmental applications of microbial technology:**Environmental application of microbes; Ore leaching; Biodegradation - biomass recycle and removal; Bioremediation - toxic waste removal and soil remediation; Global Biogeochemical cycles; Environment sensing (sensor organisms/ biological sensors); International and National guidelines regarding use of genetically modified organisms in environment, food and pharmaceuticals.	**6 Hrs**
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 (biologicals 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).	**8Hrs**
Unit-4	**Food applications of microbial technology:** Application of microbes and microbial processes in food and healthcare industries - food processing and food preservation, antibiotics and enzymes production, microbes in targeted delivery application – drugs and vaccines (bacterial and viral vectors); Non- recombinant ways of introducing desirable properties in Generally	**7Hrs**

	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.*).	
Unit-5	**Advances in microbial technology:** Microbial genomics for discovery of novel enzymes, drugs/ antibiotics; Limits of microbial genomics with respect to use in human welfare; Metagenomics and metatranscriptomics – 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.	**8Hrs**

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO 1	2	2	1	3	1	2	2	2	1	1	2	1	2	1	1
Average	**2**	**2**	**1**	**3**	**1**	**2**	**2**	**2**	**1**	**1**	**2**	**1**	**2**	**1**	**1**

References

1. Lee, Y. K. (2013). Microbial Biotechnology: Principles and Applications. Hackensack, 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.
4. The New Science of Metagenomics Revealing the Secrets of Our Microbial Planet. (2007). Washington, D.C.: National Academies Press.
5. Journals: (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)

Course code	**MSBT-251**				
Category	**Applied Sciences**				
Course title	**Genetic Engineering Lab.**				
Scheme and Credits	**CR**	**L**	**T**	**P**	
	2	0	0	4	

Pre-requisites (if any)	Nil
Objectives	The objectives of this course are to provide students with experimental knowledge of molecular biology and genetic engineering.
Outcomes	On completion of this course, studentsshouldbeableto: 1. Gain hands- on experience in gene cloning, protein expression and purification. This experience would enable them to begin a career in industry that engages ingenetic engineering as well as in research laboratories conducting fundamental research.

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO 1	2	3	1	3	2	2	3	3	1	1	2	1	2	3	1
Average	**2**	**3**	**1**	**3**	**2**	**2**	**3**	**3**	**1**	**1**	**2**	**1**	**2**	**3**	**1**

Experiment details

1. Concept of lac-operon:
   a) Lactose induction of B-galactosidase.
   b) Glucose Repression.
   c) Diauxic growth curve of E.coli
2. UV mutagenesis to isolate amino acid auxotroph
3. Phage titre with epsilon phage/M13
4. Genetic Transfer-Conjugation, gene mapping
5. Plasmid DNA isolation and DNA quantitation
6. Restriction Enzyme digestion of plasmid DNA
7. Agarose gel electrophoresis
8. Polymerase Chain Reaction and analysis by agarose gel electrophoresis
9. Vector and Insert Ligation
10. Preparation of competent cells
11. Transformation of E.coli with standard plasmids, Calculation of transformation efficiency
12. Confirmation of the insert by Colony PCR and Restriction mapping
13. Expression of recombinant protein, concept of soluble proteins and inclusion body formation in E.coli, SDS-PAGE analysis
14. Purification of His-Tagged protein on Ni-NTA columns

a) Random Primer labeling

b) Southern hybridization.

Course code	**MSBT-252**				
Category	**Applied Sciences**				
Course title	**Immunotechnology Lab.**				
Scheme and Credits	**CR**	**L**	**T**	**P**	
	2	0	0	4	
Pre-requisites (if any)	Nil				
Objectives	The objectives of this laboratory course are to develop an understanding about practical aspects of components of immune system as well as their function. Basic as well as advanced methods will be taught to detect different antigen andantibody interactions, isolation of different lymphocyte cells *etc*. and how they can be used in respective research work.				
Outcomes	On completion of this course, students should be able to: 1. Evaluate usefulness of immunology in different pharmaceutical companies 2. Identify proper research lab working in area of their owninterests; 3. Apply their knowledge and design immunological experiments to demonstrate innate, humoral or cytotoxic T lymphocyte responses and figure out kind of immune responses in setting of infection (viral or bacterial) by looking at cytokine profile.				

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO 1	2	3	1	3	2	2	2	2	2	1	1	1	3	-	1
CO 2	2	1	2	2	1	2	-	2	1	2	2	2	-	3	2
CO 3	2	2	1	1	1	2	3	3	2	1	2	1	2	3	1
Average	**2.0**	**2.0**	**1.3**	**2.0**	**1.3**	**2.0**	**1.7**	**2.3**	**1.7**	**1.3**	**1.7**	**1.3**	**1.7**	**2.0**	**1.3**

Experiment details

1. Selection of animals, preparation of antigens, immunization and methods of blood collection, serum separation and storage.
2. Antibody titre by ELISA method.
3. Double diffusion, Immuno-electrophoresis and Radial Immuno diffusion.
4. Complement fixation test.
5. Isolation and purification of IgG from serum or IgY from chicken egg.

6. SDS-PAGE, Immunoblotting, Dot blot assays.
7. Blood smear identification of leucocytes by Giemsa stain.
8. Separation of leucocytes by dextran method.
9. Demonstration of Phagocytosis of latex beads and their cryopreservation.
10. Separation of mononuclear cells by Ficoll-Hypaque and their cryopreservation.
11. Demonstration of ELISPOT.
12. Demonstration of FACS.

Course code	**MSBT-253**				
Category	**Applied Sciences**				
Course title	**Bioinformatics Lab.**				
Scheme and Credits	**CR**	**L**	**T**	**P**	
	2	0	0	4	
Pre-requisites (if any)	Nil				
Objectives	The aim of this course is to provide practical training in bioinformatics methods including accessing major public sequence databases, use of different computational tools to find sequences, analysis of protein and nucleic acid sequences by various software packages.				
Outcomes	On completion of this course, studentsshouldbeableto: 1. Describe contents and properties of most important bioinformatics databases; 2. Perform text- and sequence-based searches and analyze and discuss results in light of molecular biological knowledge; 3. Explain major steps in pairwise and multiple sequence alignment, explain principle and execute pairwise sequence alignment by dynamic programming; 4. Predict secondary and tertiary structures of protein sequences.				

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO 1	2	3	1	3	2	2	2	2	2	1	1	1	3	-	1
CO 2	1	1	2	2	1	2	-	2	1	2	2	2	-	3	2
CO 3	1	3	1	3	2	2	2	2	2	1	1	1	3	-	1
CO 4	2	2	1	1	1	2	3	3	2	1	2	1	2	3	1
Average	**1.5**	**2.3**	**1.3**	**2.3**	**1.5**	**2.0**	**1.8**	**2.3**	**1.8**	**1.3**	**1.5**	**1.3**	**2.0**	**1.5**	**1.3**

Experiment details

1. Using NCBI and Uniprot web resources
2. Introduction and use of various genome databases.
3. Sequence information resource: Using NCBI, EMBL, Genbank, Entrez, Swissprot/

TrEMBL, UniProt.
4. Similarity searches using tools like BLAST and interpretation of results.
5. Multiple sequence alignment using ClustalW.
6. Phylogenetic analysis of protein and nucleotide sequences.
7. Use of gene prediction methods (GRAIL, Genscan, Glimmer).
8. Using RNA structure prediction tools.
9. Use of various primer designing and restriction site prediction tools.
10. Use of different protein structure prediction databases (PDB, SCOP, CATH).
11. Construction and study of protein structures using Deepview/PyMol.
12. Homology modelling of proteins.
13. Use of tools for mutation and analysis of the energy minimization of protein structures.
14. Use of miRNA prediction, designing and target prediction tools.

SEMESTER-III

Course code	**MSBT -301**				
Category	**Applied Sciences**				
Course title	**Plant Biotechnology**				
Scheme and Credits	**CR**	**L**	**T**	**P**	
	4	4	0	0	
Pre-requisites (if any)	Nil				
Objectives	The objective of the course is to give students new knowledge and widening of the knowledge acquired in other course by handling of classical and modern plant biotechnology processes, including breeding of healthy plants, plants with improved characteristics and plants for biomolecule production.				
Outcomes	On completion of this course,studentsshouldbeableto: 1.Gain fundamental knowledge in plant biotechnology and their applications.				
S. No.	**Unit details**				**Time Allotted**
Unit-1	**Introduction to Plant Tissue culture:** Micropropagation: Introduction, Stages of micropropagation, advantages and disadvantages of micropropagation. **Techniques:** Axillary bud proliferation- methodology, advantages, disadvantages and applications. Organogenic				**8Hrs**

	differentiation- introduction, methodology and applications. Virus –free plant production. Embryo culture- methodology and significance. Somaclonal variations: Nomenclature, methods, applications and disadvantages. Somatic Embryogenesis: methods and applications, Artificial/ synthetic seeds.	
Unit-2	**In vitro Haploid Production:** Androgenic methods: anther culture, microspore culture, ovule culture, factors effecting and organogenesis. Significance and use of haploids, chromosome doubling. Gynogenic haploids: factors effecting gynogenesis, chromosome elimination techniques for production of haploids in cereals. **Protoplast isolation and culture**: Methods of protoplast isolation, protoplast culture, Protoplast fusion, Products of protoplast fusion.	**6 Hrs**
Unit-3	**Cryobiology:** Cryopreservation of plant cell cultures and establishment of gene banks. **Biological nitrogen fixation:** Concept of nitrogen fixation, mechanism, Microbes involved, systems for studying nitrogen fixation, molecular biology of nitrogen fixation. **Phytoremediation-** Mechanism and applications. Introduction to Forest Biotechnology.	**6 Hrs**
Unit-4	**Plant Transformation studies:** Ti and Ri plasmid vectors, Binary vectors, Genetic markers, viruses and transposable elements. **Vectorless or direct DNA transfer:** Physical, chemical and imbibation methods of gene transfer	**8 Hrs**
Unit-5	**Plant Transgenics:** Chloroplast engineering, Development of stress tolerant plants- disease resistance, herbicide resistance. Transgenic plants as bioreactors: production of secondary metabolites, edible vaccines. Commercial transgenic crops. Issues related to transgenic crops.	**8 Hrs**

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO 1	2	3	1	3	2	2	2	2	2	1	1	1	3	-	1
Average	**2**	**3**	**1**	**3**	**2**	**2**	**2**	**2**	**2**	**1**	**1**	**1**	**3**	**-**	**1**

References

1. Chawla, H. S. (2000). Introduction to Plant Biotechnology. Enfield, NH: Science.
2. Razdan, M. K. (2003). Introduction to Plant Tissue Culture. Enfield, NH: Science.
3. Slater, A., Scott, N. W., & Fowler, M. R. (2008). Plant Biotechnology: an Introduction to Genetic Engineering. Oxford: Oxford University Press.

Course code	**MSBT -302**				
Category	**Applied Sciences**				
Course title	**Biostatistics**				
Scheme and Credits	**CR**	**L**	**T**	**P**	
	3	3	0	0	
Pre-requisites (if any)	Nil				
Objectives	The objective of this course is to give conceptual exposure of essential contents of statistics to students.				
Outcomes	On completion of this course,studentsshouldbeableto: 1.Learn data collection, organization, summarization and analysis. 2.Demonstrate skills in drawing inferences about a body of data when only a part of the data is observed. 3. Demonstrate skills in interpreting and communicating the results of statistical analysis, orally and in writing. 4. Apply basic statistical concepts commonly used in Health and Medical Sciences.				
S. No.	**Unit details**				**Time Allotted**
Unit-1	**Measures of central tendency and dispersion:**Basic terms, measures of central tendency and dispersion: Population, sample, variable, parameter, primary and secondary data, screening and representation of data. Frequency distribution, tabulation, bar diagram, histograms, pie diagram, cumulative frequency curves. Mean median, mode, quartiles and percentiles, measures of dispersion: range, variance, standard deviation, coefficient of variation.				**7 Hrs**
Unit-2	**Probability and distributions:** Sample space, events, equally likely events. Definition of probability (frequency approach), independent events. Addition and multiplication rules, conditional probability, examples bernoulli, binomial, poisson and normal distributions.				**5 Hrs**
Unit-3	**Methods of sampling:** Methods of sampling: Use of random numbers to generate simple random samples				**4Hrs**

	with replacement and without replacement. Sampling distribution and standard deviation of sample mean. Stratified sampling and its advantages.	
Unit-4	**Hypothesis testing:** Hypothesis testing: Hypothesis, critical region, and error probabilities. Tests for proportion, equality of proportions, equality of means of normal populations when variance known and when variances are unknown. Chi-square test for independence. P-value of the statistic. Introduction to analysis of variance.	**8 Hrs**

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO 1	2	2	1	1	1	3	-	2	2	1	1	1	3	-	1
CO 2	2	1	2	2	2	-	3	2	1	2	2	2	-	3	2
CO 3	2	2	1	1	1	3	-	2	2	1	1	1	3	-	1
CO 4	3	2	1	2	1	2	3	3	2	1	2	1	2	3	1
Average	**2.3**	**1.8**	**1.3**	**1.5**	**1.3**	**2.0**	**1.5**	**2.3**	**1.8**	**1.3**	**1.5**	**1.3**	**2.0**	**1.5**	**1.3**

References	1. Methods in Biostatistics: For Medical Students and Research Workers, 7th Edition, Mahajan BK. 2. Understanding Biostatistics, Kallen A, 2011. 3. Fundamentals of Biostatistics 7th Edition, Rosner B, 2010.

Course code	**MSBT -303**				
Category	**Applied Sciences**				
Course title	**Animal Biotechnology**				
Scheme and Credits	**CR**	**L**	**T**	**P**	
	4	4	0	0	
Pre-requisites (if any)	Nil				
Objectives	The objective of the course is to give students new knowledge and widening of the knowledge acquired in other course by use of science and engineering to modify living organisms. The goal is to make products, to improve animals and to develop microorganisms for specific agricultural uses.				
Outcomes	On completion of this course,studentsshouldbeableto: 1. Understand various applications of biotechnology for livestock improvement. 2. Develop skills for animal cells culture in laboratory. 3. Learn about the cloning and livestock genetic characterization.				

	4. Learn methods of micromanipulation. 5. Analyze the causes of different animal diseases and their diagnostics.	
S. No.	**Unit details**	**Time Allotted**
Unit-1	Structure and organization of animal cell and equipmentsandmaterial for animal cell culture technology.Primary cell culture & establishment of cell lines.History of Animal cell culture medium-balanced salt solution and simple growth medium role of CO_2 serum and supplements. Serum and protein free defined media.	**6Hrs**
Unit-2	Viability and cytotoxicity measurement, cell characterization, growth kinetics. Scaling-up of animal cell culture. Cell synchronization, Cell cloning & micro manipulation.	**10Hrs**
Unit-3	Recombinant approaches to vaccine production; Hybridoma technology; Diagnostic assays based on Antigen-antibody; radioimmunoassay and enzyme immunoassays; Immunoblotting; Nucleic acid Restriction endonuclease analysis; PCR, Real time PCR; Nucleic acid sequencing; Animal disease diagnostic kits; Probiotics.	**10Hrs**
Unit-4	Cryopreservation of sperms and ova of livestock; Artificial insemination; Super ovulation; in vitro fertilization; Culture of embryos; Cryopreservation of embryos; Embryo transfer; Embryo-splitting; Embryo sexing; Micromanipulation of animal embryos. Transgenic animal technology and its different applications; Animal cloning- basic concepts; Cloning from embryonic cells and adult cells; Ethical, social and moral issues related to cloning; in situ and ex situ preservation of germplasm; in utero testing of foetus for genetic defects; Pregnancy diagnostic kits; Anti-fertility animal vaccines.	**8 Hrs**
Unit-5	Genetic characterization of livestock breeds; Introduction to animal genomics; Different methods for characterization of animal genomes, SNP, STR, QTLS, RFLP, RAPD, proteomics, metabolomics; Genetic basis for disease resistance; Gene knock out technology and animal models for human genetic disorders. Immunological and nucleic acid based methods for identification of animal species; Detection of adulteration in meat using DNA based methods; Detection of food/feed adulteration with animal protein; Identification of wild animal species using DNA based methods using different	**8 Hrs**

	parts including bones, hair, blood, and skin confiscated by anti-poaching agencies.	

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	2	1	1	1	2	2	2	2	1	1	1	3	2	1
CO 2	2	1	2	2	2	1	3	2	1	2	2	2	2	2	2
CO 3	2	-	1	1	1	-	2	-	2	1	1	1	-	1	1
CO 4	3	2	1	-	1	2	3	3	2	1	2	1	2	-	1
CO 5	3	2	1	2	1	2	3	3	2	1	2	1	2	3	1
Average	**2.4**	**1.4**	**1.2**	**1.2**	**1.2**	**1.4**	**2.6**	**2**	**1.8**	**1.2**	**1.6**	**1.2**	**1.8**	**1.6**	**1.2**

References

1. Glick, B. R., & Pasternak, J. J. (2010). Molecular Biotechnology: Principles and Applications of Recombinant DNA. Washington, D.C.: ASM Press.
2. Brown, T. A. (2006). Gene Cloning and DNA Analysis: an Introduction. Oxford: Blackwell Pub.
3. Primrose, S. B., &Twyman, R. M. (2006). Principles of Gene Manipulation and Genomics. Malden, MA: Blackwell Pub.
4. Pörtner, R. (2007). Animal Cell Biotechnology: Methods and Protocols. Totowa, NJ: Humana Press.

Course code	**MSBT -304**				
Category	**Applied Sciences**				
Course title	**Intellectual Property Rights, Biosafety and Bioethics**				
Scheme and Credits	**CR**	**L**	**T**	**P**	
	3	3	0	0	
Pre-requisites (if any)	Nil				
Objectives	The objectives of this course are: • To provide basic knowledge on intellectual property rights and their implications in biological research and product development; • To become familiar with India's IPR Policy; • To learn biosafety and risk assessment of products derived from biotechnology and regulation of such products; • To become familiar with ethical issues in biological research. This course will focus on consequences of biomedical research technologies such as cloning of whole organisms, genetic modifications, DNA testing.				
Outcomes	On completion of this course,studentsshouldbeableto: • Understand the rationale for and against IPR and especially patents;				

	• Understand why India has adopted an IPR Policy and be familiar with broad outline of patent regulations; • Understand different types of intellectual property rights in general and protection of products derived from biotechnology research and issues related to application and obtaining patents; • Gain knowledge of biosafety and risk assessment of products derived from recombinant DNA research and environmental release of genetically modified organisms, • national and international regulations; • Understand ethical aspects related to biological, biomedical, health care and biotechnology research.	
S. No.	**Unit details**	**Time Allotted**
Unit-1	**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 to history of GATT, WTO, WIPO and TRIPS; plant variety protection and farmers rights act; concept of 'prior art': invention in context of "prior art"; patent databases - country-wise patent searches (USPTO, EPO, India); analysis and report formation.	**5Hrs**
Unit-2	**Agreements and Treaties:** History of GATT & TRIPS Agreement; Madrid Agreement; Hague Agreement; WIPO Treaties; Budapest Treaty; PCT; Indian Patent Act 1970 & recent amendments	**8Hrs**
Unit-3	**Concept of biosafety:**Biorisk, Hazardous characteristics of the agent, Laboratory procedures, Good lab practices, Principles of biosafety, Biosafety levels to personnel, environment and community	**8Hrs**
Unit-4	**Biosafety guidelines:** Definition of GMOs & LMOs; Roles of Institutional Biosafety Committee, RCGM, GEAC etc. for GMO applications in food and agriculture; Environmental release of GMOs; Risk Analysis; Risk Assessment; Cartagena Protocol.	**6 Hrs**
Unit-5	**Perceptions of ethical biotechnology:** Morality, Legality and ethics, Principles of bioethics, Ethical	**6 Hrs**

	conflicts in biotechnology, , Social and ethical implications of biological weapons, Ethical limits of biotechnology	

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	2	1	1	1	3	2	2	2	1	1	1	3	2	1
CO 2	2	1	2	2	2	2	2	2	1	2	2	2	2	2	2
CO 3	-	2	1	1	1	-	1	-	2	1	1	1	-	1	1
CO 4	3	2	1	2	1	2	-	3	2	1	2	1	2	-	1
CO 5	3	2	1	2	1	2	3	3	2	1	2	1	2	3	1
Average	**2**	**1.8**	**1.2**	**1.6**	**1.2**	**1.8**	**1.6**	**2**	**1.8**	**1.2**	**1.6**	**1.2**	**1.8**	**1.6**	**1.2**

References	1. Ganguli, P. (2001). Intellectual Property Rights: Unleashing the Knowledge Economy.New Delhi: Tata McGraw-Hill Pub. 2. National IPR Policy, Department of Industrial Policy & Promotion, Ministry of Commerce, GoIComplete Reference to Intellectual Property Rights Laws. (2007). Snow White Publication Oct. 3. Kuhse, H. (2010). Bioethics: an Anthology. Malden, MA: Blackwell.Office of the Controller General of Patents, Design & Trademarks; Department of Industrial Policy & Promotion; Ministry of Commerce & Industry; Government of India. http://www.ipindia.nic.in/ 4. Karen F. Greif and Jon F. Merz, Current Controversies in the Biological Sciences-Case Studies of Policy Challenges from New Technologies, MIT Press

Course code	**MSBT -305**				
Category	**Applied Sciences**				
Course title	**Bioprocessing Technology**				
Scheme and Credits	**CR**	**L**	**T**	**P**	
	4	4	0	0	
Pre-requisites (if any)	Nil				
Objectives	The objectives of this course are to educate students about the fundamental concepts of bioprocess technology and its related applications, thus preparing them to meet the challenges of the new and emerging areas of biotechnology industry.				
Outcomes	On completion of this course,studentsshouldbeableto: • Appreciate relevance of microorganisms from industrial context;				

	• Carry out stoichiometric calculations and specify models of their growth; • Give an account of design and operations of various fermenters; • Present unit operations together with the fundamental principles for basic methods in production technique for bio-based products; • Calculate yield and production rates in a biological production process, and also interpret data; • Calculate the need for oxygen and oxygen transfer; • Critically analyze any bioprocess from market point of view; • Give an account of important microbial/enzymatic industrial processes in food and fuel industry.

S. No.	**Unit details**	**Time Allotted**
Unit-1	**Basic principles of biochemical engineering:**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.	**4Hrs**
Unit-2	**Stoichiometry and models of microbial growth:**Elemental balance equations; metabolic coupling – ATP and NAD+; yield coefficients; unstructured models of microbial growth; structured models of microbial growth.	**4 Hrs**
Unit-3	**Bioreactor design and analysis:**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.	**8 Hrs**
Unit-4	**Downstream processing and product recovery:** Separation of insoluble products - filtration, centrifugation, sedimentation, flocculation; Cell disruption; separation of soluble products: liquid-liquid extraction, precipitation, chromatographic techniques, reverse osmosis, ultra and	**8 Hrs**

	micro filtration, electrophoresis; final purification: drying; crystallization; storage and packaging.	
Unit-5	**Applications of enzyme technology in food processing:** 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. **Applications of microbial technology in food process operations and production, biofuels and biorefinery:** 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	**8 Hrs**

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	2	1	1	1	3	2	2	2	1	1	1	3	2	1
CO 2	2	1	2	2	2	2	2	2	1	2	2	2	2	2	2
CO 3	-	2	1	1	1	-	1	-	2	1	1	1	-	1	1
CO 4	3	2	1	2	1	2	-	3	2	1	2	1	2	-	1
CO 5	3	2	1	2	1	2	3	3	2	1	2	1	2	3	1
CO 6	2	2	1	1	1	3	2	2	2	1	1	1	3	2	1
CO 7	-	2	1	1	1	-	1	-	2	1	1	1	-	1	1
CO 8	2	1	2	2	2	2	2	2	1	2	2	2	2	2	2
Average	**1.8**	**1.8**	**1.3**	**1.5**	**1.3**	**1.8**	**1.6**	**1.8**	**1.8**	**1.3**	**1.5**	**1.3**	**1.8**	**1.6**	**1.3**

References	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. 4. Bailey, J. E., &Ollis, D. F. (1986). Biochemical Engineering Fundamentals. New York: McGraw-Hill.

Course code	**MSBT -306**				
Category	**Applied Sciences**				
Course title	**Nanobiotechnology**				
Scheme and Credits	**CR**	**L**	**T**	**P**	
	4	4	0	0	
Pre-requisites (if any)	Nil				
Objectives	The course aims at providing a general and broad introduction to multi-disciplinary field of nanotechnology. It will familiarize students with the combination of thetop-down approach of microelectronics and micromechanics with the bottom- up approach of chemistry/biochemistry; a development that is creating new and exciting cross-disciplinary research fieldsand technologies. The course will also give an insight into complete systems where nanotechnology can be used to improve our everyday life.				
Outcomes	On completion of this course,studentsshouldbeableto: describe basic science behind the properties of materials at nanometre scale, and the principles behind advanced experimental and computational techniques for studying nanomaterials.				
S. No.	**Unit details**				**Time Allotted**
Unit-1	**Introduction to nanobiotechnology:**Introduction to Nanobiotechnology; Concepts, historical perspective; Different formats of nanomaterials and applications with example for specific cases; Cellular Nanostructures; Nanopores; Biomolecular motors; Bio-inspired Nanostructures, Synthesis and characterization of different nanomaterials.				**5Hrs**
Unit-2	**Nano – films:**Thin films; Colloidal nanostructures; Self Assembly, Nanovesicles; Nanospheres; Nanocapsules and their characterisation.				**5 Hrs**
Unit-3	**Nano – particles:**Nanoparticles for drug delivery, concepts, optimization of nanoparticle properties for suitability of administration through various routes of delivery, advantages, strategies for cellular internalization and long circulation, strategies for enhanced permeation through				**5Hrs**

	various anatomical barriers.	
Unit-4	**Applicationsof nano – particles:** Nanoparticles for diagnostics and imaging (theranostics); concepts of smart stimuli responsive nanoparticles, implications in cancer therapy, nanodevices for biosensor development.	**5Hrs**
Unit-5	**Nano – materials:** Nanomaterials for catalysis, development and characterization of nanobiocatalysts, application of nanoscaffolds in sythesis, applications of nanobiocatalysis in the production of drugs and drug intermediates. **Nano – toxicity:** Introduction to Safety of nanomaterials, Basics of nanotoxicity, Models and assays for Nanotoxicity assessment; Fate of nanomaterials in different stratas of environment; Ecotoxicity models and assays; Life Cycle Assessment, containment.	**10Hrs**

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO 1	2	2	1	1	1	3	2	2	2	1	1	1	3	2	1
Average	**2**	**2**	**1**	**1**	**1**	**3**	**2**	**2**	**2**	**1**	**1**	**1**	**3**	**2**	**1**

References

1. GeroDecher, Joseph B. Schlenoff, (2003); Multilayer Thin Films: Sequential Assembly of Nanocomposite Materials, Wiley-VCH Verlag GmbH & Co. KGaA
2. David S. Goodsell, (2004); Bionanotechnology: Lessons from Nature; Wiley-Liss
3. Neelina H. Malsch (2005), Biomedical Nanotechnology, CRC Press
4. Greg T. Hermanson, (2013); Bioconjugate Techniques, (3rd Edition); ElsevierRecent review papers in the area of Nanomedicine.

Course code	**MSBT -307**				
Category	**Applied Sciences**				
Course title	**Vaccines**				
Scheme and Credits	**CR**	**L**	**T**	**P**	
	4	4	0	0	
Pre-requisites (if any)	Nil				
Objectives	This course will provide students with an overview of current developments in different areas of vaccines.				
Outcomes	On completion of this course, students should be able to: • Understand fundamental concepts of human immune system and basic immunology; • Differentiate and understand immune responses in relation to infection and vaccination;				

	• Understand requirement and designing of different types of vaccines; • Understand importance of conventional and new emerging vaccine technologies.	
S. No.	**Unit details**	**Time Allotted**
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.	**6Hrs**
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 of CD4+ and CD8+ T cells; Memory responses: Memory and effector T and B cells, Generation and Maintenance of memory T and B cells.	**9Hrs**
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 in vaccination; Oral immunization and Mucosal Immunity.	**8Hrs**
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.	**3Hrs**
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).	**4Hrs**

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	2	1	1	1	3	2	2	2	1	1	1	3	2	1
CO 2	3	2	1	2	1	2	-	3	2	1	2	1	2	-	1
CO 3	-	2	1	1	1	-	1	-	2	1	1	1	-	1	1
CO 4	2	1	2	2	2	2	2	2	1	2	2	2	2	2	2
Average	**1.8**	**1.8**	**1.3**	**1.5**	**1.3**	**1.8**	**1.3**	**1.8**	**1.8**	**1.3**	**1.5**	**1.3**	**1.8**	**1.3**	**1.3**

References

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 Vaccination Strategies. Weinheim: Wiley-VCH.
4. Journal Articles (relevant issues) from: Annual Review of Immunology, Annual Review of Microbiology, Current Opinion in Immunology, Nature Immunology, Expert review of vaccines.Nature; Wiley-Liss

Course code	**MSBT-351**
Category	**Applied Sciences**
Course title	**Plant Biotechnology Lab.**

Scheme and Credits	**CR**	**L**	**T**	**P**
	2	0	0	4

Pre-requisites (if any)	Nil
Objectives	The objectives of this course are to provide hands-on training in basic experiments of plant biotechnology.
Outcomes	On completion of this course, studentsshouldbeableto: 1. Gain basic skills in plant biotechnology.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	2	1	1	1	3	2	2	2	1	1	1	3	2	1
Average	**2**	**2**	**1**	**1**	**1**	**3**	**2**	**2**	**2**	**1**	**1**	**1**	**3**	**2**	**1**

Experiment details

1. Prepare culture media with various supplements for plant tissue culture.
2. Prepare explants of *Vallerianawallichii* for inoculation under aseptic conditions.
3. Attempt in vitro andro and gynogenesis in plants (*Daturastramonium*).
4. Isolate plant protoplast by enzymatic and mechanical methods and attempt fusion by PEG (available material).
5. Culture *Agrobacterium tumefaciens* and attempt transformation of any dicot species.
6. Generate an RAPD and ISSR profile of *Eremuruspersicus* and *Vallerianawallichii*.
7. Prepare karyotypes and study the morphology of somatic chromosomes of *Allium cepa, A. sativum, A. tuberosum* and compare them on the basis of karyotypes.

8. Pollen mother cell meiosis and recombination index of select species(one achiasmate, and the other chiasmate) and correlate with generation of variation.
9. Undertake plant genomic DNA isolation by CTAB method and its quantitation by visual as well as spectrophotometeric methods.
10. 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.
11. Study genetic fingerprinting profiles of plants and calculate polymorphic information content.

Course code	**MSBT-353**														
Category	**Applied Sciences**														
Course title	**Animal Biotechnology Lab.**														
Scheme and Credits	**CR**	**L**	**T**	**P**											
	2	0	0	4											
Pre-requisites (if any)	Nil														
Objectives	The objectives of this course are to provide hands-on training in basic experiments of animal biotechnology.														
Outcomes	On completion of this course, studentsshouldbeableto: 1. Gain basic skills in animal biotechnology.														
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO 1	3	2	1	1	2	3	2	2	1	1	2	2	2	3	1
Average	**3**	**2**	**1**	**1**	**2**	**3**	**2**	**2**	**1**	**1**	**2**	**2**	**2**	**3**	**1**

Experiment details

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.
6. Isolate DNA from animal tissue by SDS method.
7. Attempt animal cell fusion using PEG.

Course code	**MSBT-381**
Category	**Applied Sciences**
Course	**Seminar**

title					
Scheme and Credits	**CR**	**L**	**T**	**P**	
	2	0	0	4	

SEMESTER-IV

Course Code	**Course / Title**	**L**	**T**	**P**	**Credit**
MSBT-481	Seminar	0	0	04	2
MSBT-491	Dissertation	0	0	24	12
	Total	**0**	**0**	**28**	**14**