

## **Savitribai Phule Pune University**

(Formerly University of Pune)

Two Year Degree Program in Microbiology

(Faculty of Science & Technology)

Revised Syllabi for

M.Sc. (Microbiology) Part-II

(For Department of Microbiology Savitribai Phule Pune University)

Choice Based Credit System Syllabus

To be implemented from Academic Year 2019-2020

M. Sc. [II]

## **Syllabus:**

	Semester III		
Subject Code	Subject Title	No. of Lectures/ Practical	No. of Credits
MB3.1.2 C	Instrumentation and Biophysical Techniques		02
	1. <b>Spectroscopic Methods</b> : Principles and Applications	12	
	of UV-Visible, Fluorescence, Infrared, NMR, X-ray		
	Diffraction and structure determination.		
	2. Basic Concepts, Principles and Applications Of	5	
	Centrifugation Methods: Ultra centrifugation,		
	Differential centrifugation, Isopycnic and Rate zonal		
	centrifugation.		
	3. Basic principles of optical microscopy, Concept of	12	
	resolution and magnification, Different contrast	13	
	enhancing techniques: Phase contrast, dark field, differential interference contrast, Fluorescence etc.		
	Concepts of digital microscopy and image analysis,		
	Confocal microscopy and introduction to super		
	resolution microscope, Electron and cryo-electron		
	microscopy, Introduction to magnetic and optical		
	tweezers.		
MB3.2.2 C	Molecular Biology II		02
	1. Prokaryotic and Eukaryotic Transcription and its	13	
	regulation		
	a. Prokaryotic Transcription and Regulation:		
	RNA Polymerase, Transcription unit, Initiation-		
	promoter recognition, Elongation, intrinsic and		
	rho-dependant termination, Concept of Operon		
	(lactose, galactose, arabinose, tryptophan,		
	histidine, phage lambda), Positive and Negative		
	regulation, Regulation by attenuation, Phage strategies to regulate transcription,		
	antitermination.		
	b. Eukaryotic Transcription and Regulation:		
	RNA Polymerases I, II and III, Transcription unit		
	for each polymerase, Transcription factors,		
	Processing of transcripts, promoters and		
	enhancers.		
	c. Post Transcriptional Modifications: Processing		
	of hnRNA, tRNA, rRNA, 5'-Cap formation, 3'-end		
	processing and polyadenylation, Splicing, RNA		
	editing, Nuclear export of mRNA, mRNA		
	stability, Catalytic RNA. Transcriptional and post-		
	transcriptional gene silencing.	12	
	2. Prokaryotic and Eukaryotic Translation and its	13	
	regulation  a. Genetic code.		
	b. Prokaryotic and Eukaryotic Translation:		
	Activation of tRNA, Initiation – role of initiation		

	Semester III		
Subject Code	Subject Title	No. of Lectures/ Practical	No. of Credits
	factors, Shine Dalgarno sequences, Elongation – Role of elongation factors, translocation of ribosomes, Termination – termination codons, role of release factors, GTP as an important source of energy for translation, Fidelity of translation.  c. Co and post-translational modifications and regulation.  d. miRNA and RNAi, CRISPER-Cas system and its application to molecular biology.  e. Molecular biology in organogenesis and development.  3. <b>Protein Targeting</b> -Transport: Transport of proteins and molecular chaperones, Protein stability, Protein	04	
15222	turn over and degradation.		
MB3.3.2 C	Microbial Technology  1. Microbial Strain Improvement: The need for strain improvement programme for industrial applications, Strategies of strain improvement for primary and secondary metabolites, Problems associated with strain improvement programme, Preservation of	02	
	<ul> <li>cultures after strain improvement programme.</li> <li>2. Basic Aspects of Bioengineering: Design of fermenter/ bioreactors- Design aspects of flask, Stirred tank reactor, Air-lift fermenter, Tower fermenter, Kinetics of operation of bioreactors, Batch, Fed-batch, Continuous processes, Design and operation of immobilized cell reactors.</li> </ul>	03	02
	3. Aeration and Agitation of Fermentation Broth: Aeration-Theory of oxygen transfer in bubble aeration, Oxygen transfer kinetics, determination of K <sub>La</sub> , Agitation-Design of impellers and their hydrodynamics, Fermentation broth rheology and power requirements for agitation-Concept of Newtonian and non-Newtonian fluids, effect of broth rheology on heat, nutrient and oxygen transfer, Reynolds number, power number, aeration number.	04	
	4. <b>Monitoring of Process Variables:</b> Use of various types of sensors and biosensors for monitoring environmental parameters (pressure, pH, temperature, DO, DCO <sub>2</sub> etc.)	03	
	5. Concept of Primary (Growth Associated) and Secondary (Growth Non-Associated) Metabolites: Their control, Kinetics of growth and product	03	
	formation (growth rate, yield coefficient, efficiency).  6. <b>Down-stream Processing and Product Recovery:</b> Principle and general description of instrumentation, Recovery of particulates (cells and solid particles), Recovery of intracellular products, primary isolation	10	

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	<ul> <li>(extraction, sorption), Precipitation, Industrial processes for chromatography and fixed bed adsorption, Membrane separations.</li> <li>7. Production, Recovery, Assay and Applications With Respect to Following Examples: Vitamin B and C, Antibiotics (Penicillin acylase, Cycloheximide, Tetracyclins), Microbial enzymes (Chitinase, Lipase), Polysaccharide (Xanthum gum and PHB), Citric acid, Ethanol, Wine, SCP, Recombinant and synthetic vaccines, Bioemulsifier/Biosurfactant.</li> </ul>	05	
MB3.4.2 C	Ecology, Environmental and Agricultural		02
	Microbiology 1. Ecology: Interactions between environment and biota, Concept of habitat and ecological niches, Limiting factor, Energy flow, food chain, food web and tropic levels, Ecological pyramids and recycling, Biotic Community-Concept, Structure, Dominance, Fluctuation and succession.	05	
	Geomicrobiology: Microbes in metal extraction,     Mineral leaching and mining, Microbes in petroleum product formation.	05	
	<ol> <li>Space Microbiology: Historical development of space microbiology, Life detection methods-Evidence of metabolism (Gulliver), Evidence of photosynthesis (autotrophic and heterotrophic).</li> <li>Bioremediation: Treatment of solid saccharification, gasification, composting including vermicomposting, and liquid industrial wastes, Microbial degradation of</li> </ol>	10	
	pesticides, Xenobiotics, Microbial enhanced oil recovery (MEOR), Phytoremediation, Bioremediation - Advantages and disadvantages.	02	
	5. <b>Agricultural Microbiology</b> : Useful and harmful microbes to crop growth. Microflora of rhizosphere and rhizoplane, phyllosphere and phylloplane. Plant growth promoting rhizobacteria (PGPR), Biological control agents: <i>Bacillus thuringiensis</i> , <i>Trichoderma</i> , Baculoviruses and Chitinase producing fungi, Bacteriophages.	08	
MB3.01.3	Environmental and Agricultural Microbiology		03
	(Any 15 Practical)  1. Effect of Plant growth promoting rhizobacteria (PGPR) on plant growth in normal and high salinity conditions.	03P 02P	
	2. Bioleaching of metals from waste.	02P	
	<ul><li>3. Utilization of microbial consortium for the treatment of solid waste.</li><li>4. Production of fungal biopolymers (chitin and</li></ul>	03P	
	chitosan).	02P	

	Semester III		
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	5. Waste water analysis: pH, conductivity, total		
	dissolved solids (TDS), Dissolved oxygen (DO),		
	Chemical oxygen demand (COD), Biochemical	01P	
	oxygen demand (BOD), alkalinity, chloride and	01P	
	hardness measurements.	0.00	
	6. Removal of suspended solids by sand filter method.	02P	
	7. Determination of heavy metals (Fe/Cu) by	02P	
	spectrophotometric methods.	02P	
	8. Decolourization/adsorption dye.		
	9. Use of Fenton reaction for degradation of pollutants.		
MB3.02.3	10. Photocatalytic degradation of pollutants.  Microbial Technology		03
WID5.02.5	(Any 15 Practical)	04P	03
	1. Isolation of industrially important microorganisms for	041	
	microbial processes (Organic acid / antibiotic /		
	enzymes / amino acid) and improvement of strain for		
	increase yield by mutation.	06P	
	2. Lab scale media optimization, production and		
	extraction for any two of the following: Organic acid /		
	Antibiotic / Enzyme / Amino acid / Wine /		
	Biosurfactant / Polysaccharide / PHB production.	01P	
	3. Preservation of industrially important bacteria by		
	lyophilisation.	01P	
	4. Cell disruption for intracellular enzymes by various		
	extraction methods.	01P	
	5. Enzymatic clarification of fruit juices.	02P	
	6. Culturing of <i>Chlorella / Spirulina</i> .	01P	
	7. Liquefaction and saccharification of corn or molasses.	02P	
	8. Biomedical applications of microbial products.	02P	
	9. Microbial enhanced oil recovery.		
MB3.03.2	Advanced Instrumentation Techniques		
MD5.05.2	Advanced Instrumentation Techniques (Any 10 Practical)		
	1. Fluorescence microscopy analysis of live cells.	01P	
	2. Cell segmentation and image quantification.	011 01P	02
	3. NMR and FTIR spectroscopy.	02P	02
	4. Determination of surface and interfacial tension using	01P	
	Tensiometer.	01P	
	5. Fluorescence lifetime measurement and determination	-	
	of quantum yield.	02P	
	6. Next generation DNA sequencing (NGS).	03P	
	7. Mass spectroscopy.	01P	
	8. Separation of biomolecules using HPLC and GC.	02P	
	9. Real-time quantitative PCR.		
	10. Application of CRISPER-Cas system.		

	Semester III		
Subject Code	Subject Title	No. of Lectures/ Practical	No. of Credits
B3.1.2 E	Cancer Biology and Clinical Immunology		02
	1. Cellular transformations during neoplastic growth, Classification of tumors based on histological, physiological, biochemical and immunological properties, Tumors of lymphoid system (lymphoma,	05	
	myeloma, Hodgkin's disease).  2. Different mechanism of cancer cell adaptations, Hallmarks of cancer, Tumor suppressor genes and oncogenes, Tumor microenvironment and cancer cell heterogeneity, Physical and biological factors associated with tumorigenesis, Cancer cell heterogeneity and cancer stem cells, Molecular mechanism of metastasis, Epithelial to mesenchymal transition, mitogenic cell signaling (Ras-Raf-MAPK, ErbB, c-myc, signaling pathways), Concept of tumor associated and tumor specific antigens, role of immune system in cancer, Immunosurveillance and	12	
	<ul> <li>immunoediting.</li> <li>3. Cancer Diagnostics: Conventional and molecular methods, Clinical grading of tumors, Cancer therapy: basic principles of chemotherapy and radiation therapy, Emerging concepts in cancer therapy- Cancer immunotherapy, Passive and adoptive cancer immunotherapy, hyperthermia.</li> </ul>	03	
	<ul> <li>4. Immunological Disorders: Pathophysiology, diagnosis, prognosis and therapeutic approaches to:         <ul> <li>a. Immunodeficiency disorders – Phagocytic deficiencies, humoral deficiencies, Cell mediated deficiencies, combined deficiencies and complement deficiencies.</li> <li>b. Autoimmune disorders (Immunopathological mechanisms and theories of autoimmunity) - Rheumatoid arthritis, Systemic Lupus Erythomatosus (SLE), Multiple myeloma, Myasthenia gravis.</li> </ul> </li> </ul>	10	
MB3.2.2 E	Gene Manipulation/Recombinant Technology		02
 	<ol> <li>Introduction to Recombinant DNA Technology</li> <li>General Strategies for Recombinant DNA Technology and Gene Cloning: genomic libraries, cDNA libraries, single gene cloning.</li> </ol>	01 02	<u> </u>
	3. Tools of Recombinant DNA Technology: Enzymes - DNA ligase, Klenow enzyme, T4 DNA polymerase, Polynucleotide kinase, Alkaline phosphatise, Vectors - Plasmids, cosmids, lambda phage, shuttle vectors, YACs, BACs, Baculovirus and <i>Pichia</i> vectors system, Plant based vectors, Ti and Ri as vectors, Yeast vectors, Shuttle vectors, Cohesive and blunt end ligation, Linkers, Adaptors, Homopolymeric tailing.	12	

	Semester III		
Subject	Subject Title	No. of	No. of
Code		Lectures/ Practical	Credits
	4. Screening and Characterisation of Transformants :	10	
	Hybridization techniques, probe preparation using		
	radioactive and nonradioactive ligands, detection of		
	hybrids, site directed mutagenesis.		
	5. Genetic manipulation of animals.	03	
	6. <b>Purification of recombinant proteins</b> : His-tag, GST-tag, MBP-tag etc.	02	
MB3.3.2 E	Environmental Pollution Monitoring and Wastewater		02
	Technology		
	1. Environmental Pollution Monitoring: Basic	02	
	concepts.	03	
	2. Natural Resources: Water and Land. Components		
	and structure of the environment, Levels of		
	organization in nature - Food chain and Trophic		
	structure, Biogeochemical Cycles, Interdependence of		
	man and environment.	10	
	3. Concepts, Causes and Consequences of Human		
	Impact on the Natural Environment: Definition and		
	sources of pollution, Different types of pollution and		
	their global, regional and local aspects: Air (Global		
	warming, Green-house effect), Water, Radiation, E-		
	wastes, Biomedical wastes.		
	4. Wastewater Technology: Wastewater treatment	15	
	system (unit process): Physical screening, flow		
	equalization, mixing, flocculation, flotation, granular		
	medium filtration, adsorption, Chemical precipitation,		
	disinfection, Dechlorination, Biological: (aerobic and		
	anaerobic, suspended and attached growth processes.)		
	Working treatment systems and their analysis		
	(reactions and kinetics, mass balance analysis, reactor		
	types, Hydraulic character of reactors, selection of		
	reactor type,) Critical operating parameters like DO,		
	hydraulic retention time, mean cell residence time,		
	F/M ratio etc, Effluent disposal, control and reuse.		
	Water pollution control, Regulation and limit for		
	disposals in the lakes, rivers, oceans, and land. Direct		
	and indirect reuse of treated effluents and solid		
	wastes, Current industrial wastewater treatment and		
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	disposal processes (Textile, food and dairy, paper and pulp manufacturing industries).		

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Semester IV

C-1-14	Semester IV		NI1
Subject	Subject Title		Number
Code			of Credita
MD4 01 9 C	D:4-4:		Credits
MB4.01.8 C	Dissertation		08
Elective Cour	rses		
Subject	Subject Title	No. of	Number
Code	Subject Title	Lectures/	of
Coue		Practical	Credits
MB4.1.3 E	Advanced Techniques: Bioinformatics/ Computational	Tactical	03
MD4.1.3 L	Biology		03
	1. Introduction and Biological Databases: Nucleic	15	
	acids, proteins, Genomes-structure data bases, Search	13	
	engines, Sequence data forms and submission tools,		
	Scoring matrices for sequence alignments,		
	Algorithms-pairwise sequence alignments, database		
	similarity searches-BLAST, FASTA phylogenetic		
	analysis and tree building methods, Motif searches,		
	_ =		
	comparative analysis.  2. <b>Protein Modeling and Structure Based</b>	15	
	8	13	
	<b>Approaches:</b> Force field methods, energy, buried and		
	exposed residues, Side chains and neighbors, Fixed		
	regions, hydrogen bonds, Mapping properties onto		
	surfaces, fitting monomers, RMS fit of conformers,		
	Assigning secondary structures, Sequence alignment-		
	methods, Evaluation, Scoring, Protein structure		
	prediction, alignment algorithms, Sequence based		
	methods of structure prediction, Prediction using		
	inverse folding, fold prediction, Significance analysis,		
	Scoring techniques, Sequence-sequence scoring,	1.5	
	Protein function prediction.  2. Computational Pipelagra Introduction to	15	
	3. Computational Biology: Introduction to		
	mathematical modeling in biology, Basic concepts of		
	modeling using ordinary differential equation,		
	Modeling population growth, Logistic, Stochastic and		
	Deterministic models, Modeling molecular processes		
	in the cells-Ligand-receptor binding, Enzymatic		
MD422E	reaction, Transcription and translation.		02
MB4.2.3 E	IPR/ Bioethics and Biosafety / Quality Assurance and		03
	Validation in Industries	10	
	1. Introduction to Intellectual Property (IPR): Types	10	
	of IP: Patents, Trademarks, Copyright and Related		
	Rights, Industrial Design, Traditional Knowledge,		
	Geographical Indications, Protection of New GMOs,		
	International framework for the protection of IP		
	Invention in context of "prior art".	05	
	2. Patent, Filing and Infringement: Types of patents,	05	

	databases, Indian Patent Act 1970, Recent		
	Amendments, Patent application- types (Provisional		
	and complete specifications), forms and guidelines,		
	fee structure, time frames, Precautions before		
	patenting-disclosure/non-disclosure, World		
	Intellectual Property Organization (WIPO) Treaties,		
	Budapest Treaty, Patent Cooperation Treaty (PCT)		
	and Implications, Role of a Country Patent Office,		
	Procedure for filing a PCT application.		
	3. Bioethics and Biosafety: Introduction, Historical	10	
	Background, Introduction to Biological Safety		
	Cabinets, Primary Containment for Biohazards,		
	Recommended Biosafety level for Infectious Agents		
	and Infected Animals, Biosafety Levels of Specific		
	Microorganisms, Biosafety guidelines - Government		
	of India, Definition of genetically modified organisms		
	(GMOs), Roles of Institutional Biosafety Committee,		
	Review Committee on Genetic Modification (RCGM)		
	India, Genetic Engineering Appraisal Committee		
	(GEAC) India etc. for GMO applications in food and		
	agriculture, Environmental release of GMOs, Risk		
	Analysis, Risk Assessment, Risk management and		
	communication, Overview of National Regulations		
	and relevant International Agreements including		
	Cartagena Protocol.		
	4. Quality Assurance and Validation in Industries:	05	
	The concept of ISO Certification, Preparation of		
	Standard Operating procedure (SOP),		
	Validation protocols for methods in - Quality Control,		
	Process validation-The above should be discussed		
	within World Health Organization (WHO) Norms,		
	Exercises on preparation of SOPs, Operation and validation for analytical methods.		
MB4.3.3 E	Omics Concepts in Biology		03
1.3.3 1	1. Introduction to Genomics: Pre and Post Genomic	20	
	era, Major advancements in Genomic approaches,	20	
	Epigenetics and Metagenomics, Forward versus		
	reverse Genomics, Genome analysis-Genome editing		
	approaches and their applications, Gene expression		
	approaches and their applications. Next Generation		
	Sequencing (NGS)-Illumina (Solexa), Roche 454,		
	Sequencing by Oligonucleotide Ligation and		
	detection (SOLiD), Ion Torrent Technology etc.		
	Parallel sequencing, Nanopore sequencing, Sequence		
	analysis and their applications: Human Genetics and		
	Human Genome Project, Genomic insights into		
	evolution, advantages of comparative genomic		
	analysis, Analysis of microarray data.	15	
	2. <b>Proteomics</b> : Introduction, types of proteomics		
	investigation and importance of proteomics Tools of		
	proteomics-Separation technology (SDS PAGE, 2D		
	PAGE), Liquid chromatography, Mass Spectrometry		

	<ul> <li>(Ionizers, analyzers and detectors), Protein and peptide microarray-based technology, Protein identification by peptide mass fingerprinting. Polymerase chain reaction (PCR)-directed protein in situ arrays, Structural proteomics, Applications of proteomics: Host-pathogen interaction, protein-protein interaction, drug discovery.</li> <li>3. Metabolomics: Basic concept of metabolomics, Metabolic fingerprinting, and metabolic profiling, Tools of metabolomics: Capillary electrophoresis, Gas chromatography (GC), Electrochemical detectors, Applications of Metabolomics in Biology.</li> </ul>	10	
MB4.4.2 E	Therapeutics: Vaccine Technology		02
	1. Basic principles of a vaccine action, a short history of vaccination, Mechanism of vaccine action, Active and passive immunization, General immunization practices, Live, killed, attenuated, sub unit vaccines, Toxoid vaccines, Role and properties of adjuvants, Recombinant DNA and protein based vaccines, plant-based vaccines, Reverse vaccinology, Peptide vaccines, Conjugate vaccines, Licensed vaccines, Viral Vaccine (Poliovirus vaccine-inactivated and Live, Rabies vaccines, Hepatitis A and B vaccines), Bacterial Vaccine (Anthrax vaccines, Cholera vaccines, Diphtheria toxoid), Parasitic vaccine (Malaria Vaccine), Vaccination of immunocompromised hosts.	15	
	2. The vaccine industry, Vaccine manufacturing, Evolution of adjuvants across the centuries, Vaccine additives and manufacturing residuals, Immunization and World Health Organization (WHO) guidelines, Regulation and testing of vaccines, Vaccine safely, Limitations of vaccines.	15	
MB 4.5.2 E	Molecular Diagnostics: Sensors, Biosensors and other		02
	Diagnostic Techniques		
	1. <b>Biosensors</b> : Basic principles and operations, types of biosensors and applications of biosensors. Point of care medical diagnostic devices.	07	
	2. <b>Medical Diagnostic Techniques</b> : Biochemical, analysis, DNA / RNA based analysis, etc., Necessity for rapid and <i>in situ</i> medical analysis, Miniaturization of medical diagnostic devices-Microfabrication	12	
	<ul> <li>(Materials, processes, techniques for detection).</li> <li>3. Microfluidics: Concept, Procedure, Applications and Challenges, Integrated microfluidic devices: Lab-on-a-chip, system-on-a-chip, micro-total analysis system (μTAS), Present research scenario and future prospects.</li> </ul>	11	
MB4.6.2 E	Stem cell and Regenerative Medicine 1. Stem cell biology: Concepts of stem cells, Adult stem cells, Embryonic stem cells, Induced pluripotent stem cells and Hematopoetic stem cells, Cancer stem cells,	15	02

	Stem cell molecular biology, Cultivation and		
	characterization of stem cells, Extracellular matrices		
	and signalling cues, Stem cell niches,		
	Mechanochemical regulation of cell behaviour,		
	Morphogenesis and tissue engineering.		
	2. <b>Regenerative Medicine</b> : Concepts of Regenerative	15	
	medicine, Three dimensional cell culture,	13	
	Biomaterials and tissue scaffolds, Bioprinting of		
	Organs and Tissues, Translational approaches of		
	Tissue Engineering, Regenerative therapy,		
	Regeneration of bone and cartilage, Molecular		
	therapy for regeneration, Application of Regenerative		
	medicine in Human health, Nanotechnology and		
	Regenerative medicine, Personalized therapy in		
	regenerative medicine.		
MB4.7.1 E	Fungal and Algal Biotechnology		01
	1. Fungal enzymes-Conversion of biomass to bioenergy	02	
	and high value products.		
	2. Fungal products in agricultural management and other	05	
	biological applications.	0.2	
	3. Fungal genetics- post genomic prospective.	03	
	4. Pharmacologically active compounds produced using	02	
	<ul><li>fungi.</li><li>5. Biotechnological applications of algae: Nutrient based</li></ul>	03	
	supplements-lipids and polyunsaturated fatty acids	03	
	(PUFA), protein rich cattle feed, phytosterols,		
	polysaccharides, pigments, antioxidants, biofuels.		
MB4.8.1 E	Physical Biology of Cell		01
1,12 1,0,1 2	1. Concepts of orders and Magnitudes in terms of	05	01
	biological molecules, Physical basis of Internal and		
	external cellular structures, Physical properties of		
	biopolymers, Cellular Thermodynamics.		
	2. Physics of Cell Membrane: membrane rheology,		
	electrical properties of cell membrane, action	05	
	potential, Osmosis and diffusion, Physics of		
	intracellular transport, cell movement and division,		
	Physical basis of protein synthesis.		
	3. Reynolds number and its implication for sustenance	05	
	of Microbial life, Viscoelastic properties of the cell,		
	Molecular motors, Probabilistic view of cellular		
	activity, Randomness in Biology, Biological		
	specificity and kinetic proofreading, Tools and		
MB4.9.1 E	techniques of biophysics research.  Advanced Microscopy		01
WID4.7.1 L	1. Principles of confocal fluorescence microscopy,	06	01
	resolution and point spread function, Light sources in	00	
	fluorescence microscopy, The advanced fluorescence		
	microscope optical train, pinhole and signal channel		
	configurations, detectors, pixels and voxels, contrast,		
	spatial sampling: temporal sampling: signal-to-noise		
	ratio, multichannel images.		
Ī	2. Multiphoton microscopy, Image deconvolution and	09	

	quantification, Advanced fluorescence microscopy techniques: Foerster Resonance Energy Transfer (FRET) microscopy, Fluorescence Lifetime Imaging microscopy (FLIM) and Fluorescence Correlation Spectroscopy (FCS), Total internal Reflection Fluorescence (TIRF) microscopy, Breaking the		
	diffraction barrier: Concept of optical superresolution, Stimulation Emission Depletion (STED) microscopy,		
	Single molecule localization microscopy: Stochastic Optical Reconstruction Microscopy (STORM) and		
	Photoactivation Localization Microscopy (PALM).		
MB4.10.1 E	Analytical and reasoning skills	15	01
	1. Statistical analysis of data.		
	2. Problems based biological experiments in genetics,		
	immunology, Environmental microbiology, Molecular		
	biology, Waste water technology etc.		
MB4.11.1 E	Nanobiotechnology		01
	1. <b>Introduction to Nanotechnology</b> : Different types of		
	nanoparticles, their synthesis and characterization,	05	
	Biomimetics and nanotechnology.		
	2. <b>Applications of Nanobiotechnology</b> : Quantum dots,		
	magnetic nanoparticles and plasmonic nanoparticles	10	
	in biology and medicine, Carbon nanotubes and		
	grapheme, Nanotechnology in agriculture – Fertilizer		
	and pesticides.		