Department: Microbiology, Savitribai Phule Pune University
Course: M.Sc.
Duration: 2 years

Subject Code	Subject Title	No. of Lectures/ Practical	No. of Credits
Semester III			
MB3.1.2 C	**Instrumentation and Biophysical Techniques**		02
	1. **Spectroscopic Methods**: Principles and Applications of UV-Visible, Fluorescence, Infrared, NMR, X-ray Diffraction and structure determination.	12	
	2. **Basic Concepts, Principles and Applications Of Centrifugation Methods:** Ultra centrifugation, Differential centrifugation, Isopycnic and Rate zonal centrifugation.	5	
	3. Basic principles of optical microscopy, Concept of resolution and magnification, Different contrast 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.	13	
MB3.2.2 C	**Molecular Biology II**		02
	1. **Prokaryotic and Eukaryotic Transcription and its regulation**	13	
	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.		

Semester III			
Subject Code	**Subject Title**	**No. of Lectures/ Practical**	**No. of Credits**

	2. **Prokaryotic and Eukaryotic Translation and its regulation**
	  a. Genetic code.
	  b. **Prokaryotic and Eukaryotic Translation:** Activation of tRNA, Initiation – role of initiation 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. **Protein Targeting**-Transport**:** Transport of proteins and molecular chaperones, Protein stability, Protein turn over and degradation.
		13
		
		04	

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 cultures after strain improvement programme. 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. 3. **Aeration and Agitation of Fermentation Broth**: Aeration-Theory of oxygen transfer in bubble aeration, Oxygen transfer kinetics, determination of K_{La}, 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. 4. **Monitoring of Process Variables:** Use of various types of sensors and biosensors for monitoring environmental parameters (pressure, pH, temperature,	02 03 04 03	02

Semester III			
Subject Code	**Subject Title**	**No. of Lectures/ Practical**	**No. of Credits**
	DO, DCO_2 etc.)		
	5. **Concept of Primary (Growth Associated) and Secondary (Growth Non-Associated) Metabolites:** Their control, Kinetics of growth and product formation (growth rate, yield coefficient, efficiency).	03	
	6. **Down-stream Processing and Product Recovery:** Principle and general description of instrumentation, Recovery of particulates (cells and solid particles), Recovery of intracellular products, primary isolation (extraction, sorption), Precipitation, Industrial processes for chromatography and fixed bed adsorption, Membrane separations.	10	
	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.	05	
MB3.4.2 C	**Ecology, Environmental and Agricultural Microbiology**		02
	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	
	2. **Geomicrobiology**: Microbes in metal extraction, Mineral leaching and mining, Microbes in petroleum product formation.	05	
	3. **Space Microbiology**: Historical development of space microbiology, Life detection methods-Evidence of metabolism (Gulliver), Evidence of photosynthesis (autotrophic and heterotrophic).	10	
	4. **Bioremediation**: Treatment of solid saccharification, gasification, composting including vermicomposting, and liquid industrial wastes, Microbial degradation of pesticides, Xenobiotics, Microbial enhanced oil recovery (MEOR), Phytoremediation, Bioremediation - Advantages and disadvantages.	02	
	5. **Agricultural Microbiology**: Useful and harmful microbes to crop growth. Microflora of rhizosphere and rhizoplane, phyllosphere and phylloplane. Plant growth promoting rhizobacteria (PGPR), Biological	08	

Semester III			
Subject Code	**Subject Title**	**No. of Lectures/ Practical**	**No. of Credits**
	control agents: *Bacillus thuringiensis, Trichoderma*, Baculoviruses and Chitinase producing fungi, Bacteriophages.		
MB3.01.3	**Environmental and Agricultural Microbiology** **(Any 15 Practical)** 1. Effect of Plant growth promoting rhizobacteria (PGPR) on plant growth in normal and high salinity conditions. 2. Bioleaching of metals from waste. 3. Utilization of microbial consortium for the treatment of solid waste. 4. Production of fungal biopolymers (chitin and chitosan). 5. Waste water analysis: pH, conductivity, total dissolved solids (TDS), Dissolved oxygen (DO), Chemical oxygen demand (COD), Biochemical oxygen demand (BOD), alkalinity, chloride and hardness measurements. 6. Removal of suspended solids by sand filter method. 7. Determination of heavy metals (Fe/Cu) by spectrophotometric methods. 8. Decolourization/adsorption dye. 9. Use of Fenton reaction for degradation of pollutants. 10. Photocatalytic degradation of pollutants.	03P 02P 02P 03P 02P 01P 01P 02P 02P 02P	03
MB3.02.3	**Microbial Technology** **(Any 15 Practical)** 1. Isolation of industrially important microorganisms for microbial processes (Organic acid / antibiotic / enzymes / amino acid) and improvement of strain for increase yield by mutation. 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. 3. Preservation of industrially important bacteria by lyophilisation. 4. Cell disruption for intracellular enzymes by various extraction methods. 5. Enzymatic clarification of fruit juices. 6. Culturing of *Chlorella / Spirulina*. 7. Liquefaction and saccharification of corn or molasses. 8. Biomedical applications of microbial products. 9. Microbial enhanced oil recovery.	04P 06P 01P 01P 01P 02P 01P 02P 02P	03

Semester III			
Subject Code	**Subject Title**	**No. of Lectures/ Practical**	**No. of Credits**
MB3.03.2	**Advanced Instrumentation Techniques (Any 10 Practical)** 1. Fluorescence microscopy analysis of live cells. 2. Cell segmentation and image quantification. 3. NMR and FTIR spectroscopy. 4. Determination of surface and interfacial tension using Tensiometer. 5. Fluorescence lifetime measurement and determination of quantum yield. 6. Next generation DNA sequencing (NGS). 7. Mass spectroscopy. 8. Separation of biomolecules using HPLC and GC. 9. Real-time quantitative PCR. 10. Application of CRISPER-Cas system.	01P 01P 02P 01P 01P 02P 03P 01P 02P	02
B3.1.2 E	**Cancer Biology and Clinical Immunology** 1. Cellular transformations during neoplastic growth, Classification of tumors based on histological, physiological, biochemical and immunological properties, Tumors of lymphoid system (lymphoma, myeloma, Hodgkin's disease).	05	02
	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 immunoediting.	12	
	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.	03	
	4. **Immunological Disorders**: Pathophysiology, diagnosis, prognosis and therapeutic approaches to: a. Immunodeficiency disorders – Phagocytic deficiencies, humoral deficiencies, Cell mediated deficiencies, combined deficiencies and complement deficiencies.	10	

Semester III			
Subject Code	**Subject Title**	**No. of Lectures/ Practical**	**No. of Credits**
	b. Autoimmune disorders (Immunopathological mechanisms and theories of autoimmunity) - Rheumatoid arthritis, Systemic Lupus Erythomatosus (SLE), Multiple myeloma, Myasthenia gravis.		
MB3.2.2 E	**Gene Manipulation/Recombinant Technology**		02
	1. Introduction to Recombinant DNA Technology	01	
	2. General Strategies for Recombinant DNA Technology and Gene Cloning: genomic libraries, cDNA libraries, single gene cloning.	02	
	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 *Pichia* vectors system, Plant based vectors, Ti and Ri as vectors, Yeast vectors, Shuttle vectors, Cohesive and blunt end ligation, Linkers, Adaptors, Homopolymeric tailing.	12	
	4. Screening and Characterisation of Transformants : Hybridization techniques, probe preparation using radioactive and nonradioactive ligands, detection of hybrids, site directed mutagenesis.	10	
	5. Genetic manipulation of animals.	03	
	6. Purification of recombinant proteins: His-tag, GST-tag, MBP-tag etc.	02	
MB3.3.2 E	**Environmental Pollution Monitoring and Wastewater Technology**		02
	1. Environmental Pollution Monitoring: Basic concepts.	02	
	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.	03	
	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.	10	
	4. Wastewater Technology: Wastewater treatment system (unit process): Physical screening, flow equalization, mixing, flocculation, flotation, granular medium filtration, adsorption, Chemical precipitation,	15	

Semester III			
Subject Code	**Subject Title**	**No. of Lectures/ Practical**	**No. of Credits**
	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 disposal processes (Textile, food and dairy, paper and pulp manufacturing industries).		

Semester IV			
Subject Code	**Subject Title**		**Number of Credits**
MB4.01.8 C	**Dissertation**		08
Elective Courses			
Subject Code	**Subject Title**	**No. of Lectures/ Practical**	**Number of Credits**
MB4.1.3 E	**Advanced Techniques: Bioinformatics/ Computational Biology**		03
	1. **Introduction and Biological Databases**: Nucleic acids, proteins, Genomes-structure data bases, Search 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, Epitope prediction, Data mining tools and applications, Promoter and gene prediction, comparative analysis.	15	
	2. **Protein Modeling and Structure Based Approaches**: 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, Protein function prediction.	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 reaction, Transcription and translation.	15	
MB4.2.3 E	**IPR/ Bioethics and Biosafety / Quality Assurance and Validation in Industries**		03
	1. **Introduction to Intellectual Property (IPR)**: Types of IP: Patents, Trademarks, Copyright and Related Rights, Industrial Design, Traditional Knowledge,	10	

	Geographical Indications, Protection of New GMOs, International framework for the protection of IP Invention in context of "prior art".		
	2. **Patent, Filing and Infringement**: Types of patents, 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.	05	
	3. **Bioethics and Biosafety**: Introduction, Historical 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.	10	
	4. **Quality Assurance and Validation in Industries**: 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.	05	
MB4.3.3 E	**Omics Concepts in Biology**		03
	1. **Introduction to Genomics**: Pre and Post Genomic era, Major advancements in Genomic approaches, 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	20	

	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. **Proteomics**: Introduction, types of proteomics investigation and importance of proteomics Tools of proteomics-Separation technology (SDS PAGE, 2D PAGE), Liquid chromatography, Mass Spectrometry (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.	10	
	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.		
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 Diagnostic Techniques**		02
	1. **Biosensors**: Basic principles and operations, types of biosensors and applications of biosensors. Point of care medical diagnostic devices.	07	
	2. **Medical Diagnostic Techniques**: Biochemical, analysis, DNA / RNA based analysis, etc., Necessity	12	

	for rapid and *in situ* medical analysis, Miniaturization of medical diagnostic devices-Microfabrication (Materials, processes, techniques for detection). 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.	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, 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. **Regenerative Medicine**: Concepts of Regenerative medicine, Three dimensional cell culture, 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.	15 15	02
MB4.7.1 E	**Fungal and Algal Biotechnology** 1. Fungal enzymes-Conversion of biomass to bioenergy and high value products. 2. Fungal products in agricultural management and other biological applications. 3. Fungal genetics- post genomic prospective. 4. Pharmacologically active compounds produced using fungi. 5. Biotechnological applications of algae: Nutrient based supplements-lipids and polyunsaturated fatty acids (PUFA), protein rich cattle feed, phytosterols, polysaccharides, pigments, antioxidants, biofuels.	02 05 03 02 03	01
MB4.8.1 E	**Physical Biology of Cell** 1. Concepts of orders and Magnitudes in terms of 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 potential, Osmosis and diffusion, Physics of intracellular transport, cell movement and division,	05 05	01

	Physical basis of protein synthesis.		
	3. Reynolds number and its implication for sustenance 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 techniques of biophysics research.	05	
MB4.9.1 E	**Advanced Microscopy**		01
	1. Principles of confocal fluorescence microscopy, resolution and point spread function, Light sources in 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.	06	
	2. Multiphoton microscopy, Image deconvolution and 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).	09	
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. **Introduction to Nanotechnology**: Different types of nanoparticles, their synthesis and characterization, Biomimetics and nanotechnology.	05	
	2. **Applications of Nanobiotechnology**: Quantum dots, magnetic nanoparticles and plasmonic nanoparticles in biology and medicine, Carbon nanotubes and grapheme, Nanotechnology in agriculture – Fertilizer and pesticides.	10	