DEPARTMENT OF MICROBIOLOGY

SAVITRIBAI PHULE PUNE UNIVERSITY

REVISED SYLLABUS

FOR

CREDIT BASED

POST GRADUATE COURSE IN MICROBIOLOGY

M. Sc. (MICROBIOLOGY)

Conducted at

Department of Microbiology, SPPU

M. Sc. Part I – w. e. f. June 2018

GENERAL INSTRUCTIONS

1. A full Master's degree course in Sciences would be of 80 credits, where one credit course of theory will be of one clock hour per week, running for 15 weeks and one credit for practical course will consist of 15 clock hours of laboratory exercises. Each practical conducted in the practical course will be of 3 hour duration.

2. For M.Sc. in Microbiology a student should take admission in the Microbiology Department and complete at least 75% courses identified in the syllabus structure of Microbiology. If students so desire, remaining 25% courses can be chosen from other Departments with credit structure. In any case, a student will have to earn compulsory credits from the parent Department (Microbiology).

3. **Course Structure:** There shall be four semesters, at each semester there will be average 20 credits total for theory courses and Practical courses. Theory course shall be core / compulsory credits (C) as well as optional/elective credits (E). Practical course shall have 8 core / compulsory credits (C) per semester, of which the last semester would be for dissertation/ project work.

Credit Distribution per semester

Semester	Theory		Practical
	Core	Elective	Core
I	10	4	8
II	10	4	8
III	8	6	8
IV	0	20	8
	28	34	32

Details of courses for Semester III and IV will be declared later.

4. Course No. are designed to indicate the subject, semester, course serial number, credits assigned and the nature as theory or practicals.
   - MB indicates the subject, Microbiology.
   - 1st digit indicates the semester.
   - Last digit indicates the credits assigned to the course.
   - Middle number indicates the serial number. The serial number beginning with zero signifies that the course is a practical course.
     eg. MB 1.1.2 means 1st semester, 1st paper with two credits.
     Whereas, **MB 1.01.4** means 1st semester, 1st practical course with four credits.

5. Each course will be evaluated for 25 marks per credit of which 50% will be based on continuous / internal evaluation.

6. Results at the end of the semester will be declared using a grade point system as per the University rules.

7. The formula for GPA will be based on weighted average. The final GPA will not be printed unless a student passes courses equivalent to minimum 80 credit hours. Total credit hours means sum of credit hours of the courses which a student has passed.

8. All other rules will be as per the university guidelines for postgraduate courses under credit based system.

9. The above circular supersedes all previous circulars on the credit system being operated at Department of Microbiology, SPPU.

Semester I			
Subject Code	**Subject Title**	**No. of Lectures/ Practicals**	**No. of credits**
Core Courses			
MB1.1.2 C*	**Microbial systematics** 1. **Introduction to Bacterial Taxonomy:** Species concept, Science of classification, 5-Kingdom classification system, 3-Domain classification system, Bergey's Manuals and the classification of prokaryotes, Determinative Bacteriology (Phenetic Approach), Systematic Bacteriology (Phylogenetic Approach), Polyphasic Approach. 2. **Exploration of Un-culturable bacteria:** Concept of 'unculturable' bacterial diversity, Strategies for culture of 'unculturable' bacteria, Culture independent molecular methods for identifying unculturable bacteria, Methods of extracting total bacterial DNA from a habitat and metagenome analysis. 3. **Taxonomy of Fungi:** 6 Classes of Fungi, differentiating characters among different Classes of fungi, importance of morphological characters in fungal differentiation and classification. 4. **Microbial Diversity:** The expanse of microbial diversity, Estimates of total number of species, Species divergence and measurement of microbial diversity, Measures and indices of diversity. 5. Review of classical and current important experimental techniques in microbial taxonomy.	10 08 07 07 05	02
MB1.2.2 C*	**Quantitative Biology/Statistics and Mathematics:** 1. **Concepts in statistics:** Population and sample, Qualitative and quantitative data, Discrete and continuous series data, Measure of central tendency and dispersion, Mean, Mode, Median, Standard deviation and standard error, Random variable and probability distribution (normal, log-normal, binomial, Poisson and exponential). 2. **Hypothesis testing:** Tests of significance based on normal, t and chi-squire distribution, Analysis of variance technique. 3. Displaying of data, Frequency plots, Bar chart, Histograms, Scatter plots, Box plots, Linear regression and correlation, least square fit, Pearson's correlation coefficient, Non-linear regression and data fitting. 4. **Concepts in Mathematics:** Mathematical functions and graph of a function: Linear function, Quadratic function, Exponential function, Periodic function, Logarithmic function, Slope of curves, Limits and idea of derivative, Derivative of simple and exponential function, Calculus, Diffusion equation and mean square displacement.	05 05 05 15	02

Semester I			
Subject Code	**Subject Title**	**No. of Lectures/ Practicals**	**No. of credits**
MB1.3.2 C	**Basic Biochemistry** 1. The nature of the chemical bond, Ionic, Covalent, Coordinate bonds, Dipole-dipole interactions, Electrostatic interactions, Van der Waal's forces, Hydrogen bond. 2. Structure of water, Ionization and concept of pH, Buffer, Mole concept. 3. Structure and function of biological macromolecules. Amino acid and protein structure, Amino acid chemistry, Ramachandran plot, stereochemistry, Carbohydrate chemistry, Nucleic acid structure, Physical and biological basis of nucleic acid structure, Nucleic acid chemistry, Building blocks of lipids, Fatty acid chemistry. 4. Discussion of the classical papers in biochemistry.	05 03 20 02	02
MB1.4.2 C	**Biochemistry and Molecular Biology Techniques** 1. Principles of isolation and purification of biomolecules, Salting out and solvent extraction. 2. **Chromatography:** Theory of partition chromatography, Principles and applications of gel filtration, Ion exchange, affinity, HPLC and FPLC, and Gas chromatography. 3. **Electrophoresis:** DNA and protein electrophoresis. 4. **Polymerase chain reaction:** Principle, Types, Applications. 5. Fluorescence in situ hybridization (FISH) and Microarray technology. 6. **Blotting techniques:** Northern, southern and western blotting. 7. **Sequencing methods:** RNA-sequencing methods and applications, Protein sequencing, DNA sequencing: Classical and next generation sequencing methods, Nanopore sequencing. 8. **Methods to study gene function:** Gene silencing and gene knockout.	04 06 03 04 02 01 07 03	02
MB1.5.2 C	**Cell Biology** 1. **Bacterial cell organization:** Cell wall of Gram positive and Gram negative bacteria, Cell membrane, Secretion system. 2. **Specialized bacterial structures:** Heterocyst and magnetosomes, Flagella, Bacterial cytoskeleton. 3. Mechanism of bacterial cell division. 4. **Eukaryotic cell organization:** cell membrane, ER, Golgi complex, Mitochondrion, Nucleus, Lysosomes and Peroxysomes, cytoskeleton. 5. **The cell cycle:** mitosis and meiosis, programmed cell death.	07 04 02 10 04 03	02

Semester I			
Subject Code	**Subject Title**	**No. of Lectures/ Practicals**	**No. of credits**
	6. Review of important experimental methods in cell biology, Discussion of the classical papers in cell biology.		
MB1.01.4	**Biochemistry** Safety rules in Laboratory. 1. **Buffer**: Determination of pKa of a monoprotic weak organic acid; Preparation of buffers using KH_2PO_4 and K_2HPO_4, acetic acid and sodium acetate, K_2HPO_4 and H_3PO_4. 2. **Isolation of biomolecules:** DNA, proteins and polysaccharides. 3. **Colorimetry and spectrophotometry**: Estimation of sugar and total carbohydrate, estimation of protein and nucleic acids, Estimation of free phosphate. 4. **Chromatography**: Separation of amino acids and sugars by paper and thin layer chromatography (TLC). 5. **Electrophoresis**: Agarose gel electrophoresis of DNA, PAGE and SDS-PAGE of proteins. 6. Denaturation and renaturation of DNA (Tm and Cot). 7. Molecular weight determination by molecular sieve chromatography.	 3 P 3P 6P 2P 3P 1P 2P	04
MB1.02.3	**Microbial Diversity and Systematics** **1. Isolation and identification of bacteria:** Isolation of Halophiles, Thermophiles and Actinomycetes, Determination of diversity index, Identification of the bacteria to at least the Genus level using the Bergey's Manual, Biotyping using Microbial identification system VITEK and 16S rRNA gene sequencing. **2. Isolation and Identification of Fungi:** Isolation of fungi, molds and yeasts, Determination of diversity index, Identification by classical methods, Biotyping using Microbial identification system VITEK and 18S rRNA gene sequencing.	 8P 7P	03
MB1.03.1	**Scientific Communication and Research Methodology** 1. **Concept of effective communication**: Presentation skills, formal scientific presentation skills; Preparing power point presentation, Presenting the work, Scientific poster preparation & presentation; Participating in group discussions. 2. **Technical writing skills:** Types, Formats of scientific reports, scientific writing skills, Significance of communicating science, ethical issues, Copy rights and plagiarism, Components of a research paper, publishing scientific papers - peer review process and problems. 3. Use of search engines for scientific data mining, Use of reference management tools, statistical data analysis using software.	 2P 2P 1P	01

Semester I			
Subject Code	**Subject Title**	**No. of Lectures/ Practicals**	**No. of credits**
Elective Courses			
MB1.1.2 E*	**Cell Trafficking and Intracellular Signaling** 1. **Introduction** to Endocytic pathways, Clathrin mediated and Clathrin independent endocytosis. 2. **Cell Trafficking:** Membrane trafficking, vesicular trafficking, trafficking to and from ER and Golgi complex, Exocytosis. 3. **Cell signaling:** Classical signal transduction pathways, Signaling in space and time, Receptor tyrosine kinases and G protein coupled receptors, MAP kinase signaling cascades, Protein kinase A and Protein kinase C pathways, JAK/STAT pathway, EGFR and Ras signaling, hormonal signaling, NF-Kb pathway, calcium signaling, Regulation of cell signaling, Cell signaling in cancer. 4. Review of important experimental techniques in cellular signaling. Discussion of representative important papers or reviews on cellular signaling.	05 05 17 03	02
MB1.2.2 E*	**Extremophiles and Evolution** **Extremophiles:** 1. Isolation, classification and properties of extremophiles (Hyperthermophiles, Psychrophiles, Halophiles, Acidophiles, Methanogenic extremophiles, etc.) 2. Adaptation mechanisms of extremophiles, biotechnological applications of extremophiles **Evolution:** 1. History and development of evolutionary theory, Neo Darwinism: Spontaneous mutation controversy, evolution of rates of mutation, types of selection, levels of selection, group selection and selfish gene. 2. Sociobiology, kin selection, evolutionary stability of cooperation, sociality and multicellularity in microorganisms, Game theory. Co-evolutionary strategies, host parasite co-evolution, Neutral evolution and molecular clocks, phylogeny and molecular distances. 3. Molecular evolution: origin of life, the origin of new genes and proteins. Evolution of life histories, ageing, evolutionary trade offs, r and k selection, Evolutionary origin of biochemical disorders: The case of insulin resistance.	07 08 05 05 05	02

Semester II			
Subject Code	**Subject Title**	**No. of Lectures/ Practicals**	**No. of credits**
Core Courses			
MB2.1.2 C	**Microbial metabolism (Enzymology, Bioenergetics and Metabolic Pathways)** 1. **Enzymology:** Purifications of enzyme, purification chart, kinetics of single substrate enzyme catalysed reaction. Kinetics of reversible inhibitions enzyme catalyzed reactions, King Altman approach to derive – two substrate enzyme catalyzed reactions, types of two substrate enzyme catalyzed reactions, concept of allosterism, positive and negative co-operativity, models of allosteric enzymes (Monad, Wyamann and Changuax and Koshland, Nemethy and Filmer model), kinetics of allosteric enzyme, Hill plot, examples of allosteric enzymes and their significance in regulation. 2. **Bioenergetics:** Laws of thermodynamics, entropy, enthalpy, free energy, free energy and equilibrium constant, Gibbs free energy equation, determination of free energy of hydrolytic and biological oxidation reduction reactions, under standard and non-standard conditions, high energy compounds, coupled reactions, determination of feasibility of reactions. 3. **Metabolic Pathways:** Glycolysis and gluconeogenesis, Regulation of glycolysis and gluconeogenesis, Pentose phosphate pathway, Glycogen synthesis; breakdown and its regulation, metabolic flux and its regulation by various metabolic intermediates, TCA cycle; its regulation, its role in energy generation, its role in generating biosynthetic intermediates and glyoxylate cycle, Fatty acid biosynthesis and degradation, Nucleotide biosynthesis, degradation and its regulation.	12 06 12	02
MB2.2.2 C*	**Medical Microbiology, Antimicrobial agents and chemotherapy, Pharmaceutical Microbiology** **Medical Microbiology:** 1. **Virulence** factors: Mechanism of adhesion, colonization and invasion of host tissues by bacterial pathogens, Mechanisms of bacterial resistance to host cellular and humoral defenses. 2. **Microbial toxins**: Characteristics, purification, Mode of action and assay (in vivo, in vitro) of diphtheria, cholera, tetanus toxins and endotoxins of Gram negative bacteria, Molecular basis of bacterial pathogenicity – cytoskeletal modulation of host cell, virulence genes and pathogenicity islands 3. **Medical mycology** – pathogenesis of fungi, structural dimorphism and role of extra cellular products in fungal infection.	10	03

Semester II			
Subject Code	**Subject Title**	**No. of Lectures/ Practicals**	**No. of credits**
	4. Epidemiological and investigational approaches for emerging infectious diseases by Viruses and ESKAPE pathogens **Antimicrobial agents and chemotherapy:** 1. Antimicrobial assays in liquid and solid media, susceptibility testing in liquid and solid media. 2. Antibiotics that inhibit peptidoglycan biosynthesis, Drugs that interfere with the biosynthesis of the cell wall of mycobacteria, Fungal cell wall as a target for antimicrobial drugs, Ionophoric antibiotics, Antifungal agents that interfere with the function and biosynthesis of membrane sterols, Inhibitors of nucleic acid biosynthesis, Inhibitors of protein biosynthesis. Nitroheterocyclic antimicrobial agents, A unique antifungal antibiotic- griseofulvin, antiviral agents, antiprotozoal agents. 3. Attack and defense: drug transport across cell walls and membranes. **Pharmaceutical Microbiology:** 1. Study of major groups of pharmacologically active molecules of plant, animal and microbial origins (Extraction and purification). 2. Physical and chemical properties, metabolic activity, identification of drug target/receptors, elucidation of the mechanism of drug action, Drug interactions, toxicity and adverse reactions, toxicity testing, assays for mutagenicity, carcinogenicity, Pyrogenicity and allergy testing. 3. Steps towards commercialization of drug 4. Regulations on drug, FDA.	10 10	
MB2.3.2 C*	**Immunology** 1. **Function and composition of immune system**: Cells and organs, Dendritic cells and antigen presentation, NK cells and their mode of action, Macrophages, T cell and B cell subtypes. 2. **T-cell and B-cell receptors:** Structure and function, Differentiation and maturation of T and B cells, Molecular genetics of TCR and BCR diversity. 3. Types and properties of immunoglobulin. 4. Antigen-antibody reactions. 5. T and B cell activation and antibody production. 6. **MHC complex:** Antigen processing and presentation. 7. Immunity towards bacterial, fungal and viral infections, Regulation of immune system, Organ transplant and Immunosuppression. 8. Discussion on classical papers and important review articles in the field of immunology.	04 05 03 02 03 04 07 02	02

Semester II			
Subject Code	**Subject Title**	**No. of Lectures/ Practicals**	**No. of credits**
MB2.4.2 C	**General Virology** 1. **Early discoveries** 2. **Morphology and ultra-structure of viruses**: Capsids; icosahedral, helical, envelope, glycoprotein, matrix proteins and lipids. 3. **Viral genome :** Double stranded viral DNA / RNA, single stranded viral DNA/RNA. 4. Archaeal viruses and virus related agents (viroids, virophage, satellite, prions). 5. **Growth of viruses:** In embryonated egg, in experimental animals and in cell cultures-primary and secondary cell lines, suspension cell cultures and monolayer cell cultures. 6. **Assay of viruses:** Physical and chemical methods of assay, (protein, nucleic acid, radioactivity tracers, electron microscopy,etc); Infectivity assay of animal viruses (plaque method, pock counting, end point method) and infectivity assay of plant viruses. 7. **Bacteriophage**: Morphology and ultra-structure of bacteriophages, one step growth curve (latent period, Eclipse period, burst size), life cycle and other details with special reference to T (odd and even). 8. **Classification and nomenclature of viruses:** ICTV recommendations, Baltimore classification system. 9. Mechanism of virus entry into host cell and strategies to replicate in host. 10. Discussion on Deadly viruses, emerging viruses and BSL4 facility. 11. Review of classical and current important experimental techniques in molecular virology.	01 04 01 02 04 05 02 02 04 02 03	02
MB2.5.2 C	**Molecular Biology I** 1. Introduction to information transfer and genetic code. 2. **Prokaryotic genome**: Structural details. 3. **Eukaryotic Genome:** Structure of Chromatin, chromosome, centromere, telomere, nucleosome. Genome organization, Chromatin remodeling. Types of Histones, Histone modifications- methylation, acetylation, phosphorylation and its effect on structure and function of chromatin, DNA methylation and gene imprinting, C value paradox and genome size, repetitive and non-repetitive DNA sequence, Cot 1/2 Pseudogenes, organelle genome. 4. DNA replication and recombination, Mutagenesis and Repair, Large scale genome dynamics. 5. Plasmids and transposable genetic materials. 6. Discussion of classical papers in molecular biology. Review of classical and current important experimental techniques in molecular biology.	03 02 10 09 03 03	02

Semester II			
Subject Code	**Subject Title**	**No. of Lectures/ Practicals**	**No. of credits**
MB2.01.2	**Enzymology** 1. Purification of enzymes (Amylase/Invertase) 2. Determination of Km, Vmax and Kcat values of enzyme 3. Optimization of parameters (pH and temperature) for enzyme activity and stability 4. Determination of enzyme activity in presence of activators and inhibitors. 5. Determination of enzyme activity from immobilized cells.	 4P 1P 2P 1P 2P	02
MB2.02.2	**Immunology and Medical Microbiology (Any 10P)** 1. Agglutination methods. 2. ELISA based detection of cytokines/ Antigens / Antibodies. 3. Western blotting. 4. Purification of Immunoglobulin. 5. Immunofluorescence. 6. Immunoprecipitation. 7. MIC, MBC, Determination of virulence traits (biofilm formation, hemolysis, siderophores). 8. Anti-biofilm, anti-adhesion assay on medical implants.	 1P 2P 2P 1P 1P 1P 4P 2P	02
MB2.03.3	**Molecular Biology techniques (Any 15P)** 1. Concept of lac-operon: Lactose induction of B-galactosidase; Glucose Repression; Diauxic growth curve of *E. coli.* 2. UV mutagenesis to isolate amino acid auxotroph. 3. Phage titration. 4. Genetic Transfer-Conjugation, gene mapping. 5. Plasmid DNA isolation and DNA quantitation. 6. Restriction enzyme digestion of plasmid DNA. 7. Polymerase Chain Reaction and analysis by agarose gel electrophoresis. 8. Vector and Insert Ligation. 9. Preparation of competent cells, transformation of *E. coli* with standard plasmids, Calculation of transformation efficiency. 10. Confirmation of the insert by Colony PCR and Restriction mapping.	 3P 2P 2P 2P 2P 1P 1P 1P 1P 2P 1P	03
MB2.04.1	Paper Presentation: Presentation of research article published in peer reviewed journal.		01
Elective Courses			
MB2.1.2 E	**Microbial Metabolism: Photosynthesis/ Respiration/ N_2 metabolism** 1. **Bacterial photosynthesis:** Photosynthetic microorganisms, Photosynthetic pigments and generation of reducing power by cyclic and non cyclic photophosphorylation, Electron transport chain (ETC)	 10	02

Semester II			
Subject Code	**Subject Title**	**No. of Lectures/ Practicals**	**No. of credits**
	in photosynthetic bacteria, Carbon dioxide fixation pathways. 2. **Respiration: Aerobic and anaerobic** Mitochondrial electron transport chain, structure and function of ATPase (bacterial and mitochondrial), generation and maintenance of proton motive force, oxidative phosphorylation, inhibitors and un-couplers of electron transport chain and oxidative phosphorylation, Atkinson's energy charge, phosphorylation potential and its significance, Anaerobic Respiration: Concept of anaerobic respiration, oxidized sulfure compounds, and nitrate as electron acceptor with respect to electron transport chain and energy generation, Biochemistry of methanogenes 3. **Nitrogen metabolism:** N_2 fixation, Amino acid synthesis, urea cycle and biological amines.	10 10	
MB2.2.2 E*	**Animal and Plant Virology** **Animal Virology**: 1. **Life cycles**: DNA viruses with special reference to herpes, pox, adeno, SV40; RNA viruses with special reference to measles, rabies, polio, influenza, retroviruses; Oncoviruses and Lentiviruses (HIV). 2. Slow and persistent viruses. 3. Mechanism of virus persistence, Genetic stability of viruses, Influence on host cell growth control, Immune response against viruses. 4. Antiviral drugs and virus vaccines. **Plant Virology** 1. **Classification and nomenclature.** 2. **Effects of viruses on plants**: Appearance of plants, histology, physiology and cytology of plants. 3. **Diagnostic techniques to detect viruses:** In seeds, seed stocks, and diseased plants (seed morphology, seedling symptomatology, indicator plants, serological methods, histo-chemical tests and fluorescence microscopy) 4. **Behaviour of viruses in plants:** Early stages of infection, biochemistry of virus replication, cellular sites of virus replication and assembly and accumulation of virus particles. 5. **Transmission of plant viruses:** With vectors (insects, nematodes, fungi, etc.) without vectors (contact, seed and pollens). 6. **Prevention of crop losses due to virus infection:** Virus free planting material, vector control, disease forecasting. 7. **Life cycle:** TMV, Cauliflower mosaic virus etc.	 08 01 04 02 01 02 03 02 02 02 03	02

Courses which can be opted for by students from outside departments

Subject Code	Subject Title	No. of Lectures	No. of Credits
MB2.3.2 E	**Basic Microbial Techniques** **Theory**: 1. Safety in Microbiology laboratory, Possible laboratory hazards, Safety precautions, Disposal of laboratory waste. 2. **Microscopy:** Principles, construction, working and applications of bright field microscopy. 3. **Staining Techniques:** Definitions: Stain (Basic and Acidic), Fixative, Mordant, decoloriser, Accentuator. Principles of staining techniques for Monochrome staining and Negative staining; Differential staining - Gram staining. 4. **Sterilization and Disinfection:** Physical and Chemical agents and their mode of action. 5. **Cultivation of Microorganisms:** Introduction to concept of pure culture and methods for pure culture; Nutritional requirements and nutritional classification; Design and preparation of media – Ingredients of media and types of media; Techniques of enrichment; Isolation and maintenance of bacterial and fungal cultures, Culture collections and their role. 6. **Bacterial Growth**: Growth Kinetics and growth curve; definitions of Generation time, Growth rate, specific growth rate; Methods of enumeration - Microscopic methods, Plate counts, Biomass, Chemical methods, Optical density **Practical: (Any 5P)** 1. Sterilization, disinfection and safety in microbiological laboratory. 2. Preparation of media, Isolation of bacteria in pure culture by streak plate method, Study of colony and growth characteristics of some common bacteria: *Bacillus, E. coli, Staphylococcus, Pseudomonas,* etc. 3. Preparation of bacterial smear and Gram's staining. 4. Enumeration of bacteria: standard plate count. 5. Antimicrobial sensitivity test and demonstration of drug resistance. 6. Maintenance of stock cultures: slants, stabs and glycerol stock cultures. 7. Determination of Minimum Inhibitory Concentration (MIC). 8. Isolation and identification of bacteria from soil/water samples.	 03 02 02 02 04 02 1P 4P 1P 1P 1P 2P 1P 2P	02