DEPARTMENT OF MICROBIOLOGY

UNIVERSITY OF KALYANI

M. Sc. (MICROBIOLOGY)

REVISED SYLLABUS (2017)
FOR
CREDIT BASED
POST GRADUATE COURSE IN MICROBIOLOGY

Semester I:

Course No.	Course Type	Course Title	Total Credits
Theoretical			
MB 1.1.3	**Hard Core**	Microbial Diversity and Systematics	3
MB 1.2.3	**Hard Core**	Biochemistry & Biophysics	3
MB 1.3.3	**Hard Core**	Microbial Metabolism	3
MB 1.4.3	**Hard Core**	Cell Biology & Cell Signaling	3
Theoretical Credits			**12**
Practical			
MB 1.5.1	**Hard Core**	Microbial Diversity and Systematics	1
MB 1.6.2	**Hard Core**	Biochemistry & Microbial Metabolism	2
MB 1.7.1	**Hard Core**	Cell Biology	1
Practical Credits			**4**
Total Credits			**16**

Semester II:

Course No.	Course Type	Course Title	Total Credits
Theoretical			
MB 2.1.3	**Hard Core**	Molecular Biology	3
MB 2.2.3	**Hard Core**	Recombinant DNA Technology	3
MB 2.3.3	**Hard Core**	Environment and Microbial Ecology	3
MB 2.4.4	**Choice based***	Microbes and Sustainable Development	4
Theoretical Credits			**13**
Practical			
MB 2.5.2	**Hard Core**	Molecular Biology and Recombinant DNA Technology	2
MB 2.6.1	**Hard Core**	Microbial Ecology	1
Practical Credits			**3**
Total Credits			**16**

***Selection of course type and corresponding credits should be transferred from any other Department during 2nd semester examination.**

Semester III:

Course No.	Course type	Course Title	Total Credits
Theoretical			
MB 3.1.3	**Hard Core**	Immunology & Immunodiagnostics	3
MB 3.2.3	**Hard Core**	Medical Microbiology	3
MB 3.3.3	**Hard Core**	Microbial Genetics	3
MB 3.4.3	**Hard core**	Bioinformatics & Biostatistics	3
Theoretical Credits			**12**
Practical			
MB 3.5.2	**Hard Core**	Immuno-Technology & Medical Microbiology	2
MB 3.6.2	**Hard Core**	Bioinformatics & Biostatistics	2
Practical Credits			**4**
Total Credits			**16**

Semester IV:

Course No.	Course type	Course Title	Total Credits
Theoretical			
MB 4.1.3	**Hard Core**	Industrial Microbiology & Intellectual Property Right	3
MB 4.2.3	**Hard Core**	Application of Microbial Technology	3
MB 4.3.3	**Hard core**	Bioprocessing Technology & Food Microbiology	3
Theoretical Credits			**9**
Practical			
MB 4.4.1	**Hard Core**	Food & Industrial Microbiology	1
MB 4.5.1	**Hard Core**	Application of Microbial Technology	1
Practical credits			**2**
MB 4.6.4	**Hard Core**	Project work and Seminar Presentation	**4**
MB 4.7.1	**Hard Core**	Review Writing	**1**
Total Credits			**16**

Semesterwise Credit Distribution:

Semester I + Semester II + Semester III + Semester IV = 16+16+16+16**= 64**

Course No. & Title	Course description
MB 1.1.3 Microbial Diversity and Systematics	**A. Origin of life:** A brief history of the physical origin of the Earth and prebiotic conditions; Hypotheses; Chemical and Cellular evolution; Microbial Diversification: Consequences for Earth's Biosphere; Endosymbiotic origin of eukaryotes **B. Microbial Systematics:** General account of systematics, Classification and nomenclature; Classification systems-artificial or phonetic, natural and phylogenetic; Species concept; monophyletic, paraphyletic, polyphyletic; Molecular taxonomy, Molecular phylogeny, Molecular chronometers; Polyphasic taxonomy, Describing a new Prokaryotic species, Valid publication of names of bacterial taxa, Culture collection. **C. Diversity of prokaryotic and eukaryotic microbes** **Bacteria**: General classification of bacteria with salient feature of major bacterial phyla according to Bergey's Manual of Systematic Bacteriology. **Archaea:** Systematics, occurrence, diversity, characteristic features and significance of different groups of Archaea **Fungi:** Modern trends of fungal classification and phylogeny. Growth, Environmental conditions for growth; nutrition and life cycle patterns, parasexuality and heterothallism. **Algae**: Distribution; classification nutrition and culture; reproduction and life cycles; algal toxins, algal bloom & its control, Economic importance of algae **Protozoa**: General account, structure, reproduction and classification of protozoa **D. Acellular organisms (Viruses, Viroids, Prion) :** **General Virology**: Discovery of viruses, morphology and ultrastructure, capsids & their arrangements, viral genome – types and structures; nomenclature and classification of virus (Animal, plant, bacterial viruses). Virus related agents – viroids, prions. **Bacteriophages**: Structural organization; Life cycle – lytic & lysogenic. Importance in bacterial genetics and biotechnology. **Animal viruses**: Life cycle and replication of SV-40, retrovirus. **Plant virus**: Structure of plant viruses like TMV, potato virus X; Brief outline of cyanophages and mycophages.
MB 1.2.3 Biochemistry & Biophysics	**A. Basic Biochemistry** **Principles of biophysical chemistry:** Structure of atoms, molecules and chemical bonds, pH, buffer, reaction kinetics. Stabilizing interactions (van der Waals force, electrostatic force, hydrogen bonding, hydrophobic interaction etc.) **Thermodynamics in Biology**: Heat, work, energy- laws of thermodynamics; entropy, free energy, spontaneity and equilibrium; Thermodynamics in biological reaction, coupled reaction. **Biomolecules:** Composition, structure and function of biomolecules (nucleic acids, proteins, carbohydrates, fat and lipids, vitamins, and steroids); Conformation of proteins (Ramachandran plot, secondary structure, domains, motif and folds); Conformation of nucleic acids (A, B, Z), t-RNA, micro-RNA). B. **Enzymology** Basics of enzymology-classes, enzyme active and binding sites, Substrate specificity, coenzyme, cofactors, holo and apo enzyme;

	Enzyme kinetics-Michaelis-Menten equation derivation, Km & Ks values, enzyme inhibition and its kinetics; enzyme kinetics –effects of pH and temperature; enzyme regulation-allosteric, covalent modification; mechanism of enzyme catalysis; isoenzymes, abzymes, ribozymes, non-protein biocatalyst. C. **Biophysico-chemical techniques** **Microscopy** : Resolving powers of different microscopes, Dark-field, phase contrast microscopy, interference polarization, electron microscopy, confocal, cryoelectron and Atomic force microscopy. **Radioactivity measurement**: types of radiation used in biology, radioactive decay, radioactive measurement units, GM counter, liquid scintillation counter, γ-ray detection and its application, stable isotopes and its use in biology. **Chromatography**: principle, types, Operation of column, Overview of Partition-, Adsorption-, Gel-, Ion exchange-, affinity chromatography, HPLC. **Electrophoresis**: Principle, Non-denaturing and denaturing electrophoresis, isoelectric focusing, Two dimensional SDS-page. **Sedimentation:** Simple theory of centrifugation, rotational speed, overview of types of centrifugation, Ultracentrifugation, Density gradient centrifugation, application of centrifugation. **Spectroscopic techniques**-Absorption spectroscopy, CD, ORD measurements, IR spectroscopy, Raman spectroscopy, Atomic absorption spectroscopy, Electronic & excitation spectroscopy, fluorescence spectroscopy, ESR, NMR, X-ray diffraction – technique and its application.
MB 1.3.3 Microbial Metabolism	1. **Bacterial nutrition and growth:** Autotrophy, heterotrophy and myxotrophy with reference to Carbon source, energy source, electron donor and electron acceptor. Nutritional Types (A brief account), nutrient requirement (A broad outline); Measurement of bacterial growth and factors affecting growth; growth condition- aerobic, anaerobic, micro-aerophilic. 2. **Photosynthesis in algae/bacteria**– oxygenic & anoxygenic photosynthesis, light absorption and energy conversion, reaction center complex, photosystems – organization of photosynthetic lamellae/thylakoid membrane, electron transport pathways, ATP synthesis, carbon assimilation pathways. 3. **Chemosynthesis in bacteria**- biochemical reactions involved in supply of energy to chemosynthetic organisms, electron transport pathways, chemiosmotic ATP synthesis. Halobacterium model for ATP synthesis. 4. **Aerobic & anaerobic respiration, fermentation; Catabolic pathways** –Embden-Meyerhoff-Pernas pathway, and regulation of glycolysis(i) Phase of energy investment, raising of free energy contents of metabolic intermediates, degradation of hexose to 3 carbon compounds. (ii) Phase of energy conserving phosphorylation steps (substrate level phosphorylation) generation of redox potential and oxidation of 3 carbon compounds to pyruvate. Regulation of glycolysis. Enter-Doudoroff pathway, pentose phosphate pathway, homolactic & heterolactic fermentation, TCA cycle (amphibolic pathway), Glyoxalate bypass (anaplerotic reaction), Lipid oxidation; degradation of PHA, Amino acid degradation; Nucleic acid break down. **Anabolic pathways** –Biosynthesis of energy rich-compounds (PHA, polyglycans, glycogen), major pathways of aminoacid synthesis. Lipid and nucleotide synthesis. 5. **Bioenergetics:** Bioenergetics of Methanogenesis, Methylotrohy, N2-fixation, Anamox and Syntrophy.

MB 1.4.3 Cell Biology & Cell Signaling	1. **Cell envelopes:** Brief description-Bacterial and fungal cell wall; primary and secondary cell wall in plants; structure, chemical composition, biosynthesis and assembly of cell wall, the extra cellular matrix-Glycocalyx, proteins, polysaccharides, matrix adhesion proteins (fibronectin, laminin, entactin), cell-cell interaction- integrin, hemidesmosome, gap junction, tight junction, focal contact, plasmodesmata mediated intracellular communication. 2. **Cell membrane:** Ultra-structure of cell membrane (*Archaea*, *Bacteria* and *Eukarya*), lipid bilayer and membrane proteins, the movement of substance across cell membranes-diffusion, ion channels, facilitated duffusion, active transport, ion pumps, mechanism of sorting and regulation of intracellular transport-endocytosis and receptor mediated endocytosis, protein trafficking in endocytosis, electrical properties of membranes. 3. **Intracellular compartments:** Mitochondria, chloroplast, peroxisome, ER, Golgi, lysosome structure and function 4. **Cellular structure and function:** Flagella, pili, capsules- ultra-structure and function, genetics Molecular mechanism of flagella movement; Bacterial perenation-cyst, endospore, akinetes- ultra-structure, formation, properties and germination. 5. **Cell inclusions:** I) used as metabolic machinery: Carboxysomes, Phycobillisomes, Chlorobium vesicles, Acidocalcisome. II) used as adjusters of environment: Magentosomes, Gas vesicles; III) used as metabolic reservoirs: PHA, Polyphasphate granules, oil droplets, cyanophycin granules, sulfur inclusions, polyglucans, Glycogen. 6. **Cell cycles**: Reproduction of bacteria-binary fission, fragmentation, budding, sporogenesis, General strategies of the cell cycle: Bacteria, yeast, animal; mechanism of cell cycle control, check points. 7. **Cell signaling and programmed cell death:** Principle of cell signaling, two component signaling in bacteria, extracellular signals: hormones, cytokines and growth factors, different types of receptors: G-protein coupled, ion channel linked, enzyme linked receptor, tyrosine kinase receptor, intracellular receptors of extra cellular signals, protein phosphorylation, kinases, phosphatases, serine threonine kinases, tyrosine kinases, MAP kinases with special relevance to yeast mating in bacterial chemotaxis, serine, threonine and tyrosine phosphatase. Bioluminescence 8. **Quorum sensing in bacteria:** Role of acyl homolacton serine in quorum sensing, types of quorum sensing, regulation of quorum sensing, cell signaling in myxobacteria.
MB 1.5.1 Microbial Diversity and Systematics	1. Observation of bacteria, yeast, microalgae, protozoa under microscope. 2. Microscopic measurements, micrometer, Haemocytometer. 3. Bacterial staining – Gram stain, Acid fast staining, flagella, capsule and spore staining; 4. Preparation of culture media – media for bacteria, fungi and actinomycetes, media according to nutritional needs of microbe (selective differential, autotrophic, heterotrophic). 5. Preparation of solid and broth – slant, stab and plate culture technique. 6. Isolation of microorganism for different habitats – dilution technique 7. Identification of isolated bacteria –cultural and biochemical tests – acquaintance with Bergey's Manual. 8. Microbial growth measurements- turbidity measurement, total count, MPN technique.

	9. Antibiotic assay: Cup assay method and MIC method. 10. Determination thermal decimal reduction time (D) and thermal death point. 11. Detection of bacteriophage in sewage using *E. coli*. *Salmonella* and *Streptococcus* – plaque method.
MB 1.6.2 Biochemistry & Microbial Metabolism	1. Quantification of protein and nucleic acid (DNA and RNA) by colorimetry. 2. Techniques of paper, thin layer and column chromatography. 3. Estimation of lipids and their separation. 4. Determination of saponification values of fat of fat. 5. Effects of pH on enzyme activity. 6. Determination of Km and V_{max} with and without competitive and non-competitive inhibitors. 7. Estimation of microbial consumption/production of carbohydrates, amino acids, organic acids. 8. Qualitative study of photosynthesis (Cyanobacteria and photosynthetic bacteria). 9. Estimation and identification of microbial enzymes – amylase and phosphatase.
MB 1.7.1 Cell Biology	1. Microscopic studies of cell organelles. 2. Study of Mitosis and Meiosis 3. Study of metaphase chromosomes. 4. Determination of osmotic fragility of RBC membrane. 5. Blood film preparation and identification of cells.
MB 2.1.3 Molecular Biology	1. **DNA replication:** Prokaryotic and eukaryotic DNA polymerases, uni-and bi-directional replication, initiation of DNA replication in Bacteria and eukaryotes, Events at the bacterial and eukaryotic replication forks, Okazaki fragments, rolling circle mode of replication; Topological problems, topoisomerases, Termination of replication in *E. Coli* and eukaryote; Maintaining the ends of linear DNA molecule. 2. **Transcription:** Prokaryotic and eukaryotic RNA polymerases, bacterial and eukaryotic sites and assembly of transcription initiation complex, transcription initiation; synthesis of bacterial & eukaryotic mRNA- capping, elongation, termination, poly adenylation; RNA content of a cell – coding, and non-coding RNAs, precursor RNA; Intron splicing of eukaryotic mRNA. Synthesis and processing of non-coding RNAs, RNA editing. 3. **Regulation of transcription:** Strategies for controlling bacterial transcription initiation, the operons, control of transcription initiation in eukaryotes; Gene regulation – negative & positive gene induction. 4. **Synthesis & processing of proteins:** Role of tRNA in protein synthesis, tRNA structure, aminoacylation, codon, anticodon interactions; Ribosome structure, bacterial and eukaryotic initiation of translation, elongation (bacteria and eukaryotic), translation determination; regulation of translational initiation; Post-translational processing of protein (protein folding, proteolytic cleavages, chemical modifications), protein turnover. 5. **Protein localization:** Chaperons and protein folding, leader or signal sequence; Translocation apparatus (signal recognition particle), co-translation and post translational translocation, protein degradation by proteosomes.
MB 2.2.3	1. **Manipulation of purified DNA:** DNA manipulative enzymes (Nucleases, ligases, polymerases, modifying enzymes), Restrictions endonucleases, restriction mapping; different methods of formation of chimeric DNA – use of linkers, adaptors, homopolymers etc.

Recombinant DNA Technology	2. **Polymerase chain reaction:** Principle, dependence on oligonucleotide primers and temperatures, sequencing of PCR products, application of PCR (Chemical diagnosis, amplification of RNA through RT-PCR, RAPD analysis. 3. **Introduction of DNA into living cells**: Chemical, Physical and biological methods. 4. **Cloning vectors :** plasmids like PBR 322 and PUC groups and their derivatives, bacteriophages M13, λ & μ insertion and replacement vectors, phasmids, cosmids, yeast plasmids, YEP, YRP, YIP, shuttle vector, YAC, Bacterial Atificial chromosomes (BAC); Cloning vectors of higher plants (*A. tumefaciens* and Ti-plasmid), binary vectors, use of plant viruses as cloning vector, animal viruses used as vector. 5. **Clone identification**: Genomic library, C-DNA library, identification of a clone carrying a specific gene from library through probe hybridization and immunological screening methods; radioactive and non-radioactive probes. 6. **Studying gene and genome structure**: Locating the position of a cloned gene on a DNA fragment by southern blotting; Localization of the cloned gene on a large DNA molecule by pulse-field electrophoresis, *in situ* hybridization, chromosome walking, automated DNA sequencing; RFLP analysis and its application ; genetic finger printing. 7. **Expression of cloned genes** : Special vectors for expression of foreign genes in *E. coli,* problems with the production of recombinant protein in *E. coli* with inserted eukaryotic DNA, technique of gel retardation and foot printing to study gene regulation; Hybrid release translation (HRT) and hybrid arrest translation (HART) techniques to study cloned gene product *in vitro,* mutagenesis and protein engineering.
MB 2.3.3 Environment and Microbial Ecology	**A. Environmental Microbiology** **Aeromicrobiology:** Study of microbes in air, concept of autochthonous and allocthonous organisms. Introduction, transmission and deposition of microbes in air, assessment of air quality – air sampling technique; Air-borne human and crop pathogens; allergens. **Aquatic microbiology** : Water ecosystems, types fresh water (ponds, lakes, streams), marine habitats (estuaries, mangroves, deep sea, hypothermal vents saltpans, coralreefs); Zonation of water ecosystems – upwelling eutrophication and its control, potability of water, microbial assessment of water quality, microbes as bioindicator of water purity, water purification (Municipal, domestic/ commercial approach). **Soil microbiology:** classification of soils – physical and chemical characters, microflora of various soil types subterranean microbes. Bio-geochemical cycles – carbon, nitrogen, sulfur phosphorus. **B. Microbial Ecology:** **1.** Microbial ecology vs. macroecology, basic concept of ecosystem and biosphere, concept of habitat and niche, concept of population and community, Basic concept of food chain-food web and energy flow; Development of microbial communities: r and k strategies, Microbial community succession-biofilm communities. **2.** Microbial interaction: symbiosis, mutualism, commensalisms, competition, amensalism, synergism, parasitism and predation-mathematical model. **3.** Physiological ecology of microorganisms: adaptation to environmental condition, abiotic growth limiting factors-Leibig's law of minimum, Shelford law of tolerance. **4.** Ecology of microorganism in extreme environments (High temperature, pressure and radiation etc.); Community resistance and

	resilience; **5.** Quantitative ecology: diversity indices, samples and samplings, concept of culturability, Determination of total and viable microbial number, molecular analysis of function and diversity of microbial community, metagenomics, measurement of microbial metabolism-stable isotope probing. **C. Agricultural microbiology:** Useful and harmful microbes to crop growth. Microflora of rhizosphere and rhizoplane, phyllosphere and phylloplane. Fungal Endophytes and plant growth promoting rhizobacteria: their potential use. Plant-microbe interaction : entry, establishment molecular mechanism of disease development (enzyme, toxin, hormone) and resistance by host (innate and inductive) phytoalexin, PR-protein; control of diseases – chemical and biological Important diseases of agricultural crops by bacteria fungi and viruses – bacterial wilt, rust of wheat, & CaMV and their control.
MB 2.4.4 Microbes and Sustainable Development	1. Definition and concepts of sustainable development, issues in Sustainable Development, Strategic Planning for Sustainable Development. 2. Microbes and its suitability in sustainable development: Brief account of bacterial cell structure, metabolic diversity, different niche occupancy 3. Concept of antisepsis, disinfection, sterilization and chemotherapeutant. General idea on bacterial drug resistance. 4. Modern approach of bacterial classification 5. Microbial Growth characteristics, strategies of cell division, stress response 6. Genetic recombination in bacteria, transformation, conjugation, transduction 7. Signal transduction in bacteria, regulation of signaling pathways, bacterial and plant two-component systems, bacterial chemotaxis and quorum sensing. 8. Host parasite interaction Recognition and entry processes of different pathogens like bacteria, viruses into animal and plant host cells, alteration of host cell behavior by pathogens, virus-induced cell transformation, pathogen-induced diseases in animals and plants, 9. Microbial fermentation and production of small and macro molecules. 10. Microbes in environmental management: Bioremediation and phytoremediation, Biosensors 11. Microbes in healthcare: antibiotics and drug developments 12. Microbes in agriculture: crop improvement and protection 13. Microbes in food processing 14. Microbes in bio-hydrometallurgy and fuel industry
MB 2.5.2 Molecular Biology and Recombinant DNA Technology	1. Isolation of genomic DNA 2. SDS-PAGE of proteins 3. β-galactosidase induction Kinetics 4. Lactose permease assay 5. Blotting techniques 6. Phage induction. 7. Isolation plasmid DNA

	8. Restriction digestion of DNA 9. DNA amplification by PCR 10. DNA cloning using plasmid vector 11. Expression of recombinant protein in *E. coli* 12. Bacterial transformation.
MB 2.6.1 Microbial Ecology	1. Microbial sampling from water and soil 2. Determination of microbial diversity and abundance 3. Isolation of free-living and symbiotic N_2-fixing bacteria. 4. Microscopic observation of VAM. 5. Determination of plant growth promoting traits. 6. Detection of siderophore production by bacteria 7. Isolation and enumeration of phosphate solubilising and cellulose decomposing bacteria from different habitats (plate count method) 8. Physico-chemical analysis of water - pH, total and dissolved solids, Dissolved oxygen, Chemical oxygen demand, Biological oxygen demand, phosphate, ammonium-N, nitrate-N. 9. Determination of potability of water following MPN methods- MPN index, presumptive and confirmatory tests of coliforms. 10. *In vitro* assessment of microbe-microbe interactions.
MB 3.1.3 Immunology & Immunodiagnostic	1. Overview of immune system; cells and organs of immune systems; innate and acquired immunity, experimental systems, Phagocytes and natural killer Cells. 2. Structure and chemistry of immunoglobulins; antibody diversity, organization and expression of *Ig* genes, generation of immunological specificity. 3. Nature of antigen, antigen presentation and induction of immune response – humoral and cell mediated. 4. Antigen-antibody interaction, complement systems, tolerance to self antigens; Autoimmunity, immune suppression and immune deficiency diseases, AIDS. 5. Monoclonal and polyclonal antibody; Immuno-haematology- isoantigens, antibodies and their significance in blood transfusion; Major histocompatibility complex (MHC) and transplantation immunity. Immunotherapy and biological response modifier. 6. Hypersensitivity: immediate and delayed types – mechanisms of hypersensitive reactions, mechanism of inflammatory reactions. Methods of inducing resistance – vaccine types, designing, and vaccination schedule. 7. Diagnostic immunologic principles and methods, immunological techniques: precipitation, agglutination, single & double immunodiffusion, immunoelectrophoresis, complement fixation, single and DAS ELISA, radio immunoassay, immunofluorescence, flow cytometry and fluorescence activated cell sorting (FACS).
MB 3.2.3	1. Normal microflora of human body, sources of infection for man, gnotobiotic study, 2. Vehicles or reservoirs of infection; exogenous infection i) patients, ii) carriers (healthy, convalescent, contact, paradoxical and chronic), iii) infected animals (zoonosis), iv) soil endogenous infection, v) water borne infections; Mode of spread of infection : i)

Medical Microbiology	respiratory, ii) skin, iii) wound & burn infection, iv) veneral infection, v) alimentary tract infection, vi) Arthropods borne infection, vii) laboratory borne infection & nosocomial infection. 3. Pathogenesis: mechanisms of pathogenesis, transmissibility, infectivity & virulence; toxigenicity and other aggressiveness – hyaluronidase, coagulate, fibrinolysins or kinase. Microbial toxins and their molecular action. 4. Study of pathogenesis, epidemiology, symptamatology, clinical diagnosis, therapy and prevention of following diseases – Cholera, Tuberculosis, Tetanus, AIDS, Hepatitis-B, Malaria, Leischmaniasis, Candidiasis, Dermatomycosis. Symptomatology and cause of the diseases caused by prion.
MB 3.3.3 Microbial Genetics	1. **Genome organization: Prokaryotic genome, Nucleoid, Eukaryotic genome, Organelle genome;** Structure of chromatin, nucleosome, chromatin organization and remodeling, higher order organization - chromosome, centromere, telomere; C value paradox and genome size, cot curves, repetitive and non-repetitive DNA sequence, Cot ½ value. 2. **Concept of gene:** Allele, multiple alleles, Pseudogenes , Gene families, Gene clusters, Super-families 3. **Inheritance biology:** Codominance, incomplete dominance, gene interactions, pleiotropy, genomic imprinting, penetrance and expressivity, phenocopy, linkage and crossing over, sex linkage, sex limited and sex influenced characters; Extrachromosomal inheritance (episomes, mitochondria and chloroplast). 4. **Types of mutations** - spontaneous and induced, Luria – Delbruk's fluctuation list, mutation rate, replica plating technique; mutagens – mechanism of action of physical and chemical mutagens; mutator genes, reverse mutation, detection of mutagens – Ames test, suppression and sensitive mutants; mutational hot spots, programmed mutation, adaptive mutations. 5. **Structural and numerical alterations of chromosomes:** Deletion, duplication, inversion, translocation, ploidy and their genetic implications. 6. **Recombination :** Homologous and non-homologous recombination including transposition. 7. **Transpososns :** IS element, composite transposon, replicative and nonreplicative mechanism of transposition; Tn transposons and evolution; use of transposon in genetic analysis. 8. **Repair of DNA :** Types of repair systems, dark repair, photoreactivation, mismatch repair, SOS repair. 9. **Gene transfer:** Transformation, conjugation, transduction, transfection- mechanisms and applications; genetic mapping in *E. coli* and yeast; overlapping genes.
MB 3.4.3 Bioinformatics & Biostatistics	A. **Bioinformatics:** Overview of bioinformatics – Database types, EMBL, Gene bank for nucleic acid and protein sequence, PDB database for protein structure, Genomics and the genome project, computer tools for sequence analysis, finding and retrieving sequences, similarity searching pair wise and multiple alignment structure function relationship; Sequencing and sequence assembling using computers; Phylogenetics. B. **Biostatistics**: Sample and population: Sampling methods, frequency distribution, sample mean, sample standard deviation, the normal distribution, the mean mode, median, standard deviation and standard error of the normal distribution, uncertainties in estimation of a mean. Testing of hypothesis, comparison of population means and variances (F-test, ANOVA, χ^2 test, paired t-test, student-t test), notion of confidence limit; Laws of probability, correlation and regression., goodness of fit and the test of independence of two

	attributes; count data, examples of count data – bacterial cell count, radioactivity count, colony and plaque counts, statistical treatment to count data.
MB 3.5.2 Immuno-Technology & Medical Microbiology	1. Isolation and identification of pathogenic bacteria, fungi, protozoa, from clinical samples 2. Various agglutination reactors; widal test, Haemagglutination 3. Various precipitation techniques, Immunodiffusion, Immunoeletrophresis 4. ELISA test 5. Separation and characterization of serum and lymphocytes from blood 6. Isolation and characterization of bacteria from urine samples
MB 3.6.2 Bioinformatics and Biostatistics	A. **Bioinformatics** 1. General concepts of sequence analysis, identification of functional sequences, homology, brief idea of BLAST, ENTREZ, and PuBMed 2. Computer aided visualization of amino acid/nucleotide sequence of protein/DNA OR RNA and THEIR3D structure. 3. Use of various bioinformatics software. 4. Computer aided survey of scientific literature. B. **Biostatistics** 1. Calculation of mean, mode, and median. 2. Calculation of standard deviation and standard error. 3. Sampling, analysis of variance, testing of hypothesis, correlation and regression, fitting an observed distribution to a theoretical distribution, χ^2 test of goodness of fit. 4. Computer aided statistical analysis. 5. Computer presentation of statistical data, charts and diagrams.
MB 4.1 .3 Industrial Microbiology & Intellectual property right	**A. Industrial Microbiology:** Pre-requisite of industrial microorganisms; Strategies for screening, selection and improvement of industrial strains; Methods of preservation & maintenance of microbial strains & their stability; Formulation of fermentation media; methods of sterilization; culturing techniques of microbial strains; inoculum preparation and inoculum development. **Outlines of the bioprocessing of the following Industrially important microbial products and their applications** – wines, non-alcoholic beverages (coffee, tea), biopolymers (dextran, poly-hydroxyalkanoates, biosurfactants), ethyl alcohol, butanol, vinegar, vitamins, antibiotics (streptomycin, penicillin, tetracycline), amino acids (glutamic acid), organic acids (citric acid); microbial transformation of steroids and its potential use. **B. Intellectual Property Right and Bioethics** 1. Intellectual property rights: Meaning,-Evolution – Classification and forms 2. Rationale for protection of IPRs – Importance of IPRs in the fields of science and technology 3. Patents – Concepts and principles of patenting – Patentable subject matter 4. Procedure of obtaining patents – Rights of patents – Infringement of patent rights

	5. Remedies for infringement of patent rights – Patentability and emerging issues 6. Entrepreneurship 7. Biohazards, human safety, ecological and environmental hazards, 8. Concept of bioethics, Ethical consideration of using GMOs or GM foods
MB 4.2.3 Application of Microbial Technology	1. **In Agriculture :** Improvement of N_2- fixing strain, production of biofertilizers, biopesticides; Development of disease and insect resistant plants; Biocontrol by hyperparasites & hypoparasites. 2. **In Health :** Production of recombinant vaccines, interferon, and insulin 3. **Biofuel production** – Biogas, biodiesel and H_2 as fuel by microbes; microbial fuel cell. 4. **Bio-mining :** Extraction of Cu, Au, U from ore by microbes; Bio-recovery of petroleum. 5. **Bioremediation of pollutants :** Petroleum hydrocarbons, halogenated contaminants of aquifer and soil; Heavy metal contaminants of water bodies. Concept of microbially assisted phytoremediation. Lignin and azo-dye degradation. 6. **Waste treatment:** liquid and solid waste phase separation, different phases of treatments, trickling filtration, activated sludge treatment, oxidation pond. Composting & vermicomposting, Hospital waste management, Municipal solid waste management. 7. **Nanobiotechnology**: potential use in human health and environmental management
MB 4.3.3 Bioprocess Technology and Food Microbiology	**A. Bioprocess Technology** **Bioreactors/Fermentors** – Some basic concepts related to fermentations-cell formula, measurement of cell concentration, Microbial cell growth reaction, Microbial growth kinetics-Monod equation, Stoichiometry of cell growth-mass and energy balances, yield coefficients, growth limiting substrate and yield factors, Microbial growth in batch fermentor and chemostat; Basic components, design and scale-up of fermentors; modern bioreactors for solid state fermentation. **Downstream processing** – product recovery, purification, finishing and packaging – techniques followed and instrument/devices used; effluent treatment. **B. Food Microbiology:** Development of the science of food microbiology; principles of food preservation– heat processes, irradiation, high pressure low temperature, canning, chemical preservatives, modifications of atmosphere, control of water activity, compartmentalization; Microbial contaminations & food spoilage; food poisoning, microbial agents for food borne illness and intoxication; Microbiology and preservations of milk and dairy product – pasteurization, traditional and modern methods, microbiology of dairy products. Food fermentation- bread, cheese, yogurt, sour milk, oriental fermented foods, methods for the microbiological examinations of foods and controlling the microbiological quality of foods.
MB 4.4.**1** Food Microbiology	1. Microbiological (bacterial and fungal) analyses of food products 2. Detection of microbial spoilage of stored foods 3. Microbiology of fermented food products

	4. Microbial quality assessment of salad vegetables 5. Food preservation techniques- canning 6. Preparation of Yogurt 7. Immobilization of microbial cells by calcium alginate gel entrapment 8. Microbial biomass production (SCP) 9. Development of PGPR inoculant, biofertilizer inoculant and their application in pot experiment. 10. Screening of antimicrobial product from higher plants
MB 4.5.1 Industrial Microbial Technology	1. Determination of substrate consumption rate in batch culture. 2. Determination of specific cell growth rate. 3. Determination of yield coefficient of cell biomass on substrate. 4. Citric acid production in batch culture. 5. Penicillin production, its recovery and its purification 6. Solid state fermentation of some microbial products 7. Alcoholic fermentation (demonstration – industrial scale) 8. Antibiotic production in bioreactor 9. Collection and identification of important bacterial/fungal strains of industrial importance 10. Production of alkaline phosphatase in lab scale Fermenter