DEPARTMENT OF MICROBIOLOGY

UNIVERSITY OF KALYANI

REVISED SYLLABUS (2021)

CREDIT BASED POST GRADUATE COURSE IN MICROBIOLOGY
M. Sc. (MICROBIOLOGY)

Semester I

Course Code	Course Name	Credits	Weekly hours	Marks (End + Mid-term)
Theoretical				
MB COR 101	Microbial Diversity and Systematics	4	3+1+0	50 (40+10)
MB COR 102	Biochemistry & Enzymology	4	3+1+0	50 (40+10)
MB COR 103	Biophysical Techniques	4	3+1+0	50 (40+10)
MB COR 104	Microbial Metabolism	4	3+1+0	50 (40+10)
MB COR 105	Cell Biology & Cell Signaling	4	3+1+0	50 (40+10)
MB AECC 106	Infectious Disease & Public Health	2	2+1+0	25 (20+05)
Theoretical Credits				**22**
Practical				
MB COR 111	Biosafety & Microbial Culture	2	0+1+3	25 (20+05)
MB COR 112	Biochemistry & Enzymology	4	0+1+4	50 (40+10)
MB COR 113	Cell Biology	2	0+1+3	25 (20+05)
Practical Credits				**8**
Total Credits				**30**

Semester II

Course Code	Course Name	Credits	Weekly hours	Marks (End + Mid-term)
Theoretical				
MB GEC 201*	Microbes and Sustainable Development	4	3+1+0	50 (40+10)
MB COR 202	Molecular Biology	4	3+1+0	50 (40+10)
MB COR 203	Recombinant DNA Technology	4	3+1+0	50 (40+10)
MB COR 204	Microbial Ecology & Agricultural Microbiology	4	3+1+0	50 (40+10)
MB DSE 205	*One elective from the following* I. Environmental Microbiology II. Biostatistics III. Clinical Vaccinology	4	3+1+0	50 (40+10)
Theoretical Credits				**20**
Practical				
MB COR 211	Molecular Biology	4	0+1+4	50 (40+10)
MB COR 212	Recombinant DNA Technology	2	0+1+3	50 (40+10)
MB COR 213	Microbial Ecology	2	0+1+3	25 (20+5)
MB COR 214	Assignment Presentation I	2		25
Practical Credits				**10**
Total Credits				**30**

*General Elective Course for other PG courses of the University and the corresponding credits will be transferred during 2nd Semester examination.

Semester III

Course Code	Course Name	Credits	Weekly hours	Marks (End + Mid-term)
Theoretical				
MB COR 301	Immunology	4	3+1+0	50 (40+10)
MB COR 302	Medical Microbiology	4	3+1+0	50 (40+10)
MB COR 303	Microbial Genetics	4	3+1+0	50 (40+10)
MB COR 304	Virology	4	3+1+0	50 (40+10)
MB SEC 305	Immuno-diagnostics	2	2+1+0	25 (20+05)
MB SEC 306	Nano-Biotechnology & Regenerative Medicine	2	2+1+0	25 (20+05)
Theoretical Credits				**20**
Practical				
MB COR 311	Immuno-diagnostics & Medical Microbiology	4	0+1+4	50 (40+10)
MB COR 312	Computational Biology	4	0+1+4	50 (40+10)
MB COR 313	Assignment Presentation II	2		25
Practical Credits				**10**
Total Credits				**30**

Semester IV

Course Code	Course Name	Credits	Weekly hours	Marks (End + Mid-term)
Theoretical				
MB COR 401	Industrial Microbiology & Food Microbiology	4	3+1+0	50 (40+10)
MB COR 402	Bioprocess Technology & Intellectual Property Rights	4	3+1+0	50 (40+10)
MB COR 403	Bioinformatics and NGS Metagenomics	4	3+1+0	50 (40+10)
MB SEC 404	Research Methodology	2	2+1+0	25 (20+5)
Theoretical credits				**14**
Practical & Training				
MB COR 411	Food & Industrial Microbiology	4	0+1+3	50 (40+10)
MB DSE 412	Project Work & Dissertation Presentation	8		100
MB SEC 413	Review Writing & *Viva*	4		50
Practical credits				**16**
Total Credits				**30**

Course Code Convention: MB-W-XYZ [W=COR/AECC/GEC/DSE/SEC; X = 1/2/3/4 (Semester), Y = 0/1 (Theoretical/Practical), Z (Paper ID)

Semester wise Credit Distribution:

Semester I + Semester II + Semester III + Semester IV = 30+30+30+30 = 120

COR: Core Courses ; AECC: Ability Enhancement Compulsory Courses; GEC: Generic Elective Courses; SEC: Skill Enhancement Courses; DSE: Discipline Specific Elective.

Semester-wise Contents of the Syllabus

Semester I

MB COR 101: Microbial Diversity & Systematics

Origin of life: Origin of the Earth and its primitive atmosphere; Chemical and Cellular evolution; Microbial Diversification: Consequences for Earth's Biosphere; Endosymbiotic origin of eukaryotes

Microbial Systematics: Species concept; Classification systems-artificial or phenetic, natural, phylogenetic; 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.

Diversity of monera or prokaryotes

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

Diversity of protista

Fungi: Modern trends of fungal classification and phylogeny. Growth, Environmental conditions for growth; nutrition and life cycle patterns, parasexuality and heterothallism.

Algae: Micro-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

MB COR 102: Biochemistry & Enzymology

Principles of biophysical chemistry: Structure of atoms, molecules and chemical bonds and bond energy; Water-biological solvent, Buffer and pH; Chemical kinetics; Weak molecular interactions (van der Waals force, electrostatic force, hydrogen bonding, hydrophilic and hydrophobic interaction etc.)

Thermodynamics in Biology: Concept of heat, work, energy, enthalpy, entropy and free energy; Laws of thermodynamics; Reaction spontaneity and equilibrium; Thermodynamics in biological system; Coupled reaction; Energy rich biological molecules.

Biomolecules:

Nucleic acids-DNA: History, structure (A, B, Z-DNA), melting temperature and topology-relaxed and supercoiled;

RNA: Structure, types and function (mRNA, tRNA, rRNA, hnRNA, miRNA, snRNA, siRNA, sRNA and tRFs);

Carbohydrates: Composition (mono-, di-, oligo- and poly saccharides), conformation, structure, isomerism-mutarotation, physical and chemical properties; Biologically important sugar derivatives, artificial sweetener.

Proteins: Amino acids - classification and properties; Peptide bond - Ramachandran plot; Protein structure - primary, secondary, tertiary and quaternary; Proteins domains and motif; Classification of proteins; Protein turn over.

Lipids: Fatty acids structure and properties, classification of lipid molecules, lipid aggregation, membrane lipids, lipid derivatives.

Vitamins: Water and fat soluble vitamins - source, dietary recommendation, physiological functions and related diseases in human.

Enzyme: Basics concept; Enzyme-classes and nomenclature; Application of enzymatic reactions; Enzyme active site, binding sites, substrate specificity, holo-enzyme, apo-enzyme, coenzyme, cofactors, prosthetic groups, isoenzymes, abzymes, non-protein enzymes-ribozymes; Enzyme kinetics - Michaelis-Menten equation derivation, K_m, V_{max}, K_s, enzyme turn over, Enzyme unit definition; Enzyme inhibition-competitive, non-competitive and uncompetitive kinetics; Enzyme regulation - effect of pH and temperature, allosteric regulation, covalent modification.

MB COR103: Biophysical Techniques

Optical microscopy: The nature of light – its particle and wave character; Applications of optical microscopes; Concepts of numerical aperture (NA), resolution, contrast and magnification; Phase contrast, ultraviolet and interference contrast microscopes; Fluorescence microscopy, epifluorescence microscopy and confocal microscopy – their principles and biological applications.

Electron microscopy: Transmission electron microscopy (TEM) and scanning electron microscopy (SEM). Sample preparation for EM. Advantages of electron microscope over optical microscope.

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, overview of partition & adsorption, types - column, ion exchange, affinity, paper, thin layer, and HPLC.

Gel-electrophoresis: Principle, Non-denaturing and denaturing gel, isoelectric focusing, 2-D SDS-page, agarose gel electrophoresis.

Sedimentation: Principles & applications of centrifugation, rotational speed, overview of types of centrifugation, ultracentrifugation, density gradient centrifugation.

Spectroscopic techniques: Principles & applications- absorption spectroscopy, CD, ORD measurements, IR spectroscopy, Raman spectroscopy, atomic absorption spectroscopy, electronic & excitation spectroscopy, fluorescence spectroscopy, ESR, NMR, X-ray diffraction.

MB COR104: Microbial Metabolism

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.

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.

Chemosynthesis in bacteria- biochemical reactions involved in supply of energy to chemosynthetic organisms, electron transport pathways, chemiosmotic ATP synthesis. Halobacterium model for ATP synthesis.

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.
Bioenergetics: Bioenergetics of methanogenesis, methylotrohy, N_2-fixation, anamox and syntrophy.

MB COR 105: Cell Biology & Cell Signaling

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.

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.

Intracellular compartments: Mitochondria, chloroplast, peroxisome, ER, Golgi, lysosome structure and function

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.

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.

Cell cycles: Reproduction of bacteria- binary fission, fragmentation, budding, sporogenesis, General strategies of the cell cycle: yeast, animal; Cyclins and CDKs as key cell cycle mediators, their roles and modes of activation and control; Special emphasis on mammalian cell cycle; CDK inhibitors; Cell cycle checkpoints, metaphase-anaphase transition.

Cell signaling and programmed cell death: Principle of cell signaling, two component signaling in bacteria - bacterial chemotaxis; Extracellular signals: hormones, cytokines and growth factors; Different types of receptors: G-protein coupled, ion channel linked, enzyme linked, tyrosine kinase; Intracellular receptors of extracellular signals- protein phosphorylation, phosphatases, serine threonine kinases, tyrosine kinases & MAP kinases.

Quorum sensing in bacteria: Population density & signaling system, types of quorum sensing, regulation of quorum sensing- role of autoinducers, quorum quenching; Social behavior & signaling system in myxobacteria.

MB AECC106: Infectious Disease & Public Health

Definition of public health, its concept; Disease: Concept including sickness & illness, definitions, natural history of disease, causation theory: germ theory; Preventive health, practices of prevention in different levels; Concept of burden of disease, concept of wellbeing, Iceberg phenomenon, spectrum of health public intervention of control. Public health versus community health versus clinical health. Public health problems in India. Preventable diseases: waterborne diseases, communicable diseases, non-communicable diseases, uro-genital tract infections, vector-borne diseases, air-borne diseases, hospital-borne infections; Factor affecting public health: proverty, population growth, urbanization, cultural-demographic behavior, mental health, antimicrobial stewardship & drug abuse.

MB COR 111: Biosafety & Microbial Culture

1. Safety measures in laboratory, brief idea of bio-safety level.
2. Observation of bacteria, yeast, microalgae, protozoa under microscope.
3. Microscopic measurements, micrometer, Haemocytometer.
4. Bacterial staining – Gram stain, Acid fast staining, flagella, capsule and spore staining;
5. Preparation of culture media – media for bacteria, fungi and actinomycetes, media according to nutritional needs of microbe (selective differential, autotrophic, heterotrophic).
6. Culture techniques – broth, slant, stab and plate
7. Isolation of microorganism for different habitats – serial dilution technique
8. Identification of isolated bacteria –cultural and biochemical tests – acquaintance with Bergey's Manual.
9. Microbial growth measurements- turbidity measurement and generation time.
10. Antibiotic assay: Cup assay method and determination of MIC.

MB COR 112: Biochemistry & Enzymology

1. Quantification of protein (Lowry and Bradfrod methods)
2. Quantification of nucleic acid (DNA and RNA) by spectrophotometer.
3. Techniques of paper, thin layer and column chromatography.
4. Estimation of lipids and their separation.
5. Determination of saponification values of fat.
6. Effects of pH on enzyme activity.
7. Determination of K_m and V_{max} with and without competitive and non-competitive inhibitors.
8. Estimation and identification of microbial enzymes – amylase and phosphatase.

MB COR113: Cell Biology

1. Microscopic studies of cell organelles.
2. Preparation of onion root tip smear and study of mitosis
3. Determination of osmotic fragility of RBC membrane.
4. Blood film preparation and identification of cells.
5. Cell counting using haemocytometer
6. Study of metaphase chromosome

Semester II

MB GEC 201: Microbes & 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 bacterial cell structure, metabolic diversity, different niche occupancy.
3. Concept of antisepsis, disinfection and sterilization.
4. Modern approach of bacterial classification.
5. Microbial Growth characteristics, strategies of cell division, stress response.
6. Bacteria DNA, plamids; Gene transfer- transformation, conjugation, and 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 pathogens (bacteria & virus) into animal and plant cells, alteration of host cell behavior by pathogens, virus-induced cell transformation.
9. Microbial production: 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 COR 202: Molecular Biology

DNA replication: Central dogma of genetics; Semiconservative replication; Priming of DNA synthesis; Okazaki fragments; Bidirectional replication; Theta replication; Rolling circle replication; Enzymology of DNA replication - DNA polymerases, DNA helicase, SSBs, Topoisomerases, DNA ligase; Mechanism of DNA replication - initiation, elongation, and termination; Telomeres and telomerase; Shelterin; ATM kinase; ATR kinase.

Transcription: RNA polymerase; Promoter structure; Transcription Initiation; Structure and function of σ factor; σ cycle; Elongation complex; Pausing and proofreading; Transcription termination; Eukaryotic RNA polymerase and promoters; Enhancers and silencers; Coding, and non-coding RNA; RNA processing; Capping and polyadenylation; Ribosomal RNA processing; Transfer RNA processing; Transcription factors in eukaryotes.

Regulation of transcription: Strategies for controlling bacterial transcription initiation; The operons Control of transcription initiation in eukaryotes; Gene regulation – negative & positive gene induction; Catabolite repression.

Translation: Role of tRNA in protein synthesis; tRNA structure; Aminoacylation; Codon and anticodon; Ribosome structure; Mechanism of translation- initiation, elongation and termination; Post-translational processing of protein- protein folding, proteolytic cleavages, chemical modifications; Dealing with aberrant termination; tmRNA and trans-translation; Protein turnover.

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.

MBCOR 203: Recombinant DNA Technology

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.

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.

Introduction of DNA into living cells: Chemical, Physical and biological methods.

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.

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.

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.

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 COR 204: Microbial Ecology & Agricultural Microbiology

Microbial Ecology:

i. Microbial ecology versus 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.
ii. Microbial interaction: symbiosis, mutualism, commensalisms, competition, amensalism, synergism, parasitism and predation-mathematical model.
iii. Physiological ecology of microorganisms: adaptation to environmental condition, abiotic growth limiting factors-Leibig's law of minimum, Shelford's law of tolerance.
iv. Ecology of microorganism in extreme environments (High temperature, pressure and radiation etc.); Community resistance and resilience.
v. 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.

Agricultural Microbiology:

i. 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.

ii. 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
iii. Important diseases of agricultural crops by bacteria fungi and viruses – bacterial wilt, rust of wheat, & CaMV and their control.
iv. Improvement of N_2- fixing strain, production of biofertilizers, biopesticides; Development of disease and insect resistant plants; Biocontrol by hyperparasites & hypoparasites.

MB DSE 205: 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, hydrothermal 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 (large & small scale approaches).

Soil microbiology: classification of soils – physical and chemical characters, microflora of various soil types subterranean microbes. Bio-geochemical cycles – carbon, nitrogen, sulfur phosphorus.

Waste Management: Liquid and solid waste phase separation, different phases of treatments, trickling filtration, activated sludge, oxidation pond. Solid waste management, composting & vermicomposting; hospital waste management.

MB DSE 205: 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 DSE 205: Clinical Vaccinology

Introduction to vaccinology; History of vaccination, key developments, and ongoing challenges; Vaccine design, development, safety and its schedule; Study designs: clinical trials to evaluate vaccines; Key concepts in vaccine immunology; Quantitative methods for measuring vaccine efficacy (VE); Vaccines as protectant for individuals & populations; Understanding quantitative concepts in vaccinology: susceptibility, R0, contact rate, critical vaccination fraction; Maternal and infant vaccination; Adolescent and adult Vaccination; Ethical consideration for vaccines; Production of recombinant vaccines, interferon

MB COR 211: Molecular Biology

i. Isolation of bacterial genomic DNA

ii. Isolation plasmid DNA
iii. Bacterial transformation
iv. Curing of plasmid by acridine orange or ethydium bromide or heat treatment.
v. SDS-PAGE of proteins
vi. Western blotting
vii. Northern blotting
viii. Phage induction
ix. Phage titration
x. Induced mutagenesis

MB COR 211: Recombinant DNA Technology

i. DNA amplification by PCR
ii. Restriction digestion of DNA
iii. DNA cloning using plasmid vector
iv. Expression of recombinant protein in *E. coli*
v. β-galactosidase induction kinetics
vi. Lactose permease assay

MB COR 213: Microbial Ecology

i. Microbial sampling from water and soil
ii. Determination of microbial diversity and abundance
iii. Isolation of free-living and symbiotic N_2-fixing bacteria.
iv. Determination of plant growth promoting traits.
v. Cellulose decomposing bacteria from different habitats (plate count method)
vi. Physico-chemical analysis of water - pH, total and dissolved solids, Dissolved oxygen, Chemical oxygen demand, Biological oxygen demand, phosphate, ammonium-N, nitrate-N.
vii. Determination of potability of water following MPN methods- MPN index, presumptive and confirmatory tests of coliforms.

MB COR 214: Assignment Presentation I

One article from peer reviewed journal of International repute selected by the student and is to be presented.

<u>Semester III</u>

MB COR 301: Immunology

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.
7. Methods of inducing resistance – vaccine types, designing, and vaccination schedule.
8. Cancer: Incidence and etiology of cancer; Hallmarks of cancer, metastasis; Molecular and cellular events, regulation of gene expression, genome maintenance, cell growth and death, differentiation and homoeostasis.

MB COR 302: Medical Microbiology

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) 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: i) bacterial- Cholera, Diphtheria, Tuberculosis, Tetanus, ii) viral- AIDS, Hepatitis-B, iii) protozoan- Malaria, Leischmaniasis, iv) fungal- Candidiasis, Dermatomycosis. Symptomatology and cause of prion-associated diseases.

MB COR 303: Microbial Genetics

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.

Concept of gene: Allele, multiple alleles, Pseudogenes, Gene families, Gene clusters, Super-families; Overlapping genes; Genetic mapping

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).

Mutation: Spontaneous and induced mutation – Luria-Delbruk's fluctuation test; Significance of mutation; Types of gene mutation - base substitution, missense, nonsense, silent, neutral, insertions & deletions, frame shift, forward & reverse, conditional, lethal, suppressor; Nonsense mutation and translation; Chromosome mutations – Y-chromosome infertility, Down syndrome, XX male syndrome, Amniocentesis, CMT, DiGeorge syndrome, DMD, 5p minus syndrome; Aneuploidy & Polyploidy - Nondisjunction; Mutation rate & mutation frequency- mutational hot spots; Causative agent of mutation - Spontaneous & induced; Methods for mutant study - Replica plating, Penicillin enrichment, Ames test, Chromogenic substrate, Gene probes & Southern blotting, and PCR & Gel electrophoresis.

Repair of DNA: DNA damage & mutation; Reversal of damage - Photoreactivation, removal of methyl groups; Nucleotide excision repair; Base excision repair; Mismatch repair; Global genome NER, Transcription-coupled NER; Nonhomologous end-joining repair; Recombination repair; Error-prone bypass - SOS repair; DNA polymerase V & *umuDC* operon; Lynch syndrome.

Recombination: Intramolecular & bimolecular recombination**;** Homologous recombination - Holliday junction; Meiotic recombination; Gene conversion.

Transpososns: Bacterial transposons; Insertion sequences - IS element; Complex transposons; Mechanisms of transposition - replicative & nonreplicative; Eukaryotic transposons; P elements; Retrotransposons - junk DNA.

Gene transfer: Conjugative plasmids, episome, F-factor; Transformation; Conjugation; Transduction; Transfection - methods and applications.

MB COR 304: Virology

Discovery of viruses, Virus morphology and ultrastructure, capsids & their arrangements, Viral genome – types and structures; nomenclature and classification of virus. Virus attachment and entry in to host cells, Cellular and molecular biology of host virus interaction. Genome replication strategies and mRNA production by RNA viruses, Reverse transcription and integration in to the host genome (retroviruses), DNA virus replication strategies, Unique features of viral gene expression, Translational control of viral gene expression. Structural organization and Life cycle of lambda phage – lytic & lysogenic, Life cycle and replication of SV-40, Hepadnaviruses, Herpesviruses, Adenoviruses. Brief outline of cyanophages and mycophages. Viral pathogenesis and cell transformation by viruses. Role of interferon in viral infections, contributions of various host defense mechanisms in viral infections; Viroids

MB SEC 305: Immuno Diagnostics

Diagnostic immunologic principles and methods, immunological techniques: Precipitation reactions- precipitation reaction in fluids & in gel, radial immunodiffusion, double diffusion (Ouchterlony method). Agglutination- Prozone effect, direct agglutination and passive agglutination. Advanced immunological techniques and its working principles- ELISA, RIA, Immunofluorescence, Immunoelectrophoresis, complement fixation, flow cytometry and fluorescence activated cell sorting (FACS).

MB SEC 306: Nano-Biotechnology & Regenerative medicine

1. Introduction to Nanobiotechnology: Background of nanoscience and nanotechnology, Properties of nanomaterials, natural nanobiomaterials, bioactive nanomaterials and their applications.
2. Advanced Nanobiotechnology: Biosynthesis of nanoparticles. Biofunctionalization of gold nanoparticles. Biomolecular nanomotor and power generation. Nano biosensor and its applications. Importance of magnetosomes in nanobiotechnology and cultivation of magnetotactic bacteria.
3. Biomedical nanotechnology: disease diagnosis, targeted drug delivery, use of biocompatible nanoparticles as medicine.
4. Nanotoxicology: mechanisms of toxicity of nanoparticles. Entry of nanoparticle through biological membrane and specific tissues.

5. Regenerative therapy- Basics and principles. Applications of regenerative medicine. Large scale manufacturing of cells, tissues and organs. Stem cells- basics, properties and classification. Artificial organs. Principles of stem cell culture. Engineered tissues and regenerative medicine.

MB COR 311: Immuno Diagnostics & Medical Microbiology

i. Isolation and microscopic observation of pathogenic bacteria & fungi, from clinical samples
ii. Various agglutination reactors; widal test, Haemagglutination
iii. Various precipitation techniques, Immunodiffusion, Immunoeletrophresis
iv. ELISA test
v. Separation and characterization of serum and lymphocytes from blood
vi. Antibiogram study
vii. Bacterial biofilm analysis

MB COR 312: Computational Biology

i. Calculation of mean, mode, and median.
ii. Calculation of standard deviation and standard error.
iii. 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.
iv. Computer aided statistical analysis.
v. Computer presentation of statistical data, charts and diagrams.

MB COR 313: Assignment Presentation II

One article from peer reviewed journal of International repute selected by the student and is to be presented.

<u>Semester IV</u>

MB COR 401: Industrial and Food Microbiology

Industrial Microbiology

1. Pre-requisite of industrial microorganisms; screening, selection and improvement of industrial strains; Methods of preservation & maintenance of microbial strains & their stability; Formulation of fermentation media; inoculum preparation and inoculum development.
2. Outlines of the bioprocessing of the following: industrially important microbial products and their applications – alcoholic & non-alcoholic beverages, biopolymers (poly-hydroxyalkanoates, biosurfactants), ethanol, vinegar, vitamin B12, antibiotics (streptomycin, penicillin), glutamic acid, citric acid; steroid; biotransformation and its potential use.
3. Bioremediation of pollutants : Petroleum hydrocarbons, halogenated contaminants of aquifer and soil; Heavy metal contaminants of water bodies. Concept of phytoremediation. Lignin and azo-dye degradation.

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 COR 402: Bioprocess Technology & Intellectual Property Rights

Bioprocess Technology

1. 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.
2. Microbial growth in batch fermentor and chemostat; Basic components, design and scale-up of fermentors; modern bioreactors for solid state fermentation. Membrane biofilm reactor
3. Mass transfer in aerobic fermenter, Mass transfer coefficient (KLA).
4. Formulation of medium: Medium optimization
5. Downstream processing – product recovery, purification, finishing and packaging – techniques followed and instrument/devices used; effluent treatment.
6. Biofuel production – Biogas, biodiesel and H_2 as fuel by microbes; microbial fuel cell.
7. Bio-mining : Extraction of Cu, Au, U from ore by microbes; Bio-recovery of petroleum.

Intellectual Property Right

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

MB COR 403: Bioinformatics & NGS Metagenomics

Bioinformatics

Overview of bioinformatics – Database types, EMBL, Nucleic acid and protein sequence database, computer tools for sequence analysis, finding and retrieving sequences, similarity searching, pair wise and multiple sequence alignment; phylogenetic analysis and tree building methods, motif searches, epitope prediction, promoter and gene prediction; Protein secondary structure prediction, threading approaches, homology based methods for protein tertiary structure prediction, visualization tools, structure evaluation and validation, antigen-antibody interactions

Next generation DNA sequencing (NGS) and Metagenomics

1. Major advancements in Genomic approaches
2. Epigenetics and Metagenomics
3. Next Generation Sequencing (NGS)-Illumina (Solexa), Roche 454, Sequencing by Oligonucleotide Ligation and detection (SOLiD), Ion Torrent Technology etc. Parallel sequencing, Nanopore sequencing
4. Sequence analysis and their applications: Human Genetics and Human Genome Project
5. Metagenomic analysis of microbial community
6. Genomic insights into evolution, advantages of comparative genomic analysis

7. Analysis of microarray data
8. Forward versus reverse Genomics
9. Genome editing approaches and their applications

MB SEC 404: Research Methodology

Research methodology: Meaning of Research; Objectives of research; Motivation in research; Types of research; Research methods versus Methodology; Importance of knowing how research. Research problem. Selecting the problem; Necessity of defining the problem; Meaning of research design; Need for research design

Research and publication ethics: Copy rights; Philosophy and ethics; Citation & acknowledgment; Scientific misconducts: falsification, fabrication and plagiarism – redundant publications: duplicate and overlapping publications.

Bioethics & safety: Biohazards, human safety, environmental hazards & occupational health hazards; Concept of bioethics, ethical consideration of using GMOs or GM foods.

MB DSE 411: Food & Industrial Microbiology

i. Microbiological (bacterial and fungal) analyses of food
ii. Microbiology of fermented food products
iii. Analysis of milk quality
iv. Preparation of yogurt
v. Immobilization of microbial cells by calcium alginate gel entrapment
vi. Determination of substrate consumption rate in batch culture.
vii. Determination of specific cell growth rate.
viii. Determination of yield coefficient of cell biomass on substrate.
ix. Solid state fermentation of some microbial products
x. Alcoholic fermentation (demonstration)
xi. Collection and identification of important bacterial/fungal strains of industrial importance
xii. Production of alkaline phosphatase (lab scale)

MB COR 412: Project Work & Dissertation Presentation

Two-months duration research work to be done any laboratory. The outcome of the work is to be presented during end-term examination with submitting a project dissertation write up duly certified by the host institute or supervisor.

MB SEC 413: Review Writing & *Viva*

One review article on any topic relevant to the course-curricula is to be prepared by the student in standard journal format and to be defended during *viva-voce* before end-term examination.