New CBCS Syllabus for M.Sc. Microbiology Course: Effective from 2020- 2022 session onwards.

Semester I

Course				Lect. Hr /week	Dur. of Exam (in H)	Marks			Credit
Course code	Type	T/P	Name			I.A.	E.T	Total	
MSMI101	Core	T	Prokaryotic Microorganisms	4	2	10	40	50	4
MSMI102	Core	T	Acellular and Eukaryotic Microorganisms	4	2	10	40	50	4
MSMI103	Core	T	Biochemistry	4	2	10	40	50	4
MSMI104	Core	T	Microbial Metabolism	4	2	10	40	50	4
MSMI105	Core	P	General Microbiology	8	6	20	30	50	4
MSMI106	Core	P	Biochemistry & Microbial Metabolism	8	6	20	30	50	4
					Total credit				24

Semester II

Course				Lect. Hr /week	Dur. of Exam (in H)	Marks			Credit
Course code	Type	T/P	Name			I.A.	E.T	Total	
MSMI201	Core	T	Molecular Biology	4	2	10	40	50	4
MSMI202	Core	T	Cell Biology & Microbial Genetics	4	2	10	40	50	4
MSMI203	Core	T	Statistics and Bioinformatics	4	2	10	40	50	4
MSMI204	Core	T	Principles & Applications of Microbial techniques	4	2	10	40	50	4
MSMI205	Core	P	Molecular Biology & Microbial Genetics	8	6	20	30	50	4
MSMI206	Core	P	Statistics and Bioinformatics	8	6	20	30	50	4
					Total credit				24

Semester III

Course				Lect. Hr /week	Dur. of Exam (in H)	Marks			Credit
Course code	Type	T/P	Name			I.A.	E.T	Total	
MSMI301	Core	T	Industrial Microbiology & Recombinant DNA Technology	4	2	10	40	50	4
MSMI302	Core	T	Agriculture & Environmental Microbiology	4	2	10	40	50	4
MSMI303	Core	P	Industrial Microbiology & Recombinant DNA Technology	8	6	20	30	50	4
MSMI304	GE	T	Introduction to General & Applied Microbiology	2	1	5	20	25	2
MSMI305-I	DE	P	Agriculture & Environmental Microbiology	8	6	20	30	50	4
OR									
MSMI305-II	DE	T	Advance Microbial genetics	4	2	10	40	50	4
MSMI306-I	DE	T	Food Microbiology, IPR, Biosafety & Bioethics	4	2	10	40	50	4
OR									
MSMI306-II	DE	T	SWAYAM	4	2	10	40	50	4
MSMI307	CE	N.A.	Social Outreach & Educational Tour	N.A.	N.A.	0	15+10	25	2
					Total credit				24

** CE: Compulsory Community Engagement Programme; DE: Discipline-centric Elective; GE: Generic elective.

Semester IV

Course				Lect. Hr /week	Dur. of Exam (in H)	Marks			Credit
Course code	Type	T/P	Name			I.A.	E.T	Total	
MSMI401A	Core	T	Immunology	4	2	10	40	50	4
MSMI402	Core	T	Medical Microbiology	4	2	10	40	50	4
MSMI403	Core	P	Immunology & Medical Microbiology	8	6	5	20	25	4
MSMI404-I	DE	P	Food Microbiology, IPR and Biosafety	8	6	5	20	30	4
OR									
MSMI404-II	DE	T	Advance Agriculture Microbiology	4	2	10	40	50	4
MSMI405-I	DE	NA	Review	4		10	40	50	4
OR									
MSMI405-II	DE	T	Advance Food Microbiology	4	2	10	40	50	4
MSMI406	Project/ Term paper	N.A.	Project	4	---	---	50	50	4
					Total credit				24

DE: Discipline-centric Elective; GE: Generic elective.

SEMESTER -I

Paper MSMI-101(Theory) – Prokaryotic Microorganisms. 4 Credit. Marks 50 (40 + 10*)

1. Recent Advancements in Microbiology & contribution by Indian Scientists. (**1L)**
2. Origin of basic bio-molecules, Abiotic synthesis of organic monomers and polymers; Concept of Oparin & Haldane; Experiment of Miller (1953); origin of first cell; Evolution of prokaryotes; Endosymbiogenesis; origin of unicellular & multicellular organisms. The evolutionary time scale; Eras, Periods and Epoch; major events in the evolutionary time scale. **(10L)**
3. Prokaryotic diversity & Taxonomy: estimates & indices of diversity. Culture dependent & independent methods. Prokaryotic taxonomy- classical and modern (polyphasic approach). Prokaryote and eukaryote species concept. Genome based taxonomy. **(9L)**
   General account of cellular structures (morphological & ultra structural) of bacteria. Flagella, Transcriptional regulation of flagellar gene expression in bacteria and role of alternative sigma factors. Pili, Fimbriae, & Perennating bodies- (Cysts, myxospores). Chemotaxis, Phototaxis, magnetotaxis. Pigments of prokaryotes & their applications. **(7L)**
4. Archaea: Diversity, Occurrence, Major groups, characteristics & potential application. **(3L)**
5. General idea of control of microorganisms. Multidrug resistance in Microbes: importance & mechanisms. **(3L)**
6. Maintenance of microbial culture: Principles and techniques. **(2L)**
7. Cell cycle & Cell division in Prokaryotes: Proteins involved; molecular aspects. Binary fission, multiple fission, budding. **(4L)**
8. Cultivation of bacteria: General principles. Aerobic and anaerobic cultures, synchronous and asynchronous culture, batch, fed batch and continuous culture. Measurement of growth, factors affecting growth. **(5L)**
9. Extreamophiles: halophiles, thermophiles, psychrophiles, alkalophiles and acidophiles – adaptations. **(6L)**

Paper- MSMI-102 (Theory) Acellular and eukaryotic microorganisms. 4 Credit. Full Marks 50 (40+ 10*) (Virology, Phycology, Mycology, Protozoa & Helminthes - 20+ 10 + 10+10)

1. History and development of virology, distinctive, properties of virus, morphology, architecture, capsid arrangement, types of envelope and their composition. **(2 L)**
2. Viral nomenclature, classification of virus including Baltimore's classification, assay of virus – plant, animal and bacteriophage. **(3 L)**
3. Transmission of plant, animal and bacterial viruses. **(3L)**
4. Viral nucleic acid types, replication of viral DNA and RNA types. **(2L)**
5. Variations in structure of bacteriophages, lytic cycle of bacteriophages with reference. **(2L)**
6. Lysogeny: molecular mechanism of lytic-lysogenic conversion, significance. **(2L)**
7. Life cycles and replication of Ebola virus, Covid-19, HPV **(3L)**
8. Viral vaccines and antiviral agents. **(5L)**
9. Prions, Viroids and Virusoids and disease caused by them **(3L)**
10. Phycology: General account of Diversity, distribution, nutrition, mode of reproduction, Life cycle patterns, recent status of algae (evolutionary perspective), ecological significance, phycotoxins, economic importance including role in human affairs (algal pigments, biofuels, hydrogen production, important bioactive molecules, role of algae in sustainable environment). **(10L)**
11. Fungi: Diversity, modes of reproduction, ecological significances, sex hormones, mycotoxins, fungal associations with plants (endophytes, mycorrhizal fungi), animals and humans. economic importance, Secondary metabolites from fungi: Terpenes, Non-ribosomal peptides, hydrophobins, peptaibols, indole, alkaloids, detailed emphasis on polyketides. **(10L)**
12. Protozoa and Helminths:
    A. Protozoa: Diversity, reproduction, classification, importance to human affairs. **(3L)**
    B. Helminthes: General account, reproduction, classification, importance. **(2L)**

Core Paper MSMI-103 (Theory) – Biochemistry. 4 Credit. Full Marks-50 marks (40 + 10*)

1. Concept of different chemical interactions: covalent and non-covalent interactions (hydrogen, electrostatic, hydrophobic and van der Waals) and their importance in biological system. **(3L)**

2. Physical properties of water: structure and interactions of water molecules, weak interactions in aqueous solution, Ionization of water, Water as an excellent solvent, Proton mobility in water, Bronsted – Lowry concept of acid and bases, Concept of pH, Acid dissociation constant of weak acids, Henderson-Hasselbalch equation, Concept of buffer and its related parameters,

strength of buffer, buffer value, Important biological buffers and their mechanism of action, numerical problems associated with buffering capacity. **(4L)**

3. Carbohydrate Chemistry: Mono, di, oligosaccharides and polysaccharides, with examples, Classification of sugar, Concept of conformation and configuration, Monosaccharides as chiral compound and their nomenclature, Cyclization of Aldoses and Ketoses, asymmetric centre in sugars, D-series, L-series, dextro, leavo-rotatory, Structure of disaccharides, reducing and non-reducing sugars, sugar anomers, sugar epimers, sugar derivatives (sugar phosphate, sugar alcohols, amino sugars, sugar acids, deoxy sugars and ascorbic acid), Glycoconjugates (proteoglycans, peptidoglycans and glycoproteins). **(5L)**

4. Protein Chemistry: Chemistry of amino acids, Structural features of amino acids, classification of amino acids, amino acids as buffers, chemical reactions of amino acids, peptide linkage, partial double bond nature of peptides, four levels of protein structure, determination of primary structure of polypeptide (N-terminal, C-terminal determination), structural classification of proteins (primary, secondary, tertiary and quaternary structures), Ramachandran plot, Shape of protein molecules, classification based on composition, Classification based on functions ; enzyme, protein-storage, regulatory and transport protein, classification based on composition, classification based on molecular shape(globular and fibrous), unfolding of protein structure, effect of heat, pH and chemicals, *in vivo* protein folding: concept of chaperones, determination of N- and C- terminals, protein folding and denaturation of proteins, purification of proteins, assessment of purity of protein. Protein sequencing. Stability of protein. **(14L)**
5. Nucleic acid Chemistry: Concept of genetic material, central dogma, Structure of DNA (A, B, Z) and their biological relevance, Triple helical DNA, Slipped strand DNA, DNA unwinding elements, supercoiling, nucleosomes Purine, pyrimidine - definition and structure. Nucleoside, nucleotide: definition and structure. A-DNA, B-DNA & Z-DNA (structure and differences). Chemical Properties Hydrolysis (acid, alkali), enzymatic hydrolysis of DNA. Cot curve, Tm, General structure and types of RNA (tRNA, mRNA, rRNA), secondary structure of RNA, small RNA-snRNA, miRNA, siRNA, Cot curve, Tm. **(4L)**

6. Lipid Chemistry: Classification of lipids according to chemical structure, fatty acids: types and nomenclature, saturated, unsaturated, branched, nomenclature, system, structure and function of triacylglycerol, glycerophospholipids, sphingolipids, and steroids, Some biologically important lipids (prostaglandins, waxes etc.), steroids. Techniques used to study lipids. **(3L)**

7. Vitamins: Structure and function of water soluble and fat soluble vitamins as vitamins Coenzymes: Classification and importance, Some biologically important coenzymes (ATP, FAD and FMN, Coenzyme A, Pyridoxal phosphate, Biotin, Tetrahydropholate etc). Protein coenzymes. **(5L)**
8. Enzymes : Enzymology- Introduction, General characteristics of enzymes, Activation energy, Coupled reactions, active site and its importance, Factors influencing catalytic efficiency.Classes of enzymes ; active and binding sites; co-enzymes, co-factors, idea of prosthetic groups, holo and apoenzymes, isoenzyme, abzymes,enzyme activity, units; Equilibrium dialysis, Effect of pH on enzyme stability and activity, Effect of temperature on enzyme stability. enzyme inhibitors and activators, enzyme kinetics – Michaelis –Menten derivation, km values, association and dissociation constant, inhibition and its kinetics, effect of pH and temperatures on enzymes action, enzyme regulation, allosteric, covalent modification, isoenzyme, abzymes, ribozymes other non-protein biocatalysts. **(12L)**

Core Paper MSMI-104(Theory) – Microbial Metabolism. 4 Credit. Full Marks-50 marks (40 + 10*)

1. **Photosynthesis**: Regulation of dark and light reactions. RUBISCO-structure and molecular regulation, Consortium of photosynthetic microbes , Biotechnological applications of microbial photosynthesis. **(7L**).

2. Microbial Metabolic regulation strategies, Regulation and energetics of hexose and pentose metabolism. Peptidoglycan synthesis. **(7L)**

3**. Chemolithotrophy**: Hydrogen, Sulphur, Iron bacteria; Methanogenesis and Methylotrophy, Anammox. **(6L)**

4. **Biological N2-fixation**: Types (symbiotic; asymbiotic, associative and endophytic); Molecular mechanism and Genetic regulation of N2-fixation; nitrogenase structure and assay, alternate nitrogenase. **(4L)**.

5. **Protein turn over and Biosynthesis and degradation of amino acids** with reference to aspartate and aromatic amino acid families. **(4L).**

6. **Aerobic and Anaerobic Respiration:** Redox Potential**.** Mechanisms and bioenergetics of ETC and oxidative phosphorylation. Uncouplers and inhibitors. Respirasome, ATP synthasome, P/O ratio, Generation of ATP in alkaliphiles. NO_3 respiration, SO_4 respiration, Halorespiration. (**5L**)

7. Fermentation pathways: Fermentation reactions**,** Fermentation balances, Homo and Heterolactic fermentation, Alcohol fermentation, Acetic acid, Butyric acid, Mixed Acid and Propionic acid fermentation, Stickland reaction, Secondary fermentation. (**5L)**

8. Biosynthesis and degradation of nucleotides: *de novo* and salvage pathway Purine and Pyrimidine nucleotide biosynthesis and degradation. **(4L)**

9. Biosynthesis and degradation of Lipid: Degradation of glycerol, Oxidation of fatty acids (α, β, ω oxidation), Oxidation of MUFA and PUFA, Ketone bodies, Biosynthesis of fatty acids (saturated and unsaturated). (**4L)**

10. Nutrient transport: Mechanism of Active, Passive and Facilitated Transport, Carriers and Channels, Aquaporin, Ionophore, Types of ATPase, Group Translocation, Siderophores, Osmosis, Exocytosis and Endocytosis, thermodynamics of transport, Sec and TAT pathway of protein transport. (**4L)**

Core Paper MSMI-105 (Practical) – General Microbiology. 4 Credit 50 marks (30 + 20*)

1. Laboratory rules, safety and regulation, First Aid and ethics.
2. Experiment Design & Quantitative data: Practical aspects
3. Enrichment culture of Prokaryotes: Halophiles, Thermophiles, iron oxidizer & Sulphate reducers.
4. Identification of Pure Prokaryotic isolates (Up to genus level) by phenotypic characterization using Bergey's Manual.
5. Study of various reserve food material (Glycogen / polyphosphates, PHB, oil) of microbes.
6. Culture preservation & revival: -80°C glycerol stock & Lyophilization.
7. Demonstration of Great Plate Count Anomaly.
8. Identification of Algae, fungi & eukaryotic microorganisms through permanent slides.
9. Phenol coefficient
10. Viral specimen collection, viral transport medium and egg inoculation. And SEM study.

Core Paper MSMI-106 (Practical) Biochemistry & Microbial Metabolism. 50marks (30 + 20*)

1. pH, pK, Henderson – Hassel batch equation. Measurement of pH, Preparation of buffer in acidic, alkaline and neutral range, Determination of pK values.
2. Isolation of phospholipids from microbes and their separation by thin layer chromatography.

3. Determination of saponification value of fat.
4. Estimation of protein by Bradford/Biuret method.
5. Isolation and separation of photosynthetic pigments by TLC/gel filtration and study of their absorption spectra.
6. Determination of Km, Vmax with and without inhibitors using bacterial alkaline phosphatase or any other enzyme.'
7. SDS-page Separation of Protein & determination of Molecular wt.
8. Purification of enzyme from natural source by (any one method): Ammonium sulfate precipitation, Organic solvent precipitation, Gel filtration.
9. Study of isozymes of any suitable enzyme by zymogrphy.

SEMESTER- II

Core Paper MSMI-201(Theory) – Molecular Biology. 4 credit. Marks 50 (40 + 10*)

1. Concept of Informational molecules & Central dogma; Comparative study of Genome (Viral, prokaryotic, eukaryotic & organellar). Chromatin arrangement, remodeling & nucleosome formation. C value paradox; Operons, pseudogene, gene families, gene cluster, super families. Euchromatin & heterochromatin; unique and repetitive DNA. SNPs & Their function. **(6)**
2. DNA replication: Prokaryotic and Eukaryotic DNA replication; mechanism, Initiation, elongation, termination and regulation of replication; DNA replication machinery, polymerases; Uni and bi-directional replication, D loop and rolling Circle model of replication. Maintaining the ends of Linear DNA molecule, cell cycle and regulation of genome replication. Extra chromosomal replicons. **(8)**
3. DNA damage and repair and recombination: Direct repair, base excision repair, nucleotide excision repair, mismatch repair, recombination repair, SOS repair. Homologous & site specific recombination; Proteins involved in recombination; Holliday model of recombination. Gene conversion. **(8)**
4. Transcription: Comparative account in Prokaryotes & Eukaryotes- Mechanisms (Transcription factors & machinery), inhibitors of transcription**.** Post transcriptional modifications in eukaryotes; RNA transport; Structure & function of different types of RNA. SnRNAs (Snurps and Snorps), Ribozymes; RNAi & miRNA- mechanism and significance. **(10L)**

5. Protein Synthesis Comparative account in Prokaryotes & Eukaryotes- Mechanisms (various factors & machinery), Regulation, Processing & inhibitors**.** Genetic code; Codon usage & codon bias. Translational proof-reading. Post translational modifications of proteins. Protein folding. **(10L)**
6. Regulation of Gene Expression: Positive and Negative regulation; Inducible & repressible system, attenuation; *E. coli*- Lac, ara, his and trp operons; Lysine ribo-switch anti termination. Global regulatory response & role of small molecules (ppGpp & cAMP). **(8L)**

Core Paper MSMI-202 (Theory)- Cell biology & Microbial Genetics. 4 Credit. Marks 50 (40 + 10*)

Cell Biology: 2 Credits

1. Interaction of host & Parasite: process of recognition and entry in host (plant & animal) cells by different pathogens (bacteria, virus and fungi). Alteration of host cell behavior by pathogens. Cell transformation by virus, pathogen induced diseases in plants & animals. Cell to cell fusion in normal & abnormal cells. **(6L)**
2. Cell signaling: signaling by GPCR, signal transduction pathways (mechanisms of bacterial & eukaryotic pathogens in relation to man) & their regulation, second messengers; bacterial two component system. Quorum sensing in prokaryotes- molecular mechanism. **(6L)**
3. Cellular communication & Cancer Biology: General principle of cell communication, cell adhesion & various molecules involved in it, gap junctions, extracellular matrix, integrins. Biochemical and molecular changes in transformed cells, Genetic rearrangements in progenitor cells, oncogenes, tumor suppressor genes, cancer and the cell cycle, virus-induced cancer, metastasis, interaction of cancer cells with normal cells, therapeutic interventions of uncontrolled cell growth. Mechanism of apoptosis. **(13L)**

Microbial Genetics: 2 Credits

1. Plasmids & mobile genetic elements:

   Plasmid types, replication, copy number control. distribution & importance. Plasmid Addiction Systems in bacteria: Proteic Plasmid Addiction Systems (PPAS)- *hig* system in Rts1, ω-ε-ζ system in pSM19035, *pem/parD* system in R1, *ccd* system in F plasmids. Implications of bacterial transposons as tool in genetic analysis. Retrotransposons, their replication, Poly-A-retro-transposons, Reverse splicing mechanism, SINEs and LINEs. **(5L)**

2. Methods of genetic transfer in Bacteria: Transformation, natural transformation systems, chemical and electro-transformation method, Conjugation: discovery, Conjugation, Hfr and F' strains, Transfer systems in Gram positive bacteria, interrupted mating and maping of bacterial genomes, Transduction-Generalized and specialized transduction, sex-duction. **(10L)**

3. Mutation: Types, mutation rate and frequency, spontaneous and induced mutagenesis, forward and backward mutation, reversions versus suppression, Mutant types- lethal, conditional, polar mutation, antimorphic mutation, loss of function, gain of function, germinal versus somatic mutants, insertional mutagenesis. Isolation and selection of mutants- sugar utilizing auxotrophs, amino acid utilizing auxotrophs, temperature sensitive mutants, mutation enrichment technique, Replica plating, Complementation assay, Ames test, Fluctuation test, Transposon mutagenesis. **(10L)**

Core Paper MSMI-203 (Theory)-Statistics and Bioinformatics. 4 Credit. Marks 50 (40 + 10*)

Statistics: 1 Credit

1. Introduction to principles of statistical sampling from a population. Frequency Distributions and Statistical Measures: mean, mode, median, variance, standard deviation, coefficient of variation, measures of skewness and kurtosis. Introduction to theory of Probability, Conditional Probability, Bayesian Rules, Binomial, Poisson, Normal and extreme value distribution. Confidence intervals, Type of errors, Level of significance;Hypothesis testing: Test of significance viz. Z test, t test, pair t test, chi-square test of goodness of fit, Analysis of Variance; Correlation and Regression. **(15L)**

Bioinformatics- 3 credit

2. Introduction to operating systems and programming language and their importance in Bioinformatics: Windows/Unix/Linux; C programming and it's applications in sequence analysis; Preliminary idea about Perl and R programming language. **(10L)**

3. Introduction to Bioinformatics: Overview of Bioinformatics resources on the web (NCBI, ExPASy etc.), Biological Databases: Nucleic acid sequence databases (GenBank/EMBL/DDBJ) Protein sequence databases (UniProtKB); Overview of concepts in sequence analysis: Pair-wise sequence alignment algorithms (Needleman & Wunsch and Smith & Waterman algorithm), Scoring matrices for Nucleic acids and proteins (PAM and BLOSUM); Database Similarity Searching through BLAST(Algorithm and Types); Multiple sequence alignment with

CLUSTAL; Derived databases (Prosite, BLOCKS, Pfam/Prodom); Biological structural databases (PDB); Multiple sequence alignment, Phylogenetic analysis algorithms(Distance-based: UPGMA, Neighbor-Joining), Maximum Parsimony, Concept of phylogenetic tree and its reliability, Software used for Phylogenetic analysis. Software for epitope, promoter and gene prediction. data mining tools and applications, comparative analysis. **(15L)**

4. Protein structure prediction (Methods and software used) and analysis; Protein visualization tools, Preliminary idea on Molecular Dynamic Simulation of protein, Basic idea of bacterial genome sequencing, assembly and annotation and in silico comparative genomics; Preliminary idea about computer aided drug designing (CADD). Antigen antibody reaction. **(10L)**

Core Paper MSMI-204 (Theory)– Principles & Applications of Microbial techniques. **4 Credit**. **Marks 50 (40 + 10*)**

1. Chromatographic techniques: Basic concepts, Bioautography, Gel filtration chromatography, Ion-exchange chromatography, Affinity chromatography, Gas chromatography, High Performance Liquid Chromatography. **(6L)**
2. Electrophoresis: Basic concepts, Gel Electrophoresis –Agarose, Acrylamide (native, denaturing and gradient), 2D electrophoresis, immuno-electrophoresis. **(5L)**
3. Centrifugation: Basic concepts, Ultra centrifugation, Density gradient centrifugation, differential centrifugation, Isopycnic centrifugation. **(4L)**
4. Spectroscopy: Basic concepts, Circular Dichroism (CD) and Optical Rotatory Dispersion (ORD), Fluorescence spectroscopy, Infrared spectroscopy, FTIR, NMR spectroscopy. Mass spectroscopy- MALDI-TOF, Nano-SIMS. **(5L)**
5. Radiography: Basic concept, Autoradiography, FISH-MAR, Pulse chase experiment, Čerenkov radiation, Liquid scintillation counting, Phosphor imaging, IRMA. **(5L)**
6. X-ray crystallography: Crystallization of proteins, instrumentation, acquisition of the diffraction pattern, basic principles of x-ray diffraction, Phase determination. **(3L)**

7. Microscopy: - Basic principles and application of Phase Contrast and Confocal Laser microscopes, Fluorescence and Electron microscope (SEM & TEM), Radio Microscopy. **(5L)**
8. Hybridization techniques: Southern, Northern and Western hybridization techniques. FISH, GISH, Chromosome painting. Chromosome walking, DNA fingerprinting techniques. **(4)**
9. Protein sequencing methods. Measuring post translational modifications of proteins**.** **(4)**
10. DNA sequencing methods: Classical Sanger methods, NGS techniques. Genome sequencing strategies. **(4)**

11. Polymerase Chain reaction: General concept, Primer designing, various types (Gradient, Touchdown, Inverse, Vectorette, Multiplex, Long, Reverse Transcriptase PCR etc). PCR product cloning, 5' and 3' RACE, qPCR, Real Time PCR. Genome amplification techniques. **(5)**

Core Paper MSMI-205 (Practical) – Molecular Biology & Microbial Genetics 4 Credits Marks 50 (30 + 20*)

1. Isolation of Metagenome from different samples & its analysis by agarose gel electrophoresis.
2. Estimation of purity & concentration of DNA.
3. Primer designing
4. Amplification of gene by PCR.
5. Preparation of Competent cells & Transformation of Plasmid DNA in *E.coli.*
6. Curing of plasmid
7. Induced mutation by UV &/or Chemical.
8. Isolation and culturing of Auxotrophic mutant & antibiotic resistant strains.

Core Paper MSMI-206 (Practical) – Statistics and Bioinformatics, 4 Credits, Marks 50 (30 + 20*)

Statistics: 1 credit

1. Test of significance: Chi-Square test, Student T test, Z test, F test.
2. Correlation & Regression.
3. ANOVA

[All the above parameters will be determined by using different statistical software(MATLAB/STASTICA/SPSS)]

Bioinformatics: 3 credits

1. Exposure to different sequence/structural/Genome database through web server (NCBI, SWISS-PROT, PDB, JCVI/CMR, IMG, EBI, GOLD etc.).
2. Exposure to different protein structure visualization tool (PyMol, Swiss PDB Viewer etc.)
3. Sequence similarity searching by different types of BLAST.
4. Writing different programmes in C/Perl for sequence handling/ manipulation. Demonstration of R language.
5. Exposure to different sequence analysis software.

Semester-III

Core Paper MSMI-301 (Theory)- Industrial Microbiology & Recombinant DNA Technology. . 4 Credit. Marks 50 (40 + 10*).

Industrial Microbiology 2 Credit:

1. Introduction to industrial microbiology, sources of industrially important microbes, screening and development of strain, types of fermentation and fermenters, sterilization, medium formulation , medium and process optimization. **(5L)**
2. Operational modes of bioreactors: Batch, Fed-batch and Continuous processes: Applications, advantages and limitations of each type. gas-liquid mass transfer, bioreactor monitoring and control. **(5L)**
3. Downstream processing of microbial products: Filtration, centrifugation, cell disruption, liquid-liquid extraction, chromatography, membrane processes, drying (lyophilization and spray drying), and crystallization. Importance of automation in fermentation technology. **(3L)**
4. Production aspects: Medium optimization, down stream processing and applications of amino acids (lysine), antibiotics (nisin), enzymes (protease), microbial polysaccharide (Xanthan Gum), Wine (Champagne), Biofuel (Hydrogen), steroids (Cortisone). **(10L)**
5. Microbes and mineral recovery: Bioleaching of copper, gold and uranium. **(2L)**

Recombinant DNA Technology. 2 Credit:

1. Enzymes in DNA manipulation. Fundamental techniques used in RDT [isolation and purification of DNA (Genomic & plasmid) and RNA. Restriction digestion, ligation (adapters, linkers etc). **(2L)**

2. Vectors & Hosts of RDT: Cloning and expression vectors. Cloning and expression host. TA cloning, TOPO cloning, Plasmid, Phages Lambda and M13, Cosmid, Phagemid, YAC, BAC. Functional genomics. Over-expression and tagging of recombinant proteins. Selection and screening of clones, Construction of genomic and cDNA libraries. **(4L)**

3. Gene knockout techniques: In vitro mutagenesis and deletion techniques, In frame deletion method. **(2L)**

4. Analysis of DNA-protein and protein-protein interactions: Gel retardation assay, DNA footprinting by DNase I, South-Western, Yeast two hybrid system, Co-immunoprecipitation, Phage display. **(3L**)

5. Protein sequencing methods. Measuring post translational modifications of proteins. **(2L)**

6. DNA sequencing methods: Classical Sanger methods, NGS techniques. Genome sequencing strategies. **(2L)**

7. DNA fingerprinting techniques- concept & application. **(1L)**

8. Basic concept & application of Genomics, metagenomics, metabolomics, transcriptomics (enzymatic and bioluminescent reporter, S1 mapping, Promoter analyses, DD, EST analysis, DNA microarray, SAGE) pharmacogenomics (Human protein replacements – insulin, hGH, Human therapies –interferon, antisense molecules). **(5L)**

9. Basics of plant tissue culture. Role of Ti plasmid in plant biotechnology. Transgenic animals and plants. Animal cloning. **(2L)**

10. Bio-molecular calculations & software used in RDT: DNA- RNA- Protein size, mass, concentration, amount and number related problems. Calculation related to library representation, coverage etc. Knowledge of various software for in-silico RDT analyses. **(2L)**

Core Paper MSMI-302 (Theory)- Agriculture & Environmental Microbiology. **4 Credit. Marks 50 (40 + 10*)**

Agricultural Microbiology: 2 Credits

1. **Microbial biofertilizers:** Types and microbes used, characteristics of inoculant production, the principle of Cross inoculation, production of inoculant biomass, formulation & packaging technology, application of microbial inoculant. Plant growth promoting bacteria of rhizosphere (PGPR)- Implication of Green biotechnology. Vermicast organic fertilizer: the concept of biological stimulation, role of microorganisms, mass production technology, application of vermiculture. **(6L)**

2. **Microbial insecticides:** Types and microbes used. Production of inoculants, their formulation strategies and application. Bt crops, special reference to Bt corn, Bt cotton**.** **(3 L)**

3. **Host-Parasite interactions:** Important diseases in agricultural crops by bacteria (crown gall), viruses (CaMV) and fungi (rust of wheat) and their control (chemical & biological). Microbial diseases of aquacultural animals- finfish and shell fish, their prevention strategies and treatment. **(6 L)**

4. **Plant-Microbe interactions:** Molecular mechanism of disease development (enzyme, toxin and hormonal disturbances). Resistance by hosts- anatomical & biochemical mechanisms. Role of phytoalexins, PR proteins, phytoncides, plantibodies; programmed cell death. Control of diseases (chemical, physical, biological and biotechnological). **(10L)**

Environmental Microbiology: 2 credits

1. Microbial ecology: Basic concepts of ecology, habitat and niche, Thermodynamics and energy flow within ecosystem. r & K selection,community structure, diversity indices.Benevolent and

antagonistic interactions.Development of microbial community in biosphere. Ecological homeostasis and co-evolution. Physiological ecology of microorganisms- Liebig's law of minimum and Shelford's law of tolerance. Ecology of microorganisms in extreme environments, Biofilm and ecological implication. **(8L)**

2. Aero microbiology: Significance of air, Indoor aero microbiology, assessment of air quality, air sampling techniques, Phylloplane microflora, nature of bioaerosols, their fate and transport;aeroallergens and aero allergy, control, biosafety and bioterrorism. **(4L)**
3. Soil microbiology: Physical and chemical characters of soil, microflora of various soil types, autochthonous and allochthonous microorganisms, subterranean microbes, role of microorganisms in soil quality management. Rhizosphere and phyllosphere. **(4L)**

4. Aquatic microbiology: Types of aquatic ecosystem- fresh water and marine habitat, zonation of marine ecosystem,growth and distribution of marine micro plankton, mechanism of dissolved organic matter production and utilization. Marine microbes and their applications. (**3L)**
5. Microbial bioremediation:Concept of bioaugmentation, biostimulation, bioimmobilization, rhizoremediation. Methods of bioremediation, critical factors affecting remediation. Bioremediation of persistent organic pollutants, heavy metals, synthetic polymers. **(3L)**
6. Wastewater Microbiology:Microbial assessment of water quality, microbes as bio-indicators, potability of water.Treatment of municipal waste water.Solid and liquid based treatment, biological (aerobic, anaerobic, primary, secondary, tertiary) treatment. Vermifiltration for recycling of wastewater and solid wastes. **(3L)**

Core Paper MSMI-303 (Practical)- Industrial Microbiology & Recombinant DNA Technology. **4 Credit. Marks 50 (30 + 20*)**

1. Restriction digestion and restriction mapping.
2. Primer designing
3. Amplification of gene by PCR.
4. RFLP, RAPD,
5. Gene Cloning using E. coli based plasmids.
6. Southern blotting
7. Isolation of RNA & its analysis.
8. Preparation of enzyme immobilized columns for biotransformation –e.g. yeast cells immobilized in calcium alginate beads
9. Isolation of exo-polysaccharide producing microbes and purification of the polysaccharide and analysis of its component monosachharides.
10. Production of wine from fruits.

GE Paper MSMI- 304 (Theory) – Introduction to General & Applied Microbiology. 2 Credits. Marks 25 (20 + 5*)

Microbial Diversity and Applications 6L

Diversity of Prokaryotes and their applications in agriculture.

Extremophiles, their applications, habitats and relation to the extraterrestrial life forms.

Metabolic regulation of microbes 6L

Various strategies adopted by microbes at enzyme activity and synthesis level to regulate their metabolism- regulation of catabolic and anabolic pathways, concept of metabolomics.

Chromatin remodeling and epigenetic mechanism: **6L**

Chromatin structure and modification: Structure of nucleosome and DNA; States of chromosomes during cell cycle; Euchromatin and heterochromatin; The major epigenetic mechanisms: classifications of HDAC, HAT, DNA methyl transferases and scaffold attached regions

Basic bioinformatics: 7L

Definition and applications of Bioinformatics, concept of various web based tools used in Bioinformatics, Concept of pair wise and multiple sequence alignment and their relation in database similarity searching,

DE Paper MSMI-305-I (Practical) – Agriculture & Environmental Microbiology. 4 Credits. Marks 50 (30 + 20*)

1. Isolation of *Azospirillum/Rhizobium* and detection of IAA and siderophore produced by them.
2. Isolation and identification VAM fungi from angiosperm root.
3. Study of phycobionts and mycobionts in lichen
4. Isolation of phosphate solubilizing bacteria from soil and study of its effect on plant growth
5. Bio-sorption of dyes (Congo red) or metals using dead microbial biomass.
6. Enumeration of PPFM from phyllosphere.
7. Enumeration of microorganism from air: settle plate technique, air sampling technique.

DE Paper MSMI-305-II (Theory) ADVANCE MICROBIAL GENETICS 4 Credits. Marks 50 (40 + 10*)

1. Prokaryotic Genome: *E. coli* chromosome- coiled, supercoiled (plectonemic, solenoid), folded fiber model. *Mycoplasma genitalium* and *E. coli* genome. **4L**

   2. Eukaryotic Genome: Structure of chromatin, chromosome, centromere, telomere, nucleosome, genome organization, split gene, overlapping genes and Cot curves, chromatin remodeling; types of histones, histone modifications- methylation, acetylation, phosphorylation and their effects on structure and function of chromatin, DNA methylation, repetitive and non-repetitive DNA sequence. Law of DNA constancy, C value paradox and genome size, karyotype and idiogram, chromosome banding pattern, types of chromosomes. Organelle genome. **10L**

2. Gene and Mutation: Gene as unit of mutation, molecular basis of spontaneous and induced mutations and their role in evolution; mutagens, types of mutations, transposon mutagenesis, site directed mutagenesis; environmental mutagenesis; Ame‟s and other toxicity testing. **8L**

3. Genetic recombination: Genetic recombination in bacteriophages and E. coli, synopsis of homologous duplexes, breakages and re-union role of RecA and other recombinases, generalized & specialized transduction, transformation and conjugation, legitimate & illegitimate recombination, gene conversion, overview of bacterial genetic map. **10L**

4. Gene transfer mechanisms: Bacterial transformation; Host cell restriction; Transduction; complementation; conjugation and transfection, mechanisms and applications, genetic analysis of virus, bacteria and yeast genomes. Genetics of fungi-alteration of generation, induction of mutation in Neurospora crassa and yeast, cytoplasmic inheritance and biochemical mutants. **10L**

5. Plasmids and Bacteriophages: Plasmids, F-factors - description and their uses in genetic analysis, Colicins and Col Factors, R plasmids. Lysogeny and lytic cycle in bacteriophages, Life cycle and their uses in microbial genetics. Lytic phages-T7 and T4, Lysogenic phages Lamda, M13 and ΦX174. **8L**

DE Paper MSMI-306-I (Theory) – Food Microbiology, IPR , Biosafety and Bioethics. 4 Credits, Marks 50 (40 + 10*)

Food Microbiology. 2 Credit:

1. Introduction to Microbes in Foods: History and development of food microbiology, Characteristics of Predominant Microorganisms in Food, Sources of Microorganisms in Foods. **(5L)**

2. Microbial Growth Response in the Food Environment: Microbial Growth Characteristics, Factors Influencing Microbial Growth in Food. **(5L)**

3. Microbial spoilage of foods: Important Factors in Microbial Food Spoilage, Spoilage of Specific Food Groups, Food Spoilage by Microbial Enzymes, Indicators of Microbial Food Spoilage, Concept of Hazard Analysis and Critical Control Points (HACCP). **(5L)**

4. Fermentation processes: Production of non-diary fermented food, milk products, plant based products, fish products, meat products and food beverages, Intestinal Beneficial Bacteria **(5L)**

5. Food-borne diseases: Idea of Infections, Toxicoinfections and Intoxications with specific examples. **(5L)**

IPR, Bioethics & Biosafety. 2 Credit:

1. Intellectual Property: Basic concept. Protection of new GMOs. International framework for the protection of IP in R&D. Case studies in Microbial Biotechnological innovations. Introduction to the history of GATT, WHO, WIPO and TRIPS. **8L**

2. Basics of Patents: Definition, Biological patents, Patent databases-International and country wise patent searches. Indian Patent Act 1970, Recent amendments. Filing of a patent application-provisional and complete specifications. **8L**

3. Bio-safety: Primary containment for Biohazards, Bio-safety levels. Bio safety guidelines-Definition of GMO's and LMO's. Role of International Biosafety committee. Environmental release of GMOs, Overview of National Regulations and relevant International Agreements. **9L**

DE Paper MSMI-306-II (Theory) – SWAYAM Course 4 Credits, Marks 50 (40 + 10*)

Paper MSMI-307 Social Outreach and Educational Tour. 2 Credit Compulsory Paper. Marks 25 (15+10)

Semester-IV

Core Paper MSMI-401 (Theory)- Immunology. 4 Credit. Marks 50 (40 + 10*)

1. Immunology-fundamental concepts and anatomy of the immune system: **(1)**

2. Components of innate and acquired immunology, phagocytosis, complement and inflammatory responses, haematopoesis, organs and cells of the immune system-primary and secondary lymphoid organs, lymphatic systems (MALT & GALT). (4)

2. Antigens- immunogens, requirements for immunogenicity, haptens, antigen antibody interactions, affinity and avidity, adjuvants , cross reactivity, antigen presenting cells (APC). (5)

3. Major Histocompatibility complex (MHC)- MHC genes, antigen processing and presentation, HLA typing. (5)

B. **Immune responses generated by lymphocytes. (20L)**

1. Immunoglobulins- Basic structure, classes & sub classes, antigenic determinants, action of antibody, kinetics of immune response, B-cell receptor, B-cell maturation , activation and differentiation, monoclonal antibodies, clonal selection theory.

2. Multigene organization of immunoglobulin genes, generation of antibody diversity, class switching, allelic exclusion, affinity maturation.

3. Cytokines and its properties (pleiotropic, redundancy, synergy, antagonism).

4. T-cell and cell mediated immunity-structure of T-cell receptor, co-receptor molecules.

5. T-cell receptor diversity, T-cell maturation, activation and differentiation, function of T cells.

C. Clinical immunology. (8L)

1. Hypersensitive reactions (Type I, II, III and iv).
2. Auto immunity, example of some auto immune diseases: Congenital & acquired immune-deficiencies.
3. Tissue transplantation and graft rejection.
4. Tumor antigens, immune response to tumors and immunotherapy of tumors.

5. Active and passive immunization; live, killed, sub unit, DNA and recombinant vector vaccine.

D. Antigen - Antibody interactions. (7L)

Precipitation reactions- precipitation reaction in fluids& in gel,radial immunodiffusion (Mancini method), double diffusion (Ouchterlony method). Agglutination- Prozone effect, direct agglutination

and passive agglutination. Advanced immunological techniques- RIA, ELISA, Immunofluorescence, Immunoelectrophoresis, Immunomicroscopy.

Core Paper MSMI-402 (Theory)- Medical Microbiology. **4 Credit. Marks 50 (40 + 10*)**

1. A step wise process of infection – Crossing physical, chemical and biological barriers, Colonization, Association, Adhesion and Invasion of host tissue and toxigenesis with details account of virulence factors – Adhesins (pili, capsule, hemagglutinins), Invasins (Fibrinolysins, hyaluronidase, hemolysins, hypal extensions), Evasins (catalase, coagulase, Siderophores, Leucocidins, Kinins), Toxins (diphtheria, cholera, tetanus toxins and endotoxins of Gram negative bacteria – mode of action and *in vivo*and *in vitro* assay systems). **(8)**

2. Mechanisms of bacterial resistance to host cellular (phagocytosis) and humoral defenses. Antibiotic/Drug resistance- origin, cause and clinical implication with special references of multidrug resistant tuberculosis, MRSA and New Delhi metallo beta lactamase. **(6)**

3. Molecular basis of bacterial pathogenecity – cytoskeletal modulation of host cell, virulence genes and pathogenecity islands. **(4)**

4. Antibiotic and chemotherapeutic agents: Sulfur drugs, Antibiotics and their classification, Mode of action, chemical nature of different antibiotics, antibiotic assay and sensitivity test, non-medical uses of antibiotics ; antiviral drugs. **(4)**

5. **Drug discovery :**

a. Historical perspective

b. Current approaches to drug discovery: Rational Drug design, receptor / target concept in drug designing, Introduction to pharmacogenomics, Combinatorial chemistry, High Throughput Screening. Lead discovery, Lead compound optimization, Candidate drug selection.

d. Preclinical development: i. Safety profile of drugs (Pyrogenecity, Toxicity –hepato, - nephro, - cardio and neurotoxicity) ii. Toxicological evaluation of drug: LD50, Acute, subacute and chronic toxicity. iii. Mutagenecity (Ames test, micronucleus test), Carcinogenicity and Teratogenecity. **(12)**

6. **Clinical development of biologicals:**

a. Regulatory authorities for introduction of medicines in market – Role of Food and Drug Administration, FDA guidelines for drugs / biologicals, Validation (GMP,GLP, GCP, etc.).

b. Clinical studies: Phase I, phase II, phase III and phase IV of clinical trials –Objectives, Conduct of trials, Outcome of trials.

c. Delivery systems – formulations, targeted drug delivery, Sustained release drugs.

d. Drug distribution in body, bio-availability and pharmacokinetic studies. **(8)**

7. Development of antimicrobial agents:

a. Screening strategies for new antimicrobial agents acting on bacterial cell wall, cell membrane, nucleic acid and protein metabolism.

b. Bioassay of antibacterial agents in liquid media and in agar media using standard guidelines (e.g. National Committee for Clinical Laboratory Standards (NCCLS) /Clinical and Laboratory Standards Institute (CLSI)), Factors affecting bioassay, Laboratory methods to assess activity of antimicrobial combinations (antagonism, synergism and additive effect).

c. Methodologies for testing of antibacterial, antifungal, antiparasitic and antiviral drugs (*in vivo* and *in vitro* infectivity models). **(8)**

Core Paper MSMI-403 (Practical)- Immunology & Medical Microbiology. 4 Credit. Marks 50 (30 + 20*)

1. Ochtarlony double diffusion agar cup assay,
2. Latex agglutination assay,
3. Immunofluorescence
4. Immuno-electrophoresis.
5. Serological test-Tuberculin Test, ELISA,
6. Microbial flora of the mouth: determination of susceptibility to dental caries.
7. Study of natural microflora of throat and skin.
8. Isolaion & Identification of *Streptococcus pneumonia.*
9. Isolation and identification of *Staphylococcus* sp. from natural flora of human body and determination of antibiotic sensitivity profile of the isolates.
10. Extraction of phenolics/alkaloids from plant part(s) and testing their antimicrobial (*Staphylococcusaureus/ Mycobacterium sgmagmatis* and *Candida* sp.) activity by agar cup assay or bioautography method.

DE Paper MSMI-404-I (Practical) – Food Microbiology, IPR and Biosafety . 4 Credits, Marks 50 (30 + 20*)

1. Practice of biosafety, necessary for Microbiology research.
2. Preparation of wine from locally available fruit juices
3. Preparation of lactose free milk using immobilized lacatase enzme/lactase positive permeable bacterial whole cell
4. Detection of bacterial load of milk/meat/fruits/packed food items
5. Isolations and identification of Salmonella in processed foods.
6. Bioethanol production from potato.
7. Isolation of bacteriocin producing bacteria from fermented milk product (s).
8. Mock filing of patent application

DE Paper MSMI-404-II (Theory) – ADVANCE AGRICULTURE MICROBIOLOGY . 4 Credits, Marks 50 (40 + 10*)

1. Microbes and soil fertility: Role of microbes in soil fertility. Decomposition of organic matter by microorganisms - cellulose, hemicellulose, lignin, xylan and pectin. Soil fertility evaluation and improvement. Effect of pesticides on soil microflora. **4L**

2. Biological nitrogen fixation(BNF): Nitrification, denitrification; symbiotic nitrogen fixation (Rhizobium, Frankia), non-symbiotic nitrogen fixation (Azotobacter, Azospirillum); Nitrogenase enzyme, nif genes and molecular mechanism of nitrogen fixation. Role of nodulin genes in nodule development and symbiosis. Genetic engineering of BNF . **8L**

3. Plant-microbe interactions: Mutualism, commensalism, parasitism, amensalism, synergism. Rhizosphere microorganisms- phyllosphere, spermosphere and rhizoplane, methods of enumeration, rhizosphere effect, factors influencing rhizosphere microbes. PGPR, Siderophores and VAM. **10L**

4. Bioinoculants: Biofertilizer - types, production and quality control. Cultivation and mass production of bioinoculants- Azotobacter, Rhizobium, Azospirillum, Cyanobacteria, phosphate solubilising microorganisms, Azolla. Carrier-based inoculants - production and applications. Biopesticides – types and applications (Pseudomonas fluroscence, Bacillus thuringiensis, Trichoderma harzianum, Trichoderma viridae, Nuclear Polyhedrosis Virus). **10L**

5. Molecular plant pathology: Recognition and entry of pathogens into host cells. Alteration of host cell behaviour by pathogens. Molecular mechanisms of disease establishment; enzymes, phytotoxins, growth regulators. involvement of elicitors; role of R and r genes in disease development. Molecular mechanisms of disease diagnosis. Resistance mechanisms in plants,

Systemic resistance, resistance genes, phytoalexins, PR proteins, signalling mechanisms. Transgenic approaches for crop protection. **6L**

6. Plant diseases: (Symptomatology, etiology & control) Diseases caused by :

a) Fungi: Wilt diseases, Downy mildews, Powdery mildews, Rusts, Smuts)

b) Bacteria: (Bacterial wilt, Bacterial blight of rice, Angular leaf spot of cotton, Citrus canker)

c) Mycoplasmal diseases: (Sandal spike, Grassy shoot of sugar cane)

d) Viral diseases: (Cauliflower mosaic disease, Banana bunchy top, Cucumber mosaic, Cow pea mosaic, Tobacco mosaic)

e) Protozoa: (Hartrot of coconut, Phloem necrosis of coffee).

f)Viroids: (Potato spindle tuber viroid).

g) Parasitic plants: (Dodder, Mistletoes)

Post-harvest diseases and control measures. Integrated pest management. **12L**

DE Paper MSMI-405-I – Review. 4 Credits, Marks 50 (30 + 20*)

DE Paper MSMI-405-II – ADVANCE FOOD MICROBIOLOGY (Theory). 4 Credits, Marks 50 (40 + 10*)

1. Introduction: Development of food microbiology as a science, scope of food microbiology. Food as substrate for microorganisms, intrinsic and extrinsic factors affecting the growth of microbes, important microorganisms in food (molds, yeasts and bacteria) and their source (air, soil, water, plants and animals). **6L**
2. Food contamination and spoilage: Sources of food contamination. Principles of food spoilage; spoilage of cereals, sugar products, vegetables, fruits, meat and meat products, milk and milk products, fish and sea foods, poultry; spoilage of canned foods; conventional and modern methods for detection of spoilage and characterization. **10L**
3. Food-borne infections and intoxication: Bacterial- Brucella, Bacillus, Clostridium, Escherichia, Listeria; Food intoxication- Botulism, Staphylococcal. Mycotoxins & their types – aflatoxins, ochratoxins, fuminosins, trichothecenes, zealenone, ergot alkaloids; food borne outbreaks and lab testing procedures. Preventive measures. Molds, Algae, Protozoa, Viruses. **10L**

4. Food preservation: Principles and methods of food preservation- Physical (temperature, irradiation, drying, canning, processing for heat treatment-D, Z and F values) Chemical (Organic acids, food additives. Class I and Class II preservatives), Biopreservation (Lactic acid

bacteria). Food Packaging- Types of packaging materials, properties and benefits. **10L**

5. Microbial and Fermented foods: SCP- Nutritional & therapeutic importance, Quorn and SCO and their Industrial production. Fermented Vegetables (olives, cucumbers), Meat (sausages), Beverage (cocoa and coffee); Bread, Idli, Dairy foods (cheese, srikhand). production methods of Kefir, Yogurt, Acidophilus milk; Probiotics, Prebiotics and Synbiotics, Nutraceuticals (Cr/Se yeast), functional foods and their quality standards. Application of fungal pigments in food industry. **10L**

6. Food and sanitation: Good Hygiene Practices, Sanitation in manufacture and retail trade; food control agencies and their regulation, hazard analysis and critical control points (HACCP); GMP, plant sanitation – employees‟ health standard, waste treatment, disposal, quality control. Recent trends and development in food technologies in India. **4L**

MSMI-406 - Project. 4 Credits, Marks 50 (30 + 20*)