THE UNIVERSITY OF KALYANI
DRAFT UG-CBCS SYLLABUS
IN
MICROBIOLOGY (Honours)

A. Number of courses:

Types of course	Core course (CC)	Elective course		Ability enhancement course		TOTAL
		Discipline specific elective course (DSE)	Generic elective course(GE)	Ability Enhancement compulsory course (AECC)	Skill Enhancement course (SEC)	
No. of course	14	4	4	2	2	26
Credit/course	6	6	6	2	2	140

TABLE-1: DETAILS OF COURSES & CREDIT UNDER CBCS

S. No.	Particulars of Course	Credit Point
1.	**Core Course: 14 papers**	**Theory + Practical**
1.A.	Core Course: Theoretical (14 papers)	14x4 = 56
1.B.	Core Course (Practical) (14 papers)	14x2 = 28
2.	**Elective Courses: 8 papers**	
2.A.	A. Discipline specific Elective(DSE): Theoretical (4 papers)	4x4 = 16
2.B.	DSE (Practical) (4 papers)	4x2 =8
2C.	General Elective(GE) (Interdisciplinary): Theoretical (4 papers)	4x4 = 16
2.D.	GE (Practical) (4 papers)	4x2 =8
3. Ability Enhancement Courses		
A.	AECC (2 papers of 2 credits each) ENVS, English Communication/MIL	2x2 = 4
B.	Skill Enhancement Course (SEC) (2 papers of 2 credits each)	2x2 = 4
	Total Credit:	**140**

TABLE-2: SEMESTERWISE DISTRIBUTION OF COURSE & CREDITS IN B.SC. HONS in Microbiology

Courses/ (Credits)	Sem-I	Sem-II	Sem-III	Sem-IV	Sem-V	Sem-VI	Total No. of Courses	Total credit
CC (6)	2	2	3	3	2	2	14	84
DSE (6)	--	--	--	--	2	2	04	24
GE (6)	1	1	1	1	--	--	04	24
AECC (2)	1	1			--	--	02	04
SEC (2)	--	--	1	1	--	--	02	04
Total No. of Course/ Sem.	4	4	5	5	4	4	26	--
Total Credit /Semester	**20**	**20**	**26**	**26**	**24**	**24**	------	**140**

❖ **COURSE CODE & COURSE TITLE:**

A. Core courses (CC)

1. MB-H-CC-L-01: Basic Microbiology and Culture Techniques
   MB-H-CC-P-01: Basic Microbiology and Culture Techniques
2. MB-H-CC-L-02: Biomolecules and Enzymology
   MB-H-CCP-02: Biomolecules and Enzymology
3. MB-H-CC-L-03: Fundamental Cell Biology
   MB-H-CC-P-03: Fundamental Cell Biology
4. MB-H-CC-L-04: Instrumentation and Biotechniques
   MB-H-CC-P-04: Instrumentation and Biotechniques
5. MB-H-CC-L-05: Microbial Diversity and Systematics
   MB-H-CC-P-05: Microbial Diversity and Systematics
6. MB-H-CC-L-06: Bioenergetics and Microbial Metabolism
   MB-H-CC-P-06: Bioenergetics and Microbial Metabolism
7. MB-H-CC-L-07: Molecular Biology
   MB-H-CC-P-07: Molecular Biology
8. MB-H-CC-L-08: Microbial Genetics
   MB-H-CC-P-08: Microbial Genetics
9. MB-H-CC-L-09: Recombinant DNA Technology
   MB-H-CC-P-09: Recombinant DNA Technology
10. MB-H-CC-L-10: Immunology
    MB-H-CC-P-10: Immunology
11. MB-H-CC-L-11: Medical Microbiology
    MB-H-CC-P-11: Medical Microbiology
12. MB-H-CC-L-12: Microbial Ecology and Agricultural Microbiology
    MB-H-CC-P-12: Microbial Ecology and Agricultural Microbiology
13. MB-H-CC-L-13: Environmental Microbiology
    MB-H-CC-P-13: Environmental Microbiology
14. MB-H-CC-L-14: Food and Industrial Microbiology
    MB-H-CC-P-14: Food and Industrial Microbiology

B. Discipline specific elective courses (DSE)

1. MB-H-DSE-L-01: 'Biostatistics and Bioinformatics' or 'Virology'
   MB-H-DSE-P-01: 'Biostatistics and Bioinformatics' or 'Virology'
2. MB-H-DSE-L-02: 'Microbial Biotechnology' or 'Biosafety and Intellectual Property Rights'
   MB-H-DSE-P-02: 'Microbial Biotechnology' or 'Biosafety and Intellectual Property Rights'
3. MB-H-DSE-L-03: 'Inheritance Biology' or 'Microbes in Sustainable Agriculture and Development'
   MB-H-DSE-P-03: 'Inheritance Biology' or 'Microbes in Sustainable Agriculture and Development'
4. MB-H-DSE-L-04: Project paper and Seminar (compulsory)

C. Generic elective courses (GE) [for the students of other discipline]:

1. MB-H-GE-L-01: Fundamentals and Techniques in Microbiology
   MB-H-GE-P-01: Fundamentals and Techniques in Microbiology
2. MB-H-GE-L-02: Microbial Systematic and Diversity
   MB-H-GE-P-02: Microbial Systematic and Diversity
3. MB-H-GE-L-03: Immunology and Medical Microbiology
   MB-H-GE-P-03: Immunology and Medical Microbiology
4. MB-H-GE-L-04: Environmental Microbiology
   MB-H-GE-P-04: Environmental Microbiology

D. Ability enhancement compulsory courses (AECC)

1. AECC-1: Environmental Sciences
2. AECC-2: English/MIL Communication

E. Skill enhancement courses (SEC)

1. MB-H-SEC-L-01: 'Microbial Quality Control in Food and Pharmaceutical Industries' or 'Food Fermentation Techniques'
2. MB-H-SEC-L-01: 'Management of Human Microbial Diseases' or 'Microbiological Analysis of Air and Water'

TABLE-3: SEMESTER & COURSEWISE CREDIT DISTRIBUTION IN IN B.SC.(Hons.) in Microbiology
(6 Credit: 75 Marks)

SEMESTER-I			
Course Code	**Course Title**	**Course wise Class (L+P)**	**Credit**
MB-H-CC-L-01 MB-H-CC-P-01	Basic Microbiology and Culture Techniques	60 60	4 2
MB-H-CC-L-02 MB-H-CC-P-02	Biomolecules and Enzymology	60 60	4 2
MB-H-GE-L-01 MB-H-GE-P-01	Fundamentals and Techniques in Microbiology	60 60	4 2
AECC-1	Environmental Sciences	30	2
Total	**4 courses**	**390**	**20**
SEMESTER-II			
Course Code	**Course Title**	**Course wise Class**	**Credit**
MB-H-CC-L-03 MB-H-CC-P-03	Fundamental Cell Biology	60 60	4 2
MB-H-CC-L-04 MB-H-CC-P-04	Instrumentation and Biotechniques	60 60	4 2
MB-H-GE-L-02 MB-H-GE-P-02	Microbial Systematic and Diversity	60 60	4 2
AECC-2	English/MIL Communication	30	2
Total	**4 courses**	**390**	**20**
SEMESTER-III			
Course Code	**Course Title**	**Course wise Class**	**Credit**
MB-H-CC-L-05 MB-H-CC-P-05	Microbial Diversity and Systematics	60 60	4 2
MB-H-CC-L-06 MB-H-CC-P-06	Bioenergetics and Microbial Metabolism	60 60	4 2
MB-H-CC-L-07 MB-H-CC-P-07	Molecular Biology	60 60	4 2
MB-H-GE-L-03 MB-H-GE-P-03	Immunology and Medical Microbiology	60 60	4 2
MB-H-SEC-L-01	'Microbial Quality Control in Food and Pharmaceutical Industries' or 'Food Fermentation Techniques'	30	2
Total	**5 courses**	**510**	**26**
SEMESTER-IV			
Course Code	**Course Title**	**Course wise Class**	**Credit**
MB-H-CC-L-08 MB-H-CC-P-08	Microbial Genetics	60 60	4 2
MB-H-CC-L-09 MB-H-CC-P-09	Recombinant DNA Technology	60 60	4 2
MB-H-CC-L-10	Immunology	60	4

MB-H-CC-P-10		60	2
MB-H-GE-L-04 MB-H-GE-P-04	Environmental Microbiology	60 60	4 2
MB-H-SEC-L-02	'Management of Human Microbial Diseases' or 'Microbiological Analysis of Air and Water'	30	2
Total	**5 courses**	**510**	**26**
SEMESTER-V			
Course Code	**Course Title**	**Course wise Class**	**Credit**
MB-H-CC-L-11 MB-H-CC-P-11	Medical Microbiology	60 60	4 2
MB-H-CC-L-12 MB-H-CC-P-12	Microbial Ecology and Agricultural Microbiology	60 60	4 2
MB-H-DSE-L-01 MB-H-DSE-P-01	'Biostatistics and Bioinformatics' or 'Virology'	60 60	4 2
MB-H-DSE-L-02 MB-H-DSE-P-02	'Microbial Biotechnology' or 'Biosafety and Intellectual Property Rights'	60 60	4 2
Total	**4 courses**	**480**	**24**
SEMESTER-VI			
Course Code	**Course Title**	**Course wise Class**	**Credit**
MB-H-CC-L-13 MB-H-CC-P-13	Environmental Microbiology	60 60	4 2
MB-H-CC-L-14 MB-H-CC-P-14	Food and Industrial Microbiology	60 60	4 2
MB-H-DSE-L-03 MB-H-DSE-P-03	'Inheritance Biology' or 'Microbes in Sustainable Agriculture and Development'	60 60	4 2
MB-H-DSE-L-04 MB-H-DSE-P-04	Project paper and Seminar (compulsory)	Course duration	6
Total	**4 courses**	**360**	**24**
Total (All semesters)	***26 courses***	***2640***	***140***

****The preferable Generic Elective (*Four*) courses to be taken by Microbiology Students are as suggested below. Course content or name or code whatever available in the colleges will be in accordance to the BoS of the respective discipline. The preferable courses are:**

i. Physical Chemistry
ii. Plant Physiology
iii. Animal Physiology
iv. Parasitology
v. Organic Chemistry

COURSE OBJECTIVES:

- The inter-disciplinary approach of the subject is imperative in the present scenario. The modern biological development is going on at a tremendous pace. Microbiology has taken a unique position in respect of basic and applied aspects of food and dairy products, environment, agriculture, various industries and medical and public health.

- The courses offered would help the aspirant students in getting a broad based knowledge about theoretical and applied aspects of different disciplines of microbiology in general and its frontier areas in particular. It is aimed at offering high quality training and generating expertise in the frontier areas of microbial technology, and to provide appreciative atmosphere to the bright young talents indent to continue higher study.

Course-wise contents in detail
[B.Sc. (H) in Microbiology]

Core Courses

MB-H-CC-L-01: Basic Microbiology and Culture Techniques (Credits 4; FM 50)

Unit 1: Introduction, History and Scope of Microbiology- General concept of microbes, their distribution and dimension. History and scope of microbiology as a modern science. Branches of Microbiology. Contribution of Scientists to the field of Microbiology - Antony Von Leewenhoek, Edward Jenner, Lazaro Spallanzani, Louis Pasteur, Joseph Lister, Robert Koch, Alexander Fleming and Iwanovsky. Theories of origin of life.

Unit 2: Microbial growth requirements and culture techniques- Nutritional requirements of microorganisms -Macronutrients, micronutrients and growth factors. Nutritional types of microorganisms: Autotrophs and heterotrophs, phototrophs and chemotrophs. Physical factors affecting growth of microorganisms: Temperature, pH and Oxygen. Culture media: Components of media, Synthetic or defined media, Complex media, enriched media, selective media, differential media, enrichment culture media. Pure culture isolation: Streaking, serial dilution and plating methods, cultivation, maintenance and stocking of pure cultures, cultivation of anaerobic bacteria; Growth: concept of growth of microorganisms; measurement of growth; Culture system: concept of batch and continuous culture, growth kinetics in batch system emphasizing different phases of bacterial growth, specific growth rate, growth curve, diauxic growth. Counting of bacteria -Viable count, Total count and turbidimetric estimation.

Unit 3: Stains and Staining Techniques- Nature of dyes. Physical and chemical theories of staining- Staining techniques; principle, procedure and applications: i) Simple staining- negative staining, ii) Differential staining-Grams and acid fast staining, iii) Structural staining- cell wall, endospore, flagella and capsular staining.

Unit 4: Sterilization and aseptic Techniques- Definition of terms -sterilization, disinfectant, antiseptic, sanitizer, germicide, microbicidal agents, microbiostatic agents and antimicrobial agent. Evaluation of antimicrobial chemical agents -Tube dilution and agar plate techniques- well method and disk plate method. Physical methods of control -Principle, construction and application of moist heat sterilization- Boiling, Pasteurization, Fractional sterilization, Tyndallization and Moist heat under pressure- autoclave. Dry heat sterilization- Incineration and hot air oven, Filtration- membrane filter and laminar air flows, Radiation- Ionizing radiation and non-ionizing radiation. Chemical methods: Alcohol, aldehydes, phenols, halogen, metallic salts, quaternary ammonium compounds and sterilizing gases as antimicrobial agents. Selection of a chemical agent for practical applications.

MB-H-CC-P-01: Basic Microbiology and Culture Techniques (Credits 2; FM 25)

1. Safety measures in Laboratory.
2. Study of student microscope and research microscope -Construction, working principle, care to be taken while using the microscope. Use of oil immersion objective
3. Study of instruments - Autoclave, hot air oven, Laminar air flow bench, Inoculation chamber, inoculation loop and needle, Incubator, centrifuge, pH meter, seitz filter, colony counter, membrane filter and colorimeter/spectrophotometer.
4. Cleaning and sterilization of glassware.
5. Study of aseptic techniques -preparation of cotton plugs for test tubes and pipettes, wrapping of petriplates and pipettes.
6. Staining of bacteria - Simple staining -methylene blue staining; Gram staining.
7. Structural staining -cell wall, endospore staining and capsule staining

MB-H-CC-L-02: Biomolecules and Enzymology (Credits 4; FM 50)

Unit 1: Carbohydrates- General properties, classification of carbohydrates, families of monosaccharides: structural concept, isomerism. Sugar derivatives, glucosamine, galactosamine, muramic acid, N-acetyl neuraminic acid. Disaccharides. Concept of reducing and non-reducing sugars. Polysaccharides- storage polysaccharides, starch and glycogen. Structural Polysaccharides- cellulose, chitin and peptidoglycan.

Unit 2: Lipids- Fatty acids: definition, types, structures and functions, essential fatty acids. Lipid: definition, nomenclature and classification (triacylglycerols, phosphoglycerides, phosphatidylethanolamine, phosphatidylcholine, sphingosine, ceramide, sphingomyelins, cerebrosides and gangliosides) with structures and properties. Functions of lipid. Introduction of lipid micelles, monolayers, bilayers. Membrane structure. Steroids and wax.

Unit 3: Proteins- Amino acids structure and properties. Titration curve of amino acid and its significance. Ninhydrin reaction. Non protein amino acids. Structure of proteins: Primary, Secondary, Tertiary and Quaternary. Peptide unit and its salient features. The alpha helix, the beta pleated sheet and their occurrence in proteins. Ramachandran plot. Human haemoglobin structure.

Unit 4: Vitamins and Nucleic Acids- Classification and characteristics of Vitamins with suitable examples, sources and importances. Purine, pyrimidine bases, nucleoside, nucleotide-structure, properties. Types of DNA and RNA. Primary and secondary structure of DNA.

Unit 5: Enzymes- Structure of enzyme: Apoenzyme and cofactors, prosthetic group, coenzyme. Classification of enzymes, Mechanism of action of enzymes: Lock and key hypothesis, and induced Fit hypothesis, active site, specificity. Enzyme kinetics: Michaelis-Menten equation and their transformations, Km and allosteric mechanism, specific activity and turnover number. Factors affecting enzyme action: pH, temperature, substrate concentration, enzyme concentration, time. Enzyme inhibition and its kinetics: competitive; non-competitive, uncompetitive.

MB-H-CC-P-02: Biomolecules and Enzymology (Credits 2; FM 25)

1. Concept of pH and buffers, preparation of buffers – phosphate and acetate buffer.
2. Qualitative/Quantitative tests for carbohydrates, reducing sugars, non reducing sugars (DNS method)
3. Qualitative/Quantitative tests for proteins (Lowry method), amino acids (Ninhydrine), DNA(DPA) and RNA(Orcinol).
4. Qualitative/Quantitative assay of amylase.
5. Study of enzyme kinetics – calculation of Vmax, Km, Kcat values.
6. Study the effect of temperature, pH and Heavy metals on enzyme activity (amylase).
7. Estimation of any one vitamin – Ascorbic acid.
8. Identification and estimation of amino acids, organic acids.

MB-H-CC-L-03: Fundamental Cell Biology (Credits 4; FM 50)

Unit 1: Prokaryotic cell organization- Cell size, shape and arrangements, capsule, flagella and pili, Composition and detailed structure of cell envelope of gram- positive, gram- negative bacteria and archaea. Bacterial Structure, chemical composition and functions of bacterial and archaeal cell membranes, Ribosomes, cellular inclusions, nucleoid, plasmids; structure, formation and stages of endosporulation; bacterial cell division

Unit 2: Structure and organization of living cell- Plasma membrane: Structure and transport of small molecules
Cell Wall: Eukaryotic cell wall, Extracellular matrix and cell matrix interactions. Mitochondria, chloroplasts and peroxisomes. Cytoskeleton: Structure and organization of actin filaments, association of actin filaments with plasma membrane

Unit 3: Nucleus- Nuclear envelope, nuclear pore complex and nuclear lamina Chromatin – Molecular organization, Nucleolus

Unit 4: Protein Sorting and Transport- Ribosomes, Endoplasmic Reticulum – Structure, targeting and insertion of proteins in the ER, Protein folding, processing and quality control in ER, Smooth ER and lipid synthesis, Export of proteins and lipids from ER. Golgi Apparatus – Organization, protein glycosylation, protein sorting and export from Golgi apparatus. Lysosomes.

Unit 5: Cell Signalling- Modes of Cell to Cell Signalling. Signalling molecules and their receptors. Function of cell surface receptors. Pathways of intra-cellular receptors **–** Cyclic AMP pathway, cyclic GMP and MAP kinase pathway

Unit 6: Cell Cycle, Cell Death and Cell Renewal- Regulation of Programmed cell death. Development of cancer causes and types. Concept of stem cells- embryonic stem cell and induced pleuripotent stem cells. Bacterial cell division.

MB-H-CC-P-03: Fundamental Cell Biology (Credits 2; FM 25)

1. Study a representative plant and animal cell by microscopy
2. Study of the structure of cell organelles through electron micrographs
3. Cytochemical staining of DNA – Feulgen
4. Identification and study of cancer cells by photomicrographs
5. Study of different stages of Mitosis
6. Study of different stages of Meiosis

MB-H-CC-L-04: Instrumentation and Biotechniques (Credits 4; FM 50)

Unit 1: Microscopy- Brightfield and darkfield microscopy, Fluorescence Microscopy, Phase contrast Microscopy, Confocal Microscopy, Electron Microscopy (Scanning and Transmission Electron Microscopy) and Micrometry.

Unit 2: Chromatography- Principles and applications of paper chromatography (including Descending and 2-D), Thin layer chromatography. Column packing and fraction collection. Gel filtration chromatography, ion exchange chromatography and affinity chromatography, GLC, HPLC.

Unit 3: Electrophoresis- Principle and applications of native polyacrylamide gel electrophoresis, SDS-polyacrylamide gel electrophoresis, 2D gel electrophoresis, Isoelectric focusing, and Agarose gel electrophoresis.

Unit 4: Spectrophotometry- Principle and use of study of absorption spectra of biomolecules. Analysis of biomolecules using UV and visible range. Colorimetry and turbidometry.

Unit 5: Centrifugation- Preparative and analytical centrifugation, fixed angle and swinging bucket rotors. RCF and sedimentation coefficient, principle and application of differential centrifugation, density gradient centrifugation and ultracentrifugation.

MB-H-CC-P-04: Instrumentation and Biotechniques (Credits 2; FM 25)

1. Fluorescent microscopy, Electron microscopy, Phase contrast microscopy (Demo only)
2. Separation of mixtures by paper / thin layer chromatography.
3. Demonstration of column packing in any form of column chromatography.
4. Separation of protein mixtures by any form of chromatography.
5. Separation of protein mixtures by Polyacrylamide Gel Electrophoresis (PAGE).
6. Determination of λmax for an unknown sample and calculation of extinction coefficient.
7. Separation of components of a given mixture using a laboratory scale centrifuge.

MB-H-CC-L-05: Microbial Diversity and Systematics (Credits 4; FM 50)

Unit 1: Microbial Systematics- General account of systematics, classification and nomenclature; Classification systems- artificial or phonetic, natural and phylogenetic; Species concept in microbiology, monophyletic, paraphyletic, polyphyletic; Newer approaches for exploring unculturable bacteria-molecular taxonomy, molecular phylogeny, molecular chronometers; Chemotaxonomy; Polyphasic taxonomy,

Unit 2: Phylogeny of prokaryons- Diversity of more complex unicellular complex microorganisms: Monera (Prokaryote), Protista. Five kingdom domains in Whittaker's system of classfication and Archaea, Bacteria and Eukarya, RNA world. Theory of endosymbiogenesis.

Unit 3: An account of prokaryons- Brief accounts of major subgroups of these classes. The thermophlic, methanogenic and halophilic Archaea; photosynthetic bacteria, Cyanobacteria, Gram positive and Gram negative Eubacteria; including the five classes of Proteobacteria, Spirochetes and Actinomyectes.

Unit 4: Phycology- General characteristics of algae including occurrence, thallus organization, algaecellultrastructure, pigments, flagella, eye spot, food reserves and vegetative, asexual and sexual reproduction, General characters of the following classes: Chlorophyta, Xanthophyta, Cyanophyta. Applications of algae in agriculture, industry, environment and food.

Unit 5: An account of eukaryotic microbes- Fungi including Zygomycetes, Oomycetes, Ascomycetes, Basidiomycetes and Deuteromycetes (imperfect and perfect stages) and Protozoa (*Giardia*, *Entamoeba* and *Plasmodium*).

Unit 6: General Account of Virology- Discovery of viruses, distinctive property of viruses; morphology and ultrastructure, capsids & their arrangements. Types of envelopes and their composition; viral genome – types and structures; nomenclature and classification of virus (Animal, plant, bacterial viruses). Virus related agents – viriods, prions. Structural organization of bacteriophage; Life cycle – lytic & lysogenic,

MB-H-CC-P-05: Microbial Diversity and Systematics (Credits 2; FM 25)

1. Preparation of culture media (Nutrient Broth an Nutrient Agar) for bacterial cultivation
2. Sterilization of medium using Autoclave and assessment for sterility
3. Sterilization of glassware using Hot Air Oven
4. Sterilization of heat sensitive material by filtration
5. Isolation and enumeration of bacteria from air
6. Study of *Rhizopus, Penicillium, Aspergillus* using permanent mounts
7. Study of *Spirogyra, Chlamydomonas* using permanent Mounts
8. Study of *Paramecium, Plasmodium* using permanent mounts
9. Isolation of pure cultures of bacteria by streaking method.
10. Preservation of bacterial cultures by various techniques.
11. Estimation of CFU count by spread plate method/pour plate method.

MB-H-CC-L-06: Bioenergetics and Microbial Metabolism (Credits 4; FM 50)

Unit 1: Bioenegetics- First and second laws of Thermodynamics. Definitions of Gibb's Free Energy, enthalpy,and Entropy and mathematical relationship among them, Standard free energy change and equilibrium constant. Coupled reactions and additive nature of standard free energy change, Energy rich compounds: Phosphoenolpyruvate, 1,3- Bisphosphoglycerate, Thioesters, ATP

Unit 2: Nutrient uptake and Transport- Passive and facilitated diffusion; Primary and secondary active transport, concept of uniport, symport and antiport; Group translocation; Iron uptake

Unit 3: Chemoheterotrophic Metabolism- Concept of aerobic respiration, anaerobic respiration and fermentation; Sugar degradation pathways i.e. EMP, ED, Pentose phosphate pathway, TCA cycle, Electron transport chain: components of respiratory chain, comparison of mitochondrial and bacterial ETC, electron transport phosphorylation, uncouplers and inhibitors

Unit 4: Chemoheterotrophic Metabolism- Anaerobic respiration and fermentation, Anaerobic respiration with special reference to dissimilatory nitrate reduction (Denitrification; nitrate/nitrite and nitrate/ammonia respiration; fermentative nitrate reduction); Fermentation - Alcohol fermentation and Pasteur effect; Lactate fermentation (homofermentative and heterofermentative pathways), concept of linear and branched fermentation pathways

Unit 5: Chemolithotrophic and Phototrophic Metabolism- Introduction to aerobic and anaerobic chemolithotrophy with an example each. Hydrogen oxidation (definition and reaction) and methanogenesis (definition and reaction) Introduction to phototrophic metabolism - groups of phototrophic microorganisms, anoxygenic *vs.* oxygenic photosynthesis with reference to photosynthesis in green bacteria, purple bacteria and cyanobacteria

Unit 6: Nitrogen Metabolism - an overview; Introduction to biological nitrogen fixation, Ammonia assimilation, Assimilatory nitrate reduction, dissimilatory nitrate reduction, denitrification

MB-H-CC-P-06: Bioenergetics and Microbial Metabolism (Credits 2; FM 25)

1. Study and plot the growth curve of *E. coli* by turbidometric and standard plate count methods.
2. Calculations of generation time and specific growth rate of bacteria from the graph plotted with given data
3. Effect of temperature on growth of *E. coli*
4. Effect of pH on growth of *E. coli*
5. Effect of carbon and nitrogen sources on growth of *E.coli*
6. Effect of salt on growth of *E. coli*
7. Demonstration of alcoholic fermentation
8. Demonstration of the thermal death time and decimal reduction time of *E. coli.*

MB-H-CC-L-07: Molecular Biology (Credits 4; FM 50)

Unit 1: Structures of DNA and RNA/Genetic Material- DNA Structure: Miescher to Watson and Crick-historic perspective, DNA structure, Salient features of double helix, Types of DNA, Types of genetic material, denaturation and renaturation, cot curves. DNA topology – linking number, topoisomerases; Organization of DNA Prokaryotes, Viruses, Eukaryotes.RNA Structure, Organelle DNA -- mitochondria and chloroplast DNA.

Unit 2: Replication of DNA (Prokaryotes and Eukaryotes)- Bidirectional and unidirectional replication, semi- conservative, semi- discontinuous replication; Mechanism of DNA replication: Enzymes and proteins involved in DNA replication –DNA polymerases, DNA ligase, primase, telomerase – for replication of linear ends; Various models of DNA replication including rolling circle, D- loop (mitochondrial), Θ (theta) mode of replication and other accessory protein, Mismatch and excision repair

Unit 3: Transcription in Prokaryotes and Eukaryotes- Transcription: Definition, difference from replication, promoter - concept and strength of promoter; RNA Polymerase and the transcription unit; Transcription in Eukaryotes: RNA polymerases, general Transcription factors

Unit 4: Post-Transcriptional Processing- Split genes, concept of introns and exons, RNA splicing, spliceosome machinery**,** concept of alternative splicing, Polyadenylation and capping, Processing of rRNA, RNA interference: siRNA, miRNA and its significance

Unit 5: Translation (Prokaryotes and Eukaryotes)- Translational machinery, Charging of tRNA, aminoacyl tRNA synthetases, Mechanisms of initiation, elongation and termination of polypeptides in both prokaryotes and eukaryotes, Fidelity of translation, Inhibitors of protein synthesis in prokaryotes and eukaryote

Unit 6: Regulation of gene Expression in Prokaryotes and Eukaryotes- Principles of transcriptional regulation, regulation at initiation with examples from *lac* and *trp* operons, Sporulation in *Bacillus,* Yeast mating type switching, Changes in Chromatin Structure - DNA methylation and Histone Acetylation mechanisms.

MB-H-CC-P-07: Molecular Biology (Credits 2; FM 25)

1. Study of different types of DNA and RNA using micrographs and model / schematic representations
2. Study of semi-conservative replication of DNA through micrographs / schematic representations
3. Isolation of genomic DNA from *E. coli*
4. Estimation of salmon sperm / calf thymus DNA using colorimeter (diphenylamine reagent) or UV spectrophotometer (A_{260} measurement)

5. Estimation of RNA using colorimeter (orcinol reagent) or UV spectrophotometer (A260 measurement)
6. Resolution and visualization of DNA by Agarose Gel Electrophoresis.
7. Resolution and visualization of proteins by Polyacrylamide Gel Electrophoresis (SDS-PAGE).

MB-H-CC-L-08: Microbial Genetics (Credits 4; FM 50)

Unit 1: Genome Organization and Mutations- Genome organization: *E. coli*, *Saccharomyces*, *Tetrahymena*. Mutations and mutagenesis: Definition and types of Mutations; Physical and chemical mutagens; Molecular basis of mutations; Functional mutants (loss and gain of function mutants); Uses of mutations; Reversion and suppression: True revertants; Intra- and inter-genic suppression; Ames test; Mutator genes

Unit 2: Plasmids- Types of plasmids – F plasmid, R Plasmids, colicinogenic plasmids, Ti plasmids, linear plasmids, yeast- 2 μ plasmid, Plasmid replication and partitioning, Host range, plasmid-incompatibility, plasmid amplification, Regulation of copy number, curing of plasmids

Unit 3: Mechanisms of Genetic Exchange- Transformation - Discovery, mechanism of natural competence, Conjugation - Discovery, mechanism, Hfr and F' strains, Interrupted mating technique and time of entry mapping, Transduction - Generalized transduction, specialized transduction, LFT & HFT lysates, Mapping by recombination and co-transduction of markers

Unit 4: Phage Genetics- Features of T4 genetics , Genetic basis of lytic *versus* lysogenic switch of phage lambda

Unit 5: Transposable elements- Prokaryotic transposable elements – Insertion Sequences, composite and non-composite transposons, Replicative and Non replicative transposition, Mu transposon, Eukaryotic transposable elements - Yeast (Ty retrotransposon), Drosophila (P elements), Maize (Ac/Ds); Uses of transposons and transposition

MB-H-CC-P-08: Microbial Genetics (Credits 2; FM 25)

1. Preparation of Master and Replica Plates
2. Study the effect of chemical and physical (UV) mutagens on bacterial cells
3. Study survival curve of bacteria after exposure to ultraviolet (UV) light
4. Isolation of Plasmid DNA from *E.coli*
5. Study different conformations of plasmid DNA through Agarose gel electrophoresis.

MB-H-CC-L-09: Recombinant DNA Technology (Credits 4; FM 50)

Unit 1: Introduction to Genetic Engineering- Milestones in genetic engineering and biotechnology

Unit 2: Molecular Cloning- Tools and Strategies; Mode of action and applications of Type I, II and III restriction endonuclease in genetic engineering; Definition and function of restriction site, linkers, adaptors, Topoisomerase, DNA ligase, Genomic library, DNA Modifying enzymes: Terminal deoxynucleotidyltransferase, kinases, phosphatise. Definition and Properties of following Cloning Vectors: pBR322, pUC8, Bacteriophage lambda, M13, Cosmids, BACs and YACs vectors, Mammalian SV40-based expression vectors

Unit 3: Methods in Molecular Cloning- Gene delivery: Microinjection, electroporation, ballistic method (gene gun), liposome and Viral mediated delivery, *Agrobacterium* - mediated delivery. Agarose gel electrophoresis, Southern and Northernblotting, dot blot, DNA microarray analysis, SDS-PAGE and Western blotting

Unit 4: DNA Amplification and DNA sequencing- Basic concept of PCR, RT-PCR, Real-Time PCR Sanger's method of DNA Sequencing: traditional and automated sequencing. Primer walking and shotgun sequencing

Unit 5: Construction and Screening of Genomic and cDNA libraries- Genomic and cDNA libraries: Preparation and uses, Screening of libraries: Colony hybridization and colony PCR, Chromosome walking and chromosome jumping

Unit 6: Applications of Recombinant DNA Technology- Products of recombinant DNA technology: Insulin, hGH, Antisense molecules Bt transgenic - cotton, brinjal. Gene therapy, recombinant vaccines, protein engineering and site directed mutagenesis.

MB-H-CC-P-09: Recombinant DNA Technology (Credits 2; FM 25)

1. Perform bacterial Transformation by standard method
2. Digestion of DNA using restriction enzymes and analysis by agarose gel electrophoresis
3. Ligation of DNA fragments
4. Interpretation of sequencing gel electropherograms
5. Designing of primers for DNA amplification
6. Demonstration of amplification of DNA by PCR
7. Perform Southern blotting

MB-H-CC-L-10: Immunology (Credits 4; FM 50)

Unit 1: Introduction- Fundamental concept of Innate and Adaptive immunity. Contributions of following scientists to the development of field of immunology - Edward Jenner, Louis Pasteur, Karl Landsteiner, Robert Koch, Paul Ehrlich, Elie Metchnikoff, Peter Medawar, MacFarlane Burnet and Rodney Porter

Unit 2: Immune Cells and Organs- Structure, Functions and Properties of: Immune Cells –B cell, T cell, NK cell, Macrophage, Dendritic cell, Stem cell Immune Organs – Bone Marrow, Thymus, Lymph Node, Spleen

Unit 3: Antigens- Characteristics of an antigen; T-dependent and T-independent antigens Concept of Epitopes, Adjuvants, Haptens, Carrier

Unit 4: Antibodies- Types, Structure, and Functions of antibodies. Production and Clinical uses of Monoclonal antibodies

Unit 5: Major Histocompatibility Complex- Organization of MHC locus (Mice & Human) Structure and Functions of MHC I & II molecules

Unit 6: Complement System- Components of the Complement system. Complement Activation pathways (Classical, Alternative and Lectin pathways). Biological consequences of complement Activation

Unit 7: Generation of Immune Response and Hypersensitive reactions - Different types of hypersensitive response; Generation of Humoral and Cell Mediated Immune Response. Antibody dependent cellular cytotoxicity (ADCC)

Unit 8: Types of Immunization- Characteristics and functions of Active and Passive Immunization

Unit 9: Immunological Techniques- Principles of Precipitation, Agglutination, Immunodiffusion, Immunoelectrophoresis, ELISA, ELISPOT, Western blotting, Immunofluoresence, Immunoelectron microscopy

MB-H-CC-P-10: Immunology (Credits 2; FM 25)

1. Agglutination test
2. Identification of human blood groups
3. Perform Total Leukocyte Count of the given blood sample
4. Separate serum from the blood sample (demonstration)
5. Demonstration of immunoelectrophoresis
6. Perform immunodiffusion by Ouchterlony method
7. Perform DOT ELISA

MB-H-CC-L-11: Medical Microbiology (Credits 4; FM 50)

Unit 1: Normal microflora of the human body and host pathogen interaction- Normal microflora of skin, respiratory tract, gastrointestinal tract, urogenital tract. Host pathogen interaction: Infection, Invasion, Pathogen, Pathogenicity, Virulence,Toxigenicity, Carriers, reservoir, Opportunistic infections, Nosocomial infections, Epidemic, Endemic, Pandemic. Disease forecasting. Disease cycle. Herd immunity. Mode of entry, colonization and growth. Damage to host cell, virulence, virulence factors- exotoxins, endotoxins, neurotoxins and enzymes with special reference to Cholera toxin, enterotoxin, dephtheria toxin and tetanospasmin

Unit 2: Bacterial diseases- Symptoms, mode of transmission, prophylaxis and control of following diseases: Respiratory Diseases: tuberculosis; Gastrointestinal Diseases: typhoid, cholera; Wound infections: tetanus; Veneral disease: Syphilis

Unit 3: Viral diseases- Symptoms, mode of transmission, prophylaxis and control of following diseases: AIDS, Dengue, Chikungunya, Japanese Encephalitis

Unit 4: Protozoan diseases- Symptoms, mode of transmission, prophylaxis and control of following diseases: Malaria, Kala-azar

Unit 5: Fungal diseases- General account on transmission, symptoms and prevention of Cutaneous mycoses, Systemic mycoses, Opportunistic mycoses (Candidiasis)

Unit 6: Antimicrobial agents: General characteristics and mode of action- Naturally produced drugs. Antibiotics produced by bacteria, actinomycetes and fungi used in chemotherapy. Classification of antibiotics on the basis of structure and mode of action. Assay of antibiotics, antibiotic spectrum Semisynthetic antibiotic. Sulfa drugs, their use and mechanism of action. Naldixic acid, nitrofurans, isonicotinic hydrazide, metronidazole; Prophylactic agents. Drug toxicity. Drug resistance – chromosomal mutation and plasmid-borne multiple drug resistance.

MB-H-CC-P-11: Medical Microbiology (Credits 2; FM 25)

1. Identify bacteria (*Bacillus, Staphylococcus, E. coli, Pseudomonas,*) on the basis of cultural, morphological and biochemical characteristics
2. Study of composition and use of important differential media for identification of bacteria: EMB Agar, McConkey agar, Mannitol salt agar, TCBS
3. Study of bacterial flora of skin by swab method
4. Perform antibacterial sensitivity by Agar cup method
5. Determination of minimal inhibitory concentration (MIC) of an antibiotic (Tetracycline/ Kanamycin)
6. Determination of phenol coefficient

MB-H-CC-P-12: Microbial Ecology and Agricultural Microbiology (Credits 4; FM 50)

Unit 1: Basic concept- 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. Ecology of microorganism in extreme environments (High temperature, pressure and radiation etc.); Community resistance and resilience;

Unit 2: Microbial interaction- symbiosis, mutualism, commensalisms, competition, amensalism, synergism, parasitism and predation-mathematical model.

Unit 3: 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.

Unit 4: Plant-microbe interaction- Useful and harmful microbes to crop growth. Microflora of rhizosphere and rhizoplane, phyllosphere and phylloplane.

Unit 5: Plant-pathogen 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, blight of potato & CaMV and their control.

Unit 6: Microbes and crop productivity- biofertilizers, plant growth promoting rhizobacteria and Mycorrhizal fungi; microbes in crop protection

MB-H-CC-P-12: Microbial Ecology and Agricultural Microbiology (Credits 2; FM 25)

1. Isolation and enumeration of phosphate solubilising, cellulose decomposing, free-living N_2-fixing and starch hydrolyzing bacteria from different habitats (plate count method).
2. Assessment of nitrifying activity in soil.
3. Measurement of soil pH, N-content (Kjeldahl method), P-content, C-content.
4. *In vitro* study of antagonism (dual culture technique).
5. Isolation of *Rhizobium* from root nodules.
6. Nodulation study (pot experiment)

MB-H-CC-L-13: Environmental Microbiolgy (Credits 4; FM 50)

Unit 1: Microorganisms and their Habitats- Structure and function of ecosystems, Terrestrial Environment: Soil profile and soil microflora. Aquatic Environment: Microflora of fresh water and marine habitats, Atmosphere: Aeromicroflora and dispersal of microbes, Animal Environment: Microbes in/on human body (Microbiomics) & animal (ruminants) body.Extreme Habitats: Extremophiles: Microbes thriving at high & low temperatures, pH, high hydrostatic & osmotic pressures, salinity, & low nutrient levels.

Unit 2: Biogeochemical Cycling- Carbon cycle: Microbial degradation of cellulose, hemicelluloses, lignin and chitin, Nitrogen cycle: Nitrogen fixation, ammonification, nitrification, denitrification and nitrate reduction, Phosphorus cycle: Phosphate immobilization and solubilisation, Sulphur cycle: Microbes involved in sulphur cycle, Other elemental cycles: Iron.

Unit 3: Waste Management- Solid Waste management: Sources and types of solid waste, Methods of solid waste disposal (composting and sanitary landfill). Liquid waste management: Composition and strength of sewage (BOD and COD), Primary, secondary (oxidation ponds, trickling filter, activated sludge process and septic tank) and tertiary sewage treatment.

Unit 4: Microbial Bioremediation- Principles and degradation of common pesticides, organic (hydrocarbons, oil spills) and inorganic (metals) matter, biosurfactants.

Unit 5: Water Potability- Treatment and safety of drinking (potable) water, methods to detect potability of water samples: (a) standard qualitative procedure: presumptive test/MPN test, confirmed and completed tests for faecal coliforms (b) Membrane filter technique and (c) Presence/absence tests.

MB-H-CC-P-13: Environmental Microbiolgy (Credits 2; FM 25)

1. Analysis of water quality by MPN method
2. Isolation of microbes (bacteria & fungi) from soil (28ºC & 45ºC).
3. Isolation of microbes (bacteria & fungi) from rhizosphere and rhizoplane.
4. Assessment of microbiological quality of water.
5. Determination of BOD of waste water sample.
6. Study the presence of microbial activity by detecting (qualitatively) enzymes (dehydrogenase, amylase, urease) in soil.

MB-H-CC-L-14: Food and Industrial Microbiology (Credits 4; FM 50)

Unit 1: Microbial spoilage of various foods- Intrinsic and extrinsic factors that affect growth and survival of microbes in foods, natural flora and source of contamination of foods in general. Spoilage of vegetables, fruits, meat, eggs, milk and butter, bread, canned Foods; Food-borne intoxication and infection- Botulism, aflatoxicosis, ergotism, cholera, salmonellosis.

Unit 2: Principles and methods of food preservation- Principles, physical methods of food preservation: temperature (low, high, canning, drying), irradiation, hydrostatic pressure, high voltage pulse, microwave processing and aseptic packaging, chemical methods of food preservation: salt, sugar, organic acids, SO2, nitrite and nitrates, ethylene oxide, antibiotics and bacteriocins, Canning.

Unit 3: Fermented foods- Dairy starter cultures, fermented dairy products: yogurt, acidophilus milk, dahi and cheese, other fermented foods: dosa, sauerkraut, soy sauce, Probiotics: Health benefits, types of microorganisms used, probiotic foods available in market.

Unit 4: Introduction to industrial microbiology- Brief history and developments in industrial microbiology; Sources of industrially important microbes and methods for their isolation, preservation and maintenance of industrial strains, strain improvement,

Unit 5: Types of fermentation processes, bio-reactors and measurement of fermentation parameters- Types of fermentation processes - Solid-state and liquid-state (stationary and submerged) fermentations; batch, fed-batch (eg. baker's yeast) and continuous fermentations. Components of a typical bio-reactor, Types of Bioreactors- Laboratory, pilot- scale and production fermenters, constantly stirred tank and air-lift fermenters, Measurement and control of fermentation parameters - pH, temperature, dissolved oxygen, foaming and aeration.

Unit 6: Down-stream processing- Cell disruption, filtration, centrifugation, solvent extraction, precipitation, lyophilization and spray drying.

Unit 7: Microbial production of industrial products- micro-organisms involved, media, fermentation conditions, downstream processing and uses for the production of Citric acid, ethanol, penicillin, Vitamin B12, amylase, Wine, beer, microbial biopolymers; Use of biomining and bioleaching of ores.

MB-H-CC-P-14: Food and Industrial Microbiology (Credits 2; FM 25)

1. MBRT of milk samples and their standard plate count.
2. Alkaline phosphatase test to check the efficiency of pasteurization of milk.
3. Isolation of any food borne bacteria from food products.
4. Isolation of spoilage microorganisms from spoiled vegetables/fruits.
5. Preparation of Yogurt/Dahi.
6. Microbial quality study of fresh salad vegetables using dilution plating technique.
7. Microbial fermentations for the production and estimation (qualitative and quantitative) of amylase and citric acid.

Discipline Specific Elective Courses (DSE)

MB-H-DSE-L+P-01: 'Biostatistics and Bioinformatics' or 'Virology' (Credit 6; Marks 75)

Biostatistics and Bioinformatics (Theoretical) (Credits 4; FM 50)

Biostatistics

Sample and population: Sampling methods, construction of histogram, interpretation of histogram, sample mean, sample standard deviation, the normal distribution, the mean mode, median and standard deviation of the normal distribution, uncertainties in estimation of a mean.

Laws of probability, theorem of total probability.

Testing of hypothesis, comparison of population means and variances- F-test, notion of confidence limit. χ^2 test, 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.

Poisson distribution, standard error, confidence limits of counts; test of significance, difference of means in large samples, t-test (small samples), paired and unpaired data with computation of critical difference; Binomial, Gaussian distribution filling on observed data. Analysis of variance of one-way and two-way classified data, Simple linear regression.

Bioinformatics

Introduction to Bioinformatics and Biological Databases- Biological databases - nucleic acid, genome, protein sequence and structure, gene expression databases, Database of metabolic pathways, Mode of data storage - File formats - FASTA, GenBank and Uniprot, Data submission & retrieval from NCBI, EMBL, DDBJ, Uniprot, PDB.

Sequence Alignments, Phylogeny and Phylogenetic trees- Local and Global Sequence alignment, pairwise and multiple sequence alignment. Scoring an alignment, scoring matrices, PAM & BLOSUM series of matrices. Types of phylogenetic trees, Different approaches of phylogenetic tree construction - UPGMA, Neighbour joining, Maximum Parsomony, Maximum likelihood

Protein Structure Predictions- Hierarchy of protein structure - primary, secondary and tertiary structures, modeling. Structural Classes, Motifs, Folds and Domains. Protein structure prediction in presence and absence of structure template. Energy minimizations and evaluation by Ramachandran plot. Protein structure and rational drug design

Biostatistics and Bioinformatics (Practical) (Credits 2; FM 25)

1. Mean, Median, Mode from grouped and ungrouped Data set
2. Standard Deviation and Coefficient of Variation
3. Curve fitting
4. Correlation and Regression
5. Testing of Hypothesis- t-test, χ^2 test
6. Introduction to bioinformatics databases (any three): NCBI/PDB/DDBJ, Uniprot, PDB
7. Sequence retrieval using BLAST
8. Sequence alignment & phylogenetic analysis using clustalW & phylip

Virology (Theoretical) (Credits 4; FM 50)

Nature and Properties of Viruses- Introduction: Discovery of viruses, nature and definition of viruses, general properties, concept of viroids, virusoids, satellite viruses and Prions. Theories of viral origin. Structure of Viruses: Capsid symmetry, enveloped and non-enveloped viruses. Isolation, purification and cultivation of viruses. Viral taxonomy: Classification and nomenclature of different groups of viruses

Bacteriophages- Diversity, classification, one step multiplication curve, lytic and lysogenic phages (lambda phage) concept of early and late proteins, regulation of transcription in lambda phage

Viral Transmission, Salient features of viral nucleic acids and Replication- Modes of viral transmission: Persistent, non-persistent, vertical and horizontal. Salient features of viral Nucleic acid : Unusual bases (TMV, T4 phage), overlapping genes (ϕX174, Hepatitis B virus), alternate splicing (HIV), terminal redundancy (T4 phage), terminal cohesive ends (lambda phage), partial double stranded genomes (Hepatitis B), long terminal repeats (retrovirus), segmented (Influenza virus), and non-segmented genomes (picornavirus), capping and tailing (TMV), Viral multiplication and replication strategies: Interaction of viruses with cellular receptors and entry of viruses. Replication strategies of viruses as per Baltimore classification (ϕX174, Retroviridae, Vaccinia, Picorna), Assembly, maturation and release of virions

Viruses and Cancer- Introduction to oncogenic viruses, Types of oncogenic DNA and RNA viruses: Concepts of oncogenes and proto-oncogenes

Prevention & control of viral diseases- Antiviral compounds and their mode of action. Interferon and their mode of action. General principles of viral vaccination

Applications of Virology- Use of viral vectors in cloning and expression, Gene therapy and Phage display

Virology (Practical) (Credits 2; FM 25)

1. Study of the structure of important animal viruses using electron micrographs (Demo)
2. Enumeration of bacteriophages (PFU) from water/sewage sample using double agar layer technique
3. Phage induction
4. Plant virus transmission by local lesion technique for assaying plant viruses (pot experiment).

MB-H-DSE-L+P-02: 'Microbial Biotechnology' or 'Biosafety and Intellectual Property Rights' (Credit 6; Marks 75)

Microbial Biotechnology (Theoretical) (Credits 4; FM 50)

Microbial Biotechnology and its Applications- Microbial biotechnology: Scope and its applications in human therapeutics, agriculture (Biofertilizers, PGPR, Mycorrhizae), environmental, and food technology; Use of prokaryotic and eukaryotic microorganisms in biotechnological applications; Genetically engineered microbes for industrial application: Bacteria and yeast

Therapeutic and Industrial Biotechnology- Recombinant microbial production processes in pharmaceutical industries - Streptokinase, recombinant vaccines (Hepatitis B vaccine); Microbial polysaccharides and polyesters, Microbial production of bio-pesticides, bioplastics, Microbial biosensors

Applications of Microbes in Biotransformations- Microbial based transformation of steroids and sterols; Bio-catalytic processes and their industrial applications: Production of high fructose syrup and production of cocoa butter substitute

Microbial Products and their Recovery- Microbial product purification: filtration, ion exchange & affinity chromatography techniques; Immobilization methods and their application: Whole cell immobilization

Microbes for Bio-energy and Environment- Bio-ethanol and bio-diesel production: commercial production from lignocellulosic waste and algal biomass, Biogas production: Methane and hydrogen production using microbial culture. Microorganisms in bioremediation: Degradation of xenobiotics, mineral recovery, removal of heavy metals from aqueous effluents

Microbial Biotechnology (Practical) (Credits 2; FM 25)

1. Study yeast cell immobilization in calcium alginate gels
2. Study enzyme immobilization by sodium alginate method
3. Microbial Pigment production
4. Isolation of amylase or protease producing microbes
5. Study of algal Single Cell Proteins

Biosafety and Intellectual Property Rights (Theoretical) (Credits 4; FM 50)

Biosafety- Introduction; biosafety issues in biotechnology; Biological Safety Cabinets & their types; Primary Containment for Biohazards; Biosafety Levels of Specific Microorganisms; Biosafety Guidelines: Biosafety guidelines and regulations (National and International); GMOs/LMOs- Concerns and Challenges; Role of Institutional Biosafety Committees (IBSC), RCGM, GEAC etc. for GMO applications in food and agriculture; Environmental release of GMOs; Risk Analysis; Risk Assessment; Risk management and communication. AERB/RSD/RES guidelines for using radioisotopes in laboratories and precautions.

Introduction to Intellectual Property- Patents, Types, Trademarks, Copyright & Related Rights, Industrial Design and Rights, Traditional Knowledge, Geographical Indications- importance of IPR – patentable and non patentables – patenting life – legal protection of biotechnological inventions – World Intellectual Property Rights Organization (WIPO). Grant of Patent and Patenting Authorities: Types of patent applications: Ordinary, PCT, Conventional, Divisional and Patent of Addition; An introduction to Patent Filing Procedures; Patent licensing and agreement; Patent infringement- meaning, scope, litigation, case studies, Rights and Duties of patent owner.

Agreements and Treaties- GATT, TRIPS Agreements; Role of Madrid Agreement; Hague Agreement; WIPO Treaties; Budapest Treaty on international recognition of the deposit of microorganisms; UPOV & Brene conventions; Patent Co-operation Treaty (PCT); Indian Patent Act 1970 & recent amendments.

Biosafety and Intellectual Property Rights (Practical) (Credits 2; FM 25)

1. Study of components and design of a BSL-III laboratory
2. Filing applications for approval from biosafety committee
3. Filing primary applications for patents
5. Study of steps of a patenting process
4. A case study

MB-H-DSE-L+P-03: 'Inheritance Biology' or 'Microbes in Sustainable Agriculture and Development' (Credit 6; Marks 75)

Inheritance Biology (Theoretical) (Credits 4; FM 50)

Introduction to Genetics- Historical developments; Model organisms in genetic analyses and experimentation: *Escherichia coli*, *Saccharomyces cerevisiae, Neurospora crassa*, *Caenorhabditis elegans Drosophila melanogaster, Arabidopsis thaliana*

Mendelian Principles- Mendel's Laws: Dominance, segregation, independent assortment, deviation from Mendelian inheritance, Rediscovery of Mendel's principles, Chromosome theory of inheritance: Allele, multiple alleles, pseudoallele, complementation tests, Extensions of Mendelian genetics: Allelic interactions, concept of dominance, recessiveness, Incomplete dominance and co-dominance, Multiple alleles, Epistasis, penetrance and expressivity

Linkage and Crossing over- Linkage and recombination of genes, Cytological basis of crossing over, Crossing over at four-strand stage, Molecular mechanism of crossing over, mapping

Extra-Chromosomal Inheritance- Rules of extra nuclear inheritance, Organelle heredity -Chloroplast mutations in *Chlamydomonas*, mitochondrial, mutations in *Saccharomyces*, Maternal effects – Shell coiling in *Limnaea peregra*. Infectious heredity - Kappa particles in *Paramecium*

Characteristics of Chromosomes- Structural organization of chromosomes - centromeres, telomeres and repetitive DNA, Packaging DNA molecules into chromosomes, Concept of euchromatin and heterochromatin, Normal and abnormal karyotypes of human chromosomes, Chromosome banding, Giant chromosomes: Polytene and lampbrush chromosomes, Variations in chromosome structure: Deletion, duplication, inversion and translocation, Variation in chromosomal number and structural abnormalities.

Recombination- Homologous and non-homologous recombination, including transposition, site-specific recombination.

Human genetics- Pedigree analysis, lod score for linkage testing, karyotypes, genetic disorders.

Inheritance Biology (Practical) (Credits 2; FM 25)

1. Mendelian deviations in dihybrid crosses (kit based experiment)
2. Studying Barr Body with the temporary mount of human squamous epithelial cells
3. Studying *Rhoeo* translocation with the help of photographs

4. Karyotyping with the help of photographs
5. Goodness of fit analysis
6. Study of polytene chromosomes of salivary glands of *Chiromonas /Drosophila* larvae using prepared slides.
7. Study of pedigree analysis

Microbes in Sustainable Agriculture and Development (Theoretical) (Credits 4; FM 50)

Soil Microbiology: Soil as Microbial Habitat, Soil profile and properties, Soil formation, Diversity and distribution of microorganisms in soil.

Mineralization of Organic & Inorganic Matter in Soil: Mineralization of cellulose, hemicelluloses, lignocelluloses, lignin and humus, phosphate, nitrate, silica, potassium.

Microbial Activity in Soil and Green House Gases: Carbon dioxide, methane, nitrous oxide, nitric oxide – production and control.

Microbial Control of Soil Borne Plant Pathogens: Biocontrol mechanisms and ways, Microorganisms used as biocontrol agents against Microbial plant pathogens, Insects, Weeds.

Biofertilization, Phytostimulation, Bioinsecticides: Plant growth promoting bateria, biofertilizers – symbiotic (*Bradyrhizobium*, *Rhizobium*, *Frankia*), Non-symbiotic (*Azospirillum*, *Azotobacter*, *Mycorrhizae*, Phosphate solubilizers, algae), Novel combination of microbes as biofertilizers, PGPRs.

Secondary Agriculture Biotechnology: Biotech feed, Silage, Biomanure, biogas, biofuels – advantages and processing parameters.

GM crops: Advantages, social and environmental aspects, Bt crops, golden rice, transgenic animals.

Microbes in Sustainable Agriculture and Development (Practical) (Credits 2; FM 25)

1. Study soil profile (Demo)
2. Study microflora of different types of soils.
3. Isolation of *Rhizobium* and *Azotobacter.*
4. *Rhizobium* and *Azotobacter* as soil inoculants and its application (pot test).
5. Isolation of cellulose degrading and phosphate solubilizing microorganisms.

MB-H-DSE-L-04: Project paper and Seminar (Compulsory, Topic to be selected by student) (Credit 6; Marks 75)

Generic Elective Courses [GE]

MB-H-GE-L-01: Fundamentals and Techniques in Microbiology (Credits 4; FM 50)

Unit 1: Introduction, History and Scope of Microbiology- General concept of microbes, their distribution and dimension. History and Scope of microbiology as a modern science. Branches of Microbiology. Contribution of Scientists to the field of Microbiology - Antony Von Leewenhoek, Edward Jenner, Lazaro Spallanzani, Louis Pasteur, Joseph Lister, Robert Koch, Alexander Fleming and Iwanovsky. Theories of origin of life.

Unit 2: Microbial growth requirements and culture techniques- Nutritional requirements of microorganisms -Macronutrients, micronutrients and growth factors. Nutritional types of microorganisms: Autotrophs and heterotrophs, phototrophs and chemotrophs. Physical factors affecting growth of microorganisms: Temperature, pH and Oxygen. Culture media: Components of media, Synthetic or defined media, Complex media, enriched media, selective media, differential media, enrichment culture media. Pure culture isolation: Streaking, serial dilution and plating methods, cultivation, maintenance and stocking of pure cultures, cultivation of anaerobic bacteria; Growth: concept of growth of microorganisms; measurement of growth; Culture system: concept of batch and continuous culture, growth kinetics in batch system emphasizing different phases of bacterial growth, specific growth rate, growth curve, diauxic growth. Counting of bacteria - Viable count, Total count and turbidimetric estimation.

Unit 3: Stains and Staining Techniques- Nature of dyes. Physical and chemical theories of staining- Staining techniques; principle, procedure and applications of i) Simple staining- negative staining, ii) Differential staining - Grams and acid fast staining, iii) Structural staining- cell wall, endospore, flagella and capsular staining.

Unit 4: Sterilization and aseptic Techniques- Definition of terms -sterilization, disinfectant, antiseptic, sanitizer, germicide, microbicidal agents, microbiostatic agents and antimicrobial agent. Evaluation of antimicrobial chemical agents- Tube dilution and agar plate techniques- well method and disk plate method. Physical methods of control- Principle, construction and application of moist heat sterilization- Boiling, Pasteurization, Fractional sterilization- Tyndallization and Moist heat under pressure- autoclave. Dry heat sterilization- Incineration and hot air oven, Filtration -membrane filter and laminar air flows, Radiation -Ionizing radiation– γ rays and non-ionizing radiation- UV-rays. Chemical methods: Alcohol, aldehydes, phenols, halogen, metallic salts, quaternary ammonium compounds and sterilizing gases as antimicrobial agents. Selection of a chemical agent for practical applications.

MB-H-GE-P-01: Fundamentals and Techniques in Microbiology (Credits 2; FM 25)

1. Safety measures in Laboratory.
2. Study of student microscope and research microscope - Construction, working principle, care to be taken while using the microscope. Use of oil immersion objective
3. Study of instruments - Autoclave, hot air oven, Laminar air flow bench, Inoculation chamber, inoculation loop and needle, Incubator, centrifuge, pH meter, seitz filter, colony counter, membrane filter and colorimeter/spectrophotometer.
4. Cleaning and sterilization of glassware.
5. Study of aseptic techniques -preparation of cotton plugs for test tubes and pipettes, wrapping of petriplates and pipettes.
6. Staining of bacteria - Simple staining -methylene blue staining; Gram staining.
7. Structural staining - cell wall, endospore staining and capsule staining

MB-H-GE-L-02: Microbial Systematics and Diversity (Credits 4; FM 50)

Unit 1: Microbial Systematics- General account of systematics, classification and nomenclature; Classification systems- artificial or phonetic, natural and phylogenetic; Species concept in microbiology, monophyletic, paraphyletic, polyphyletic; Newer approaches for exploring unculturable bacteria-molecular taxonomy, molecular phylogeny, molecular chronometers; Chemotaxonomy; Polyphasic taxonomy,

Unit 2: Phylogeny of prokaryons- Diversity of more complex unicellular complex microorganisms: Monera (Prokaryote), Protista. Five kingdom domains in Whittaker's system of classfication and Archaea, Bacteria and Eukarya, RNA world. Theory of endosymbiogenesis.

Unit 3: An account of prokaryons- Brief accounts of major subgroups of these classes. The thermophlic, methanogenic and halophilic Archaea; photosynthetic bacteria, Cyanobacteria, Gram positive and Gram negative Eubacteria; including the five classes of Proteobacteria, Spirochetes and Actinomyectes.

Unit 4: Phycology- General characteristics of algae including occurrence, thallus organization, algal cell ultrastructure, pigments, flagella, eye spot, food reserves and vegetative, asexual and sexual reproduction, General characters of the following classes: Chlorophyta, Xanthophyta, Cyanophyta. Applications of algae in agriculture, industry, environment and food.

Unit 5: An account of eukaryotic microbes- Fungi including Zygomycetes, Oomycetes, Ascomycetes, Basidiomycetes and Deuteromycetes (imperfect and perfect stages) and Protozoa (*Giardia*, *Entamoeba* and *Plasmodium*).

Unit 6: General Account of Virology- Discovery of viruses, distinctive property of viruses; morphology and ultrastructure, capsids & their arrangements. Types of envelopes and their composition; viral genome – types and structures; nomenclature and classification of virus (Animal, plant, bacterial viruses). Virus related agents – viriods, prions. Structural organization of bacteriophage; Life cycle – lytic & lysogenic,

MB-H-GE-P-02: Microbial Systematics and Diversity (Credits 2; FM 25)

1. Preparation of culture media (Nutrient Broth an Nutrient Agar) for bacterial cultivation
2. Sterilization of medium using Autoclave and assessment for sterility
3. Sterilization of glassware using Hot Air Oven
4. Sterilization of heat sensitive material by filtration
5. Isolation and enumeration of bacteria from air
6. Study of *Rhizopus*, *Penicillium*, *Aspergillus* using permanent mounts
7. Study of *Spirogyra*, *Chlamydomonas* using permanent Mounts
8. Study of *Paramecium*, *Plasmodium* using permanent mounts
9. Isolation of pure cultures of bacteria by streaking method.
10. Preservation of bacterial cultures by various techniques.
11. Estimation of CFU count by spread plate method/pour plate method.

MB-H-GE-L-03: Immunology and Medical Microbiology (Credits 4; FM 50)

Unit 1: Human and its defenses against pathogens : Different line of defenses: physical barrier, chemical defense and cellular defense. Components of cellular defense – blood and lymphatics, leukocytes, lymphocytes (B - cell, and Tcells), phagocytes, macrophages. The immune response – non-specific defense, opsonization, phagocytosis; specific immune response and acquired immunity, antigens and antibodies: nature and functions; Immunoglobulins - structure and diversity. Antigen – antibody reactions. Cytokines, T-Cell receptors. Antigen presentation; Major histocompatibili ty complexes. Blymphocytes and antibody production, memory cells; complement system; Hypersensitivity; Inflammation autoimmune response. Graft rejection. Super antigens, Immunodeficiencies.

Unit 2: Immuno-diagnostics : Neutralization, precipitation, agglutination. Completement fixation, immunoduffusion, Enzyme-linked Immounosorbent Assay (ELISA). Immuno-fluorescence. Radioimmunoassay.

immunobloting. Serotyping. Immunization for prevention of diseases: vaccines, toxoids. Immuniz ation programmes – role of WHO.

Unit 3: Epidemiology : Direct and indirect host to host transmission, zoonosis, hospital borne infections. General account of epidemiology and disease surveillance. Measures for prevention of epidemics. Disease forecasting. Disease cycle. Herd immunity

Unit 4: Human and microbes interactions : Normal microbial flora of the human body. Mode of entry, colonization and growth. Damage to host cell, virulence, virulence factors- exotoxins, endotoxins, neurotoxins and enzymes with special reference to Cholera toxin, enterotoxin, dephtheria toxin and tetanospasmin. Pathogens, symptomatology, epidemiology, and measures of AIDS, Cholera, Tuberculosis, Tetanus, Dermatomycosis, Malaria.

Unit 5: Antimicrobial agents: General characteristics and mode of action- Naturally produced drugs. Antibiotics produced by bacteria, actinomycetes and fungi used in chemotherapy. Classification of antibiotics on the basi s of structure and mode of action. Assay of antibiotics, antibiotic spectrum Semisynthetic antibiotic. Sulfa drugs, their use and mechanism of action. Naldixic acid, nitrofurans, isonicotinic hydrazide, metronidazole; Prophylactic agents. Drug toxicity. Drug resistance – chromosomal mutation and plasmid-borne multiple drug resistance.

MB-H-GE-P-03: Immunology and Medical Microbiology (Credits 2; FM 25)

1. Agglutination test
2. Identification of human blood groups
3. Perform Total Leukocyte Count of the given blood sample
4. Separate serum from the blood sample (demonstration)
5. Demonstration of immunoelectrophoresis
6. Perform immunodiffusion by Ouchterlony method
7. Study of composition and use of important differential media for identification of bacteria: EMB Agar, McConkey agar, Mannitol salt agar, TCBS
8. Study of bacterial flora of skin by swab method
9. Perform antibacterial sensitivity by Agar cup method
10. Determination of minimal inhibitory concentration (MIC) of an antibiotic (Streptomycin/ Kanamycin)
11. Determination of phenol coefficient

MB-H-GE-L-04: Environmental Microbiolgy (Credits 4; FM 50)

Unit 1: Microorganisms and their Habitats- Structure and function of ecosystems, Terrestrial Environment: Soil profile and soil microflora. Aquatic Environment: Microflora of fresh water and marine habitats, Atmosphere: Aeromicroflora and dispersal of microbes, Animal Environment: Microbes in/on human body (Microbiomics) & animal (ruminants) body.Extreme Habitats: Extremophiles: Microbes thriving at high & low temperatures, pH, high hydrostatic & osmotic pressures, salinity, & low nutrient levels.

Unit 2: Biogeochemical Cycling- Carbon cycle: Microbial degradation of cellulose, hemicelluloses, lignin and chitin, Nitrogen cycle: Nitrogen fixation, ammonification, nitrification, denitrification and nitrate reduction, Phosphorus cycle: Phosphate immobilization and solubilisation, Sulphur cycle: Microbes involved in sulphur cycle, Other elemental cycles: Iron.

Unit 3: Waste Management- Solid Waste management: Sources and types of solid waste, Methods of solid waste disposal (composting and sanitary landfill). Liquid waste management: Composition and strength of sewage (BOD and COD), Primary, secondary (oxidation ponds, trickling filter, activated sludge process and septic tank) and tertiary sewage treatment.

Unit 4: Microbial Bioremediation- Principles and degradation of common pesticides, organic (hydrocarbons, oil spills) and inorganic (metals) matter, biosurfactants.

Unit 5: Water Potability- Treatment and safety of drinking (potable) water, methods to detect potability of water samples: (a) standard qualitative procedure: presumptive test/MPN test, confirmed and completed tests for faecal coliforms (b) Membrane filter technique and (c) Presence/absence tests.

MB-H-GE-P-04: Environmental Microbiolgy (Credits 2; FM 25)

1. Analysis of water quality by MPN method
2. Isolation of microbes (bacteria & fungi) from soil (28ºC & 45ºC).
3. Isolation of microbes (bacteria & fungi) from rhizosphere and rhizoplane.
4. Assessment of microbiological quality of water.
5. Determination of BOD of waste water sample.
6. Study the presence of microbial activity by detecting (qualitatively) enzymes (dehydrogenase, amylase, urease) in soil.

Skill Enhancement Elective Courses [SEC]

MB-H-SEC-L-01: 'Microbial Quality Control in Food and Pharmaceutical Industries' or 'Food Fermentation Techniques' (Credit 2; Mark 25)

Microbial Quality Control in Food and Pharmaceutical Industries

Microbiological Laboratory and Safe Practices- Good laboratory practices - Good laboratory practices, Good microbiological practices; Biosafety cabinets – Working of biosafety cabinets, using protective clothing, specification for BSL-1, BSL-2, BSL-3. Discarding biohazardous waste – Methodology of Disinfection, Autoclaving & Incineration

Determining Microbes in Food / Pharmaceutical Samples- Culture and microscopic methods - Standard plate count, Most probable numbers, Direct microscopic counts, Biochemical and immunological methods: Limulus lysate test for endotoxin, gel diffusion, sterility testing for pharmaceutical products; Molecular methods - Nucleic acid probes, PCR based detection, biosensors.

Pathogenic Microorganisms of Importance in Food & Water- Enrichment culture technique, Detection of specific microorganisms from clinical samples using selective media. Ascertaining microbial quality of milk by MBRT, Rapid detection methods of microbiological quality of milk at milk collection centres.

HACCP for Food Safety and Microbial Standards- Hazard analysis of critical control point (HACCP) - Principles, flow diagrams, limitations; Microbial Standards for Different Foods and Water – BIS standards for common foods and drinking water

Food Fermentation Techniques

Fermented Foods- Definition, types, advantages and health benefits

Milk Based Fermented Foods- Dahi, Yogurt, Buttermilk (*Chhach*) and cheese: Preparation of inoculums, types of microorganisms and production process

Grain Based Fermented Foods- Soy sauce, Bread, Idli and Dosa: Microorganisms and production process

Vegetable Based Fermented Foods- Pickels, Saeurkraut: Microorganisms and production process

Fermented Meat and Fish- Types, microorganisms involved, fermentation process

Probiotic Foods- Definition, types, microorganisms and health benefits

MB-H-SEC-L-01: 'Management of Human Microbial Diseases' or 'Microbiological Analysis of Air and Water' (Credit 2; Marks 25)

Management of Human Microbial Diseases

Human Diseases- Infectious and non infectious diseases, microbial and non microbial diseases, occupational diseases, Incubation period, mortality rate, nosocomial infections.

Microbial diseases- Respiratory microbial diseases, gastrointestinal microbial diseases, Nervous system diseases, skin diseases, eye diseases, urinary tract diseases, Sexually transmitted diseases: Types, route of infection, clinical systems and general prevention methods, study of recent outbreaks of human diseases (SARS/Swine flu/Ebola) – causes, spread and control, Mosquito borne disease – Types and prevention.

Therapeutics of Microbial diseases- Treatment using antibiotics: beta lactam antibiotics (penicillin, cephalosporins), quinolones, polypeptides and aminoglycosides. Judicious use of antibiotics, importance of completing antibiotic regimen, Concept of DOTS, emergence of antibiotic resistance, current issues of MDR/XDR microbial strains. Treatment using antiviral agents: Amantadine, Acyclovir, Azidothymidine. Concept of HAART.

Prevention of Microbial Diseases- General preventive measures, Importance of personal hygiene, environmental sanitation and methods to prevent the spread of infectious agents transmitted by direct contact, food, water and insect vectors. Addressing emerging diseases

Vaccines- Importance, types, vaccines available against microbial diseases, vaccination schedule (compulsory and preventive) in the Indian context.

Microbiological Analysis of Air and Water

Aeromicrobiology- Bioaerosols, Air borne microorganisms (bacteria, Viruses, fungi) and their impact on human health and environment, significance in food and pharma industries and operation theatres, allergens

Air Sample Collection and Analysis- Bioaerosol sampling, air samplers, methods of analysis, CFU, culture media for bacteria and fungi, Identification characteristics

Control Measures- Fate of bioaerosols, inactivation mechanisms – UV light, HEPA filters, desiccation, Incineration

Water Microbiology- Water borne pathogens, water borne diseases

Microbiological Analysis of Water- Sample Collection, Treatment and safety of drinking (potable) water, methods to detect potability of water samples: (a) standard qualitative procedure: presumptive/MPN tests, confirmed and completed tests for faecal coliforms (b) Membrane filter technique and (c) Presence/absence tests

Control Measures- Precipitation, chemical disinfection, filtration, high temperature, UV light