

SYLLABUS

M.Sc. in Microbiology

CBCS



ENLIGHTENMENT TO PERFECTION

DEPARTMENT OF MICROBIOLOGY
UNIVERSITY OF NORTH BENGAL
RAJA RAMMOHUNPUR

DIST.DARJEELING, PIN-734013 WEST
BENGAL

DURATION: Two years (4 Semesters)

CURRICULUM

SEMESTER I

CORE COURSE

Sl No	Paper Code	Group	Course Title	Full marks	Credit	
Theory						
1	MICR-CT 101	A	Thermodynamics in Biology	25	50	2
		B	Biomolecules and Enzymology	25		
2	MICR-CT 102	A	Diversity of Prokaryotic and Eukaryotic Microbes	25	50	2
		B	Cell Biology	25		
3	MICR-CT 103	A	Microbial Metabolism and Growth	25	50	2
		B	Molecular Biology	25		
Practical						
1	MICR-CP 104		Biochemistry and Analytical Technique	25	1	
2	MICR-CP 105		General Microbiology	25	1	
3	MICR-CP 106		Microbial Metabolism and Molecular Biology	25	1	

ELECTIVE COURSE (Student's may choose any one of the listed papers)

Sl No	Paper Code	Group	Course Title	Full marks	Credit
Theory					
1	MICR-ET	A	Instrumentation and Biotechniques	75	3
		B	Microbiological analysis of air and water	75	3

	107	C	Cancer Biology	75	3
		D	Metabolic Disorders	75	3

CONTINUING EVALUATION

Sl No	Paper Code	Group	Course Title	Full marks	Credit
Theory					
1	MICR-CP-108		Class Tests/ Assignments /Seminar/Journal Club	100	4
Total				400	16

SEMESTER II

CORE COURSE

Sl No	Paper Code	Group	Course Title	Full marks	Credit	
Theory						
1	MICR-CT 201	A	Genetic Engineering	25	50	2
		B	Genetics	25		
2	MICR-CT 202	A	Agricultural Microbiology	25	50	2
		B	Environmental Microbiology	25		
3	MICR-CT 203	A	Bioprocess Engineering and Industrial Microbiology	25	50	2
		B	Food Microbiology	25		
Practical						
1	MICR-CP 204		Genetic Engineering and Genetics	25	1	
2	MICR-CP 205		Agricultural and Environmental Microbiology	25	1	
3	MICR-CP 206		Bioprocess Engineering and Food Microbiology	25	1	

ELECTIVE COURSE (Student's may choose any one of the listed papers)

Sl No	Paper Code	Group	Course Title	Full marks	Credit
Theory					
1	MICR-ET 207	A	Waste water treatment	75	3
		B	Pharmacogenetics and Pharmacogenomics	75	3
		C	Value Added Product from Agro-wastes	75	3
		D	Microbial Ecology	75	3

CONTINUING EVALUATION

Sl No	Paper Code	Group	Course Title	Full marks	Credit
Theory					
1	MICR-CP 208		Class Tests And Assignments /Seminar/Journal Club	100	4
			Total	400	16

SEMESTER III**CORE COURSE**

Sl No	Paper Code	Group	Course Title	Full marks	Credit
Theory					
1	MICR-CT 301	A	Virology	25	50
		B	Immunology	25	
2	MICR-CT 302	A	Medical Microbiology	25	50
		B	Antibiotics and Chemotherapeutics	25	
3	MICR-CT 303	A	Biostatistics	25	50
		B	Bioinformatics	25	
Practical					
1	MICR-CP 304		Virology and Immunology	25	1

2	MICR-CP 305		Medical Microbiology	25	1
3	MICR-CP 306		Biostatistics and Bioinformatics	25	1

ELECTIVE COURSE (Student's may choose any one of the listed papers)

Sl No	Paper Code	Group	Course Title	Full marks	Credit
Theory					
1	MICR-ET 307	A	Quality control in food and pharmaceutical industry	75	3
		B	Soil Microbiology	75	3
		C	Management of Microbial Diseases in human	75	3
		D	Biofertilizer Biocontrol agents	75	3

CONTINUING EVALUATION

Sl No	Paper Code	Group	Course Title	Full marks	Credit
Theory					
1	MICR-CP 308		Class Tests And Assignments /Seminar/Journal Club	100	4
			Total	400	16

SEMESTER IV

CORE COURSE

Sl No	Paper Code	Group	Course Title	Full marks	Credit
1	MICR-CT 401	A	Genomics	25	50
		B	Proteomics	25	
2	MICR-CP		Dissertation/Review work	175	7

	402				
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ELECTIVE COURSE (Student's may choose any one of the listed papers)

Sl No	Paper Code	Group	Course Title	Full marks	Credit
Theory					
1	MICR-ET 403	A	Bioethics & IPR	75	3
		B	Inheritance Biology	75	3
		C	Biodegradation & Bioremediation	75	3
		D	Evolutionary Biology	75	3

CONTINUING EVALUATION

Sl No	Paper Code	Group	Course Title	Full marks	Credit
Theory					
1	MICR-CP 404		Industrial visit/Field study/Summer training	50	2
2	MICR-CP 405		Seminar/Journal Club/Assignments/Class Test	50	2
			Total	400	16

16 Credits /Semester= 9 Credits in Core Courses + 3 Credits in Elective Courses + 4 Credits in Continuing evaluation

Total Credits = 16 X 4 semester = 64

1Credits = 25 Marks

Total Marks= 64 Credit X 25= 1600

Credit = 1Hour of Theory class.

1 Credit = 2 Hour of Practical class.

SEMESTER I Core Courses

Theory

Paper MICR-CT 101

Group A: Thermodynamics in Biology

Laws of thermodynamics, entropy, enthalpy, free energy, free energy and equilibrium constant.

Gibbs free energy equation, determination of free energy of hydrolytic and biological oxidation reduction reactions, under standard and non-standard conditions.

High energy compounds, coupled reactions, determination of feasibility of reactions. ATP and other different groups of high energy phosphate compounds.

Transport across membrane - passive diffusion, facilitated diffusion & active transport - (definition and examples); gradient of chemical potential as driving force in transport, equilibria and transport across membranes;

Diffusion, osmosis, sedimentation, osmotic pressure, Donnan equilibrium, diffusion potential, membrane potential.

Bonds: ionic bonding, Ion-dipole, covalent, H-bonds, Van der Waals' interaction, Hydrophobic and hydrophilic interactions Water as a biological solvent and its role in biological processes pH, Henderson-Hasselbalch equation, concept of buffer, strength of buffer, range of buffer, important biological buffers.

Group B: Biomolecules and Enzymology

Chemical basis of life: Composition of living matter; Water-properties; pH; ionization and hydrophobicity: Biomolecular hierarchy

Protein: Amino acids-Structure and functional group properties; Covalent structure of Peptide; Hierarchy in protein structure; Elucidation of primary and higher order structures

Carbohydrate: Mono, di and polysaccharides; Glycosylation of other biomolecules-glycoproteins and glycolipids

Lipids: Structure and properties of important members of Storage and Membrane lipids; Lipoproteins

Nucleic acid: Components of DNA and RNA, Structure of DNA and RNA, Watson-Crick model, Alternate double helical structures of DNA, Supercoiling of double helix, DNA renaturation kinetics

Enzyme catalysis: Definition of enzyme, active site, substrate, coenzyme, cofactor and different kinds of enzyme inhibitors; Michaelis-Menten Kinetics; Methods of plotting enzyme kinetics Lineweaver-Burk, Hanes-Woolf, Edie-Hofstee and Dixon plot, Two substrate kinetics, Deviation from linear kinetics; Ligand binding studies, Rapid kinetics, Association and dissociation constants; Factors influencing catalytic efficiency Effect of pH, temperature and isotopically labeled substrates on enzyme activity; Solvent effects; Allosteric model of enzyme regulation, substrate induced conformational change in enzyme

Recommended Books:

1. Physical Chemistry: With Applications to the Life Sciences by D. Eisenberg and D. Crothers (Benjamin/Cummings)
2. Biochemistry, **6e**, by J.M. Berg, J.L. Tymoczko and L. Stryer (W.H. Freeman)
3. Biophysics, **3e**, by W. Hoppe *et al.*, (Springer-Verlag)
4. Biochemistry, **4e**, by D. Voet and J.G. Voet (Wiley)
5. Biochemistry, 4e, by G. Zubay (William C. Brown)
6. Physical Biochemistry, **2e**, by K.E Van Holde (Prentice Hall)
7. Lehninger Principles of Biochemistry, 6e, by David L. Nelson, Michael M. Cox
8. Principles and Techniques of Practical Biochemistry, **7e**, by Keith Wilson and John Walker.
9. Physical Biochemistry: Applications to Biochemistry and Molecular Biology, 2e, by David Freifelder
10. Biophysical Chemistry: Part III: The Behavior of Biological Macromolecules, by Charles R. Cantor Paul R. Schimmel

Paper MICR-CT 102

Group A: Diversity of Prokaryotic and Eukaryotic Microbes

Biodiversity: Concepts and levels; Role of biodiversity in ecosystem functions and stability; Speciation and extinction

Microorganisms: Classification and survey; Prokaryotes - General characteristics, Modes of reproduction; Classification-Criteria, Numerical taxonomy and Bergey's Manual; Microbial phylogeny as revealed by rRNA sequencing; Metagenomics; Extremophiles

General characteristics of various groups of prokaryotes: Archaea, Bacteria-Mycoplasmas, Rickettsiae, Chlamydiae, Spirochaetes, Cyanobacteria, and Actinomycetes

General characteristics, Structure, classification, life cycles (important forms), sexual and asexual reproduction and evolution of Algae

General characteristic, structure, classification, life cycles (important forms), sexual and asexual reproduction of Yeasts and Moulds

General characteristics, Classification and importance of Protozoa

Group B: Cell Biology

Cell theory; Cell morphology and significance of being small

Cytoplasmic membrane: Structure, function and composition; Membrane transport systems; Cellular junction and adhesions; Protein trafficking in Endoplasmic reticulum and Golgi apparatus

Variation in microbial cell wall structures

Molecular basis of Chemotaxis; Functional biology of Cilia and Flagella

Biogenesis of Chloroplast and Mitochondria

Nucleus: Structure and function of Nuclear envelop, Lamina and Nucleolus; Nucleoid

Inclusion bodies: Carbon storage polymers; Other storage materials

Gas vacuoles: structure and functions

Cell cycle regulation in Prokaryotes and Eukaryotes

Cell signaling: Cell signaling receptors, GPCR, Enzyme linked receptors

Recommended Books:

1. General Microbiology, 5e, by R.Y. Stanier (Palgrave Macmillan)
2. Microbiology, 5e, by M.J. Pelczar (Tata McGraw-Hill)
3. Microbiology, 9e, by L.M. Prescott (William C. Brown)
4. Brock Biology of Microorganisms, 14e, by M. Madigan *et al.* (Benjamin Cummings)
5. Biodiversity of Microbial Life, by J.T. Staley and A.L. Reysenbach (John Wiley)
6. Microbial Ecology: Fundamentals and Applications, 6e, by R.M. Atlas and R. Bartha (Benjamin Cummings)
7. Bacterial Metabolism, 2e, by G. Gottschalk (Springer)
8. Microbial Physiology, 2e, by I.W. Dawes and I.W. Southerland (Blackwell)
9. Prokaryotic Development, by Y.V. Brun and L.J. Shimkets, eds (ASM Press)
10. Molecular Biology of the Cell, 4e, by B. Alberts (Garland)

Paper MICR-CT 103

Group A: Microbial Metabolism and Growth

Microbial growth kinetics: Growth curve; Measurement of growth; Continuous culture; Influence of environmental factors on growth; Microbial growth in natural environments; Counting viable but non-culturable prokaryotes; Quorum sensing; Growth under starvation

Growth control of microorganisms: Pattern of microbial growth; Condition influencing the effectiveness of antimicrobial agent activity; Use of physical and chemical methods in control

Nutritional types of microorganisms; Culture media

Carbohydrate Metabolism: Fermentation, Anaerobic and Aerobic respiration - EnterDoudoroff pathway, TCA cycle, Pentose Phosphate pathway, Hexose Monophosphate shunt, Glyoxylate cycle, Regulation of sugar degradation pathways; Glycogenesis; Gluconeogenesis; Electron transport systems and ATP generation

Lipid Metabolism: Biosynthesis of Fatty acids, Triacylglycerols, Membrane phospholipids, Oxidation of fatty acids

Amino acid Metabolism: Lysine, Glycine, Proline, Tryptophan, Ornithin cycle; Urea cycle

Biosynthesis of Nucleic acids: Salvage and de novo pathways

Peptidoglycan biosynthesis; Oxygenic and anoxygenic photosynthesis

Autotrophy; Photolithoautotrophy; Energy conservation in Chemolithotrophic bacteria

Heterotrophic CO₂ assimilation: Acetogenesis; Methanogenesis; Hydrogen production

Nitrogen Metabolism: Nitrification, Denitrification; Nitrogen fixation - Symbiotic and Asymbiotic; Ammonification

Dissimilatory and assimilatory Sulphurmetabolism

Group B: Molecular Biology

Organization of genomes: Genes and chromosomes; Satellite DNA, Euchromatin, Heterochromatin, Palindromes and Inverted repeats

DNA Replication: General principle; Semiconservative and Semidiscontinuous nature of replication, Okazaki fragments; Enzymes and accessory proteins; Initiation, Elongation and Termination of Replication, Models of replication-Eyes, Rolling circles and D loops; Topology of DNA replication

Recombination and Repair: Homologous, nonhomologous and site specific recombination; Holiday junction; Cre/Lox recombination; DNA repair enzymes, Photoreactivation; Excision repairs; Mismatch repair, SOS repair

Mutation: Nonsense, missense and point mutation; Intragenic and Intergenic suppression; Physical, chemical and biological mutagens; Role of Transposons in mutation

Transcription: Prokaryotic transcription-Transcription Unit; Enzymes and accessory proteins; Initiation, Elongation and Termination-rho dependent and rho independent termination of RNA chains; Attenuation and Anti-termination; Eukaryotic transcription-Promoter, Enhancer, General Transcription factors

Translation in Prokaryotes and Eukaryotes: Translational machinery, Ribosome, Genetic code- Degeneracy of codons, Wobble hypothesis; Activation of amino acids; Mechanism of Initiation, Elongation and Termination; Post-translational modifications

Recommended Books:

1. Genes XI, by Benjamin Lewin (Oxford University Press)
2. Molecular Biotechnology, 2e, by S.B. Primrose (Wiley-Blackwell)
3. Molecular Biology of the Gene, 7e, by J.D. Watson *et al.* (Benjamin Cummings)
4. Recombinant DNA Methodology II, by R. Wu, ed. (Academic Press)
5. Molecular Biology of Cell, 2e, by David P. Clark (Academic Press)
6. General Microbiology, 5e, by R.Y. Stanier (Palgrave Macmillan)
7. Microbiology, 5e, by M.J. Pelczar (Tata McGraw-Hill)
8. Microbiology, 9e, by L.M. Prescott (William C. Brown)
9. Brock Biology of Microorganisms, 14e, by M. Madigan *et al.* (Benjamin Cummings)

Practical

Paper MICR-CP 104 (Biochemistry and Analytical Technique)

1. Standard buffer solution preparation and pH determination
2. Phase contrast microscopy (demonstration)
3. Fluorescence microscopy (demonstration)
4. Isolation of photosynthetic pigments and study of their absorption spectra
5. Techniques of Thin layer, Ion exchange and Gel filtration chromatography
6. Estimation of carbohydrates and proteins
7. Isolation and partial purification of bacterial enzyme
8. Determination of specific activity and stability of partially purified enzymes
9. Effect of substrate concentration, pH, temperature, salt concentration, activator, and inhibitor on enzyme activity
10. Determination of K_m and V_{max} with and without competitive and non-competitive inhibitors for partially purified enzyme
11. SDS-Polyacrylamide gel electrophoresis of protein

Paper MICR-CP 105 (General Microbiology)

1. Microbial staining techniques (Simple staining; Gram staining; Endospore staining; Flagella staining; Cell wall staining; Negative staining) and Microscopic studies of microbial morphology (shape, size, arrangement etc.)
2. Enrichment and morphological study of Endospore-forming bacteria, Phototrophic bacteria, Myxobacteria
3. Isolation of Microbiota from different habitats – Aliquot preparation, Dilution techniques, Streak method, Enrichment method by using selective media and by modifying microenvironment, Identification of isolated bacteria (microscopic, cultural, biochemical and physiological tests)
4. Isolation of Protozoa from soil
5. Isolation of Bacteriophage

Paper MICR-CP 106 (Microbial Metabolism and Molecular Biology)

1. Study of Microbial Growth Curves; Determination of generation time; Estimation of growth –Plate count method (Viable colony count of microbes), MPN Technique, Turbidimetry, Microscopic counts with Haemocytometer, Dry weight Estimation; Diauxic growth curve.
2. Effect of environmental factors (temperature, pH, carbon and nitrogen sources) on growth of microorganisms

3. Isolation of genomic and plasmid DNA - preparation of 'cot' curve
4. Absorption spectra of isolated protein and DNA
5. Induction of mutation, and selection of mutants using Replica Plating Technique 6. Auxotrophic mutant isolation

Elective courses

MICR-ET 107 A: Instrumentation and Biotechniques

Microscopy: Theory and applications in Biological sciences, Dark-field, Phase contrast and interference, Polarisation, Confocal, Atomic force, Fluorescence and Electron (SEM and TEM) microscopy; Fluorescence activated cell sorter

Radioactivity measurement: Radioactive decay, Liquid scintillation counter- γ ray detection and its applications; Use of stable isotopes in Biological sciences; Autoradiography

Chromatography: Basic principle; Paper, Thin layer and Column chromatography; Protein purification; Liquid chromatography; Gas chromatography

Electrophoresis: Basic principle; Agarose gel electrophoresis, Polyacrylamide gel electrophoresis, Counter current electrophoresis, Immuno-electrophoresis; Isoelectric focusing

Centrifugation: Basic principle; RCF and Sedimentation Coefficient; Types of Centrifugation - High speed and Ultracentrifugation, Differential and Density-gradient centrifugation; Analytical centrifugation and applications

Spectroscopy; Theory and applications; UV-Visible, Fluorescence, IR, FTIR, NMR, Mass, Raman and Atomic absorption spectroscopy; Fluorescence polarization

Recommended Books:

1. Physical Chemistry: With Applications to the Life Sciences by D. Eisenberg and D. Crothers (Benjamin/Cummings)
2. Biophysics, **3e**, by W. Hoppe *et al.*, (Springer-Verlag)
3. Physical Biochemistry, **2e**, by K.E Van Holde (Prentice Hall)
4. Lehninger Principles of Biochemistry, 6e, by David L. Nelson, Michael M. Cox
5. Principles and Techniques of Practical Biochemistry, **7e**, by Keith Wilson and John Walker.
6. Physical Biochemistry: Applications to Biochemistry and Molecular Biology, 2e, by David Freifelder
7. Biophysical Chemistry: Part III: The Behavior of Biological Macromolecules, by Charles R. Cantor Paul R. Schimmel

B. Microbiological analysis of water and air.

Introduction: Disease caused by air borne microbes: Bacterial Diseases :Brucellosis, Pulmonary Anthrax Diseases Caused by Streptococcus Pyogenes, Diphtheria. Air Borne Fungal Diseases: Cryptococcosis ,Aspergillosis Airborne crop pathogen. Air Borne Viral Diseases: Influenza ,Adeno Viral Diseases

Sources of microorganism in air: Droplet Nuclei, Infectious Dust.

Bioaerosol control in laboratory: Ventilation, Filtration, Biocidal agents, Factors affecting microbial survival in air: Atmospheric humidity, Temperature.

Enumeration of Microbes in air: Impingement in liquids, Impingement on solids, Airsampling methods:

Air pollution and its control: Control of gaseous emissions, control of pollutants from vehicles.

Examination of water, Potable water, Standards for drinking water. Microbiological analysis of water (total count, indicative organism), B.O.D. & C.O.D. -determination and implication.Coliform test - detection of faecal and non-faecalcoliform); IMViC test; determination of MPN. Viable but not culturable microorganisms

Drinking water – epidemiology – risk assessment – water safety plans: Microorganisms and potable water,Origin of microorganisms of public health significance,Characteristics, types, metabolism, multiplication, survival,Health problems caused by polluted drinking water,Epidemiology of drinking water infections, Risk assessment methods – applications – examples.

Waterborne infections and outbreaks:Introduction to Epidemiology , Epidemiological studies ,Waterborne epidemics-study ,Examples of water-borne epidemics Examination of the specific microorganisms that influence climate change, Metabolic activity and metabolic by-products,Effects of climate change on parameters of water quality, Methods of water reclamation, current aspects of water reuse, legionnaire’s disease – epidemiology

Recommended Books:

- 1.General Microbiology, 5e, by R.Y. Stanier (Palgrave Macmillan)
- 2.Microbiology, 5e, by M.J. Pelczar (Tata McGraw-Hill)
- 3.Microbiology, 9e, by L.M. Prescott (William C. Brown)
- 4.Brock Biology of Microorganisms, 14e, by M. Madigan *et al.* (Benjamin Cummings)
- 5.Biodiversity of Microbial Life, by J.T. Staley and A.L. Reysenbach (John Wiley)
- 6.Microbial Ecology: Fundamentals and Applications, 6e, by R.M. Atlas and R. Bartha (Benjamin Cummings)

C. Cancer Biology

Types of cancer, Development, Causes and properties of cancer cell, Metastasis ,angiogenesis, apoptosis, Transformation of cells in culture

Virus induced cancer: Papiloma, Herpes viruse

Interaction of cancer cell with normal cell

Oncogene, Protooncogene, oncogene in human cancer, function of oncogene products.

Tumour suppressor genes: Retinoblastoma, p53

Therapeutic intervention of uncontrolled cell growth

Prevention and early detection of cancer, Molecular diagnosis, Treatment.

Recommended Books:

1. Molecular Biology of the Cell, 4e, by B. Alberts (Garland)
2. Karp's Cell and Molecular Biology, 8e by Gerald Karp, Janet Iwasa, Wallace Marshall.
3. The Cell: A Molecular Approach, 7e by Geoffrey M. Cooper, Robert E. Hausman
4. Introduction to cancer biology, 2e by Momna Hejmadi

D. Metabolic Disorders

The normal physiology and biochemistry, including changes during childhood, fluid and electrolyte balance. · acid - base regulation · intermediary metabolism including blood glucose and metabolic response to fasting, lactate, ammonia, aminoacids, organic acids and fatty acids. · relevant aspects of brain metabolism including neurotransmitters. The role of the blood brain barrier · enzyme biochemistry and tissue expression Metabolic Disease: The pathological and biochemical changes, clinical symptoms, investigations and management in metabolic disorders of these pathways and organelles, as listed in the appendix. · Drug management. An understanding and experience of the drugs used for the treatment of metabolic disorders. The principles of dietary therapy including the consequences of changes in the intakes of nutrients. Consequences of under-nutrition and specific nutritional deficiencies. Genetics · Mechanisms of inheritance and an understanding of molecular genetics including mitochondrial DNA · Understanding of principles of prenatal diagnosis

Recommended Books:

1. Biochemistry, 4e, by D. Voet and J.G. Voet (Wiley)
2. Biochemistry, 4e, by G. Zubay (William C. Brown)
3. Lehninger Principles of Biochemistry, 6e, by David L. Nelson, Michael M. Cox
4. Principles and Techniques of Practical Biochemistry, 7e, by Keith Wilson and John Walker.
5. Biochemistry, 6e, by J.M. Berg, J.L. Tymoczko and L. Stryer (W.H. Freeman)

Paper MICR-CP 108 (Class Tests / Assignments / Seminar)

Average of continuing class test and assignments scores on all the theoretical and practical subjects taught in semester I

A seminar topic will be allotted to individual student according to his/her area of interest (students are also suggested to propose topics with relevant published information during

the time of allotment), on which a report should be prepared and submitted after presentation as per schedule.

SEMESTER II Core Courses

Theory

Paper MICR-CT 201

Group A: Genetic Engineering

Basic Concepts: Restriction enzymes; DNA ligase, Klenow enzyme, T4 DNA ligase, Polynucleotide kinase, Alkaline phosphatase; Linkers and Adaptors; Labelling of DNA - Nick translation, Random priming, Radioactive and non-radioactive probes; Northern and Southern hybridization; DNase foot printing; DNA sequencing methods

Cloning vectors: Plasmid (pBR322, pUC, Blue script), Phagemid, Lambda vectors, Cosmid; Artificial chromosomes (YAC, BAC); Bacterial Expression vectors (pMal, pET based vectors); Cloning in yeast, Yeast vector development, YEp, YRp, YCp and YIp, 2 μ plasmid, Transformation in yeast; Shuttle vector; *Agrobacterium tumefaciens*; Genetic elements present in Ti plasmid, disarmed Ti plasmid, Plant transformation-binary and cointegrate vectors

Cloning Methodologies: Insertion of Foreign DNA into host cells, Genomic and cDNA library; Expression cloning

PCR: Principle, Thermostable DNA polymerase, Proofreading enzymes, Primer design; Types of PCR-Reverse transcriptase, Real Time PCR, Degenerate PCR, Inverse PCR; Cloning of PCR products, TA-cloning, PCR based mutagenesis, Application of PCR in bacterial and viral detection

Group B: Genetics

DNA as genetic material; Physical basis of heredity; Chromosomes; Cell division

Gene transfer mechanisms: Transformation, Conjugation, Transduction

Extra-chromosomal genetic elements and their inheritance; Mitochondrial DNA

IS element and Transposons

Genetic analysis of Bacteriophages: general outline (lambda and T4 Phage)

Regulation of gene expression in prokaryotes and eukaryotes: Operon concept-*lac*, *ara* and *trp* operons, *nif* regulon; Environmental factors of gene regulation; Chromosome remodeling; RNA editing; SiRNA and RNA Interference

Outline of Mendelian genetics; Linkage and Chromosome mapping; Cross over, chi square test for linkage; Recombination frequency and map construction; Tetrad analysis in yeast and recombination mapping with tetrad; Mapping with molecular markers

Recommended Books:

1. Principles of Gene Manipulation, **6e**, by S.B. Primrose, R.M.Twyman and R.W. Old
2. Genetic Engineering, **3e**, by S. Rastogi and N. Pathak (Oxford University Press)
3. Molecular Cloning, A Laboratory Manual **4e**, by J.Sambrook and D.W.Russel (CSHL Press)
4. Genetics as a Tool in Microbiology, vol. 31, by S.W. Gloover and D.A. Hopwood (Cambridge University Press)
5. Molecular Genetics of Bacteria, 4e, by L. Snyder and W. Champness (ASM Press)
6. Genetics of Bacteria, by A. Galizzi, ed. (Academic Press)
7. Molecular Biology of the Gene, 7e, by J.D. Watson *et al.* (Benjamin Cummings)
8. Principles of Genetics, 8e, by Gardner, Simmons, Snustad

Paper: MICR-CT 202

Group A: Agricultural Microbiology

Soil microorganisms in Agro-ecosystems: Types of microbial communities; Soil microbial diversity- Significance and conservation; Effect of agricultural practices on soil organisms

Biological Nitrogen fixation: Diversity of nitrogen-fixing organisms, Rhizobium-legume association, Nitrogenase, Mechanism of nitrogen-fixation

Chemical transformation by microbes: Organic matter decomposition, Nutrient mineralization and immobilization; Transformation of carbon and carbon compounds; Availability of phosphorus, sulfur, iron and trace elements to plants; Biodegradation of Herbicides and Pesticides.

Biofertilizer: Mass cultivation of microbial inoculants; Green manuring; Algalization; Biopesticides

Introduction to Phytopathogens: Symptoms, Pathogenesis, Molecular aspects of plant pathogens interactions, Host defence mechanisms; Mycotoxins and Aflatoxin; Disease forecasting and assessment of losses; Prevention of epidemics and disease control

Symbiotic associations: Mycorrhizae; Lichens and PGPR

Group B: Environmental Microbiology

Microbiome: Microbes in terrestrial, aquatic, atmospheric and biological environments; Animal as an environment- microbial population of alimentary canal, skin and rumen

Eutrophication and its control; Biofilm reactors and its ecological implications

Significance of microbial activities in the environment: Role of microorganisms in the cycling of bioelements; Biotransformation; Microbial degradation of recalcitrant chemicals and xenobiotics (petroleum and hydrocarbons)

Bioremediation: Biomagnification; Bioaugmentation; Microorganisms in mineral recovery

Structure and development of microbial communities and ecosystems- succession of microbiota in decomposing plant materials

Biological interactions: Microbe-microbe interactions

Microorganism and pollution: Microbial aspects of air and water pollution; Role of microbes in biomonitoring of water quality - Indicator organisms, Single species laboratory bioassays; A brief idea of various stage of wastewater treatment- Trickling filter - community, design and operation, Activated sludge; Oxidation pond, Facultative ponds, Anaerobic treatment of waste water and sludge; Methane production; Use of microbes for removing toxic metal ions from waste water-mechanisms, absorption and desorption, batch and continuous systems; Microbial toxins in the environment; Biosensors.

Recommended Books:

1. Microbial Ecology: Fundamentals and Applications, 6e, by R.M. Atlas and R. Bartha (Benjamin Cummings)
2. Biology of Industrial Microorganisms, 3e, by A.L. Demain and N.A. Solomon, eds (Benjamin/ Cummings)
3. Waste Water Treatment for Pollution Control, 2e, by S.J. Arceivala (McGraw-Hill)
4. Biodegradation and Bioremediation, 2e, by M. Alexander (Academic Press)
5. Manual of Environmental Microbiology, 3e, C.J. Hurst et al., eds (ASM Press)
6. Microbial Mineral Recovery (Environmental Biotechnology), by H.L. Ehrlich and C.L. Brierley (McGraw-Hill)
7. Biochemistry and Molecular Biology of Plants, 2e, by Buchanan et al (ASPP, Maryland)
8. Soil Microbiology and Sustainable Crop Production, 3e, G.R. Dixon, Emma L. Tilston, eds
9. Soil Microbiology, Ecology and Biochemistry, by Eldor Paul (Academic Press)
10. Plant Pathology, 5e, by George N. Agrios (Elsevier Science)
11. Agricultural Microbiology, by D. J. Bagyaraj and G. Rangaswami
12. Microbial Interactions in Agriculture and Forestry by N.S.Subbarao and Y.R. Dommergues (Science publishers).

Paper- MICR-CT 203

Group A: Bioprocess Engineering and Industrial Microbiology

Suitability of microbes in industrial processes and their source; Types of fermentations and bioreactors; Substrates for industrial fermentations; Growth kinetics in batch and continuous fermentation processes; Strain improvement

Design of a fermentor; Instrumentation and control; Methods for the recovery and purification of fermentation products (downstream processing); Economic aspects of fermentation processes

Production aspects (Microbial strains, Substrate, Flow diagrams, Product optimization, and Applications) of the following: Industrial alcohol and alcoholic beverages and glycerol; Organic acids-citric, lactic, acetic, propionic, gluconic acid; Amino acids- glutamic acid, lysine; Enzymes- extracellular amylases and proteases; Vitamins-Vit. B₁₂ and riboflavin; Antibiotics- β -lactam, whole cell and enzyme immobilization and their industrial application

Single cell protein; Polysaccharides; Recombinant DNA products-Insulin; Somatostatin; Interferon; Microbial insecticides

Biogas from wastes: Anaerobic digestion and Methanogenesis; Microbiota involved in anaerobic digestion; Ensilaging and methane generation; Bio-hydrogen; Techno-economics of biogas generation from fruits and vegetable wastes

Group B: Food Microbiology

Factors affecting the growth and survival of microorganisms in foods: Intrinsic factors-Nutrient content, pH, E_h, antimicrobials and A_w; Extrinsic factors-Relative humidity; temperature, and gaseous atmosphere

Methods for studying microbes and their products in food stuffs

Spoilage of fruits and vegetables; Fresh and processed meats and poultry; Miscellaneous foods such as eggs, bakery products, Dairy products, Beers and Wines, Fermented solidsubstrate foods, and canned foods

Microbiology and food preservation with chemicals, irradiation, low and high temperatures, high pressure, modified atmosphere, low humidity and drying

Manufacture of fermented foods: Dairy products (Acidophilus milk, Cheese and Yogurt), Meat and fishery products (Dry sausages and Fish sauces); Plant products (Cocoa beans, Coffee beans, Olives, Pickles, Sauerkraut, Soy sauce, Tempe and Idli); Breads; Beverages (Cider, Sake, Vinegar and Palm wines)

Food-borne diseases and food poisoning by microbial agents: *Clostridium perfringens*; Helminthes and Nematodes; Protozoa (*Giardia*, *Entamoeba*); Toxigenic fungi (*Penicillium* and *Fusarium*)

The hazard analysis and critical control point (HACCP) concept in controlling microbiological quality of foods; Predictive models; Law in terms of food preservation and regulation

Recommended Books:

1. Biology of Industrial Microorganisms, by A.L. Demain and N.A. Solomon, eds (Benjamin/ Cummings)
2. Food Microbiology: Fundamentals and Frontiers, 3e, by M.P. Doyle and L.R. Beuchat (ASM Press)
3. Food Microbiology, 3e, by M.R. Adams and M.O. Moss (Royal Society of Chemistry)
4. Microbial Energetics, 2e, E. A. Dawes (Chapman & Hall)
5. Principles of Fermentation Technology, 3e, by P.F. Stanbury et al. (ButterworthHeinemann)
6. Microbiology, 9e, by L.M. Prescott (William C. Brown)
7. Brock Biology of Microorganisms, 14e, by M. Madigan *et al.* (Benjamin Cummings)

Practical

Paper- MICR-CP 204 (Genetic Engineering and Genetics)

1. Isolation of bacterial genomic DNA and plasmid
2. Bacterial transformation and conjugation
3. Pedigree analysis
4. PCR and TA Cloning
5. Bacterial expression of proteins
6. Restriction enzyme digestion of DNA
7. RT-PCR

Paper MICR-CP 205 (Agricultural and Environmental Microbiology)

1. Enumeration of soil microorganisms: bacteria, actinomycetes, fungi by standard plate count
2. Isolation of cellulose decomposing microbes and estimation of cellulase activity
3. Specimen study of some plant diseases
4. Isolation of plant pathogens (fungi, bacteria and viruses) from different plant parts
5. Physico-chemical analysis of water- pH, TDS, DO, COD, BOD, phosphate, NH_4^+ - N, NO_3^- - N
6. Estimation of organic carbon
7. Determination of ammonification, nitrification and denitrification rates in soil and water
8. Sampling and quantification of microorganisms from air

9. Analysis of soil: Texture, pH, Moisture content, Water-holding capacity, Percolation, Nitrogen and Organic matter
10. Determination of microbial activity in soil and composting plant materials
11. Isolation of microbes from rhizoplane, rhizosphere and phylloplane
12. Tests for presence of enzymes in soil : dehydrogenase, amylase, invertase and catalase

Paper- MICR-CP 206 (Bioprocess Engineering and Food Microbiology)

1. Detection and enumeration of indicator and index organisms for foodborne pathogenesis (Total Enterobacteriaceae, Total coliforms, Faecal coliforms, *Escherichia coli*, and Aerobic sporeformers)
2. Microbiological examination of processing plant, equipment, working surfaces etc.
3. Quantifying the thermal death point of microorganisms (D and z Values)
4. Bioassay of Vitamin B₁₂
5. Mushroom production
6. Determination of the role of yeasts in bread making
7. Determination of the role of moulds in tempe making
8. Isolation of antibiotic producing microorganisms by crowded plate technique
9. Immobilization of microbial cells by entrapment method
10. Ethanol production from whey, fruit wastes, malt etc.
11. Production and estimation of citric acid from pineapple waste in solid state fermentation using a selected strain of *Aspergillus*
12. Saccharification of agro-based industry waste materials by fungal cellulases and hemicellulases

Elective courses

MB- MICR-ET 207

A: Waste water treatment

A brief idea of various stage of wastewater treatment

Trickling filter - community, design and operation,

Activated sludge- community, design and operation

Oxidation pond, Facultative ponds,

Anaerobic treatment of waste water and sludge; Methane production

Use of microbes for removing toxic metal ions from waste water-mechanisms, absorption and desorption, batch and continuous systems **Recommended Books:**

1. General Microbiology, 5e, by R.Y. Stanier (Palgrave Macmillan)

2. Microbiology, 5e, by M.J. Pelczar (Tata McGraw-Hill)
3. Microbiology, 9e, by L.M. Prescott (William C. Brown)
4. Brock Biology of Microorganisms, 14e, by M. Madigan *et al.* (Benjamin Cummings)
5. Biodiversity of Microbial Life, by J.T. Staley and A.L. Reysenbach (John Wiley)
6. Microbial Ecology: Fundamentals and Applications, 6e, by R.M. Atlas and R. Bartha (Benjamin Cummings)

B. Pharmacogenetics and Pharmacogenomics

Basic principles of genetic medicine and personalized medicine, Mechanisms of drug metabolism and transport with genetic variation,

Clinical response and outcomes. methodology used for standard genotyping assays , VNTR, SNTR, RFLP, AFLP, EST, SNP

Pharmacogenomics in drug discovery and development, High throughput screening in genome for drug discovery-identification of gene targets,

Pharmacokinetics and pharmacodynamics,

Issues in Clinical Antibiotic Therapy,

Case study: Mechanism of action, effect, side effect, drug metabolization with allelic variation: Warfarin ,codeine, thiopurine drugs .

Recommended Books:

1. Principles of Pharmacogenetics and Pharmacogenomics, 1e by Russ B. Altman , David Flockhart , David B. Goldstein
2. Concepts in Pharmacogenomics 1e by Martin M. Zdanowicz
3. Pharmacogenomics, 2e by Werner Kalow, Urs B. Meyer, Rachel F. Tyndale
4. Pharmacogenomics: Challenges and Opportunities in Therapeutic Implementation, 1e by Yui-Wing Francis Lam, Larisa H. Cavallari

C. Value Added Product from Agro - wastes

Generation of microbial biomass from wastes of cereal, oil crops, fruit wastes, vegetable waste, fermentation waste industry and whey

Baker's yeast production

Fermented edible products from wastes: vinegar, organic acid- citric acid, gluconic acid, lactic acid, Amino acid-lysine and glutamic acid, Vitamins, Enzyme production- amylase, lipase, cellulose, pectinase, Bioethanol Microbial flavours, Microbial pigment

Microbial gums and polysaccharides

Biogas from wastes: Anaerobic digestion and Methanogenesis; Microbiota involved in anaerobic digestion; Ensilaging and methane generation; Bio-hydrogen; Techno-economics of biogas generation from fruits and vegetable wastes

Recommended Books:

1. Biology of Industrial Microorganisms, by A.L. Demain and N.A. Solomon, eds (Benjamin/ Cummings)
2. Food Microbiology: Fundamentals and Frontiers, 3e, by M.P. Doyle and L.R. Beuchat (ASM Press)
3. Food Microbiology, 3e, by M.R. Adams and M.O. Moss (Royal Society of Chemistry)
4. Microbial Energetics, 2e, E. A. Dawes (Chapman & Hall)
5. Principles of Fermentation Technology, 3e, by P.F. Stanbury et al. (ButterworthHeinemann)
6. Microbiology, 9e, by L.M. Prescott (William C. Brown)

D. Ecology

Community ecology: community structure, benevolent interactions (control within the microbial communities of rhizosphere), antagonistic interactions, (competition, antibiosis, predation etc.).

Rhizosphere, rhizoplane, siderophore, flavonoids from plants, lectines, octapine, niptine, indole acetic acid.

Biomagnification; Bioaugmentation, Ecological niche, Bioacclimatization

Mycorrhiza: Host-fungus specificity, host fungus interactions, rhizosphere environment and recognition phenomenon, interaction of mycorrhizal fungi with non-host plants, functional capability.

Marine ecosystem: Environment of marine bacteria, bacterial growth in sea and its regulation by environmental conditions, modeling of growth and distribution of marine micro plankton, mechanism of dissolved organic matter production (DOM), strategies of organic matter utilization and microbial utilization of organic matter in sea.

Recommended Books:

1. Microbial Ecology: Fundamentals and Applications, 6e, by R.M. Atlas and R. Bartha (Benjamin Cummings)
2. Biology of Industrial Microorganisms, 3e, by A.L. Demain and N.A. Solomon, eds (Benjamin/ Cummings)

3. Waste Water Treatment for Pollution Control, 2e, by S.J. Arceivala (McGraw-Hill)
4. Biodegradation and Bioremediation, 2e, by M. Alexander (Academic Press)
5. Microbiology, **9e**, by L.M. Prescott (William C. Brown)
6. Brock Biology of Microorganisms, **14e**, by M. Madigan *et al.* (Benjamin Cummings)

Paper MICR-CP 208 (Class Tests /Assignments /Seminar)

Average of continuing class test and assignments scores on all the theoretical and practical subjects taught in semester 2

A seminar topic will be allotted to individual student according to his/her area of interest (students are also suggested to propose topics with relevant published information during the time of allotment), on which a report should be prepared and submitted after presentation as per schedule.

SEMESTER III Core

Courses

Theory

Paper MICR-CT 301

Group A: Virology

Classification and general properties of major families of viruses including their modes of replication

Detailed study viz., pathology, pathogenesis, symptoms, epidemiology, transmission, diagnosis, prevention and control of important genera of viruses causing diseases in man, animals, plant and insects included in the following families-DNA (Herpes, Hepatitis B, Adenovirus, SV40, CAMV, Baculo Virus) and RNA (Polio, Influenza, Retro, TMV) viruses

Mechanism of virus entry into plant cells; Methods of assay of plant viruses

Biochemical changes induced by virus in plant cells; Biology and mode of transmission of plant viruses

Group B: Immunology

Cells and organs of immune system; Antibody specificity, diversity, memory, and self and non-selfdiscrimination; Theories of antibody production; Immunogens, Immunoglobulinsfine structure, classification, function, synthesis and evolutionary aspects; Hybridoma production; Monoclonal antibodies - general properties and applications; Antigen-antibody reactions

Complement system; Basic biology of B cells and T cells- their ontogeny, subsets and functions; Phagocytosis; Triggering of immune response-both humoral and cell-mediated antibody formation; Mechanism of cell-mediated immunity; Mitogens; Adjuvants; Immune tolerance, developing and mechanism; Immunosuppression; Immunological hazards of transfusion

Immunological methods - Immunofluorescence, Immunoelectrophoresis, Counter current Immuno-electrophoresis, RIA, ELISA, and Immunoblotting

Immunogenetics: Structure, distribution and function of histocompatibility antigens; Major histocompatibility gene complex; HLA and H-2 systems; MHC Restriction; Immune response genes; HLA and disease; Immunogenetics of tissue transplantation; HLA-typing

Immunopathology: Classification of immunopathological disorders; General account of immune deficiency disorders - both primary and secondary types; Acquired immune deficiency syndrome (AIDS); Atopy, Allergy and Hypersensitivity reactions; Autoimmunity; Mechanism of development of autoimmune diseases; Vaccines

Tumour immunology: Host-tumour interactions; Classification of tumour specific transplantation antigens; Antibody dependent cell cytotoxicity; Natural killer cells; Immune surveillance; Tumour escape mechanisms; Blocking antibodies; Immunotherapy of cancer; Immunotoxins

Recommended Books:

1. Immunology, **8e**, by J. Kuby, RA Goldsby, TJ Kindt, Barbara, A. Osborne (W.H. Freeman)
2. Basic Virology, 3e, by Edward K. Wagner, M. J. Hewlett, D. C. Bloom, D. Camerini (Wiley-Blackwell)
3. Introduction to Modern Virology, 6e, N.J. Dimmock, A. J. Eastern and K. N. Lepard (Blackwell)
4. Field's Virology I and II, 6e by Bernard N Fields, David M. Knipe Peter Howley
5. Principles of Virology, 3e, by S. June Flint et al.
6. Virus Taxonomy by M. H. V. Van Regenmortel, C. M. Fauquet, D. H. L. Bishop (Academic Press)
7. Roitt's Essential Immunology, 12e, by P.J. Delves, S.J. Martin, D.R. Burton, I.M. Roitt

Paper MICR-CT 302

Group A: Medical Microbiology

History of Medical Microbiology: Koch postulates; Microflora in human body in relation to pathogenesis and epidemiology

Study of the following genera of bacteria in relation to pathogenesis: *Corynebacterium*; *Staphylococcus*; *Escherichia*; *Klebsiella*; *Salmonella*; *Shigella*; *Virbrio*; *Campylobacter*; *Pseudomonas*; *Pasteurella*; *Haemophilus*; *Bordetella*; *Bacillus*; *Clostridium*; *Mycobacterium*; *Actinomyces*; *Nocardia*; *Listeria*; *Legionella*

General description, biological properties and diseases caused by the following groups of pathogens: Mycoplasmas; L-phase variants; Rickettsiae; Chlamydiae; Spirochetes

General account of the diseases caused by pathogenic fungi: *Candidiasis*; *Aspergillosis*

Preliminary account of biology, prevention and infectious potential of protozoa: *Entamoeba*; *Plasmodium*; *Giardiasis*

A general account of routinely employed diagnostic tests in microbial diseases– Culture, Smear, Biochemical tests, Antimicrobial testing, Introduction to animal inoculation, Skin tests and Serological tests (Precipitation, Immuno-electrophoresis, Flocculation-VDRL, Agglutination- Widal, Immunofluorescence, Haemagglutination, Neutralization and ELISA)

Group B: Antibiotics and Chemotherapeutics

Chemical non-medicinal antimicrobials: Sanitizers; Disinfectants; Antiseptics

Bactericidal and bacteriostatic agents; Factors affecting static and cidal activity; Phenols and phenolic compounds; Alcohols; Halogens; Heavy metals; Dyes; Detergents; Aldehydes

Synthetic medicinal agents (drugs): Sulphonamides; Antitubercular compounds; Nitrofurans; Nalidixic acid; Metronidazoles

Antibiotics: Definition of antibiotics; Types (chemical) of antibiotics; Classification of antibiotics on the basis of mode of action; Non-medical uses of antibiotics

Antimicrobial spectrum and mode of action of common antibacterial antibiotics- Penicillins, Cephalosporins, Chloramphenicol, Streptomycin, Rifampicin, Tetracycline, Erythromycin, Polymyxins, Vancomycin, Nalidixic acid, Ethambutol and Novobiocin

Qualitative assay of drugs (Drug sensitivity testing); Quantitative assays; Choice drug determination; Dosage; Route of administration; Combined drug therapy; Policies of antibiotic usage

Antifungal antibiotics: Chemical nature, Mode of action and Action spectra of Amphotericin B, Nystatin, Griseofulvin, Flucytosine and Ketoconazole

Antiviral agents; Interferon and its action; Chemical antiviral agents

Mechanism and prevention of drug resistance in bacteria

Recommended Books:

1. Brock Biology of Microorganisms, 12e, by M. Madigan *et al.* (Benjamin Cummings).
2. Prescott's Microbiology, 7e, by J. Willey *et al.* (McGraw-Hill).
3. Microbial Physiology, 2e, by I.W. Dawes and I.W. Southerland (Blackwell).
4. Medical microbiology vol I, Microbial Infection. vol II, Practical Medical Microbiology by Mackie and McCarthey.
5. Introduction to Medical Microbiology, 2e, by Ananthanarayan.
6. Medical Microbiology and Infection, 5e , by Tom Elliott, Anna Casey, Peter A. Lambert, Jonathan Sandoe (Wiley-Blackwell).
7. Microbiology, (W.B. Saunders Company), by T. Stuart Walker
- 8 .Schaechter's Mechanisms of Microbial Disease,5e, by N Cary Engleberg,Victor J Dirita ,Terence S Dermody

Paper MICR-CT 303

Group A: Biostatistics

Concept of matrix; Matrix as an operator; Types of matrices; Matrix diagonalization; Determinant of a matrix; Rank of a matrix

Frequency and distribution of biological variations; Measures of central tendency - Mean, Median and Mode; Measures of dispersion- Range, Standard deviation and Standard error

Classification and identification of probability; Laws of probability; Theorems of total probability

Binomial distribution, Normal distribution, Poisson and Gaussian distribution; Fitting of observed distribution to a theoretical distribution

Statistical models: Methods and applications; Sampling; Non-paired data; Heterogenicity of variance

Test of hypothesis and tests of significance: z-test (large samples), t-test (small samples), confidence limits of mean, F-test and Analysis of variance (ANOVA) in one way and two way classification, Least significance difference (LSD), Chi- square (X^2) goodness of fit tests

Correlation and regression- definition, formulae and statement of properties; Performance of biostatistics on MS excel and SPSS software

Group B: Computer Applications and Bioinformatics

Basics concepts of computers: Architecture-Input, Output, CPU, ALU etc; MATLAB; Generations of hardware and software; A brief introduction on input-output devices-disks, printers, CD-ROMS and other storage media etc.; Operating systems- WINDOWS and UNIX; System and application software; Basics of internet-LAN, MAN and WAN; Concepts of websites

Electronic spread sheet: Creating, opening and saving files; Working with worksheets and work books; Entering data and selecting cells; Editing worksheets; Creating formulae; Working with charts; Summarizing data in lists and tables; Analyzing data with Pivot tables; Analyzing sample statistical data; Validating cells

Genomics and Proteomics data analysis: Entire genome expression analysis- Microarrays, Expressed sequence tags (EST), Single nucleotide polymorphism (SNP), and Serial analysis of gene expression (SAGE); Gen bank; Protein data bank, Pair wise sequence comparison; Sequencing genomes and proteomes; Sequence assembly; Multifunctional tools for sequence analysis; Multiple sequence alignments; Genomes and proteomes on the web; Sequence queries against biological databases - BLAST and FASTA; Annotating and analyzing genome and proteome sequences; Biochemical pathway databases; Swiss-prot; Phylogenetic alignment; Profiles and motifs

Homology modeling, Threading, Structure prediction, Structure-structure Comparison of macromolecules, Simulated docking, Ligand data base.

Recommended Books:

1. Probability and Statistics, by M.H. DeGroot and M. J. Schervish (Addison-Wesley)
2. Biostatistics DeMYSTiFied, by A. Lewis (McGraw-Hill)
3. Bioinformatics: Sequence, Structure and Databank, A Practical Approach, by D. Higgins and W. Taylor, eds (Oxford University Press)
4. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, 2e, by A.D. Baxevanis and B.F.F. Ouellette (Wiley-IEEE)
5. Introduction to Computer, by P. Norton (McGraw-Hill)

Practical

Paper- MICR-CP 304 (Virology and Immunology)

1. Isolation and enumeration of bacteriophages (using double agar layer technique)
2. Determination of one-step growth curve of bacteriophage
3. Haemagglutination test for presence of antigens (microorganisms)
4. Infectivity of plant viruses (using local lesion method)
5. Study of cytopathic effect of viruses
6. Serological tests of diagnostic importance including complement fixation, precipitin reaction, slide agglutination test, Widal test, Tuberculin test and ELISA
7. Counter electrophoresis
8. Blood examination for ABO groups and Rh factors
9. Haemagglutination inhibition test
10. To perform western blotting

11. To study morphological and staining characteristics of lymphocytes, neutrophils, monocytes, eosinophils and basophils

Paper MICR-CP 305 (Medical Microbiology)

1. Estimation of urine bacteria by calibrated loop-direct streak method and pour plate method
2. Urine culture and microbial analysis for antibiotic sensitivity
3. Isolation of enteric pathogens from stools by direct plating method
4. Study for antimicrobial spectrum of antimicrobials
5. Determination of cidal and static activity
6. Screening for antibiotic producing microbes
7. Production, separation and detection of antibiotics by bioautographic methods
8. Microbiological assay of antibiotics using tube dilution, well diffusion and agar dilution methods

Paper MICR-CP 306 (Biostatistics and Bioinformatics)

1. Frequency distribution: Measures of central tendency and dispersion; Sampling; Analysis of variance; Testing of hypothesis; Correlation and regression; Fitting an observed distribution to a theoretical distribution; Application of computers in biostatistics; Usages of statistical packages
2. Basics of computers: Basic commands – file creation, copying, moving and deleting in Linux and Windows; Creating spread sheets; Usage of spread sheet to biological applications; Using email; Using browsers; Search engines; Pubmed; Using biological databases; Swissprot; Protein data bank and genbank; Different types of sequence analysis queries in BLAST and FASTA; Multiple sequence alignments and Phylogenetic alignments; Protein structure prediction software; Genomes and proteomes available on the web and their use; Computer simulation of biomolecular structure; Statistical software available on the web and their use

Elective courses

MICR-ET 307

A: Quality control in food and pharmaceutical industry

Microbiological aspects of quality control of food products; Good Manufacturing Practices (GMP) and the relevance and Sanitary Standard Operating Procedures (SSOP); Importance of Total Quality

Management (TQM) in dairy industry; Application of HACCP programme in dairy industry; Safety concerns of bio-film formation on equipment surfaces and their control measures; Risk assessment approaches and role of productive microbiology in dairy foods; Conventional and

current methods like impedance, ATP luminescence, pyruvate, etc. in detection of food pathogens; Application of immunological, PCR, Real time PCR, DNA probes, Microarrays (Biochips) and Biosensors, etc. for detection of food pathogens; Biosafety of Genetically Modified Organisms (GMOs) / foods. **Recommended Books:**

1. Biology of Industrial Microorganisms, by A.L. Demain and N.A. Solomon, eds (Benjamin/Cummings)
2. Food Microbiology: Fundamentals and Frontiers, 3e, by M.P. Doyle and L.R. Beuchat (ASM Press)
3. Food Microbiology, 3e, by M.R. Adams and M.O. Moss (Royal Society of Chemistry)
4. Principles of Pharmacogenetics and Pharmacogenomics, 1e by Russ B. Altman, David Flockhart, David B. Goldstein
5. Concepts in Pharmacogenomics 1e by Martin M. Zdanowicz
6. Pharmacogenomics, 2e by Werner Kalow, Urs B. Meyer, Rachel F. Tyndal

B. Soil Microbiology

Soil microorganisms: major groups, decomposition of organic matter, soil health. Root exudates and rhizospheric effects. Manipulation of rhizosphere microflora in plant productivity.

Microbial biomass. Nitrogen cycle: ammonification, nitrification and denitrification. Biological nitrogen fixation—symbiotic and asymbiotic.

Biochemistry and genetics of nitrogen fixation. Microbial transformations of phosphorus, sulphur and minor nutrients. Role of bio-fertilizers in agriculture and forestry.

Bioremediation of problem soils, plant growth promoting rhizobacteria and their mode of action.

Formation and composition of soil organic matter: fulvic acid and humic acid.

Recommended Books:

1. Microbial Ecology: Fundamentals and Applications, 6e, by R.M. Atlas and R. Bartha (Benjamin Cummings)
2. Soil Microbiology and Sustainable Crop Production, 3e, G.R. Dixon, Emma L. Tilston
3. Soil Microbiology, Ecology and Biochemistry, by Eldor Paul (Academic Press)

C. Management of Microbial Diseases in human

Diagnosis of Infectious Disease – General Principles: collection of specimens, microscopic methods (simple stains, Gram stain & other differential stains, fluorescent stains), biochemical methods, etc. Molecular & Serologic Diagnostic Methods: cases illustrating the technology of DNA probes, DNA fingerprinting methods, PCR-based methods, precipitation

& immunodiffusion, enzyme-linked immunofluorescence assays (ELISA), radioimmunoassay (RIA), etc. Small Laboratory Diagnosis of Bacterial Diseases I – Culture & Handling: cases

illustrating collection & handling of specimens, types of pathogens to be expected for various body fluids & tissues, etc. Epidemiology: cases illustrating infections related to epidemiologic surveillance. Bacterial Genetics & Antibiotic Resistance: cases illustrating the role of gene transfer in rapid spread of antibiotic resistance & development of multiple resistance, causes of antibiotic resistance, implications for future practice of medicine. Aseptic Practice & Nosocomial Infections: cases illustrating the etiology & epidemiology of nosocomial infections, medical & economic significance, techniques for prevention of nosocomial infections.

Recommended Books:

1. Medical microbiology vol I, Microbial Infection. vol II, Practical Medical Microbiology by Mackie and McCarthey.
2. Introduction to Medical Microbiology, 2e, by Ananthanarayan.
3. Medical Microbiology and Infection, 5e , by Tom Elliott, Anna Casey, Peter A. Lambert, Jonathan Sandoe (Wiley-Blackwell).
4. Microbiology, (W.B. Saunders Company), by T. Stuart Walker
5. Schaechter's Mechanisms of Microbial Disease,5e, by N Cary Engleberg,Victor J Dirita ,Terence S Dermody

D. Biofertilizer and Biocontrol Agents

Biofertilizers – Introduction, biofertilizers using nitrogen fixing microbes – phosphate solubilization- Rhizobium, Azatobacter, Azospirillum, Azolla; Anabaena Symbiosis, blue green algae and Ecto- and Endomycorizae. Cultivation, mass production and inoculation of *Rhizobium*, *Azotobacter*, *Azospirillum*, *Azolla* and cyanobacteria, Carrier-based inoculants, methods of application, quality control, agronomic importance. Application methods for different biofertilizers.

Biopesticides– *Bacillus thuringiensis*, *B. sphaericus*, *B. popilliae*, *Psuedomonas syringae*. Biocontrol- Microbial control of plant pathogens- Trichoderma. Useful genes from microorganisms for agriculture (herbicide resistant, Bt, viral). Biological Control – Use of Baculovirus, NPV virus, protozoa & fungi in biological control.

Recommended Books:

1. Plant Pathology, 5e, by George N. Agrios (Elsevier Science)
2. Agricultural Microbiology, by D. J. Bagyaraj and G. Rangaswami
3. Microbial Interactions in Agriculture and Forestry by N.S.Subbarao and Y.R. Dommergues (Science publishers).
4. Biochemistry and Molecular Biology of Plants, 2e, by Buchanan et al (ASPP, Maryland)

Paper MICR-CP 308 (Class Tests/Assignments/ Seminar)

Average of continuing class test and Assignments scores on all the theoretical and practical subjects taught in semester III

A seminar topic will be allotted to individual student according to his/her area of interest (students are also suggested to propose topics with relevant published information during the time of allotment), on which a report should be prepared and submitted after presentation as per schedule.

SEMESTER IV Core

Courses

Theory

Paper MICR-CT 401

Group A: Genomics

Genome sequencing projects, Next generation sequencing and its applications
Molecular markers: VNTR, SNTR, RFLP, AFLP, EST, SNP, International HapMap Project
DNA Microarray and its applications
Comparative genomics of bacteria, Horizontal gene transfer and microbial evolution
Mammalian Epigenomics

Personal Genomics; Social, Legal and Ethical Implications of Human Genome
Research Populations, Gene pool, Gene frequency; Hardy-Weinberg Law; concepts and rate of change in gene frequency through natural selection, migration and random genetic drift; Adaptive radiation; Isolating mechanisms; Speciation; Allopatricity and Sympatricity; Convergent evolution; Sexual selection; Co-evolution.

Group B: Proteomics

Protein concentration; protein sequencing; 2D electrophoresis of protein; isoelectro focusing; LC/MS-MS, MALDI-TOF for identification of proteins; protein-protein interaction - Yeast two hybrid system, Phage surface display; Applications of proteomics in research

Protein microarray and its applications

Gel based proteomics, LC-based proteomics, Peptide mass finger printing, Tandem mass spectrometry, Collision induced dissociation, Electron transfer dissociation, Data dependent MS/MS, Protein Identification and data evaluation, Identification of posttranslational modifications: Phosphorylation, Glycosylation, Acetylation.

Recommended Books:

1. Principles of Gene Manipulation, by S.B. Primrose, R.M.Twyman and R.W. Old
2. Genetics: From Genes to Genomes, 5e, by Leland Hartwell, Leroy Hood, Michael Goldberg, Ann E. Reynolds, Lee Silver
3. Molecular Biotechnology: Principles and Applications of Recombinant DNA, 4e, by Bernard J. Glick, Jack J. Pasternak, Cheryl L. Patten (American Society for Microbiology)
4. Proteomics by Timothy Palzkill (Springer)

MICR-CP 402 Dissertation/Review work

Each student will be required to undertake dissertation/review work assigned to him related to R&D in any area of microbiology under the supervision of a faculty member. In principle, the research work is to be carried out by the student himself/herself taking advice from his/her supervisor when problem arises. The work will be allotted at the beginning of the fourth semester specifying the different aspects to be carried out by the student. At the end of the semester the student will submit a report on his work in typed and bound form.

Evaluation shall include oral presentation and a viva-voce. Defense of the viva on the project should be done in presence of an external examiner along with the faculties **Elective courses**

MICR-ET 403 A: Bioethics & IPR

The importance and needs of bioethics; Bioethical business practices; Laws and bioethics; Environmental protection; Creating awareness and safeguarding health of consumers; Fair trade practices; Combating plagiarism

Concept of property, rights/protection, duties, and their correlation; History and evaluation of intellectual property rights (IPR); Distinction among various forms of IPR

Introduction to Intellectual Property and the Indian Legal System; Indian Trademark fundamentals, management, practice and procedures; Contemporary and comparative perspective in different jurisdictions; Copyright fundamentals, practice, and perspective Introduction to patents; Key concepts; International Law of Patents; Indian Patent Act and practice; Patentability; Types of patents; WIPO treaties

International registration systems; Patent application; Documentation and search; Revocation of patent; Infringement or violation; Remedies against infringement; Drafting; Litigation; Commercialization and licensing

Designs law and practice; Trade secrets and confidential information; Plant varieties protection law; Biodiversity law and traditional knowledge; Legal implications and public concerns in genetic modification of foods; Computer and software IP, Semiconductor and chip law

Recommended Books:

1. IPR Biosafety and Bioethics, 1e, by Deepa Goel (Pearson Education)

B. Inheritance Biology

Prokaryotic inheritance: Methods of genetic transfers – transformation, conjugation, transduction and sex-duction, mapping genes by interrupted mating, fine structure analysis of genes.

Eukaryotic Inheritance: Mendelian principles segregation, independent assortment. complementation tests

Extensions of Mendelian principles : Codominance, incomplete dominance, gene interactions, pleiotropy, genomic imprinting, penetrance and expressivity, phenocopy, linkage and crossing over, sex linkage, sex limited and sex influenced characters.

Gene mapping methods : Linkage maps, tetrad analysis,

Extra chromosomal inheritance : Inheritance of Mitochondrial and chloroplast genes, maternal inheritance.

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

Quantitative genetics : Polygenic inheritance, heritability and its measurements, QTL mapping.

Structural and numerical alterations of chromosomes : Deletion, duplication, inversion, translocation, ploidy and their genetic implications.

Recommended Books:

1. Molecular Biology of the Gene, 7e, by J.D. Watson *et al.* (Benjamin Cummings)
2. Principles of Genetics, 8e, by Gardner, Simmons, Snustad
3. Genetics as a Tool in Microbiology, vol. 31, by S.W. Gloover and D.A. Hopwood (Cambridge University Press)
4. Genetics , 3e bt M.W. strickberger

C. Biodegradation & Bioremediation

Bioremediation: Advantages of Bioremediation, types of bioremediation.

Monitoring the efficacy of Bioremediation. Bioaugmentation, biomagnifications and Biotransformation Bioventing

Bioremediation for controlling oil spills.

Biosorption: Use of bacteria and fungi, Bioreaction for biosorption. Problems associated with disposal of xenobiotic compounds, Hazardous wastes. Biodegradation of xenobiotics: Persistent compounds, Degradation mechanisms, naphthalene, benzene, phenol, PCB's, propanil (Herbicide), urea. Biodegradation of petrochemical effluents. Global environment problems: The Green house effect, Ozone depletion, UV radiation, Acid rain.

Recommended Books:

1. Biology of Industrial Microorganisms, 3e, by A.L. Demain and N.A. Solomon, eds (Benjamin/ Cummings)
2. Waste Water Treatment for Pollution Control, 2e, by S.J. Arceivala (McGraw-Hill)
3. Biodegradation and Bioremediation, 2e, by M. Alexander (Academic Press)
4. Manual of Environmental Microbiology, 3e, C.J. Hurst et al., eds (ASM Press)
5. Microbial Mineral Recovery (Environmental Biotechnology), by H.L. Ehrlich and C.L. Brierley (McGraw-Hill)
6. Soil Microbiology and Sustainable Crop Production, 3e, G.R. Dixon, Emma L. Tilston, eds

D. Evolutionary Biology

Lamarck; Darwin–concepts of variation, adaptation, struggle, fitness and natural selection;

Origin of cells and unicellular evolution, Origin of basic biological molecules; Abiotic synthesis of organic monomers and polymers; Concept of Oparin and Haldane; Experiment of Miller (1953); The first cell; Evolution of prokaryotes; Origin of eukaryotic cells; Evolution of unicellular eukaryotes

Paleontology and Evolutionary History, The evolutionary time scale; Eras, periods and epoch; Major events in the evolutionary time scale; Origins of unicellular and multi cellular organisms; Major groups of plants and animals

Molecular Evolution, Concepts of neutral evolution, molecular divergence and molecular clocks; Molecular tools in phylogeny, classification and identification; Protein and nucleotide sequence analysis; origin of new genes and proteins; Gene duplication and divergence.

Recommended Books:

1. Evolutionary Biology Concepts, Biodiversity, Macroevolution and Genome Evolution by P. Pontarotti.
2. Evolutionary Biology by M.K. Hecht, W.C. Steere, and B.Wallace.
3. Evolutionary Biology by E.C.Minkoff.

MICR-CP 404 (Industrial visit/ Field Study/Summer Training)

In-plant training in a microbiology-based industry or an advanced centre of learning or a field visit is to be undertaken by each student. A report on the training is required to be submitted. On the basis of written report and industry manager/lab-in-charge's report, a viva-voce will be conducted for evaluation of the student.

MICR-CP 405 Seminar/Journal Club/Assignments/Class Test)

A seminar topic will be allotted to individual student according to his/her area of interest (students are also suggested to propose topics with relevant published information during the time of allotment), on which a report should be prepared and submitted after presentation as per schedule.

Average of continuing class test and assignments scores on all the theoretical and practical subjects taught in semester I is also may taken into consideration