M.SC. MICROBIOLOGY			
S.NO	PAPER CODE	NAME OF PAPERS	CREDIT
1 ST SEMESTER			
1	101	MICROBIAL PHYSIOLOGY AND BIOCHEMISTRY	4
2	102	MOLECULAR BIOLOGY AND GENETICS	4
3	103	INSTRUMENTATION AND BIOPHYSICS	4
4	104	INTRODUCTORY MATHEMATICS AND BIOSTATISTICS	4
5	105	PRACTICAL –I	3
2ND SEMESTER			
1	201	RECOMBINANT DNA TECHNOLOGY & IPR	4
2	202	IMMUNOLOGY	4
3	203	MICROBIAL BIOINFORMATICS	4
4	204	AGRICULTURAL MICROBIOLOGY	4
5	205	PRACTICAL –II	3
3RD SEMESTER			
1	301	FOOD MICROBIOLOGY	4
2	302	FERMENTATION TECHNOLOGY	4
3	303	PHARMACEUTICAL MICROBIOLOGY	4
4	304	PRACTICAL –III	4
5	305	PROJECT PROPOSAL PRESENTATION	2
4TH SEMESTER			
1	401	MEDICAL MICROBIOLOGY	4
2	402	INDUSTRIAL MICROBIOLOGY	4
3	403	ENZYMOLOGY	4
4	404	ENVIRONMENTAL MICROBIOLOGY	4
5	405	VIVA / PROJECT	3

101 MICROBIAL PHYSIOLOGY AND BIOCHEMISTRY

Unit I

Cell Structure (Special emphasis on Cell Wall & Membrane) and Microbial DiversityStructural differences between different microbial cell types and cellular organelles;Biochemical/Microscopic/Molecular methods used to differentiate between archae, eubacteria and eukaryotes;Cell wall of prokaryotes; Outer membrane of Gram -ve bacteria and control of its synthesis; Potential targets for drug design.

Unit II

Biomolecules and Principles of Microbial Nutrition Importance of non-covalent interactions in biological systems; Noninformational and Informational Macromolecules and their organization; Microbial nutrition; Different types of culture medium; C/N/P balance and making of culture medium.

Unit III

Bioenergetics and Catabolic Pathways Oxidation-reduction reactions; Electron carriers and cellular metabolism; High energy compounds and their role in microbial fermentations Enzymes as catalysts; Cellular metabolites and interconnectivity in biochemical pathways; Respiration and Electron Transport.

Unit IV

Metabolic diversity Energy from oxidation of inorganic electron donors; Iron oxidation; Methanotrophy and methylotrophy; Nitrate and Sulfate reduction; Acetogenesis; Methanogenesis; Fermentation-energetics and redox constraints; Anaerobic respiration; Chlorophylls and other pigments involved in microbial photosynthesis; Anoxygenic and oxygenic photosynthesis; Autotrophic CO2 Fixation: Calvin cycle, Reverse Citric Acid cycle, Hydroxy-propionate cycle.

Unit V

Microbial Genetics and Genomics; Mutations and their chemical basis; Mutagens and their use in Biotechnology; Modes of recombination; Comparative prokaryotic genomics

Texts/References:

1. M.T. Madigan and J.M. Martinko, Brock Biology of Microorganisms, 11th edition, Pearson Prentice-Hall, 2006.

2. L. Stryer, Biochemistry, 4th Edition, Freeman, 2002.

3. G. Gottschalk, Bacterial Metabolism, 2nd Edition, Springer-Verla

4. Jeremy M. Berg, John L. Tymoczko & Lubert Stryer: Biochemistry

102 MOLECULAR BIOLOGY AND GENETICS

Unit I

DNA Structure; Replication; Repair & Recombination - Structure of DNA - A-,B-, Z- and triplex DNA; Measurement of properties-Spectrophotometric, CD, AFM and Electron microscope analysis of DNA structure; Replication initiation, elongation and termination in prokaryotes and eukaryotes; Enzymes and accessory proteins;

Fidelity; Replication of single stranded circular DNA; Gene stability and DNA repair- enzymes; Photo-reactivation;

Nucleotide excision repair; Mismatch correction; SOS repair; Recombination: Homologous and non-homologous;

Site specific recombination; Chi sequences in prokaryotes; Gene targeting; Gene disruption; FLP/FRT and Cre/Lox recombination.

Prokaryotic & Eukaryotic Transcription - Prokaryotic Transcription; Transcription unit; Promoters - Constitutive and Inducible; Operators; Regulatory elements; Initiation; Attenuation; Termination-Rho-dependent

and independent; Anti-termination; Transcriptional regulation – Positive and negative; Operon concept-lac, trp, ara,his, and gal operons; Transcriptional control in lambda phage; Transcript processing; Processing of tRNA and rRNA, Eucaryotic transcription and regulation; RNA polymerase structure

and assembly; RNA polymerase I, II, III; Eukaryotic promoters and enhancers; General Transcription factors; TATA binding proteins (TBP) and TBP associated factors (TAF); Activators and repressors; Transcriptional andpost-transcriptional gene silencing

Unit II

Post Transcriptional Modifications - Processing of hnRNA, tRNA, rRNA; 5'-Cap formation; 3'-end processing

and polyadenylation; Splicing; RNA editing; Nuclear export of mRNA; mRNA stability; Catalytic RNA.

Translation & Transport - Translation machinery; Ribosomes; Composition and assembly; Universal genetic code; Degeneracy of codons; Termination codons; Isoaccepting tRNA; Wobble hypothesis; Mechanism of initiation,

elongation and termination; Co- and post-translational modifications; Genetic code in mitochondria; Transport of

proteins and molecular chaperones; Protein stability; Protein turnover and

Degradation.

Unit III

Mutations; Oncogenes and Tumor suppressor genes - Nonsense, missense and point mutations; Intragenic and

Intergenic suppression; Frameshift mutations; Physical, chemical elements in prokaryotes and eukaryotes; Mechanisms of transposition; Role of transposons in mutation; Viral and cellular oncogenes; Tumor suppressor

genes from humans; Structure, function and mechanism of action of pRB and p53 tumor suppressor proteins;

Activation of oncogenes and dominant negative effect; Suppression of tumor suppressor genes; Oncogenes as transcriptional activators and biological mutagens; Transposition - Transposable genetic

GENETICS

Unit IV

Genome organization - Organization of bacterial genome; Structure of eukaryotic chromosomes; Role of nuclear
matrix in chromosome organization and function; Matrix binding proteins; Heterochromatin and Euchromatin; DNA
re-association kinetics(Cot curve analysis); Repetitive and unique sequences; Satellite DNA; DNA melting and buoyant density; Nucleosome phasing; DNase I hypersensitive regions; DNA methylation & Imprinting. DNA Structure and properties; Restriction Enzymes; DNA ligase,
Klenow enzyme, T4 DNA polymerase, Polynucleotide kinase, Alkaline phosphatase; Cohesive and blunt end ligation; Linkers; Adaptors; Homopolymeric tailing; Labeling of DNA: Nick translation, Random priming, Radioactive and non-radioactive probes, Hybridization techniques: Northern, Southern and Colony hybridization,
Fluorescence in situ hybridization; Chromatin Immunoprecipitation; DNA-Protein Interactions- Electromobility shift
assay; DNaseI footprinting; Methyl interference assay

Bacterial mutants and mutations - Isolation; Useful phenotypes (auxotrophic, conditional, lethal, resistant); Mutation rate; Types of mutations(base pair changes; frameshift; insertions; deletions; tandem duplication); Reversionvs. suppression; Mutagenic agents; Mechanisms of mutagenesis; Assay of mutagenic agents (Ames test)

Unit V

Gene transfer in bacteria - History; Transduction – generalized and specialized; Conjugation – F, F', Hfr; F transfer; Hfr-mediated chromosome transfer; Transformation – natural and artificial transformation; Merodiploid
generation; Gene mapping; Transposable genetic elements; Insertion sequences; Composite and Complex transposons; Replicative and non-replicative transposition; Genetic analysis using transposons. Phenotype; Genotype; Gene frequency; Hardy Weinberg law; Factors distinguishing Hardy Weinberg equilibrium; Mutation
selection; Migration; Gene flow; Genetic drift; Human genetic diversity; Origin of major human groups.

Bacteriophages and Plasmids - Bacteriophage–structure; Assay; Lambda phage – genetic map, lysogenic and lytic
cycles; Gene regulation; Filamentous phages such as M13; Plasmids – natural plasmids; their properties and phenotypes; Plasmid biology - copy number and its control; Incompatibility; Plasmid survival strategies; Antibiotic
resistance markers on plasmids (mechanism of action and resistance); Genetic analysis using phage and plasmid.

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Text/References:

1. Benjamin Lewin, Gene IX, 9th Edition, Jones and Barlett Publishers, 2007.

2. J.D. Watson, N.H. Hopkins, J.W Roberts, J. A. Seitz & A.M. Weiner; Molecular Biology of the Gene, 6th Edition, Benjamin Cummings Publishing Company Inc, 2007.

3. Alberts et al; Molecular Biology of the Cell, 4th edition, Garland, 2002

103 INSTRUMENTATION AND BIOPHYSICS

Unit I

Basic Techniques - Buffers; Methods of cell disintegration; Enzyme assays andcontrols; Detergents and membrane
proteins; Dialysis, Ultrafiltration and other membrane techniques

Spectroscopy Techniques - UV, Visible and Raman Spectroscopy; Theory and application of Circular Dichroism;
Fluorescence; MS, NMR, PMR, ESR and Plasma Emission spectroscopy **Infrared Spectroscopy –** Principles of IR

spectroscopy, vibrational spectra of biopolymers, Fourier transform of Infra Red spectroscopy, Instrumentation,
factors influencing vibrational frequency (Vibronic coupling, H-bond, electronic factors, bond angles, etc)**NMR**
Spectroscopy – Proton magnetic resonance spectra of proteins, 13C NMR spectra of proteins, 31P NMR studies,
NMR spectra of nucleic acids, Fourier transform of NMR spectroscopy, Relaxation (ID spectra) **X-Ray Crystallography –** Instrumentation, Fourier transformation, Application

Unit II

Chromatography Techniques - TLC and Paper chromatography; Chromatographic methods for macromolecule
separation - Gel permeation, Ion exchange, Hydrophobic, Reverse-phase and Affinity chromatography; HPLC and
FPLC; Criteria of protein purity
Electrophoretic techniques - Theory and application of Polyacrylamide and Agarose gel electrophoresis; Capillary
electrophoresis; 2D Electrophoresis; Disc gel electrophoresis; Gradient electrophoresis; Pulsed field gel electrophoresis

Unit III

Centrifugation - Basic principles; Mathematics & theory (RCF, Sedimentation coefficient etc); Types of centrifuge
- Microcentrifuge, High speed & Ultracentrifuges; Preparative centrifugation; Differential & density gradient centrifugation; Applications (Isolation of cell components); Analytical centrifugation; Determination of molecular
weight by sedimentation velocity & sedimentation equilibrium methods.

Unit IV

Radioactivity - Radioactive & stable isotopes; Pattern and rate of radioactive decay; Units of radioactivity; Measurement of radioactivity; Geiger-Muller counter; Solid & Liquid scintillation counters (Basic principle, instrumentation & technique); Brief idea of radiation dosimetry; Cerenkov radiation; Autoradiography; Measurement of stable isotopes; Falling drop method; Applications of isotopes in biochemistry; Radiotracer techniques; Distribution studies; Isotope dilution technique; Metabolic studies; Clinical application; Radioimmunoassay.

Unit V

Advanced Techniques - Protein crystallization; Theory and methods; API-electrospray and MADI-TOF; Mass spectrometry; Enzyme and cell immobilization techniques; DNA & Peptide Synthesis **Molecular Modeling & Molecular Dynamics –** Modeling of Macromolecules, different types of interaction energy, molecular potential,
bonding potential, non-bonding potential, potential due to angle, torsional strain, electrostatic interaction, molecular
structure of protein, lipid, nucleic acid, carbohydrate, energy minimization (SD, ABNR), molecular dynamics simulation for simple molecules (GROMACS software)
Method of determination of size & shape of macromolecules – Molecular electron microscopy, measuring electron diffraction of a solid with Electron Microscope, determination of molecular structure in Electron Microscope, minimizing drying & shrinking artifacts, using symmetry to enhance the Electron Microscope image,
High Resolution Autoradiography, X-Ray diffraction

Text/References :

1. **Cantor & Schimmel : Biophysical Chemistry (Part I, II & III)**
2. **A. Lehninger : Principles of Biochemistry**
3. **Freifelder D., Physical Biochemistry, Application to Biochemistry and Molecular Biology, 2nd Edition, W.H. Freeman & Company, San Fransisco, 1982.**
4. **Keith Wilson and John Walker, Principles and Techniques of Practical Biochemistry, 5th Edition, Cambridge University Press, 2000.**

104 INTRODUCTORY MATHEMATICS AND BIOSTATISTICS

Unit I

Calculus review Calculus (Quick review of concepts): Review of limits, continuity, differentiability; Mean value theorem, Taylor's Theorem, Maxima and Minima;

Fundamental theorem of Calculus; Improper integrals; Applications to area, volume; Convergence of sequences and series; Power series; Partial Derivatives; Gradient and Directional derivatives; Chain rule; Maxima and Minima.

Unit II

Ordinary Differential Equations First order differential equations: Exact equations, Integrating factors and Bernoulli equations.

Second and higher order differential equations Linear ODE's with constant coefficients: the characteristic equations; Cauchy-Euler equations; Linear dependence and Wronskians; Method of undetermined coefficients; Method of variation of parameters; Laplace transforms: Inverse theorem, shifting theorems, partial fraction

Unit III

Linear Algebra Basics: Vectors, matrices, determinants; Matrix addition and multiplication; Systems of equations: Gauss elimination, Matrix rank, Linear independence, Cramer's rule; Inverse of a matrix: Gauss-Jordan elimination;Eigenvalues and Eigenvectors:characteristic polynomials, eigenvalues of special matrices(orthogonal, unitary, hermitian, symmetric, skew-symmetric, normal). Numerical methods Solution of equations by iteration; Interpolation by polynomials; Piecewise linear and cubic splines; Numeric integration and differentiation; Linear systems: Gauss elimination, Gauss-Siedel, matrix inversion; LU factorization; Matrix eigenvalues; Numerical solution of ODEs: Euler and Runge-Kutta methods, Predictor

Biostatistics

Unit IV

Probability and Statistics - Definition of Probability, Relative frequency, Probability distribution (Binomial, Poisson & normal), simple examples.

Statistics - Measure of central tendency – Mean (for grouped & ungrouped data);

Measure of dispersion- Standard Deviation (for grouped & Ungrouped data);

Sampling theory –Statistical population, Sample from population, Random sample;

Statistical Hypothesis - Test of significance, Test for proportion, means & standard deviations, Chi-square test of goodness of fit, t-test, F-test.

Correlation & Regression (linear) - Associated test of significance, simple problems.

Unit V

Fundamental concepts in applied probability - Exploratory data analysis and statistical inference; Probability and analysis of one and two way samples; discrete and continuous probability models; Expectation and variance; Central limit theorem; Inference; Hypothesis; Critical region and error probabilities; Tests for proportion; Equality of proportions; equality of means of normal populations (variance known, variance unknown); P-value of the statistic; Confidence limits; Introduction to one way and two-way analysis of variance; Data transformation Corrector methods; Exposure to software packages like Matlab or Scilab.

Texts/References

1. G. B. Thomas and R. L. Finney, Calculus and Analytic Geometry, 9th Edition, ISE Reprint, Addison-Wesley, 1998.
2. E. Kreyszig, Advanced engineering mathematics,8th Edition, JohnWiley, 1999.
3. W. E. Boyce and R. DiPrima, Elementary Differential Equations, 8th Edition, JohnWiley, 2005.

105 BIOCHEMISTRY & ANALYTICAL TECHNIQUES (P)

1. Determination of pH of unknown solution to prepare an Acetic-NaAcetate Buffer system and validate the Henderson-Hasselbach equation.
2. To determine an unknown protein concentration by plotting a standard graph of BSA using UV-Vis Spectrophotometer and validating the Beer- Lambert's Law.
3. Titration of Amino Acids and separation of aliphatic, aromatic and polar amino acids by TLC.

4. An Enzyme Purification theme (such as E.coli Alkaline phosphatase or any enzyme of the institutions choice).
(a)Preparation of cell-free lysates & Ammonium Sulfate precipitation
(b) Enzyme Kinetic Parameters: Km, Vmax and Kcat.
(c)Column Chromatography/ Ion-exchange Chromatagraphy/ Gel Filtration/ Affinity Chromatography/ Generating a
Purification Table
(d) Assessing purity by SDS-PAGE Gel Electrophoresis.
5. Determination of Molecular weight of Protein by Column chromatography
6.Determination of Surface Tension by Stalagmometer.
7..Determination of Viscosity by Oswald's Viscometer.

References :

1. **Cantor & Schimmel : Biophysical Chemistry (Part I, II & III)**
2. **Jeremy M. Berg, John L. Tymoczko & Lubert Stryer : Biochemistry**
3. **David E Metzler : Biochemistry – The Chemical Reactions of Living Cells**

106 MOLECULARBIOLOGY (P)

1. Isolation of genomic DNA
2.Isolation of plasmid DNA
3.Primer designing & PCR amplification
4.RFLP analysis of the PCR product.
5. Restriction digestion of vector (gel analysis)
6. DNA Ligation
7. a. Vector and Insert ligation
b. Transformation
8. Transformation of recombinant plasmid preperation.
9. Analysis on SDS-PAGE
10. Southern hybridization with probe and non-radioactive detection.
11. Phage titration

References :

1.Sambrook & Russell : Molecular Cloning; 3rd Ed; 2001

107 MICROBIOLOGY (P)

1. Sterilization, disinfection, safety in microbiological laboratory.
2. Preparation of media for growth of various microorganisms.
3. Identification and culturing of various microorganisms.
4. Staining and enumeration of microorganisms.
5. Growth curve, measure of bacterial population by turbidometry and studying the effect of temperature, pH, carbon and nitrogen
6. Assay of antibiotics production and demonstration of antibiotic resistance.
7. Isolation and screening of industrially important microorganisms.
8. Determination of thermal death point and thermal death time of microorganisms.

201RECOMBINANT DNA TECHNOLOGY & IPR

Unit I

Cloning Vectors - Plasmids; Bacteriophages; M13 mp vectors; PUC19 and Bluescript vectors, Phagemids; Lambda
vectors; Insertion and Replacement vectors; EMBL; Cosmids; Artificial chromosome vectors (YACs; BACs); Animal Virus derived vectors-SV-40; vaccinia/bacculo & retroviral vectors; Expression vectors; pMal; GST; pET-based vectors; Protein purification; His-tag; GST-tag; MBP-tag etc.; Intein-based vectors; Inclusion bodies;
Methodologies to reduce formation of inclusion bodies; Baculovirus and pichia vectors system, Plant based vectors,
Ti and Ri as vectors, Yeast vectors, Shuttle vectors.

Unit II

Cloning Methodologies - Insertion of Foreign DNA into Host Cells; Transformation; Construction of libraries; Isolation of mRNA and total RNA; cDNA and genomic libraries; cDNA and genomic cloning; Expression cloning;
Jumping and hopping libraries; Southwestern and Farwestern cloning; Protein-protein interactive cloning and Yeast
two hybrid system; Phage display; Principles in maximizing gene expression.

Unit III

PCR and Its Applications - Primer design; Fidelity of thermostable enzymes; DNA polymerases; Types of PCR –
multiplex, nested, reverse transcriptase, real time PCR, touchdown PCR, hot start PCR, colony PCR, cloning of PCR products; T-vectors; Proof reading enzymes; PCR in gene recombination; Deletion; addition; Overlap extension; and SOEing; Site specific mutagenesis; PCR in molecular diagnostics; Viral and bacterial detection; PCR
based mutagenesis, Mutation detection: SSCP, DGGE, RFLP, Oligo Ligation Assay (OLA), MCC (Mismatch Chemical Cleavage, ASA (Allele-Specific Amplification), PTT (Protein Truncation Test)

Unit IV

Sequencing methods - Enzymatic DNA sequencing; Chemical sequencing of DNA; Automated DNA sequencing;
RNA sequencing; Chemical Synthesis of oligonucleotides; Introduction of DNA into mammalian cells; Transfection
techniques; Gene silencing techniques; Introduction to siRNA; siRNA technology; Micro RNA; Construction of siRNA vectors; Principle and application of gene silencing; Gene knockouts and Gene Therapy; Creation of knock
out mice; Disease model; Somatic and germ-line therapy- in vivo and ex-vivo; Suicide gene therapy; Gene replacement; Gene targeting; Transgenics; cDNA and intragenic arrays; Differential gene expression and protein
array.

Unit V

IPR

PATENTS Macro economic impact of the patent system Patent and kind of inventions protected by a patent Patent
document and protection inventions. Granting of patent Rights of a patent Searching a patent Drafting of a patent
Filing of a patent The different layers of the international patent system (national,regional and international options)
COPYRIGHT General Additional Reading: Latest editions of Designs Act, Copyright RELATED RIGHTS .Distinction between related rights and copyright. Rights covered by copyright
TRADEMARKS What is a trademark. Rights of trademark. signs can be used as trademarks types of trademark function does a trademark perform registered trademark protected for .
INDUSTRIAL DESIGNS Industrial design. Protection provided by industrial designs. Need protect industrial designs

202 IMMUNOLOGY

Unit 1

Immunology- fundamental concepts and anatomy of the immune system Components of innate and acquired immunity; Phagocytosis; Complement and Inflammatory responses; Haematopoesis; Organs and cells of the immune system- primary and secondary lymphoid organs; Lymphatic system; Lymphocyte circulation;Lymphocyte
homing; Mucosal and Cutaneous associated Lymphoid tissue.(MALT&CALT); Mucosal Immunity; Antigens - immunogens, haptens; Major Histocompatibility Complex - MHC genes, MHC and immune responsiveness and disease susceptibility, HLA typing.

Unit II

Immune responses generated by B and T lymphocytes Immunoglobulins-basic structure, classes and subclasses of
immunoglobulins, antigenic determinants; Multigene organization of immunoglobulin genes; B-cell receptor;

Immunoglobulin superfamily; Principles of cell signaling; Immunological basis of self -non-self discrimination;
Kinetics of immune response, memory; B cell maturation, activation and differentiation; Generation of antibody diversity; T-cell maturation, activation and differentiation and T-cell receptors; Functional T Cell Subsets; Cell-mediated immune responses, ADCC; Cytokines-properties, receptors and therapeutic uses; Antigen processing and presentation-endogenous antigens, exogenous antigens, non-peptide bacterial antigens and super-antigens;
Cell-cell co-operation, Hapten- carrier system

Unit III

New Generation Antibodies - Multigene organization of immunoglobulin genes, Ab diversity; Antibody engineering; Phage display libraries; Antibodies as in vitro and in vivo probes

CMI and Imaging techniques - CD nomenclature, Identification of immune Cells; Principle of Immunofluorescence Microscopy, Flurochromes; Staining techniques for live cell imaging and fixed cells; Flow cytometry, Instrumentation, Applications; Cell Functional Assays – lymphoproliferation, Cell Cytotoxicity, Mixed Lymphocyte Reaction, Apoptotosis, Cytokine expression; Cell cloning, Reporter Assays, In–situ gene expression techniques; Cell imaging Techniques- *In vitro* and *In vivo*; Immuno-electron microscopy; *In vivo* cell tracking techniques; Microarrays; Transgenic mice, gene knock outs.

Antibody Related Techniques - Immuno-chemistry of Antigens - immunogenecity, Antigenecity, haptens, Toxins-Toxoids, Hapten-carrier system; Genetic basis of immune response; Role and properties of adjuvants, Immune modulators; B cell epitopes; Hybridoma Rabbit, human; Antigen–Antibody interaction, affinity, cross reactivity, specificity, epitope mapping; Immuno assays: RIA, ELISA, Western blotting, ELISPOT assay, immunofluorescence, Surface plasma resonance, Biosensor assays for assessing ligand–receptor interaction

Unit IV

Vaccinology Active and passive immunization; Live, killed, attenuated, sub unit vaccines; Vaccine technology-Role and properties of adjuvants, recombinant DNA and protein based vaccines, plant-based vaccines, reverse vaccinology; Peptid vaccines, conjugate vaccines; Antibody genes and antibody engineeringchimeric and hybrid monoclonal antibodies; Catalytic antibodies and generation of immunoglobulin gene libraries.

Unit V

Clinical Immunology

Immunity to Infection: Bacteria, viral, fungal and parasitic infections (with examples from each group); Hypersensitivity - Type I-IV; Autoimmunity; Types of autoimmune diseases; Mechanism and role of CD4+ T cells;
MHC and TCR in autoimmunity; Treatment of autoimmune diseases; Transplantation-Immunological basis of graft rejection; Clinical transplantation and immunosuppressive therapy; Tumor immunology - Tumor antigens; Immune response to tumors and tumor evasion of the immune system, Cancer immunotherapy; Immunodeficiency-Primary immunodeficiencies, Acquired or secondary immunodeficiencies.

Texts/References:

1. Kuby, RA Goldsby, Thomas J. Kindt, Barbara, A. Osborne Immunology, 6th Edition, Freeman, 2002.
2. Brostoff J, Seaddin JK, Male D, Roitt IM., Clinical Immunology, 6th Edition, Gower Medical Publishing, 2002.
3. Janeway et al., Immunobiology,4th Edition, Current Biology publications., 1999.
4. Paul, Fundamental of Immunology, 4th edition, Lippencott Raven, 1999.

203 MICROBIAL BIOINFORMATICS

Unit I

Sequence-alignment related problems. Sequence databases;Similarity matrices; Pairwise alignment; BLAST;

Statistical significance of alignment; Sequence assembly; Multiple sequence alignment; Clustal; Phylogenetics: distance based approaches, maximum parsimony. Pattern analysis in sequences Motif representation: consensus,
regular expressions; PSSMs; Markov model. Regulatory sequence identification using Meme; Gene finding: composition based finding, sequence motif-based finding.

Unit II

Structure-related problems Representation of molecular structures(DNA, mRNA, protein), secondary structures,
domains and motifs; Structure classification (SCOP, CATH); Visualization software (Pymol, Rasmol etc.); Experimental determination of structures (X-ray crystallography, NMR); Structure databases; Secondary structure prediction; RNA structure prediction; Mfold; Proteinstructure prediction by comparative modelling approaches(homology modelling, threading); Ab initio structure prediction: force fields, backbone conformer generation by Monte Carlo approaches, side-chain packing; Energy minimization; Molecular dynamics; Rosetta;
Structure comparison (DALI, VAST etc.); CASP; Protein-ligand docking; Computer-aided drug design (pharmacophore identification); QSAR; Protein-Protein interactions System-wide analyses: Transcriptomics: Microarray technology, expression profiles, data analysis; SAGE; Proteomics: 2D gel electrophoresis; Mass Spectrometry; Protein arrays; Metabolomics: NMR based metabolic flux analysis.

Unit III

Structural Bioinformatics - Protein structures, Ramchandran plot, protein folding structure function relationship,
conformational energy calculations, protein structure predictions, secondary and tertiary, protein structure classification-SCOP, CATH, Immuno-informatics-epitope prediction

Unit IV

Introduction to following DATABASEs & Tools – GenBank, Entrez, Introduction to NCBI Protein and Nucleotide Database, OMIM, PubMed, Expasy server search tools and Databases, PIR, Swissprot, TrEmble, PROSITE, PDB, NDB, KEGG, Complex Carbohydrate Structure Database (CCSD), Molecular visualizing tool (Rasmol, Molmol), Gromacs.

Unit V

Bioinformatics: The Business of Research - Research methodology (focusing on computer-based research); Case
studies of areas of current bioinformatics research; Routes to research funding (academic and commercial); Bioinformatics business models

Texts/References:

1. David W. Mount. Bioinformatics: Sequence and Genome Analysis 2nd Edition, CSHL Press, 2004.
2. A. Baxevanis and F. B. F. Ouellette, Bioinformatics: a practical guide to the analysis of genes and proteins, 2nd Edition, John Wiley, 2001.
3. Jonathan Pevsner, Bioinformatics and Functional Genomics, 1st Edition, Wiley-Liss, 2003.
4. P. E. Bourne and H. Weissig. Structural Bioinformatics. Wiley. 2003

204 AGRICULTURAL MICROBIOLOGY

Unit I

Microbes in the Terrestrial Environment – General characteristics of porous media, Distribution of microbes in
different soil zones and their metabolic states, role of microbes in surface soil formation, nutrients cycling, Soil
pathogens and diseases in plant and human.

UNIT II

Microbial Metabolism - Conversion of light energy into chemical bond energy-Photosystems I & II. production

of ATP Cyano-bacteria and green algae. Role of bacterio-chlorophyll phycocyanin, phycoerythrin and carotenoids in
photosynthetic bacteria and cholorphylls in green algae. Photosynthesis in anaerobic and sulphur bacteria. Biological N2-fixation by Free living anaerobic (*Clostridium*), facultatively anaerobic (*Azospirillum*) and aerobic
(*Azotobacter*), N2-fixers associated with stem, root and leaf, Symbiotic N2-fixation in legumes and non-legumes by
Rhizobium and *Frankia*, N2-fixation by cyanobateria. Requirement of ATP, O2-sensitivity and inhibition by ammonia
and nitrogenous substance in the case of nitrogenase, The peculiarity of alternate nitrogenase of *Streptomyces t**hermoautotrophicus,*
Brief account of microbial interactions -Symbiosis**,** neutralism, Commensalism, Competition, Ammensalism,
Synergism, Parasitism.

Unit III

Biofertilizers- Biological Nitrogen fixation- symbiotic and asymbiotic, mass production by *Rhizobium*, *Azotobacter*
and Cyanobacteria, nitrifying ammonifying and photosynthetic bacteria, Denitrification of nitrate fertilizers to N2
and N2O (a green house gas) by denitrifying bacteria, free living and in association with *Azolla*, Phosphate solubilizing bacteria. Soil anerobic methanogens in rice field, Effect of soil pH and heavy metals on microorganisms, Microbial antagonism in soil, Biological control of soil-borne microbial pathogens

Unit IV

Application of Recombinant Microorganisms in Agriculture-Agrobacterium and virus mediated gene transfer
and improvements of crops **Microorganisms and Agriculture –** Functions of Microorganisms: Putrefaction, Fermentation, and Synthesis, Relationships Between Putrefaction, Fermentation, and Synthesis of biomolecules
Classification of Soils Based on the Functions of Microorganisms (Disease-Inducing Soils, Disease-Suppressive Soils, Zymogenic Soils, Synthetic Soils), Controlling the Soil Microflora for Optimum Crop Production and Protection.

Unit V

Eco-friendly Microbes and their utilisation –Utilization of beneficial Microorganisms in Agriculture, Ice minus
bacteria and microbial pesticides
EM Technology - Effective Micro-organisms, EM-BOKASHI, EM-COMPOST, EM-5, EM-X, Recycling.

205 IMMUNOLOGICAL TECHNIQUES (P)

1. Preparation of antigens, Immunization and methods of bleeding, Serum separation, Storage.
2. Antibody titre by ELISA method.
3. Double diffusion, Immuno-electrophoresis and Radial Immunodiffusion.
4. Counter current immune electrophoresis
5. Rocket Immuno –electrophorrsis.
6. Complement fixation test.
7. Isolation and purification of IgG from serum or IgY from chicken egg.
8. SDS-PAGE, Immunoblotting, Dot blot assays
9. Blood smear identification of leucocytes by Giemsa stain
10. Separation of leucocytes by dextran method
11. Demonstration of Phagocytosis of latex beads
12. Separation of mononuclear cells by Ficoll-Hypaque
13. Flowcytometry, identification of T cells and their subsets
14. Lymphoproliferation by mitogen / antigen induced
15. Lympnode Immunohistochemistry (direct and indirect peroxidase assay)
16. Immunodiagnostics using commercial kits

206 BIOINFORMATICS

1.Retrieval of sequences using ENTREZ
2. Sequence analysis using BLAST, Align, Lalign
3. Multiple sequence alignment and Phylogenetic analyzing of housekeeping genes.(Using Clustal, ClustalW etc)
4. Studying 3D structure using RASMOL
5. Homology Modeling using Swiss PDB – Hb, Protease
6. Calculation of Phi and Psi angle - Hb, Protease
7. Docking: protein-protein; protein-small molecules
8. Potential energy calculation of regular structures
9. To mutate protein and energy minimization using Swiss PDB viewer
10. Gene prediction – Gene D'cefer
11. Adhesion protein prediction – Sea path
12. Comparative proteomics and genomics – Proteome calculator
13. Protein annotation - PLHost

207 AGRICULTURAL MICROBIOLOGY (P)

Looking for efficient Nitrate and Phosphate reducing microbes from water and soil.
1. Cultivation of microbes in nitrate broth from different environmental samples
2. Characterizing the morphology of the consortium
3. Testing the ability of nitrate removal by the consortium.
4. Testing the ability of phosphate accumulation by the consortium
5. Application of the consortium for germination trials for Mung bean in soil free medium.
6. Application of the consortium for germination trials for Mung bean in soil.
7. Testing the consortium for production of phytohormones.
8. Testing the plants growth in terms shoot length, leaf number, leaf dimension, number of nodes, chlorophyll content, number of nodules, root branching, etc.
9. The effect of PGPB on leaf epiphytic microbial consortia would be test.

301 FOOD MICROBIOLOGY

Unit – 1 Industrial Food fermentations
Starter cultures their biochemical activities, production and preservation of the following fermented foods.
a. Soy sauce fermentation by Moulds
b. Fermented vegetables – Saurkraut
c. Fermented Meat – Sausages
d. Production and application of Bakers Yeast
e. Application of microbial enzymes in food industry

Unit – 2 Quality assurances in foods
Foodborne infections and intoxications; bacterial with examples of infective and toxic types –, Clostridium, Salmonella, Shigella, Staphylococcus, Campylobacter, Listeria.
Mycotoxins in food with reference to Aspergillus species.
Quality assurance: Microbiological quality standards of food. Government regulatory practices and policies. FDA, EPA, HACCP, ISI.

Unit –3 Food preservation methods
Radiations - UV, Gamma and microwave
Temperature
Chemical and naturally occurring antimicrobials
Biosensors in food industry.

UNIT – 4 Microbiology of cheese and beverage fermentation.
Microbiology of fermented milk products (acidophilus milk, yoghurt).

Role of microorganisms in beverages – tea and coffee fermentations.
Vinegar Fermentation

Unit - 5 Advanced Food Microbiology

Genetically modified foods. Biosensors in food, Applications of microbial enzymes in dairy industry [Protease, Lipases].
Utilization and disposal of dairy by-product - whey.

302 FERMENTATION TECHNOLOGY

Unit – 1 Microbial Fermentations

Metabolic pathways and metabolic control mechanisms, industrial production of citric acid, lactic acid, enzymes (alpha-amylase, lipase, xylase, pectinases, proteases), acetone- butanol, lysine and glutamic acid.

Unit – 2 Microbial production of therapeutic compounds

Microbial production of therapeutic compounds (b lactam, aminoglycosides, Ansamycins (Rifamycin), peptide antibiotics Quinolinones), biotransformation of steroids, vitamin B12 and riboflavin fermentation.

Unit – 3 Modern trends in microbial production

Modern trends in microbial production of bioplastics (PHB, PHA), bioinsectices (thuricide), biopolymer (dextran, alginate, xanthan, pullulan), Biofertilizers (nitrogen fixer Azotobacter, Phosphate solubilizing microorganisms), Single Cell Protein and production of biological weapons with reference to anthrax.

Unit – 4 Biofuels

Useful features of bio-fuels. The substrate digester and the microorganisms in the process of biogas production (biomethanation). Production of bioethanol from sugar, molasses, starch and cellulosic materials. Ethanol recovery. Microbial production of hydrogen gas, biodiesel from hydrocarbons.

Unit – 5 Immobilization techniques , IPR and Patents

Some industrial techniques for whole cell and enzyme immobilization. Application and advantages of cell and enzyme immobilization in pharmaceutical, food and fine chemical industries.
Intellectual Property Rights (IPR), Patents, Trademarks, Copyrights, Secrets, Patenting of biological materials, international co operation, obligations with patent applications, implication of patenting, current issues, hybridoma technology etc. Patenting of higher plants and animals, transgenic organisms and isolated genes, patenting of genes and DNA sequences, plant breeders right and farmers rights.

303 PHARMACEUTICAL MICROBIOLOGY

Unit – 1 Antibiotics and synthetic antimicrobial agents

Antibiotics and synthetic antimicrobial agents
(Aminoglycosides, b lactams, tetracyclines, ansamycins, macrolid antibiotics)
Antifungal antibiotics, antitumor substances.
Peptide antibiotics, Chloramphenicol, Sulphonamides and Quinolinone antimicrobial agents.
Chemical disinfectants, antiseptics and preservatives.

Unit – 2 Mechanism of action of antibiotics

Mechanism of action of antibiotics (inhibitors of cell wall synthesis, nucleic acid and protein synthesis).
Molecular principles of drug targeting.
Drug delivery system in gene therapy
Bacterial resistance to antibiotics.
Mode of action of bacterial killing by quinolinones.
Bacterial resistance to quionolinones.
Mode of action of non – antibiotic antimicrobial agents.

Penetrating defenses – How the antimicrobial agents reach the targets (cellular permeability barrier, cellular transport system and drug diffusion).

Unit – 3 Microbial production and Spoilage of pharmaceutical Products

Microbial contamination and spoilage of pharmaceutical products (sterile injectibles, non injectibles, ophthalmic preparations and implants) and their sterilization.
Manufacturing procedures and in process control of pharmaceuticals.
Other pharmaceuticals produced by microbial fermentations (streptokinase, streptodornase).
New vaccine technology, DNA vaccines, synthetic peptide vaccines, multivalent subunit vaccines. Vaccine clinical trials.

Unit – 4 Regulatory practices, biosensors and applications in Pharmaceuticals

Financing R&D capital and market outlook. IP, BP, USP.
Government regulatory practices and policies, FDA perspective.
Reimbursement of drugs and biologicals, legislative perspective.
Rational drug design.
Immobilization procedures for pharmaceutical applications (liposomes).
Macromolecular, cellular and synthetic drug carriers.
Biosensors in pharmaceuticals.
Application of microbial enzymes in pharmaceuticals.

Unit – 5: Quality Assurance and Validation

Good Manufacturing Practices (GMP) and Good Laboratory Practices (GLP) in pharmaceutical industry.
Regulatory aspects of quality control.
Quality assurance and quality management in pharmaceuticals ISO, WHO and US certification.
Sterilization control and sterility testing (heat sterilization, D value, z value, survival curve, Radiation, gaseous and filter sterilization)
Chemical and biological indicators.
Design and layout of sterile product manufacturing unit.
(Designing of Microbiology laboratory)
Safety in microbiology laboratory.

304 FOOD MICROBIOLOGY (P)

1. Production and estimation of lactic acid by Lactobacillus Sp.
Or Streptococcus Sp.
2. Extraction and estimation of diacetyl.
3. Sauerkraut fermentation
4. Isolation of food poisoning bacteria from contaminated foods,
Dairy products
5. Extraction and detection of afla toxin for infected foods.
6. Preservation of potato/onion by UV radiation
7. Production of fermented milk by Lactobacillus acidophilus.
8. Rapid analytical techniques in food quality control using microbial
Biosensors.

References

1. Food Microbiology. 2nd Edition By Adams
2. Basic Food Microbiology by Banwart George J.
3. Food Microbiology: Fundamentals and Frontiers by Dolle

305 FERMENTATION TECHNOLOGY (P)

1. Production and characterization of citric acid using A. Niger.
2. Microbial production of glutamic acid.
3. Production of rifamycin using Nocardia strain.

4. Comparison of ethanol production using various Organic wastes /raw Material [Free cells/ immobilized cells].
5. Production and extraction of thuricide.
6. Laboratory scale production of biofertilizers [Nitrogen fixer/Phosphate Solubilizers/siderophore producers].
7. Microbial production of dextran by Leuconostoc mesenteroides
8. Microbial production of hydrogen gas by algae/bacteria

References

1. Biotechnological Innovations in Chemical Synthesis. BIOTOL. Publishers / Butterworth - Heinemann.
2. Industrial Microbiology by G. Reed (Ed), CBS Publishers (AVI Publishing Co.)
3. Biology of Industrial Microorganisms by A.L. Demain.

306 PHARMACEUTICAL MICROBIOLOGY (P)

1. Spectrophotometric / Microbiological methods for the determination of Griesofulvin.
2. Bioassay of chloremphenicol by plate assay method or turbidiometric Assay method.
3. Treatment of bacterial cells with cetrimide, phenol and detection of Leaky substances such as potassium ions, aminoacids, purines, Pyrimidines and pentoses due to cytoplasmic membrane damage.
4. To determine MIC, LD 50 of Beta-lactum/aminoglycoside/ tetracycline/ansamycins.
5. Sterility testing by Bacillus stearothermophilus
6. Sampling of pharmaceuticals for microbial contamination and load (syrups, suspensions, creams and ointments, ophthalmic preparations).
7. Determination of D value, Z value for heat sterilization in pharmaceuticals.
8. Determination of antimicrobial activity of a chemical compound (Phenol, resorcinol, thymol, formaldehyde) to that of phenol under Standardized experimental conditions.

References

1 . Pharmaceutical Microbiology – Edt. by W.B.Hugo & A.D.Russell Sixth edition. Blackwell scientific Publications.
2. Analytical Microbiology –Edt by Frederick Kavanagh Volume I & II. Academic Press New York.
3. Quinolinone antimicrobial agents – Edt. by David C. Hooper, John S.Wolfson .ASM Washington DC.
4. Quality control in the Pharmaceutical Industry - Edt. by Murray S.Cooper Vol.2. Academic Press New York.

401 MEDICAL MICROBIOLOGY

Unit-I

Basics in Medical microbiology - Infectious diseases overview. Medically important microbes. Microbial diseases - sources, route of transmission. Pathogenesis - adhesion, invasion, host cell damage, release of pathogens. Microbial virulence and virulence factors - Signs and symptoms of microbial diseases. Treatment, Prevention and control of microbial infections. Immunity of microbial diseases.

Unit-II

Diagnosis of microbial diseases - Collection, transport and preliminary processing of clinical pathogens. Clinical, microbiological, immunological and molecular diagnosis of microbial diseases. Modern methods of microbial diagnosis.

Unit-III

Bacteriology - Characteristics, classification, pathogenesis, pathology, diagnosis, treatment, prevention and control of diseases caused by Staphylococci, Streptococci, Bacillus, Clostridium, Corynebacterium,

Escherichia, Salmonella, Shigella, Klebsiella, Proteus, Vibrio, Pseudomonas, Mycobacteria, Spirochaetes, Rickettsia.

Unit-IV

Virology - Structure, multiplication, classification and medical importance of DNA viruses - Pox, Herpes, Hepatitis, Adeno; RNA viruses - Picorna, Orthomyxo, Paramyxo, Rabdo and HIV virus. Viral vaccines and antiviral agents.

Mycology - Human mycotic infections caused by Dermatophytes, Histoplasma, Cryptococcus, Candida, opportunistic mycoses. Mycotoxins.

Parasitology - Medical importance of Entamoeba, Giardia, Plasmodium, Taenia, Ascaris, Wucherhiria. Laboratory techniques in parasitology.

Reference Books

1. Chaechter M. Medoff G. and Eisenstein BC. (1993) Mechanism of Microbial Diseases 2nd edition. Williams and Wilkins, Baltimore.

2. Collee, JG. Duguid JP, Fraser AG, Marimon BP. (1989) Mackie and Mc Cartney Practical Medical Microbiology, 13th Edition. Churchill Livingstone.

402 INDUSTRIAL MICROBIOLOGY

Unit-I

Introduction to industrial microbiology: Sources of industrially important microbes, strain development, types of fermentation and fermenters, process optimization, and recent developments in fermentation technology.

Unit-II

Downstream processing of microbial products: Filtration, centrifugation, cell disruption, liquid-liquid extraction, chromatography, membrane processes, drying (lyophilization and spray drying), and crystallization

Unit-III

Fermentation economics: Basic objective for successful economically viable fermentation process, cost break down for well established fermentation processes, market potential of the products, cost aspects of various stages in the processes development including effluent treatment

Unit-IV

Production aspects: Microbial strains, substrates, strain improvement, flow diagrams, product optimization, and applications of industrial alcohol (ethanol and butanol), amino acids (lysine, phenylalanine, tryptophan), antibiotics (cephalosporins, tetracyclines, polyenes), enzymes and immobilized enzymes, SCP, microbial polyesters, biosurfactants, and recombinant products (insulin, somatostatin, thaumatin). 55

STUDY MATERIALS:

1. Biotechnology: A Text Book of Industrial Microbiology by W. Crueger & A. Crueger, Panima Publishing Corporation, New Delhi/Bangalore, 2000.

2. Principles of Fermentation Technology by P.F. Stanbury, W. Whitaker &S.J. Hall, Aditya Books (P) Ltd., New Delhi, 1997.

3. Modern Industrial Microbiology & Biotechnology by N. Okafer, Scientific Publishers, Enfield, USA., 2007.

4. Fermentation Microbiology and Biotechnology by El Mansi & Bryce, Taylor & Francis, London, Philadelphia, 1999.

5. Fermentation Biotechnology by O.P. Ward, Open University Press, Milton Keynes, U.K., 1989

403 ENZYMOLOGY

Unit I

Introduction to enzymology and historical developments in enzymology
Protein Structure: Primary, secondary, tertiary and quaternary structure, techniques used in enzyme characterization
Enzyme classification: IUB enzyme classification.
Enzyme Activity: Principle and techniques of enzymatic analysis, factors affecting enzyme
Activity, Extraction and Purification of enzyme: Objectives and strategy, separation techniques, test of purity.

Unit II

Enzyme Kinetics: Bioenergetics and Catalysis
Single substrate kinetics: Equilibrium and Steady state kinetics, significance of Km, Vmax &
Kcat. Pre-steady state and Relaxation kinetics.
Multisubstrate kinetics: General rate equation, compulsory order, random order and ping-pong mechanisms and their primary and secondary plots. Enzyme inhibition and its kinetics: Reversible and irreversible inhibition, competitive, non-competitive and uncompetitive, mixed, partial, substrate and allosteric inhibition.
Thermal kinetics: Effect of temperature on reaction rate, enzyme stability, Arrhenius equation and activation energy.

Unit III

Mechanism of Enzyme Action:
Enzyme activators, co-enzymes and co-factors in enzyme catalysis, Enzyme and substrate specificity
Investigation of active Centre, Factors affecting catalytic efficiency, Experimental approaches to determine enzyme mechanisms.
Enzyme mechanisms: Lysozyme, Chymotrypsin, Carboxypeptidase, Restriction endonuclease, Aspartate transcarbomylase. Allosteric enzymes and sigmoidal kinetics: Protein ligand binding, Co-operativity, MWC & KNF models,
Regulation of enzyme activity. Control of metabolic pathways.

Unit IV

Isoenzymes and its physiological significance, Ribozymes and Abzymes
Enzyme engineering: Chemical modification of enzymes: methods of modification of primary structure, catalytic and allosteric properties, use of group specific reagents.
Enzyme Immobilization
Enzymes in non conventional media, Enzymes sensors, Enzymes as analytical reagents.

Reference Books:

Fundamentals of Enzymologist : Nicholes C. Price and Lewis Stevens, Oxford Univ. Press.
Enzyme Structure and mechanism: Alan Fersht, Reading, USA.
Understanding Enzymes: Trevor Palmer
The chemical kinetics of enzyme action: K. J. Laider and P. S. Bunting, Oxford University
Press, London.
Enzymes: M. Dixon, E. C. Webb, CJR Thorne and K. F. Tipton, Longmans, London.

404 ENVIRONMENTAL MICROBIOLOGY

Unit 1

Global environmental problems: Global warming, Ozone depletion, Acid rain

Water pollution: Sources and types, Physical, chemical and biological pollution of water, Eutrophication and its control.

Biodeterioration of wood and metals: Role of micro-organisms, mechanisms and control.

Unit 2

Biogeochemical cycles: Role of microorganisms in nitrogen, sulfur and phosphorous cycling. Detrimental effects of diverted biogeochemical cycles.

Biological Nitrogen Fixation in detail: Asymbiotic, symbiotic and associative nitrogen fixation. Structure, function and genetic regulation of nitrogenases. Plant–microbe interactions: Mycorrhyzae, Nitrogen fixing associations between rhizobia and legumes, cyanobacteria-plant symbiosis. Plant growth promoting rhizobacteria.

Unit 3

Microbes in extreme environments: Habitat, biodiversity, adaptive strategies and biotechnological potential of thermophiles and hyperthermophiles, psychrophiles and psychrotrophs, halophiles, acidophiles and alkalophiles.

Microbial communities and ecosystems: Microbial community dynamics, structure of microbial communities, ecosystems, structure and function of some microbial communities in nature.

Unit 4

The origin of life (chemical and cellular evolution), ribosomal RNA analyses for tracing microbial evolution, genetic basis of evolution, evolution of physiological diversity.

Taxonomy, binomial nomenclature, types of bacterial classification systems, new approaches to bacterial taxonomy (numerical taxonomy, ribotyping, rRNA sequencing, fatty acid profile) Bergey's manual of systematic bacteriology.

Microbial diversity- molecular chronometers, phylogenetic trees and three domain universal phylogenetic tree.

Methods of studying microbial diversity (Conventional and molecular tools).

Reference Books:

Environmental Microbiology. R. M. Maier, I. L. Pepper & G. P. Gerba.

Comprehensive Biotechnology Vol-4, Murray Moo Young.

Biotechnology- Rehm and Reid.

Microbial Ecology: Fundamentals and Applications- Atlas & Bartha, fourth edition, Pearson Education.

Environmental science, B. J. Nebel and R. T. Wright.