Sridev Suman University

Details of UG Courses & Syllabus (Microbiology)

(M. Sc. Two year course, semester system)

Marks Distribution

Theory :External = 80, Internal assessment =20(80+20=100) each paper
Practical:(80+v Paper 1[s:]20=100) each semester,80 marks practical 20 internal

M. Sc. 1st Year

Semester 1st

Paper 1st : Principles of Bacteriology	-100
Paper 2nd : Virology	-100
Paper 3rd : General Biochemistry	-100
Paper 4th : Fungal Biology	-100
Lab course: Practical	-100

Semester 2nd

Paper 1st : Bacterial and Viral Genetics	-100
Paper 2nd : Microbial physiology and Metabolism	-100
Paper 3rd : Immunology	-100
Paper 4th: Food and Dairy Microbiology	-100
Lab course: Practical	-100

M. Sc. 2nd Year

Semester 3rd

Paper 1st : Medical Microbiology	-100
Paper 2nd : Cellular Microbiology	-100
Paper 3rd : Genetic Engineering	-100
Paper 4th : Microbial Biotechnology	-100
Lab course : Practical	-100

Semester 4th

Paper 1st : Basics & Biostatistics & Computer Applications	-100
Paper 2nd : Soil Microbiology	-100
Paper 3rd : Industrial Microbiology	-100
Paper 4th : Microbial Diversity including extermophiles	-100
Lab course: Practical/Dissertation (or Practical)	-100

M.Sc. Microbiology (First Year)
Semester 1st

Paper Ist: Principle of Bacteriology

Unit-1

Difference between prokaryotic and eukaryotic organisms.Specialized prokaryotic structures –Endospore.Exospore,cysts,akenete and Heterocysts;plasmits-structure and function; Genetic transfers-conjugation, Transduction, Methods in Microbiology:Pure culture to change,sterilization technique.Preparation of culture media,enrichment culture technique for isolation of bacteria,aerobic and anaerobic culture of bacteria, construction of media,selective and different media;Enrichment culture.

Unit-2

Characteristic features and taxonomic characteristic of gram negative anaerobic eubacteria (Veillonella, Meghasphaera,Bacteroids,Fusobacteriaand Sulfer- reducing bacteria), Gram negative eubacteria (Spirochetes,Rickettsias and Chlamydias);Gram positive unicellular endospore formers; Gram positive fermentative eubacteria(Slaphylococcus,Lactic acid bacteria); Gram positive eubacteria; the Mollecutes (Mycoplasma).

Unit-3

Microbial growth-Definition, measurement of growth, growth curve, kinetics of growth generation time,specific growth rate constant; Effect of environmental factors on growth (oxygen, temperature, pH etc); Growth of microorganisms under extremes of conditions (Temperature, hydostatic pressure, pH, osmotic pressure, radiation): Synchronous growth; batch and continuous cultures.

Control of bacteria- Sterilization- Physical (heat, filtration and radiation) and chemical agents monitoring effectiveness of antimicrobial methods.

Unit-4

Microbial evolution: Basic principal and techniques use in bacterial classification- Haeckel`s three kingdom, Whittaker`s five Kingdom and eight kingdom concepts of classification; Three domain concept of Carl Woese;Phylogenetic and numerical taxonomy; Bergey`sMannual of Systematic bacteriology; General feature of important group of bacteria-Proteobacteria (Enterobacteria,Rhizobiales, Pseudomonadales, Bdellovibrionales), Firmicutes (Clostridia, Mycoplasma,Bacilli, Lactobacilli),Actinobacteria, Spirochaetes,Rickettisia and Archaebacteria.

Paper 2nd: Virology

Unit-1

General virology: nomenclature and classification of viruses, morphology and ultra structure, capsids and their arrangements, types of envelopes and their composition, viral genome, their type and structure; Virus related agents (viroidsvirusoids and prions).

Unit-2

Isolation and cultivation of viruses- animal inoculation, embryonated hen`s egg and tissue culture (cell monolayers, primary and secondary cell structure, cell stains and cell lines);
Viral assay –electron microscopy, plaque method endopoint methods, serological methods-hemagglutination, HAI, compliment fixation immunofluorescence, ELISA, RIA.

Unit-3

Mirobial viruses: Bacteriophage structure organization (Lactic and Lysogenic); One step growth curve, transcription,DNA replication, eclipse, phase, phage production, bust size,; Bacteriophage typing ; Application in bacterial genetics: Brief account of phage M13, Mu, T_4, Lambda.

Unit-4

Plant viruses: Classification, viral structure, symptoms, effect of viruses on plants, appearance of plants histology physiology. Transmission of plant viruses with vectors (insects, nematodes, fungi) and without vectors (contact, seed dodder and pollens). Prevention of crop loss due to virus infection, virus free planting material, vector control.

Animal viruses: Classification and nomenclature of animal viruses, pathogenecity, diagnosis, prevention and control - Picorna, Orthomyxo, Retoviruses,HIV; DNA viruses – pox, herpes, hepatitis, interferon and antiviral drugs.

Paper 3rd: General Biochemistry

Unit-1

Water – property and biological role, pH, buffers; Structural features and chemistry of biomolecules; Amino acid- structure, classification, properties and functions.

Proteins – classification, function and structure (primary, secondary tertiary and quaternary), forces stabilization higher order structure of biomolecules; Carbohydrates – structure, functions, properties and classification ; (Monosaccharides, Disaccharides, Polysaccharides and Mucopolysaccharides).

Unit-2

Lipids-structure, properties and functions classification; (Phospholipids, Glycolipids, Lipoprotein and cholesterol); Nucleic acid- structure, function and properties of RNA and DNA.

Unit-3

Enzyme classification, specificity isozymes.Enzymes kinetics:Michaelis- Mention equation for simple enzymes,determination of kinetic parameters multistep reactions and limiting steps,Effects of pH and temperature on enzyme action, enzyme inhibition, allosterism, kinetic analysis of allostearic enzymes, Principles of allosteric regulation, (Simple sequential model and concerted model). Vitamins and their role as coenzyme. Artificial enzyme (beta- benzymes), Ribozymes

Unit-4

Bioenergetics: High energy compound, free energy and spontaneity of reaction, G, G^0, G` and equilibrium.Oxidation- reduction reactions coupled reaction and group transfer, ATP production,Biological transport- uniport and co- transport.

Paper 4th: Fungal Biology

Unit-1

Historical introduction to mycology, Classification, general features, mycelial organization, cell structure and cell differentiation, nutrition and reproduction in fungi. Salient features of division- Myxomycota, Plasmodiophoromycetes.

Unit-2

Eumycota: Mastigomycotina –Hypochytridiomycetes, Oomycetes; Zygomycotina – (zygomycetes, trichomycetes), Heterothallism, sex hormones in fungi. Physiological specialization and phylogeny of fungi.

Unit-3

Salient features of Ascomycotina –hemiascomycetes, plectomyctes. Discomycetes – laboulbeniomycetes; Loculoascomycetes, Basidiomycotina- teliomycetes, hymenomyctes, Deuteromycotina –hypomycetes, coelomycetes, blasomycetes.

Unit-4

Fungi and ecosystem: saprophyte, substrate groups and nutritional strategies, substrate successions, fungi and bioremediation; Economic importance of fungi; Pant diseases – *Pythium*seed rot, grapes- downy mildew, potato-early and late blight, tomato fusarial wilt, wheat- smut and rust. Attack on fungi by other microorganisms:Mycoses –superficial (Yeast like organisms), cutaneous (Dermatophytes), subcutaneous (*Sporothixschenckii*) and systemic (*Candila, Cryptococcus, Histoplasm ,Blastomyces).*

M.Sc. Microbiology (First Year)

IIndSEMESTER

Paper 1st :Bacterial and Viral Genetics

Unit I

DNA Structure ; DNA replication ; various modes of replications, properties of DNA polymerases. Inhibitors of DNA replication. Asymmetric and dimeric nature of DNA Polymerases III and simultaneous synthesis leading and lagging strands, exonucleases activity in eukaryotic DNA polymerases.Gene as a unit mutation and recombination.Molecular nature of mutations.Mutagens, Spontaneous mutations-origin.Gene conversion, site specific recombination, Transposable elements, Insertion sequences.Transposons (Structure, Mechanism and Genetics of Transposition). Types of DNA damage(deamination, oxidative damage, alkylation, pyrimidine dimers).

Unit II

Structural features of RNA (r RNA, t RNA, and m RNA), Initiator and elongate class of t RNA, cutting and modification of t RNA, ribosomesbinding site on m RNA and corresponding site on r RNA , maturation and processing of r RNA; methylation, cutting and trimming of r RNA, capping, polyadenylation and splicing of m RNA, peptidyltransferaseactivity of 23s r RNA group I and group II splicing, R Nase P.

Unit III

Transcription ; types of RNA polymerases, initiation, elongation and termination . Inhibitors of RNA synthesis ,monocistronic RNAs . Basic features of Genetic code . Translation and its steps initiation , elongation ,& termination.

Unit IV

E. coli- Gene structure, expression and regulation. Concepts of operon , catabolic repression, negative and positive regulation , inducers and co-repressor ; Plasmids and F factor. Replication of plasmids and plasmids compatibility , Bacteriophages;

lytic and lysogenicphages, genetics of T4 and lambda phages, their use in microbial genetics.

Paper 2nd: Microbial Physiology and Metabolism

Unit I

Microbial physiology and metabolism –Structure, functions and biosynthesis (assembly) of Capsule, Cell walls, Outer membrane, Flagella, Pili, Cytoplasmic membrane, Nuclear material; Ribosomes and cytoplasmic inclusions; Cellular differentiation Sporulation and Morphogenesis; Cell cycle and cell division.

Unit II

Metabolic precursors and fuelling reactions; Central peripheral and anapleurotic pathways; Metabolism of carbohydrates- EMP,ED,HMP and Phosphoketolase pathways; Krebs cycle , glyoxylate pathway , oxidative and substrate level phosphorylation. Reverse TCA cycle – gluconeogenesis.

Unit III

Bacterial fermentations- Ethanol , lactic acid , acetone , butanol and Mixed acid fermentations; Fermentation balances; Microbial degradation of starch , glycogen, pectin and cellulose; Assimilation of nitrogen – ammonia, nitrate nitrogen assimilation,dinitrogen fixation; Synthesis and regulation of major amino acids.

Unit IV

Brief account of Bacterial photosynthesis – Autotrophy, oxygenic and anoxygenic photosynthesis and their mechanism , Photosynthesis electron transport system , photo-phosphorylation, Dark reaction , C3,C4 pathways; Chemolithotrophy-sulphur,iron,hydrogen,nitrogen oxidations; Methanogenesis.

Paper 3rd : Immunology

Unit I

Immune system and immunity ; functions of cells and organs involved in immune system, Immune responses- innate immunity ,acquired immunity . Determinants of innate immunity ; species and strains ,individuals differences influence of age ,

hormonal influence, nutritional factors and mechanical barriers and surface secretions. Non specific immune mechanisms; surface defenses.opsonization, inflammatory reactions, hormone balance.

Unit II

Antigens and antibodies ; Antigens structure and properties ,types- iso and allo antigens, haptens, adjuvants, antigen specificity . Immunoglobins – structure , heterogeneity, types and sub types, properties (physiological and biological). Theories of the antibody production complement – structure, components , properties and functions of different components, complement pathways and biological consequences of the complement activation, Antigen antibody reaction in vitro methods-agglutination, precipitation complement fixation,immunofluroscence , ELISA , radioimmuno assay.

Unit III

Lymphocytes , their sub population , their properties and functions. Membrane bound receptors of lymph cells. Helper Tcells in immune response .Tcell suppression in immune response. Development and differentiation of B and T cells . Mechanism of the cell mediated immunity , immune tolerance to self antigens . Synthesis of antibodies and antibody diversity, Hybridoma technology.

Unit IV

Major Histocompatability complex and Transplantation ; structure and functions of MHC and HL-A system . Gene regulation and Ir genes . HLA and tissue transplantation ; graft verses host reaction and rejection , immune suppression – specific and non specific autoimmunity.Hypersensitivity reactions ; Antibody mediated – type I (Anaphylaxis) type II , type- III and type IV; Defects in immune system ; Primary and secondary defacts, defects in complement, phagocytes.

Paper 4th :Food and Dairy Microbiology

Unit I

Microorganisms important in food microbiology- Molds,Yeasts and Bacteria-general characteristics, classification and importance.Principles of food preservation. Asepsis- removal of microorganisms, anaerobic conditions, high

temperatures , low temperatures, drying ; Factors influencing microbial growth – Extrinsic and Intrinsic factors , chemical preservatives and food additives. Heat processing ; D, Z, and F values and working out treatment parameters for canned foods; Canning.

Unit II

Initial microflora of raw milk ; Types of micro organisms present in raw milk and spoilage caused by these organisms; Sources of contamination of milk ; cheese , acidophilus milk , kefir and yoghurt , Nutritional and therapeutic benefits of fermented milk products ; Probiotic foods; Spoilage of fermented dairy products ; Quality control in dairy industry.

Unit III

Food borne infections and intoxifications; Bacterial diseases with examples of infective and toxic types – Brucella ,Bacillus clostridium ,Escherichia, salmonella, Shigella, Staphylococcus, Vibrio,Yersinia, fungi and viruses; Alfatoxins- structures and functions; Food borne out breaks – laboratory testing procedures; Preventive measures – Sanitation in manufacture ; Food control agencies and its regulations , HACCP , ISO standards.

Unit IV

Food fermentations ; bread ,vinegar, fermented vegetables; Spoilage and prevention of spoilage of cereals, vegetables, fruits, meat and meat products fish and sea products.Foods produced by Microbes – Fermented foods, microbial cells as food (single cell proteins); Mushroom cultivation ; Bioconversion – fermented beverages- beer and wine . Industrial enzymes and their uses in food industry – amylases, proteases,cellulases; Oriental foods – Mycoprotein , Tempeh ,soya sauce ; Traditional foods.

M.Sc. Microbiology (Second Year)
IIIrd SEMESTER
Paper 1st : Medical Microbiology

Unit I

Normal microflora of human body , role of resident flora and the human host ; Epidemiology ; epidemic , pandemic ; Transmission of pathogens , route of infection . Treatment and prevention of diseases – antibiotics and drug resistance ; Brief account of vaccines and passive prophylactic measures.

Unit II

Establishment ,spreading, tissue damage and antiphagocutic factors . Mechanisms of bacterial adhesion , colonization and invasion of mucus membranes of respiratory ,enteric and urogenital tracts , Role of aggresins , depolymerizing enzymes , organotropisms, variation and virulence. Organs and cells involved in the immune system and immune response.

Unit III

Classification of pathogenic bacteria, infections caused by staphylococcus, streptococcus,Pneumococccus, Neisseria , Corynebacterium , Bacillus , Clostridium, organisms belonging to Entrobacteriaceae –E.coli, Salmonella , Shigella , Vibrio , Yersinia , Haemophillus, Mycobacterium, Spirochaetes , Rickettsia, Chlamydia.

Unit IV

General properties of viruses . Properties and important infections caused by Pox viruses, Herpes viruses, Picoma viruses , Orthomyxo viruses, Paramyxo viruses , Arbo viruses ,Rhabdo viruses , Hepatitis viruses, Retroviruses- HIV.Fungal diseases; Dermatophytes , Dimorphic fungi ; opportunistic fungal pathogens – Candidiasis, Pneumocystis, Blastomycosis and Histoplasmosis , Protozoal infections ; Plasmodium, Trypanosoma, Entamoeba Balatidium, Pneumocystis.

Paper 2nd : Cellular Microbiology

Unit I

Introduction bacterial diseases. Emergence of cellular microbiology . Cellular biology underlying prokaryotic and eukaryotic interactions ; structure of eukaryotic interactions ; structure of eukaryotic cell membrane receptors and signal transduction , Cytoskelton-regulation of assembly and disassembly Secretion system in prokaryotes. Pathogenicity islands.

Unit II

Prokaryotic and eukaryotic signalingmechanisms ; eukaryotic cell to cell signaling, Cytokines . Prokaryotic signaling ; quorum sensing and bacterial pheromones , Intracellular signaling. Signaling pathways.

Unit III

Infection and cell-cell interactions ; bacterial adherence basic principles, effect of adhesion on bacteria , effect of adhesion on host cells . Bacterial invasions of host cells; mechanisms, consequences of invasion , survival after invasion . Protein toxins classification of toxins, agents of diseases , Toxins as tools in cell biology and medicine.

Unit IV

Immune responses to bacterial infections ; innate response – complement , acute phase proteins , macrophages , cytokines and interferon , Acquired immune response , cell mediated immune response and humoral response.Cellular microbiology future directions ; virulence genes, tools for identifying virulence gene by mutation , differential expression , and by use of comparative genomics. Genomic processes in bacterial pathogen evolution role of horizontal , gene transfer in prokaryotic genome evolution . Future approach for discovery of novel therapeutics.

Paper 3rd : Genetic Engineering

Unit I

Techniques in GE; Basics concepts of southern , Northern and Western blotting . PCR methods and applications . DNA sequencing methods – Sanger's and Maxam – Gilbert method Sequence assembly . Automated sequencing. Restriction mapping (RFLP, AFLP) RAPD, REP, PCR and their use in DNA fingerprinting , Site directed mutagenesis and protein engineering.

Unit II

Strategies in gene cloning (cutting and joining of DNA) Isolation of chromosomal and plasmid DNA from bacteria and yeast . Bacterial restriction and modifications systems . Restriction endonucleases and their types . Recognition sequence for type II endonucleases .DNA ligation reaction , mechanisms of DNA ligases . joining of DNA fragments using linkers , adapters and homopolymer tails.

Unit III

Strategies in gene cloning (molecular cloning); Cloning vectors plasmids, phages, cosmids and shuttle vectors , expression vectors , promoters probe vectors, Cloning strategies , introduction of recombination vectors in to bacterial cells transformation and other methods. Selection of clones colony hybridization , deyection of translation products and immunological methods . Probes types of probes , strategies for construction of probes , use of ESTs and CDNA as probes.

Unit IV

Whole genome analysis – DNA libraries and genomics ; Genomic library , cDNA library, Use of artificial chromosomes (BAC , YAC) for library cDNA library construction. Genomics –sequences assembly , contigs and genome construction , annotation. Functional genomics – transcriptomics, proteomics . Comparative genomics.**V**Applications of RDT in pharmaceutics and medicines – recombinant human growth harmone – insulin , recombinant vaccines , food and agriculture and production of useful industrial products. Metagenomics and its applications.

Paper 4th : Microbial Biotechnology

Unit I

General considerations ; Metabolic pathways and metabolic control mechanisms. Primary and secondary metabolites. Biotechnological innovations in the chemical industry , biocatalyst in organic chemical synthesis. Efficiency of growth and product formation , growth stoichiometry , maintenance of energy requirement and maximum biomass yield . P/o quotients metabolites over production and growth efficiency.

Unit II

Shake flask cultures . Fermentation by batch , fed batch and continous cultures , microbial growth and kinetics ; Growth and product formation , heat evolution , effect of environment (Ph, Temperature , D o2, high nutrient concenteration). Media formulation , kinatics of thermal death of micro organism, batch and continous sterilization.

Unit III

Fermentor design – stirred tank , airlift fermentor, hollow fiber bioreactor and immobilized cell reactors, Instrumentation and control ; Large scale production ; Aeration and agitation – oxygen transfer kinetics , Rheology of fermentation broths – concepts of Newtonian , and Non – Newtonian fluids, Plastic fluids , apparent viscosity, foam and antifoam.

Unit IV

Industrial production of antibiotics (β – lactam and rifamcyin), citric acid,acetic acid , lactic acid , ethanol, enzymes(pectinase , amylases, lipases, proteases, cellulases). Amino acids (glutamic acid and lysine) , vitamins (Riboflavin and cynocobalmine), steroids transformation, biopesticides, fermented food beverages, biopolymers.Industrial strains . Strategies for selection and improvement , preservation and maintenance . Aseptic operation and containment of recombinant organisms . Scale up , large sacle production using recombinant micro organisms. Product recovery (down streaming).

M.Sc. Microbiology IInd year

IV th sem.

Paper I: Basics of Biostatistics & Computer Applications

Unit- I

Introduction: Definition of Statistics: population and universe, the sample and population, statistical inference, parameter and ststistics.

Interval Data: Construction of a histogram; interpretation of histogram, the normal distribution, the quartiles, the mean, mode, median and standard deviation, representing the normal curve, uncertainties in estimation of a mean, comparision of means and variances, coefficient of variance.

Unit-II

Proportion data: examples of proportion data; (MPN, sterility testing of medicines, animal toxicity, therapeutic trials of drug and vaccines, animal toxicity, infection and immunization studies) statistical treatment to proportion data. Chi-square test, goodness of fit. F- test, t-test, Z- test.

Unit-III

Analysis of variance: Analysis of co- variance; Introduction, procedure and tests, multiple comparisions, Correlation and regression and line fitting through graph points: curves; correlation, linear regression (fitting the best straight line through n series of points) MLR multicollinearity, Standard curves and interpolation of unknown Y- values.

Unit-IV

Application of biostatistics in microbiology: Count data- examples of count data (bacterial cell count, radioactivity count, colony and plaque counts), statistical treatment to count data: Poisson distribution, standard error, confidence limits of counts.

Statistical basis of biological assays: Response –Dose metameter. Delusion Assays, Direct and indirect Assays. Quantal Responces probit, logit., LD50, ED50, PD50- Standard line interpolation assay, parallel line assay (4oint, 6oint assays), slope ratio assay.

Unit-IV

Basics of Computer: Operating systems: Windows and Unix; Hardware, Software, Disk operating system, Multimedia network concepts; C- Programming; object oriented programming; internet and local network, wide area network

Bioinformatics- Biological data storage and analysis

Paper- II: Soil microbiology

Unit-I

Soil as a habitat for microorganisms: soil genesis, factor involved in soil genesis, soil profile, physiochemical properties of soil (mechanical composition of soil, organic matter and air). Soil microbes- algae, bacteria, actinomycetes, fungi, protozoa nematodes. Microbial balance in soil. Molecular markers for ecological studies of soil microorganisms.

Unit-II

Rhizosphere and rhizoplane microorganisms: reasons for increased microbial activity in rhizosphere. Composition of root exudates, factors affecting exudation, rhizosphere microorganisms, rhizosphere effect. Effect of microflora on host plants. Factors affecting microbial community in soil moisture, organic and

inorganic chemicals, soil-soil moisture, organic and inorganic chemicals, soil organic matter, types of vegetation and its growth stages, different seasons.

Unit-III

Biogeochemical cycles: C, N, P,S cycles. Nitrogen fixation- symbiotic and asymbiotic, significance of nitrogenase and nif genes, phosphate solubilization and its mechanism.

Unit-IV

Organic matter decomposition: composition of litter(cellulose, hemicelluloses,lignin) water soluble components – ether and alcohol soluble components and proteins. Organic matter dynamics in soil- microbial decomposition of cellulose, hemi-cellulose, lignin. Microbial succession on decomposing litter. Factors affecting organic matter decomposition (litter quality, temperature, aeration,soil Ph, inorganic chemical moisture); Pesticide degradation in soil, effects of pesticides on soil microflora, soil microbial biomass as an index of soil fertility.

Paper III: INDUSTRIAL MICROBIOLOGY

Unit I

General consideration: Metabolic pathways and metabolic control mechanisms, primary and secondary metabolites.Biotechnological innovations of the chemical industry, biocatalyst in organic chemical synthesis,efficiency of growth and product formation, growth stoichiometry, maintenance energy requirement and maximum biomass yield, P/O quotient.

Unit II

Shake flask culture, fermentation in batch culture, microbial growth kinetics, measurement of(cell number, direct and indirect method), growth and nutrient, growth and product formation, heat evolution, effect of environment(temp.,pH,

High nutrient concentration), media formulations. Sterilization, kinetic of thermal death of microorganisms, batch and continuous sterilization, kinetic of thermal death of microorganisms, batch and continuous sterilization, stirred tank, airlift fermenter, fed batch, continuous and immobilizedcell reactors. Fermenter design, instrumental and control.

Unit III

Aeration and agitation, oxygen transfer kinetics, concept of Newtonian and non-newtonian fluids,foam and anti foam. Industrial production of antibiotics(b-lactam and rafamycin), citric acid, acetic acid, lactic acid, ethanol enzymes(pectnase, amylase, lipase, protease, cellulose), steroids, Biofertilizers, Biopesticides, mushroom production, fermented food & beverages, Biopolymers

Unit IV

Industrial strains. Strategies for selection and improvements, preservation and maintenance, aseptic operatios and containment of recombinant organisms. Scale up product recovery (doen stream process).

Paper IV: Microbial diversity including extermophiles.

Unit I

Introduction to microbial diversity-Distribution- abundance- ecological niche. Oxidative transformation metals- Sulphur oxidation, iron oxidation, ammonia oxidation and hydrogen oxidation.

Unit II

Non-culturable culturable bacteria; conventional and molecular methods of studying microbial diversity.

Unit III

Microbial diversity of anoxic ecosystem- methanogens, reduction of carbon monoxide, reduction of iron, sulphur, manganese, nitrate and oxygen- Microbes and metal reduction, bioleaching of ore, metal corrosion. Microbial transformation of carbon, phosphorous, sulphur nitrogen and mercury.

Unit IV

Extrmophiles- acidophiles, alkalophiles, psychrophiles, thermophiles, barophiles and osmophiles. Physiology, molecular adaptation and application. Halophiles- membrane variation, electron transport.