11 MICROBIOLOGY

Unit 1: History of Microbial World

Microbial world, History of microbiology and types of micro-organisms, Prokaryotic and eukaryotic cell, Classification and major characteristics of different microbial groups.
Morphological characteristics, Internal structures and their functions in bacteria, archaea, algae, cyanophages, viroids, prions, fungi, actinobacteria, mycoplasma, rickettsias, chlamydia, viruses, bacteriophages.
Basics of microbial growth and reproduction, Bacterial communication, Environmental and nutritional requirements for microbial growth, Pure cultures, Control of microorganisms: Principles, methods including radiation, Chemicals, Antibiotics etc.
Classification of fungi. Life cycles of important phytopathogenic fungi. Economic mycology, edible fungi and entomogenous fungi. Mycorrhizal associations. Cell organelles, their morphology, functions and chemical composition.

Unit 2: Basic Microbiological Techniques

An introduction to laboratory instruments, Safety rules in laboratory, Handling of different glassware. Methods of sterilization and disinfection. Handling of autoclave, Hot air oven, BOD incubator, Laminar flow, Colony counter, pH meter, Biological filters; Spectrophotometer.
Isolation and preservation of different types of microorganisms; Microscopy: Light, Compound, Dark field, Phase Contrast, Fluorescent, EM, TEM, SEM ; Wet mount, Hanging drop technique, Stains and staining techniques.
Types of culture and culture media, Inoculation techniques, Isolation of pure culture, Proof of purity of cultures, Maintenance and preservation of pure cultures, Culture collections.
Identification of bacteria using biochemical tests, Introduction and importance of Bergey's Manual, Bioassay techniques, Antibiotic sensitivity of bacteria.
Isolation of Genomic DNA and PCR amplification in bacteria and cyanobacteria, RAPD and RFLP, Isolation of plasmids, Protein profiling by SDS-PAGE.

Unit 3: Microbial Physiology

Microbial growth, Requirements for growth; Bacterial division, growth kinetics, Energetics of growth; Types/modes of growth - Batch culture, Synchronous growth, Continuous growth, Chemostat and Turbidostat, Growth characteristics, Measurement of microbial growth: Plate counts, Filtration, The Most Probable Number (MPN) method, Direct microscopic count, Indirect methods ; Growth yield and its significance. Energy yielding pathways in microorganisms, Catabolic and anabolic reactions – Aerobic respiration: Glycolysis, Substrate level phosphorylation, Electron transport chain and oxidative phosphorylation , Hexose mono-phosphate pathway (HMP), Entner – Doudoroff Pathway (ED pathway), Tricarboxylic acid cycle (TCA cycle) and other mechanisms, Chemiosmotic mechanism of ATP generation, Obligate anaerobes, Aerotolerant anaerobes, Catabolism of other kind of organic substrates, Anaerobic

respiration, Dissimilatory and assimilatory reductions, Types of fermentation, Fermentation balances.

Microbial photosynthesis, Diversity, Chlorophylls and bacterio- chlorophylls, Accessory pigments, Light-dependent reactions and light independent reactions, Carbon dioxide assimilation in prokaryotes, Bacteriorhodopsin and Halorhodopsin and their significance, Classification and taxonomy of photosynthetic organisms: Microalgae (cyanobacteria, green algae) and bacteria, Major characteristics of different groups, Photosynthetic eubacteria: Introduction, Characteristics of important genera of photosynthetic eubacteria. Physiology of chemooligotrophs.

Enzymes and chemical reactions, Enzyme specificity and efficiency, Classification, Enzyme components, Mechanism and Factors influencing enzymatic activity: Temperature, pH, substrate concentration, Inhibitors, Feedback inhibition, Ribozymes, Coenzymes.

Cell wall and its biosynthesis; Polysachharide biosynthesis, Lipid biosynthesis, Biosynthesis of nitrogenous compounds- Amino acid and proteins, Purine and pyrimidines, Nucleic acids. Proteins break down by microorganisms, Deamination, Transamination, Assimilation of complex carbohydrates- Cellulose, Hemicellulose, Starch, Pectin and Chitin, Nitrogen fixing micro-organisms, Requirements of nitrogen fixation, Mechanism of nitrogen fixation, Nitrogenase enzyme, Biochemistry of hydrogenase enzyme and hydrogen assimilation. Secondary metabolism, Primary and secondary metabolites and their significance, Physiological response of microorganisms to salinity, alkalinity, UV, drought and heavy metals, adaptive mechanisms employed to cope with stress.

Unit 4: Microbial Genetics

Principles of microbial genetics; Gene organization in bacteria, Archeae, Eukaryotes and viruses; Gene regulation and expression in these organisms; Plasmids and their inheritance; Transposons and insertion sequences; DNA replication; Mutations and DNA repair mechanisms; Gene and genetic code; Nucleic acid synthesis and Protein synthesis: Transcription, Translation and Post Translational modifications; Genetic recombination in bacteria: Transformation, Conjugation, Transduction; Restriction enzymes; vectors; Virus multiplications and Genetics analysis of bacteriophages and cyanophages.; Genome and gene editing. Introduction to gene cloning.

Unit 5: Soil Microbiology

Role of microorganisms in soils, Major microbial indicators of soil health and their significance, Direct and indirect methods of studying soil microorganisms and their activities. Soil microbial interactions: Types and significance. Carbon cycle: Biodegradation of starch, Cellulose, Hemicellulose, Pectin and lignin in soil, Decomposition of organic matter, Humus and fulvic acid, Quantity and distribution of organic matter in soil, role of microorganisms in decomposition of soil organic matter, Dynamics of microorganisms during different stages of OM decomposition, Humus and its fractions, contribution of humus to soil quality. Nitrogen cycle: Ammonification, Nitrification, Denitrification, Non-symbiotic and symbiotic nitrogen fixation through bacteria and nitrogen assimilation. Environmental influences on microorganisms, Effect of temperature,

aeration, moisture, osmotic pressure, pH. Recent development on the role of microbial communities and role in nutrient cycling. Transformation of phosphorus, Sulphur, Iron, Manganese, Magnesium, Copper, Mercury and Arsenic.
Soil microbial biomass, microbial interactions, unculturable soil biota. Microbiology and biochemistry of root-soil interface. Phyllosphere. Soil enzymes, origin, activities and importance. Biofertilizers – definition, classification, specifications, and role in crop production.

Unit 6: Microbial diversity and Ecology

Molecular approaches for measuring the microbial diversity: RISA,TGGE, DGGE, T-RFLP, BIOLOG, FAME analysis. Plant-microbe interactions, Endophytic and pathogenic interactions, Rhizosphere, Rhizoplane, Spermosphere and phyllosphere, Root exudates, Quorum-sensing in bacteria, Flow of signals in response to carbon substrates. Legume –*Rhizobium* symbiosis, Frankia- Actinorhizal symbioses, Classification of nodulating bacteria, Formation of nodules in leguminous plants, Types of nodules, Genetics of nodulation and nitrogen fixation, *sym* genes, *nod* genes, *nif* genes and *fix* genes, NOD factors, Hydrogenases. Mycorrhizae: Types of mycorrhizae, Mycorrhizal links with plants and their functioning. Biochemical/ Molecular aspects. Type three secretion systems, Plant growth promoting rhizobacteria (PGPR) and their direct and indirect mechanisms of action, Biocontrol agents and their mechanisms.

Unit 7: Microbiology of food and water

Food and their composition, Food as substrate for micro-organisms, Important bacteria in food microbiology, Microflora of meat, fish, eggs, fruits, vegetables, juices, flour, canned foods. Food spoilages, Fermented foods (Sauerkraut, Pickle, Soy Sauce, Tempeh, Miso), Bacterial toxins in food, Food-borne diseases and intoxications, Action of microbes on different components of food, Methods of food preservation. Mycotoxins, Microbiological quality assurance, Hazard analysis and critical control point (HACCP) concept, Methods for examination of micro-organisms in food. Composition of milk and factors affecting the composition, Microbiology of milk, Fermented milk products, Cheese, Pasteurisation, Spoilage of milk and its products, Microbiological methods for examination of milk and its products, Probiotics -concept, microorganisms and proteins used in probiotics; Bacteriological standards for milk and milk products.
Microbiology of water, Sources and types of water, Procedures for water purification, Water pollution and its sources, Nuisance bacteria in water, Water-borne diseases and their spread and prevention. Modern tools in food and aquatic microbiology- PCR based techniques, microarrays, sensors.

Unit 8: Industrial Microbiology

Theory and principles of industrial fermentation, Fermentor design, Different types of fermentors used in industrial fermentation, Microbial culture selection, Strain development, The formation and extraction of fermentation product, C&N sources used for industrial fermentation.
New approaches and advances in downstream processing, Primary and secondary metabolites,

Ethanol, Second generation biofuels, Beer, Wine and Cider fermentation.
Enzyme production : Rennet, Cellulase, Amylase *etc*., Microbial enzymes, Immobilisation of enzymes, Organic acid, Vinegar production, Amino acid production : Glycine and Glutamic acid, Biomass production, Microbial insecticides. Single cell protein production for use as food and feed, Vitamin and related compounds (Carotenoid, Vitamin B12, Riboflavin), Antibiotic production, Biotransformation, Bioplastics, Bioprocess cost evaluation. High and low volume/value products, Bioprocess cost evaluation, Product finishing, formulation, encapsulation, immobilization, preservation, quality. Current advances in production of antibiotics, vaccines, Biotransformation, Bioplastics, Production of recombinant DNA products; production of vitamins and fine chemicals, source of single cell protein (SCP). Yeast technology, Genetics and strain improvement for brewing, baking and distilleries.

Unit 9: Applications of microorganisms in agriculture

Role of microbes in bioindustries, Value addition, Production of recombinant vaccines and hormones, Biosensors, Bioflavours, Biowarfare, Bioremediation Bioprocess engineering; Process design for various classes of products. Microorganisms in aquatic environment, pollution control, Bioindicators of pollution, Metal detoxification, Controlled photosynthesis and its application, Bioremediation, carbon sequestration, mitigation of global warming and environmental sustainability. Pesticides: Types, Resistance to microbes and metabolism; Residual effects of pesticides. Extremophiles as source of novel bioproducts, Microbial biofilms and their applications, Anaerobes in industry and environment, Serology and Immunodiagnostics in agriculture, Transplantation immunology. Microbial ore leaching (biomining), Microbial enzymes in clinical diagnostics, Metabolic pathway engineering, Principles of crop inoculation with microbial agents, Overview of microbial inoculants and their production, Carriers for inoculants- types and their characteristics, Strain selection for biofertilizer production and quality control, Mass multiplication – methodology and constraints/benefits, Bulk production (small scale and commercial scale), Setting up of pilot scale inoculant production plants. *Rhizobium*-evaluation as biofertilizer, *Azotobacter*-evaluation as biofertilizer, Phosphate solubilizing microorganisms: Methods for their identification, AM fungi, Ecology of inoculants/ microorganisms in soil, Biocontrol agents. Biogas production technology, Methanogens, Methanotrophs and their applications. Retting and Silage production, Techniques of composting and vermi-compost and their evaluation. Microbial inoculants: Formulation and application methods; Quality standards of inoculants.
Role of microorganisms in sewage treatment, Phyto and microbial remediation approaches; Biological oxygen demand, Effluent management, Integrated systems for pollution abatement and clean water. Microbial strategies for mitigation of stress. Patents and IPR issues in microbiology.

Unit 10: Microbial omics

Microbial Genomics, metagenomics, metatranscriptomics, Proteomics, Microbial functional genomics; Principles, methods and recent advances in DNA sequencing; RNA and protein

sequencing; Microbial Gene Manipulation-Gene fusions and reporter genes; Microbial genes for improving resistance to biotic stresses and tolerance to abiotic stresses in crop plants; Microbial genes for quality improvement in agricultural products and value addition; Concept of Microbiome: Soil and Plant Microbiome. Isolation of metagenome from environmental sources, Development of environmental libraries, DGEE, 16S rDNA community analysis, Functional and sequence based analysis of clones, Bioremediation of recalcitrant compounds. Bioinformatics, Bioprospecting, Microbial diversity and global environment issue, IPR and biosafety.

Unit 11: Data Analysis

Methods of statistical analysis as applied to agricultural data – standard deviation, standard error, accuracy and precision, analysis of variance (ANOVA), correlation and regression; t-test, chi-square (X_2), F test, Probit analysis.
Experimental designs - basic principles, completely randomized, randomized block, Latin square and split plot designs.