

Kadi Sarva Vishwavidyalaya, Gandhinagar

PART-1 (BASIC AWARENESS AND APTITUDE ON RESEARCH) – 50 Marks

PART-2 Syllabus for Ph.D Entrance Test: Microbiology (Marks-50)

- 1. Fundamentals of Microbiology**
- 2. Microbial Physiology & Diversity**
- 3. Immunology & Medical Microbiology**
- 4. Microbial Metabolism**
- 5. Molecular Biology and Genetics**
- 6. Fermentation Technology**
- 7. Environmental Microbiology**
- 8. Recombinant DNA Technology**
- 9. Analytical Techniques**
- 10. Applied Microbiology**

1. Fundamentals of Microbiology

- A. **History of microbiology**- Contributions of pioneers, Spontaneous generation *versus* biogenesis hypothesis, Germ theory, Whittaker's classification system of prokaryotes, Introduction to Bergey's manual of determinative and systematic classification.
- B. **Various groups of Microorganisms**- Bacteria, Fungi, Algae, Protozoa and Viruses, Introduction, classification, Structure and Economic Importance, Maintenance and preservation of microbial cultures
- C. **Morphology of Bacteria**- Size, shape and arrangement of bacterial cells, Structures external to cell wall- Flagella, pili, capsule, sheath and prosthecae, Structures internal to cell wall- Cell membrane, nuclear material, cell wall (Protoplast and Spheroplast), spores, cytoplasmic inclusions, magnetosomes and plasmids.
- D. **Control of Microorganisms**-• Concept of sterilization, disinfection, aseptic and sanitation, Physical methods of control- Temperature, radiation, desiccation, osmotic pressure, filtration, Chemical methods of control- Phenol, alcohol, halogens, heavy metals, dyes, detergents, quaternary ammonium compounds, aldehydes and gaseous chemosterilizers, Evaluation of antimicrobial potency of disinfectants and antiseptics- Tube dilution, Agar diffusion. Phenol coefficient.
- E. **Stains and staining techniques**- Stains and Dyes: classification and types, Types of staining- Simple (Monochrome, Negative), Differential (Gram and Acid fast) and Structural Staining.

2. Microbial Physiology & Diversity

- A. **Microbial Growth & Measurement**: Normal growth curve of bacteria, Growth rate, generation time, Continuous growth, and synchronous growth, Diauxic growth, Efficiency of growth, growth yield, maintenance of energy, Criteria for growth measurement, Cell mass, Cell number and cell constituent(C -Content N-Content, ATP Bioluminetry Method) measurements methods.
- B. **Cultivation and Pure Culture Techniques** : Nutritional requirements and nutritional types of bacteria, Classification of bacteria on the basis of growth supporting environmental factors such as Oxygen, Temperature, pH,

osmotic pressure, Salt and Hydrostatic pressure, Bacteriological media (types and uses), cultivation of aerobic and anaerobic microbes, Various Isolation techniques.

C. **Prokaryotic Diversity** : Cyanobacteria, Gram positive bacteria, Gram Negative bacteria, photosynthetic bacteria, spirochetes, Chlamydiae, Rickettsiae, and Mycoplasma.

D. **Eukaryotic & Akaryotic Diversity**: Fungi, Algae, Protozoa, Slime molds, Viruses, Virions and prions.

E. **Extremeophilic diversity**: Thermophiles, Acidophiles, Alkalophiles, Halophiles and Methanogens.

3. Immunology & Medical Microbiology

A. **Immune System and Immune Response**: Organs of Immune system- Spleen, thymus and lymph nodes, Cells of Immune system- T cells- its types and receptors. B cells and its receptors, Immunity- Innate and acquired, Host defense mechanism- First, second and third line of host-defence. Primary and secondary responses. Antigens, Haptens, Cluster of Differentiation Molecules.

B. **Antigens and Antibodies**: Antigens- Properties and types, Adjuvants, Immunoglobulin- Separation, structure and types, Generation of antibodies, Antibody diversity, Agglutination and precipitation reactions, Hemagglutination and PHA, Immunofluorescence, ELISA, RIA, Coombs test (Direct and Indirect), Complement- Components and biological activities.

C. **Immune Disorders**: Immunodeficiency. Hypersensitivity Hypersensitivity- Immediate and delayed type. Autoimmunity- Mechanism & Classification of Autoimmune diseases, Immunology of Transplantation: Classification of Transplants. Allograft reaction-(mechanism), Factors favouring Allograft survival. Graft v/s Host reaction. Immunology of Malignancy.

D. **Antimicrobial Agents**: Antibiotics- Mode of action, Development of resistance, Transmission of drug resistance, Antiviral, Antiprotozoal and antifungal drugs.

E. **Microbial Diseases** Anthrax, Pertussis (whooping cough), Botulism, Rocky Mountain, Spotted Fever, Cholera, Strep throat, Chlamydia, Syphilis,

Dental Caries (tooth decay) , Tetanus, Tuberculosis, Lyme Disease , Peptic Ulcer Disease, Fungal skin infections- Mycosis, Candidiasis, Virus- Measles, Mumps, Hepatitis, Rabies and HIV, Protozoa- Malaria and Amebiasis

4. Microbial Metabolism

- A. **Enzymes:** Introduction to Enzymes, nomenclature and classification of enzymes. Enzymes as biocatalysts, catalytic power, activation energy, substrate specificity, active site, theories of mechanisms of enzyme action. Factors affecting enzyme activity and catalysis: pH, substrate and enzyme concentration, temperature, coenzyme and cofactors, Isolation & purification of enzymes. Methods of enzyme assay. Derivation of Michaelis - Menton equation and its significance, Multi-enzyme system, Types of Enzyme inhibition and Mechanism of regulation of enzymes, membrane transport mechanisms.
- B. **Carbohydrate metabolism:** Classification and biological importance of Sugar. Aerobic and anaerobic glycolytic pathways. TCA cycle and various fates of Glucose 6 Phosphate in a cell - Gluconeogenesis, glycogen synthesis and breakdown. ATP Cycle, High energy compounds; Electron transport chain order and organization of carriers, proton gradient, respiratory controls and oxidative phosphorylation, ATP- synthetase complex. ED and PPP pathways.
- C. **Protein and Amino acid metabolism:** Proteins structure: Classification of amino acids; Primary, secondary, tertiary and quaternary structure of proteins. Properties of amino acids, Biosynthesis and degradation of amino acid. Urea cycle. Nitrogen balance, Regulation of amino acid metabolism in microbial system.
- D. **Lipid metabolism:** Classification of lipids. α , β and δ oxidation of fatty acids, metabolism of fatty acids with even and odd carbon atoms, saturated and unsaturated fatty acids. Metabolism and synthesis of phospholipids, glycolipids and sphingolipids; Ketone bodies -formation and degradation, Mobilization of fats.
- E. **Nucleic acid metabolism:** Brief overview of central dogma. Structure of nucleoside, nucleotides, purines and pyrimidines. Biosynthesis and regulation of purines and pyrimidines. Structure and Function of Ribonucleotide reductase.

5. Molecular biology and Genetics

- A. **Fundamentals of genetics:** Gene, allele, genotype, phenotype, intron, exon, cistron, recon, muton, plasmid, chromosome, genome, zygote, merozygote, Experimental proof for DNA as genetic material: Work of Griffith;

Avery, McCarty and MacLeod; Hershey and Chase, Genome organization: DNA Packing ratio, Prokaryotic genome - nucleoid and Chemistry of DNA, Watson and Crick's model of DNA structure, Semi conservative nature, Meselson and Stahl's experiment. Replication of DNA in prokaryotes - Molecular mechanism: Strand separation, formation of leading and lagging strand, Termination. Differences between prokaryote and eukaryote replications.

- B. **Gene Expression in Prokaryotes:** RNA Synthesis in Bacteria. Prokaryote RNA polymerase and Mechanism of Transcription in prokaryotes- Initiation, elongation & Termination. Differences between Prokaryote & Eukaryote Transcriptions. Overview of Post-Transcription Modifications in Eukaryotes. Genetic Code: Characteristics of Genetic Code. Translation: tRNA & ribosome, Mechanism of translation in Prokaryotes & Differences between Prokaryote & Eukaryote Translation, Post- translational modification of proteins.
- C. **Mutation:** Evidence for spontaneous nature of mutation, Molecular basis of mutation- Types of mutation, Types of bacterial mutants and their isolation, Mutagenic agents- Physical and chemical mutagens. Mutation rate and Ames test. DNA Damage and DNA Repair mechanisms.
- D. **Genetic Recombination:** Transformation- Competence, DNA uptake, artificially induced competence, electroporation. Transduction- U tube experiment, Generalized and specialized transduction. Conjugation- F factor, characters of donor and recipient, Steps in conjugation, formation of Hfr and F prime cells. Transposable elements, Plasmid- Structure, properties and types of plasmids,

6. Fermentation Technology

- A. **Introduction to Fermentation & Bioprocess Technology:** primary secondary metabolite.. Primary and secondary screening, Inoculum development, Scale up of bioprocesses. Fermentation media.
- B. **Strain Improvement:** Strategies of strain improvement: Feed Back Inhibition and Regulation, Recombination, Mutagenesis, Mutant – Auxotrophic , Analogue, Revertant, Strain improvement by modifying properties other than the yield of product.
- C. **Sterilization, Design of Fermenter and Types of Fermentation process:** Sterilization of media: Batch and Continuous, Sterilization of air and Fermenter, Types and kinetics of fermentations processes- Batch, Continuous and Fed batch, Design of typical batch fermenter, Types of fermenters. Airlift,

Tower, Cyindroconical, Cyclone column, Packed bed reactor, Stirrer Tank, Fluidised Bed reactor.

D. Downstream processes : Separation of microbial cells and suspended solids: Filtration, Centrifugation, Flootation and Flocculation, Intracellular product recovery: Cell disruption, Concentration of products : Solubilization, solvent extraction, precipitation and distillation. Purification of products : Crystallization, Chromatography, ultrafiltration, evaporation and drying. Introduction to Fermentation economics.

E. Industrial production: Penicillin, Amylase, Ethanol, Cyanocobalamin. Citric Acid, Gutamic Acid, SCP, Mushroom.

7. Environmental Microbiology

A. **Environment and Ecosystem:** Structure of earth Environment, Abiotic and Biotic Factors of Environment, Concept of various microbial Interactions among microflora , Concept of ecology, Structure, function and types of ecosystem Biomes, Ecological pyramids- pyramid of numbers, pyramid of biomass, pyramid of energy, Ecological succession.

B. **Waste water treatment:** Introduction to waste water treatment, Preliminary, Primary, Secondary: Introduction to aerobic and anaerobic treatment system Difference between aerobic and anaerobic waste water treatment, Aerobic and anaerobic waste water treatment systems, Tertiary treatment systems: Nitrogen removal, Phosphorus removal, removal of microbes.

C. **Biodegradation:** Microbiology of degradation of Xenobiotic in environment: Degradation of simple aliphatic, aromatic, polycyclic aromatic hydrocarbons, halogenated hydrocarbons, Surfactants, azo dyes, Insecticide: DDT, Herbicide: 2,4 D, Degradative plasmids: Plasmids involved in degradation of Toluene, 2,4-D, Superbug : Discovery of superbug and its role . Concept of Biodeterioration and Biomagnification.

D. **Bioremediation:** Principles of Bioremediation, Strategies of bioremediation: In situ and ex situ bioremediation technologies. Bioremediation of metals, Phytoremediation. Composting, Vermicomposting.

E. **Biogeochemical cycles:** Carbon cycle, Nitrogen Cycle, Sulphur cycle, and Phosphorus cycle.

8. Recombinant DNA Technology

- A. **Consent of R-DNA Technology:** Overview, Strategy of r-DNA technology
Tools of r-DNA Technology. Restriction Endonucleases, Methylases and other enzymes used in R-DNA Technology.
- B. **Cloning Vectors:** Plasmids, bacteriophages, cosmids, phagemids, artificial chromosome vectors (YAC, BAC), Animal virus derived vectors - SV40 and retroviral vectors.
- C. **Isolation of DNA:** Genomic DNA libraries, Shot gun gene cloning, cDNA libraries, full length cDNA cloning, Transformation of recombinant DNA.
- D. **Screening of Recombinants:** Techniques used for screening of recombinants- Insertional-Inactivation method. Blue-white selection, colony hybridization, plaque hybridization.
- E. **Techniques used in r-DNA technology:** Gel electrophoresis, Southern, Northern and Western blotting techniques. RFLP, RAPD and AFLP techniques , PCR. DNA sequencing

9. Analytical Techniques

- A. **Microscopy:** Bright Field, Dark Field, Phase Contrast, Fluorescence, Electron microscopy: SEM, TEM, phase contrast and fluorescence microscopy & scanning tunneling microscopy.
- B. **Chromatographic techniques:** Principle, methodology and applications of Paper, Thin layer gel – filtration, ion –exchange and affinity chromatography; and gas chromatography; High performance liquid chromatography.
- C. **Electrophoresis:** Principles, Factors affecting electrophoresis, types of Electrophoresis- Zone; Gel: PAGE, SDS, Isoelectric, Immune & Pulsed Field Gel Electrophoresis.
- D. **Spectrophotometry:** Principle, Instrumentation Method and Application of UV-Visible Spectroscopy, Atomic Absorbtion Spectroscopy, Flame Photometry, Nephelometry, Mass spectroscopy. Fluorescence spectroscopy, Raman spectroscopy
- E. **Centrifugation** : Basic Principles of Sedimentation, Methods and Applications of Density Gradient Centrifugation (Rate Zonal and Isopycnic), Ultracentrifugation. Types of Rotors.

10. Applied Microbiology

- A. **Biofertilizers and Biopesticides:** Nitrogen fixers, PSB, KSB and Mycorrhiza. Biopesticides- *Bacillus thuringensis* toxin and commonly used biopesticides

based on fungi, bacteria and viruses, Genetically modified crops containing insecticidal genes

- B. Biofuels:** Fuel from microorganisms – Bioethanol, Biodiesel, Biogas technology, Microbial hydrogen production, Concept of gasohol. Bioconversion of cellulosic waste.
- C. Biosensors and Biopolymers:** Enzyme-based biosensors, applications of biosensors, Biochips, Microbial Biopolymers – Biodegradable plastics, Biofilms, Microorganisms as bioindicators.
- D. Immobilization of enzymes and Cells:** Immobilization techniques: Adsorption, matrix entrapment, encapsulation, cross-linking, covalent binding and suitable examples, Bioreactors used in immobilization, applications of immobilized enzymes and cells.
- E. Biohydrometallurgy and MEOR:** Microbial leaching of copper, Zinc and uranium, Various types of Bioleaching: Dump, heap and insitu leaching. Biorecovery of petroleum- Microbial enhanced Oil Recovery process.