

## Syllabus for entrance exam for admission to PhD program in Department of Microbiology

### **MICROBIAL PHYSIOLOGY, METABOLISM & BIOCHEMICAL TECHNIQUES**

Measurement of growth, growth physiology, cell division, growth yields, growth kinetics, steady state growth and continuous growth. Primary and Secondary transport: Introduction, Kinetics, ABC transporters, Phosphotransferase system, Drug export systems, amino acid transport. Glycolysis, PPP, ED pathway, Citric acid cycle: Branched TCA and Reverse TCA, glyoxylate cycle. Utilization of sugars other than glucose and complex polysaccharides, Nitrogen assimilation, Lipid composition of microorganisms, biosynthesis and degradation of lipids. Enzyme kinetics, Rapid Equilibrium, Aqueous solution, pH, and buffer, spectrophotometry, Steady State approach, significance of Km, Haldane equation, Velocity vital Substrate concentration curves. Methods of plotting enzyme kinetics data- Lineweaver-Burk, Hanes-Woolf, Eadsie-Scatchard; Advantages and disadvantages of the methods. Enzyme Inhibition, Models and types of inhibition.

### **MICROBIAL GENETICS**

Genetic analysis of bacteria and phage: Mutations, selection of mutants, analysis by complementation and recombination tests, gene replacements. Gene transfer by conjugation: Self-transmissible and mobilizable plasmids, mechanism of conjugation. Mapping bacterial genomes using Hfr strains. Chromosomal DNA transfer by plasmids. Gene transfer by transformation and transduction: Natural transformation and competence, DNA uptake systems in bacteria, Regulation of competence in *B.subtilis*. Generalized and specialized transduction. Mapping bacterial genes by transduction. Lambda phage: gene and promoter organization, lytic cycle, establishment and maintenance of lysogeny. Events leading to induction – role of *ci* and *cro* repressors in regulating the events. Transposons: Bacterial transposons, molecular mechanisms and effects of transposition, conjugative transposons. Transposon mutagenesis. Mu transposon and derivatives. Yeast Ty-1 transposon. Site-specific recombination – loxP-Cre system, phase variation system in Salmonella. Gene regulation: Control of gene expression using *lac*, *trp*, *gal*, *ara*, *tol* operons as models.

### **IMMUNOLOGY**

Organization of immune system, structure & organization of spleen, lymph nodes, gut associated lymphocytes tissue (GALT), major histocompatibility (MHC) system and its functions, hybridoma technology, monoclonal antibodies, humoral immune system, cell-mediated immune system, natural killer (NK) cells, and dendritic cells (DC). Tolerance and its mechanism, autoimmunity and its mechanisms, immune deficiencies of B & T cells, Type I, II, III, IV hypersensitivity, tumor immunology, tumor antigens, immune therapy, transplantation immunology, GVHD, HLA-matching, xenotransplantation.

### **MICROBIAL PATHOGENICITY**

Normal microflora of the human body, pathogenicity and virulence, carriers and their types, nosocomial infections, opportunistic infections, general modes of transmission of microbial infections, symptoms, pathogenesis and control of common bacterial, viral and fungal infections: *Corynebacterium diphtheriae*, *Staphylococcus aureus*, *E.coli*, *Salmonella typhi*, *Shigella dysenteriae*, *Vibrio cholerae*, *Neisseria gonorrhoeae*, *Mycobacterium tuberculosis*, *Treponema pallidum*, Polio, Rabies, *Herpes simplex*, & dermatomycoses. Antibiotic resistance- basic mechanisms, MRSA, x-MDR. Mechanisms of action of important antibiotics. Principles and applications of basic microbial diagnostic test: ELISA, immunofluorescence, nucleic acid amplification and probe based methods.

### **VIROLOGY**

Virus infectious cycle, cultivation of viruses, assay of viruses, one step growth cycle. Structure of virus, viral genomes, virus attachment and entry, synthesis of RNA from virus RNA templates, reverse transcription and integration in retroviruses and hepadnaviruses, synthesis of RNA from viral DNA templates, replication of DNA virus genomes, processing of viral pre-mRNA, virus translation strategies, intracellular trafficking of viruses, assembly exit and maturation of viruses. Viral tropism, mechanism of virus pathogenesis, virus mediated cellular transformation and oncogenesis, viral vaccines, antiviral drugs, virus evolution, emerging viruses. Unusual infectious agents including viroids, satellites, prions.

## **MOLECULAR BIOLOGY**

The nature and structure of genetic material, organization of prokaryotic and eukaryotic genomes.

DNA replication in prokaryotes and eukaryotes: mechanism of replication, enzymes and other proteins involved, DNA copy number maintenance, telomere maintenance, chromatin assembly, regulation of DNA replication, inhibitors of DNA replication. Transcription in prokaryotes and eukaryotes: mechanism and machinery of transcription including enzymes and transcription factors, promoters, enhancers, silencers, activators. Post-transcriptional RNA processing. Transcriptional and post-transcriptional regulation, inhibitors of transcription. Translation in prokaryotes and eukaryotes: Genetic code, mechanism and machinery of translation including various enzymes and factors, ribosomes and tRNA, translation initiation complex. Regulation of translation, inhibitors of translation. Post-translational processes: Protein modification, folding.

## **RECOMBINANT DNA TECHNOLOGY**

Methods of DNA, RNA and protein analysis: Agarose and polyacrylamide gel electrophoresis and blotting techniques. RFLP analysis, DNA fingerprinting and its applications. Cloning techniques including use of linkers and adaptors, use of plasmid, phage, cosmid, BAC and YAC vectors. PCR and its applications: Concept, mechanism, enzymes, primer design, cloning PCR products, RAPD, overlap PCR, ligation chain PCR, inverse PCR, RT-PCR including 5' and 3' RACE and real time PCR. Construction and screening of cDNA and genomic DNA libraries. DNA sequencing: Sanger's, whole genome sequencing and annotation, next generation sequencing. Transcriptional analysis and transcriptomics: Use of reporters, promoter mapping by S1 and primer extension, transcriptome analysis by DNA microarrays, SAGE and RNA-seq.

Expression of recombinant proteins: in *E.coli*, in *P. pastoris*, baculovirus expression system, tet-regulatable mammalian cell expression systems. Analysis of protein-DNA and protein-protein interactions: EMSA, DNA footprinting, ChIPs. Yeast two and three hybrids. Co-immunoprecipitations and pull-downs. Use of GFP, FRET, BiFC. Phage display. Protein engineering and Proteome analysis: mutagenesis. Proteome analysis by 2D gel electrophoresis coupled to mass spectrometric analysis. Protein arrays and their applications.

## **ENVIRONMENTAL MICROBIOLOGY**

Microbial diversity in extreme environments: Occurrence, diversity, adaptations and potential applications of oligotrophs, thermophiles, psychrophiles, barophiles, organic solvent and radiation tolerants, metallophiles, acidophiles, alkaliphiles and halophiles. Global warming: The source and variety of gases which contribute to global warming, effects of global warming and remedial measures. Liquid waste management: Treatment of sewage (Primary, Secondary and Tertiary treatments) and Treatment of Industrial effluents (distillery, textile, pulp and paper). Solid waste management: Waste types & their possible usages, landfill development and composting. Bioremediation of environmental pollutants: Petroleum hydrocarbons and pesticides. Microbial mineral recovery

## **INDUSTRIAL AND FOOD MICROBIOLOGY**

Types of fermentation and fermenters, process optimization, and recent developments in fermentation technology. 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). Downstream processing of microbial products: Filtration, centrifugation, cell disruption, liquid-liquid extraction, chromatography, membrane processes, drying (lyophilization and spray drying), and crystallization. Microbial spoilage of foods and Food preservation: Food-borne diseases and fermented food products