St. Joseph's University

St. Joseph's Research and Innovation Council

School of Life Sciences

Department of Microbiology

Ph.D Entrance Examination Syllabus

Unit I: Microbial Diversity

Microbial Taxonomy: Natural system of classification, binomial nomenclature. Concepts of taxon, species, strain. Criteria used for classification. Three domain classification, classification according to Bergey's manual of systematic bacteriology. Introduction to archaea domain-extremophiles

Recent trends in Microbial Taxonomy: **a)** Chemotaxonomy: cell wall components, lipid composition, isoprenoid-quinones, cytochrome composition. **b)** Molecular method: DNA homology, G + C ratio, rRNA sequencing (principle & type of rRNA used in specific microbe identification) **c)** Numerical taxonomy **d)** Genetic methods in taxonomy, Basic concept/overview of Next Generation Sequencing and Barcoding.

Unit II: Cell Biology

Structural organization: Cell membrane- fluid mosaic model, bi-lipid layer.

Endomembrane system: Endoplasmic reticulum, golgi apparatus, lysosome, peroxisomes, vacuoles, mitochondria, chloroplast and nuclear components.

Cytoskeleton: Components and structural functions, types of filament: microtubules, intermediate filaments, microfilaments– assembly and disassembly, molecular motors and sarcomere regulation, eukaryotic cell motility.

Transport across membrane: Transmembrane transport of small molecules; endocytosis and exocytosis Protein trafficking; vesicular trafficking Prokaryotic type I, II, III secretion systems.

Integrating cells into tissues: Cell junctions and adhesions (cell-cell and cell-matrix), extracellular matrix.

Unit III: Molecular Genetics

Nucleic acids

Historical Perspective: DNA as the source of genetic information in bacteria and viruses: Griffith's experiment, Avery's experiment, Hershey and Chase experiment. RNA as the source of genetic information in TMV - Frankel-Conrat's experiment, Retrovirus (HIV).

Organization and Molecular structure: DNA structure, forms of DNA, DNA topology, DNA supercoiling, VNTRs, mini and micro genomes, Satellite DNA, Structure of RNA (Unusual forms: Tetraloop, Pseudoknot and U:A:U base triple). Genome organization (prokaryotes).

Properties of DNA: Denaturation, Renaturation (Filter binding assay and concentration dependent renaturation) and DNA heteroduplexes, G-quadruplexes. DNA constancy and C-value paradox.

DNA replication in prokaryotes and Eukaryotes: DNA replication in Prokaryotes: Origin of replication, replication fork, leading and lagging strand, semi conservative replication, rolling circle replication, enzymes involved in prokaryotic replication and DNA proof reading.

Unit IV: Microbiological Techniques

Microscopy and Staining: Principles of Microscopy (Properties of light), Light Microscopy, Bright Field Microscope, Phase Contrast Microscope, Dark Field Microscope, Fluorescence Microscope, Stereo Microscope, Preparation and staining of specimen (simple, differential and structural staining), Electron Microscopy, Transmission Electron Microscope, Scanning Electron Microscope, Newer techniques in Microscopy, Scanning Tunneling Microscope, Confocal Microscope, Atomic Force Microscope, Image analysis.

Sterilization Techniques

Control of microorganisms by physical agents: Fundamentals of control, Physical agents (high temperature, low temperature, desiccation, osmotic pressure, radiation, surface tension and interfacial tension, filtration).

Control of microorganisms by chemical agents: Characteristics of an ideal antimicrobial chemical agent, Major groups of antimicrobial agents (phenol and phenolic compounds, alcohols, halogens, heavy metals, dyes, detergent, quaternary ammonium compounds, aldehydes, gaseous agents), Evaluation of antimicrobial chemical agents (tube dilution and agar plate techniques, phenol coefficient method)

Unit V: Medical Microbiology

Bacterial diseases: List of diseases of various organ systems and their causative agents. The following diseases in detail with Culture, Signs Symptoms, mode of transmission, virulence, pathogenesis, laboratory diagnosis, prophylaxis and control. Respiratory Diseases: *Streptococcus pyogenes, Mycobacterium tuberculosis.* Gastrointestinal Diseases: *Salmonella typhi, Vibrio cholerae, Helicobacter pylori,* Skin: *Staphylococcus aureus, Clostridium tetani, Treponema pallidum, Pseudomonas aeruginosa.*

Viral, Fungal and Parasitic diseases:

Viral diseases: List of diseases of various organ systems and their causative agents. The following diseases in detail with Signs, Symptoms, mode of transmission, pathogenesis, laboratory diagnosis, prophylaxis and control; DNA viruses - Herpes, Hepatitis B virus, RNA viruses - Dengue, Zikka, H1N1, Corona, Viral zoonoses – Rabies, Oncogenic viruses.

Fungal diseases: Classification of medically important fungi. Brief description of each of the following types of mycoses and one representative disease to be studied with respect to transmission, symptoms, culture, laboratory diagnosis, pathogenesis, prevention and control.
Cutaneous mycoses- Tinea pedis (Athlete's foot), Yeast -*Cryptococcus neoformans,* Yeast like - *Candida albicans.* Filamentous –*Aspergillus spp* Dimorphic- *Histoplasma capsulatum.*

Parasitic diseases: *Giardia lamblia* and *Plasmodium spp.*

Unit VI: Industrial Microbiology

Basic design and function of a fermenter. Types of fermenters: stirred tank fermenters, tubular fermenters, tower fermenters, air-lift fermenters, membrane bioreactors, photo bioreactors, disposable fermenters, fluidized bed fermenters. Solid-state fermenters: tray fermenters, drum fermenters. Media sterilization, sterilization of fermenter, sterilization of air supply. Aseptic inoculation methods, sampling methods, monitoring and control devices. Fermentation media: media formulations, sources of carbon, nitrogen, vitamins and minerals. Role of buffers, precursors, inhibitors, inducers and antifoam agents. Development of inoculum for bacterial, fungal, and actinomycetes; Substrate for solid state fermentation; Power requirement, Oxygen transfer kinetics. Concepts of Newtonian and non-Newtonian fluids, plastic fluids, apparent viscosities.

Isolation, preservation and improvement of industrially important microorganisms:

Isolation methods, screening methods, preservation techniques, strain improvement, protoplast fusion, parasexual cycle and recombinant DNA techniques. Immobilization of enzymes and cells: methods, advantages and applications.

Unit VII: Biostatistics

Samples and Population, Variables in Biology, Sampling methods. Frequency distribution, Graphic presentation of data-histogram, frequency curve and ogives. Introduction to statistics in R, Measures of Central tendency – mean, median and mode Measures of dispersion – range, mean deviation, standard deviation, standard error, variance. Probability distribution binomial, poison and normal. Student “t” distribution. Point estimation and interval estimation. Estimating the population mean, known and unknown. Wilcoxon signed Rank test. Null and alternate hypothesis. Two tailed and one tailed test. Chi-square test – test of independence, goodness of fit and homogeneity Correlation – definition, types, and measurements of correlation. Regression analysis – equation, estimation of unknown value from known value. ANOVA – one way and two-way classification – Least significance difference (LSD). Randomization – bootstrapping.

Unit VIII: Bioinformatics

Databases: Introduction to data bases-Relational databases- Oracle, SQL, Database generation, Sequence databases- NCBI – BLAST Resources- Human Genome Project (HGP), Microbial genomes, structural databases- protein data Bank (PDB), Organization of databases, Navigation through databases.Tools For Data Bank - Pairwise Alignment - Needleman and Wusch Algorighm – Smith Waterman - Multiple Alignment - Clustral - Pras - Blast - Fast, Algorithms to analyse Sequence Data - Pdb, Cambridge Structure Data Base. Protein Sequence Analysis - Introduction - Sequence Data Banks - Wbrf – Pir – Swissport - Databases, Data Mining - Algorithms of Proteomics And Its Applications – Protein expression Profiling - Protein - Protein Interaction - Protein Modifications. Automation - Nucleic Acid Data Bank – Embl Nucleotide Sequence Data Bank - Aids Virus Sequence Data Bank - Rna Data BanK. 'Next Gen' Sequence Analysis (RNA-Seq) / Metagenomics; Introduction to Hidden Markov Models, Analysis and interpretation of results: 2D Electrophoresis, HPLC, Mass Spectrometry, Mass Fingerprinting.

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