**Ph.D. (Microbiology) Entrance Exam Syllabus**

**(2019-20)**

**Instructions for Paper Setter:**

1**.** Paper setters have to set **100** multiple Choice questions of two marks each out of given syllabus.

2. All questions should be multiple choice with four options.

**Research Methodology**

1. Laboratory safety (General rules & regulation) Handling and culturing of microbes. Culture media. Sterilization method, Sources of obtaining culture of microorganisms.
2. Different techniques/ instruments used in microbiology-Microscopy, Centrifugation, Spectroscopy Chromatography, Electrophoresis, PCR, DNA sequencing ,Fermenter, Measurements of microorganism ( Micrometry), counting of cell (Heamocytometer)
3. Isolation techniques for deferent type of microorganism from various sources-Air,Water,Soil, Infected/Diseased samples (Human & plant), Food samples etc. Purification techniques.
4. Serological reaction-Precipitation reaction, Agglutination reaction, RIA, ELISA, Immunofluorescence.
5. Assaying of enzyme activity-Amylase, Protease, Lipase, Cellulase & Hemicellulase.
6. Culture medium, types, ingredients, preparation and applications.
7. Maintenance and preservation of microorganism.
8. Morphological, cultural and biochemical characterization of bacteria.
9. Production and detection of mutants, curing of plasmids.
10. Antibiotic susceptibility and minimal inhibitory concentration of antibiotics
11. Recombinant DNA technology and gene cloning. Cloning vectors (Plasmids, phages, cosmids and gene libraries) Application of RDT in industrial microbiology and biotechnology

**Subject specific**

General & Environmental Microbiology

Discovery of microbial world: Scope and relevance of Microbiology .Role of microbes in diseases. Histological Development of Microbiology, Discovery era - Antony van Leeuwenhoek, Transition period - Francesco Redi ,Golden age of Microbiology -Louis Pasteur, Robert Koch, Stanley, Edward Jenner, Elie Metchnikoff, Era of chemotherapy- Alexander Fleming, , Microbial genetics - Joshua Lederberg and the modern molecular biology era.

Current status of microorganisms in the living world: Prokaryotic and eukaryotic cells (Diagnostic features of Bacteria, Archea Viruses, Fungi and Protozoans). Whittaker’s five kingdom concept, Three domain concept of Carl Woese. Classification of Bacteria according to the Bergey’s Manual of Determinative Bacteriology (outline).

Method of studying microorganisms: Pure culture techniques .Maintainence of pure cultures. Sterilization (Physical agents), Media for growth of microorganisms in the Laboratory. Micrometery. Simple and differential staining.

Microbiology of Air: Significance of air microbiology , Droplet nuclei, aerosol. Diversity of microorganisms in air. Outdoor and indoor microflora. Night fungal flora. Determination of the microbial content of the air. Aeroallergens. Control of air borne microorganisms.

Microbiology of waste disposal: Water microbiology and its significance- Waterborne diseases and their preventive measures. Microbes in sewage treatment system (Primary, Secondary, Tertiary and Final).Disinfection of potable water supplies. Bacterial indicators of water safety and their assessment.

Soil Microbiology: Significance of soil microbiology. Contributions of Beijerinek & Winogradsky. Diversity of soil microorganisms. Interactions between soil microorganisms (symbiosis, mutualism, commensalism, Neutralism, parasitism antagonism – competition, antibiosis, predation). Rhizosphere, mycorhizosphere and actinorrhizae.

Bioremediation and Biocontrol: Microbial degradation of Pesticides and natural products (cellulose, xylan, lignin).Biopesticides (*Bacillus thuringiensis* (Bt) toxin, Boverin, DeVine, Collego), Biofungicides (Control of *Fomes annosus*).

Mycology and Phycology

An Introduction to Fungi: Scope and significance of mycology .Major contributions of P.A.Micheli, E.M.Fries, Anton de Bary, E.J.Butler. Diagnostic features, somatic structure, mode of asexual and sexual reproduction in fungi.

Classification of fungi: Current status of fungi, criteria used for classification with reference to Ainsworth and Alexopoulos & Mims. Diagnostic features of major fungal divisions (Zygomycota, Ascomycota, Basidiomycota and Deuteromycota).

Reproduction in fungi:Heterothallism, sexual and parasexual cycles, Dimorphism.

Fungi and ecosystem: Substrate succession (Hudson & Garrett concept), Fungal interactions , symbiosis with plants (mycorrhizae) and algae (lichens).

Life cycles of industrially and medically important molds and yeasts : *Rhizopus, Aspergillus, Pencillium Cladosporium, Histoplasma, Microsporum, Epidermophyton, , Saccharomyces , Candida and Cryptococcus.*

Life cycles of important plant pathogens : *Phytophthora, Puccinia, Venturia, Alternaria, Colletotrichum*.

Fungal biotechnology in industry and agriculture: Alcholic beverages (Beer, wine), bread and fermented foods; mushrooms as a food; major antibiotics from molds (production of penicillin), fungi as biocontrol agents.

Algae: Distribution of algae, classification of algae, Somatic structure, asexual ansd sexual reproduction of microbiologically important genera of chlorophyceae, Phaeophyceae, Bacillariophyceae and Rhodophyceae. Algal nutrition, algal thallus, algal, ecology and biotechnology.

Microbial Physiology and Metabolism

Morphological types of prokaryotes. Structure & functions of cell wall of archaebacteria, gram positive & gram negative bacteria, cell membrane, capsule, flagella, pili, gas vesicles, carboxysomes, magnetosomes, nucleoid, bacterial endospore. Reserve food material- poly β-hydroxy butyrate, poly-phosphate granules, sulphur inclusions, cyanophycin granules. Peptidoglycan synthesis. Cell differentiation – sporulation and germination in *Bacillus.*

Microbial growth and its measurement, growth curve, generation time. Batch, continuous and synchronous growth. Nutrition types, cultivation of microorganisms. Factors affecting growth-solutes, pH, temperature and oxygen. Transport of nutrients across the cell membrane- passive, facilitated, active transport and group translocation. Bioluminescence in bacteria.

Metabolites-primary, secondary and precursor. ATP generation, oxidative and substrate level phosphorylation, electron transport chain. Carbohydrate metabolism- Glycolysis, Entener Doudoroff pathway, Kreb cycle, glyoxalate pathway and gluconeogenesis . CO2 fixation and reverse TCA.

Anoxygenic and oxygenic photosynthesis. Brief account of chemolithotrophy - Sulphur, iron and hydrogen oxidation, nitrification and methanogenesis. Fermentations- definition and types, homo & heterolactic fermentation, ethanol, acetate, mixed acid, butanediol, butanol, acetone, ethanoacetate fermentation. Pasteur effect

Microbial Biochemistry

Enzyme Classification: - Specificity, active site, activity unit, isozymes. Enzyme kinetics. Mechaelis Menton equation for simple enzymes. Ribozyme and abzyme. Determination of kinetic parameters. Multistep reactions and rate limiting steps, enzyme inhibition, allosterism. Principles of allosteric regulation.

Basic aspects of bioenergetics: Entropy, enthalpy, e- carriers, e- donors, inhibitors, uncouplers, energy bond. Flow of energy through biosphere, strategy of energy production in the cells, oxidation- reduction reactions, coupled reactions, group transfer, ATP production , Free energy and spontaneity of reaction G. G0, G′& equilibrium, basic concepts of acid, base, pH, and buffers.

Structure and classification of Macromolecules: - Proteins, carbohydrates, lipids and nucleic acids. Vitamins and their role as co-enzymes.

Cell metabolisms: - Catabolic principles & breakdown of carbohydrates anaplerotic reaction. β-oxidation of fatty acids. Deamination of amino acids and urea cycle. Biosynthesis of Lipids- fatty acids. Triacyl glycerol, phospholipids and regulation of fatty acid metabolism. Denovo and salvage pathways of synthesis of purine and pyrimidine.

Cellular Microbiology

Introduction: Emergence of cellular microbiology, cellular biology underlying prokaryotic and eukaryotic interactions: ultrastructure, genome expression, pathogenicity island.

Prokaryotic and eukaryotic signaling mechanisms: Eukaryotic cell to cell signaling, endocrine signaling, cytokines prokaryotic signalling: qurorum sensing and bacterial pheramones intracellular signaling, signaling pathways.

Infection and cell-cell interaction: Bacterial adherence: basic principles, effect of adhesion on bacteria, effect of adhesion on host cells. Bacterial invasion on host cells, mechanisms, consequence of invasion, survival after invasion. Protein toxins: agents of disease.

Cellular microbiology future directions:- Comparative genomics and functional genomics . Genome evolution in microbes. Phylogenetic trees.

Microbial Genetics

Nucleic acid: Experimental evidences as genetic material, DNA structure Watson crick model, Denaturation and renaturation kinetics, Cot value, different DNA polymerases, proof reading activity ,superhelicity in DNA, linking no, topological properties, mechanism of action of topoisomerases.

DNA replication: General principle, Initation ,elongation and termination, Semiconservative replication, different modes of replication, unidirectional and bidirectional replication ,replication in retroviruses ,inhibitors of DNA replication ,relationship between cell cycle and replication.

Mutation: Molecular basis of mutation, mutagenesis; type of mutants and mutagenic agents (physical, chemical), ames test, DNA repair (methyl directed mismatch repair, base excision repair, nucleotide excision repair, recombination repair), SOS system.

Recombination: Molecular mechanism of gene transfer in bacteria and their role in gene mapping.

Transformation: molecular mechanism, competence, Natural and artificial transformation

conjugation: F+, F-, Hfr ,F’ ,interrupted mating, endogenote ,exogenote

transduction: Specialised and generalized , induction

transposable genetic elements :mechanism and significance of transposition

Elements of Molecular Biology

Transcription:General principle, basic apparatus, initation, elongation, termination ,types of RNA polymerases ,monocistronic and polycistronic RNA, regulation at intiation ,alternate sigma factor, rho dependent and independent termination, hairpin and attenuation

Maturation and processing of RNA: methylation, poly A tail, capping, cutting and degradation of tRNA, splicing mechanism (group1 groupII introns)

Basic feature of genetic code: triplet code, deciphering, degeneracy, colinearity of gene and polypeptide, variation in different organism, wobble hypothesis.

Translation:Basic apparatus, initation ,elongation, termination ,coupled transcription and translation, aminoacyl site, peptidyl site, initiation, elongation and termination factors , aminoacyl tRNA synthetases, leader sequences, in vitro translation system

Regulation of gene expression: Operon concept, catabolite repression, positive and negative regulation, lac ,trp, ara operon, posttranslational modification, stringent response, ppGpp, cAMP as regulatory molecules, end product inhibition

Recombinant DNA technology

Core techniques and essential enzymes used in rDNA technology:-Restriction digestion, ligation and transformation.

Cloning vectors: - Plasmids, phages and cosmids, cloning strategies, cloning and selection of individual genes, gene libraries: cDNA and genomic libraries.

Specialized cloning strategies: - Expression vectors, promoter probe vectors, vectors for library construction-artificial chromosomes.

DNA sequencing methods: - Dideoxy and chemical method. Sequence assembly. Automated sequencing, Genome sequencing and physical mapping of genomes.

PCR:Methods and applications.

Medical Microbiology

Sources of infection for man- exogenous infections, - patient, carrier (healthy, convalescent, contact, paradoxical and chronic), infected animals, soil and endogenous infections.

Mode of spread of infections- Respiratory, skin, wound & burn, venereal, alimentary tract, arthropod borne, blood infection, laboratory infection, nosocomial infections etc. Normal microflora of human body-skin, oral cavity, respiratory tract, gastrointestinal tract and urogenital tract. Significance of normal microflora. Gnotobiotic animals and their use. True and opportunistic pathogens.

Morphology, pathogenesis, epidemiology and laboratory diagnosis of common diseases caused by *Staphylococcus aureus, Mycobacterium tuberculosis, Treponema pallidum* and *Rickettsia prowzakii, Streptococcus pyogenes.*

Pathogenic properties of bacteria, colonization, invasion of mucous membranes of respiratory, enteric and urogenital tracts. Methods for measurement of virulence.

Nonspecific antibacterial defence of host.

Exotoxins and endotoxins. Mode of action of tetanus, botulinum, diphtheria and cholera toxins.

Antibiotic susceptibility testing. Antimicrobial drug resistance- Mechanism and spread.

Hazard groups and containment levels.

Antiseptics and disinfectants.

Brief account of biomedical waste management-types of biomedical waste and waste treatment.

Virology & Immunology

Nomenclature and classification of viruses , distinctive properties of viruses , morphology and ultra structure , capsids and their arrangement , types of envelopes and their composition –viral genome , virus related agents ( viriods and prions).

Cultivation of animal viruses- animal inoculation, embryonated eggs and cell culture. Primary cell, diploid cell and continuous cell line. One step growth curve. Detection of virus growth in cell culture. Iterferon and its mechanism of action, antiviral drugs, cellular response to viral infection. Pathogenesis, lab diagnosis and prophylaxis of small pox, polio, influenza, rabies, HIV and hepatitis viruses.

Lymphocytes their sub population, their properties & functions. Types of antigen, antigen specificity, haptens, natural or innate immunity. Determinants of innate immunity, species & strains, individual differences influence of age hormonal influence nutritional factors, mechanical barrier & surface secretions. Non specific immune mechanisms, opsonization, inflammatory secretions hormone balance. Humoral, cellular, actively acquired passively acquired cellular interaction in the induction of antibody formation. Immunoglobulins - types & structure. Vaccines- requirements for a good vaccine, types of vaccine- viral, bacterial, recombinant, DNA vaccines and subunit vaccines.Transmission of plant viruses. Life cycle of plant viruses like TMV.

Microbial Biotechnology &Industrial Microbiology

Isolation, Screening, improvement and maintenance of industrial organisms

Fermenter design and instrumentation, immobilized cell reactor, solid state fermentation (SSF), substrates for industrial fermentation,

Fermentation System: Primary and secondary metabolites, batch, fedbatch and continous fermentation system, fermentation kinetics, chemostat, turbidostat, gas exchange and mass transfer

Downstream processing (DSP) and product recovery.

Production of biofertilizers, biopesticides, single cell protein (SCP), steroid conversion and biotransformation

Industrial production of

Alcoholic beverages: beer, Wine

Organic acids: citric, lactic and acetic acid

Microbial enzymes: amylases, proteases and lipases

Antibiotics: Pencillin, tetracycline

Amino acids: glutamic acid, lysine

Food Microbiology

Microbes in Food: Microorganisms important in food microbiology, molds, yeasts and bacteria and their general characteristics..

Intrinsic and extrinsic factors affecting microbial growth in foods: Intrinsic factors ( Nutrient content ,Ph , Moisture content or water activity ,Antimicrobial barriers , Antimicrobial substances) ,Extrinsic factors (Relative humidity , Temperature , Gaseous atmosphere).

Microbial spoilage of foods: Microbiology of spoilage of specific foods – Bread, Cakes, Fresh fruits and vegetables, Juices, Bottled water, Milk, Tea. Meat and meat products (Fresh and ground meat, sausages), Poultry, Eggs, Sea foods (spoilage of fish).

Food preservation (protection): Heat ,Low temperature storage ,Freezing, Dehydration and water availability ,Lyophilization ,Osmotic pressure ,Filtration, Irradiation ,Chemical preservatives ,Antibiotics ,Bacteriocins.

Food borne illnesses: Food borne intoxication and infections- Botulism, Staphylococcal food poisoning, Clostridium *perfringens* food poisoning, *Bacillus cereus* gastroenteritis, Salmonellas, *Escherichia coli* diarrhea and colitis. *Aspergillus , Penicillium ,Claviceps ,Fusarium*,

Production of foods from microorganisms: Sauerkraut, Pickles, Silage, Bread, Baker, s yeast, Yogurt, cheese, Single cell protein (Quorn ,Pruteen).

Mushroom Production: Nutritive values of mushroom. Edible and poisonous mushrooms. Spawn production technology (Agarricus bisporus, Volvariella volvacea) Tropical and Temperate mushroom.

**Chairman**