MPAT – Microbiology

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CENTRE FOR ADVANCED STUDIES
DEPARTMENT OF ZOOLOGY
UNIVERSITY OF RAJASTHAN, JAIPUR -302055 04

SYLLABUS FOR Ph.D. MICROBIOLOGY ENTRANCE EXAMINATION, MPAT- 2017

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SECTION A

Biomolecules and Cellular Metabolism

1. Structure of atoms, molecules and chemical bonds.
2. Composition, structure and functions of biomolecules: Carbohydrates, lipids, proteins, nucleic acids, vitamins.
3. Stabilizing non-covalent interactions: Van der Waals, electrostatic, hydrogen &ionic bond, hydrophobic interaction.
4. Principles of biophysical chemistry: Acids, bases, pH, pKa values and buffer.
5. Enzyme: Characteristics, nomenclature and classification, principles and mechanisms of enzyme action, enzyme kinetics, its regulation & inhibition, isozymes, coenzymes, ribozymes, allosterism, kinetic analysis of allosteric enzymes, principles of allosteric regulation.
6. Conformation of proteins: Secondary, tertiary and quaternary structure, domains, motif and folds, chaperones.
7. Conformation of nucleic acids: DNA (A-, B-, and Z- DNA), RNA (mRNA, rRNA, tRNA), micro RNA.
8. Metabolism of:
   (i) Carbohydrates: Glycolysis, Pasteur effect, fermentation of carbohydrates-homo and hetero-lactic fermentations, Kreb's cycle, oxidative phosphorylation, Pentose phosphate pathway, gluconeogenesis, glycogenolysis and glycogenesis.
   (ii) Lipids: β-oxidation and fatty acids biosynthesis.
   (iii) Proteins: Deamination, transamination, transdeamination, urea cycle and fate of carbon skeleton of amino acids.
   (iv) Nucleotides: Synthesis of purines and pyrimidines, synthesis and regulation of deoxy- & ribo-nucleotides, degradation and salvage pathways.

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9. Photosynthetic and accessory pigments: Chlorophyll, bacteriochlorophyll, rhodopsin, carotenoids, phycobiliproteins, carbohydrates-anabolism, autotrophic, oxygenic & anoxygenic photosynthesis, autotrophic generation of ATP, Calvin cycle- C3 and C4 pathways.

Bacteriology and Phycology

1. Classification of microorganisms: Kingdom schemes and modern trends in classification (ribotyping, nucleic acid hybridization, RNA fingerprinting, Molecular chronometers).
2. (i) Gram-negative bacteria: Spirochaetes, aerobic or microaerophilic curved rods, aerobic rod and cocci, facultative aerobic rods, anaerobes, Rickettsias and Chlamydia, anoxygenic phototrophs, oxygenic phototrophs, gliding bacteria, sheathed bacteria, budding and / or appendaged bacteria and chemolithotrophs.
   (ii) Gram-positive bacteria: Cocci, endospore forming, regularly shaped rods, irregularly shaped rods, mycobacteria, actinomycetes.
   (iii) Archaeobacteria: Methanotrophs, halophiles and sulphur dependent archaeobacteria.
3. Morphology, ultrastructure and morphological types of bacteria, cultivation of bacteria, growth and its characteristics, nutritional requirements of microbes, culture characteristics, types of media, factors affecting microbial growth, control of bacteria-physical and chemical agents and pure culture techniques (spread plate, pour plate & streak plate).
4. General features and classification of algae, thallus organization and reproduction in chlorophyceae, euglenophyceae, phaeophyceae, pyrrophycae and diatoms.
5. Economic importance of algae: Lichen, ascolichen, basidiolichen and deuterolichen.

Mycology and Virology

1. General features and classification of fungi (according to Alexopoluous and Nims with the general aspects of major division of fungi).
2. Nutrition of fungi, vitamin requirements, saprophytism, parasitism, mutualism, symbiotic associations of fungi (mycorrihizae and lichens),homothallism, heterothallism, heterokaryosis, parasexual cycle, sex hormones in fungi and economic importance of fungi.
3. Nomenclature and classification of plants and animal viruses, their properties, morphology & ultrastructure, viral genome & their types, viroids and prions.

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4. Structural organization of bacteriophage, life cycle lytic & lysogenic cycle, brief account of M13, Mu, T3, T4 and Lambda.
5. Nomenclature and classification of plant viruses, Tobacco mosaic virus and Cauliflower mosaic virus: their properties, morphology & ultra structure.

Immunology

1. Cells and organs involved in innate and adaptive immunity.
2. Antigens, antigenicity and immunogenicity, B and T cell epitopes.
3. Structure, types and functions of antibodies, Generation of antibody diversity.
4. Monoclonal antibodies, antigen-antibody interactions.
5. Humoral and cell-mediated immune responses, primary and secondary immune modulation, complement system, cell-mediated effecter functions.
6. MHC molecules, antigen processing and presentation.
7. Hypersensitivity.
8. Autoimmunity and immune response to infectious diseases (viral, bacterial & protozoans).
9. Vaccines (traditional & recombinant).
10. Transplantation.

SECTION B

Molecular Biology and Microbial Genetics

1. DNA (prokaryotes): Enzymes involved in replication, origin and replication fork, continuous & discontinuous synthesis, superhelicity in DNA,linking number, topological properties & mechanism of action of topoisomerases, Retroviruses and their unique mode of DNA synthesis, relation between replication and cell cycle, inhibitors of DNA replication (blocking precursor synthesis, nucleotide polymerization, altering DNA structure), ncodels for plamologous recombination, homologous protein machines DNA damage and repair types, repair pathways-methyl-directed mismatch repair, very short patch repair, nucleotide excision repair, base excision repair, recombination and SOS system.
2. RNA synthesis and processing in prokaryotes: Transcription-factors and machinery, formation of initiation complex, transcription activators and repressors, RNA polymerases, elongation & termination and RNA processing.
3. Protein synthesis and processing in prokaryotes: Formation of initiation complex, initiation factors and their regulation, elongation and elongation factors, termination, translational inhibitors, post-translational modification of proteins, catalytic RNA, genetic code.

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4. Control of gene expression at transcription and translation level: Regulation of phages, viruses, prokaryotic (*lac* operon, *trp* operon and *his* operon), global regulatory responses: heat shock response, stringent response and regulation by small molecules such as ppGpp and cAMP, regulation of rRNA & tRNA synthesis and regulation of N_2 assimilation.
5. Gene transfer mechanisms: Transformation, transduction, conjugation and transfection and their uses in genetic mapping, genetic analysis of microbes, bacteria and yeast.
6. Plasmids, F-plasmid, R-plasmid, Col-plasmid and Ti-plasmid: Description and their uses, copy number and compatibility of plasmids; transposons and their uses in genetic analysis.
7. Gene as unit of mutation and recombination, molecular nature of mutations, mutagens and spontaneous mutations.
8. Cell Signaling:Hormones and their receptors, cell surface and their receptors, signalling through G-protein coupled receptors, receptor tyrosine kinases, second messengers (cAMP,IP_3DAG),prokaryotic signalling, quorum sensing, bacterial pheromones, signal transduction pathways and intracellular pathways.

Industrial Microbiology

1. Major types of microorganism used in fermentation, primary & secondary screening industrial strain improvement-strategies, selection and improvement of recombinant organisms.
2. Types of bioreactors, their components & control systems, media preparation, sterilization, batch, continuous and fed batch process, microbial growth kinetics, measurement of growth, effect of pH, temperature and nutrient concentration on growth, downstream processing, filtration of fermentation broths and recovery of biological products.
3. Industrial production of yeast, alcohol, dextran, vitamins, organic acids, steroids, interferon, human protein, enzymes, antibiotics, vaccines and insulin.
4. Biofertilizers: Production and uses.
5. Biopatency, biopiracy, biowar and bioethics.

Food Microbiology

1. Important microorganisms: Molds, yeasts & bacteria, principles of food preservation, factors influencing microbial growth in food, chemical preservatives and food additives.
2. Fermented products: Bread, cheese, fermented vegetables & dairy products, beer, wine and vinegar.

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3. Microbial cells as food (single cell protein) and mushroom cultivation and genetically modified foods.
4. Contamination and spoilage: Cereals, sugar products, vegetables, fruits, meat and meat products, milk products, fish and sea foods and poultry, spoilage of canned food, detection of spoilage and characterization, food-borne infections and intoxications: bacterial and nonbacterial: *Brucella, Bacillus, Clostridium Escherichia, Salmonella, Staphylococcus, Vibrio, Yersinia,* nematodes, protozoans, algae, fungi and viruses.

Medical Microbiology

1. Classification of medically important microorganisms, normal microbial flora of human body & their role.
2. Establishment, spreading, tissue damage and anti-phagocytic factors, mechanism of bacterial adhesion, colonization and invasion of mucous membranes of respiratory, enteric and urinogenital tracts.
3. Life cycle, epidemiology, pathogenicity, diagnosis, prevention and treatment of various bacteria: *Staphylococcus, Streptococcus, Pneumococcus, Neisseria, Cornybacterium,* bacillus, *Clostridium,* non sporing anaerobes, organisms belonging to *Enterbacteriacae, Vibrios,* non fermenting gram negative bacilli, *Yersinia, Haemophilus, Bordetella, Brucella, Mycobacteria, Spirochaetes, Actinomycetes, Rickettsia and Chlamydia.*
4. Life cycle, epidemiology, pathogenicity, diagnosis, prevention and treatment of various viruses: Pox viruses, Herpes virus, Orthomyxo viruses, Paramyxo viruses, Arboviruses, Rhabdoviruses, Hepatitis viruses, Oncogenic viruses and Human Immunodeficiency Virus.
5. Life cycle, epidemiology, pathogenicity, diagnosis, prevention and treatment of various fungi: Dermatophytes, dimorphic fungi, opportunistic fungal pathogens, description & classification of pathogenic fungi and their laboratory diagnosis.

SECTION C

Environmental Microbiology

1. Brief account of air borne transmission of microbes: Viruses, bacteria and fungi, microbial assessment of water quality, microflora of various soil types(bacteria and nematodes in relevance to soil types), brief account of microbial interactions, biogeochemical cycles (carbon, nitrogen, phosphorous and sulphur), biofertilizers-biological nitrogen fixation - nitrogenase enzyme, nif genes, symbiotic nitrogen fixation (*Rhizobium & Frankia*), non-symbiotic microbes

(*Azotobacter & Azospirillium*), Vesicular arbuscular mycorrhizae (VAM), ecto-,endo-&ectendo-mycorrhizae and rumen microbiology.

2. Wastes: Types & characterization, treatments, Utilization of solid wastes (SCP, mushroom & yeast), fuel (ethanol & methane) and fertilizer (composting).
3. Microbial assessment of water quality, bacterial indicators of water safety, disinfection of potable water supplies.
4. Bioaccumulation, Biodegradation and detoxification of lignin, pesticides, metals, biopesticides, bioremediation, genetically modified organisms and their impact.
5. Microbial transformation of carbon, phosphorous, sulphur, nitrogen and mercury, extremophiles & halophiles and their applications.

Biostatistics

1. Measures of central tendency and mean deviation.
2. Variance, standard deviation, coefficient of variance and standard error.
3. Probability, distribution (Binomial, Poisson and-normal).
4. Hypothesis, errors (type I & II) and levels of significance
5. Difference between parametric and non-parametric statistics and confidence limits.
6. Regression and correlation.
7. t-test, analysis *of* variance (ANOVA - one way & two way).
8. Chi Square (X^2) test and Yate's correction factor.

Bioinformatics

1. Basics of computers-architecture, generations of hardware & software operating system - WINDOWS & UNIX system.
2. Systems and applications of software.
3. Basics of Internet-LAN, MAN &WAN.
4. Biological databases: Nucleic acid & protein sequence database,
5. Sequence alignment: BLAST and FASTA.
6. Important bioinformatics websites: NCBI, FBI & DDBJ.
7. Genomics & proteomics- general and application of computers.

Tools and Techniques

1. Genetic engineering: techniques and essential enzymes, cloning vectors and strategies, rationale and conditions for the design of vectors for the over expression of recombinant proteins, purification ,up scaling, determination of

purity and activity of over expressed proteins, gene libraries, cDNA & genomic libraries, PCR types, methods & applications and DNA sequencing.

2. Principles and applications of microscopy: light, bright and dark field, phase contrast, fluorescence and electron microscopes-transmission and scanning.
3. Media preparation, sterilization, spread plate, pour plate and streaking, Culture characteristics cell proliferation measurement, cell viability and Ames test.
4. Staining techniques: Simple staining, Gram's staining, negative staining, spore staining and acid fast staining. Enumeration of microbes.
5. Principles, types and applications of centrifugation, electrophoresis, chromatography and ELISA.
6. Lambert-Beer's law, principles and applications of colorimeter and spectrophotometer (UV, NMR, atomic absorption & fluorescence).
7. Radioisotopes, types of radioactivity, radioactive decay, units of radioactivity, detection & measurement of radioactivity, autoradiography and biochemical uses of isotopes (tracers, radio immunoassay).

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