Program	Ph.D.
Syllabus	Entrance Exam Syllabus for Microbiology
Examination Pattern	

Question Type	No. of Questions	Total Marks
1 Mark Domain Specific	35	35
1 Mark Research Aptitude	35	35
Total	**70**	**70**

Section – 1 - Weightage – 50%	
Sr. No.	**Topics**
1	**Molecules and Their Interaction Relevant to Biology:** • Structure of atoms, molecules and chemical bonds. • Composition, structure and function of biomolecules: carbohydrates, lipids, proteins, nucleic acids and vitamins. • Stabilizing interactions: Vander Waals, electrostatic, hydrogen bonding, hydrophobic interaction, etc. • Principles of biophysical chemistry: pH, buffer, reaction kinetics, thermodynamics, colligative properties. • Bioenergetics, coupled reaction, group transfer, biological energy transducers, oxidative & substrate level phosphorylation, glycolysis. • Principles of catalysis. Enzymes: Classification, nomenclature, kinetics, regulation, mechanism of catalysis. • Structure & conformation of proteins: Ramachandran plot, secondary structure, domains, motif and folds. • Structure & Conformation of nucleic acids (helix (A, B, Z), t-RNA, micro-RNA). Stability of proteins and nucleic acids. • Metabolism of carbohydrates, lipids, amino acids, nucleotides and vitamins.
2	**Cellular Organization:** • Membrane structure and function: Model structure of membrane, lipid bilayer and membrane protein. Electrical properties of membranes. Transport system: diffusion, osmosis, ion channels, active transport, membrane pumps, mechanism of sorting and regulation of intracellular transport. • Structural organization and functions of intracellular organelles: Cell wall, nucleus, mitochondria, Golgi bodies, lysosomes, endoplasmic reticulum, peroxisomes, plastids, vacuoles, chloroplast, structure & function of cytoskeleton and its role in motility. • Organization of genes and chromosomes: Unique and repetitive DNA, interrupted genes, gene families. Structure of chromatin and chromosomes: heterochromatin, euchromatin, transposons, operon. • Cell division and cell cycle: Mitosis and meiosis, their regulation, steps in cell cycle and control of cell cycle. • Microbial physiology: Growth yield and characteristics, strategies of cell division, stress response.
3	**Fundamental Processes:** • DNA replication, repair and recombination: Unit of replication, enzymes involved, replication origin and replication fork, fidelity of replication, extrachromosomal replicons, DNA damage and repair mechanisms, recombination and types of recombination. • RNA synthesis and processing: Transcription factors and machinery, formation of initiation complex, transcription activator and repressor, RNA polymerases, capping, elongation, and termination, RNA processing, RNA editing, splicing, and polyadenylation, structure and function of different types of RNA, RNA transport). • Protein synthesis and processing: Ribosome, formation of initiation complex, initiation factors and their regulation, elongation and elongation factors,

	termination, genetic code, aminoacylation of tRNA, tRNA-identity, aminoacyl tRNA synthetase, and translational proof-reading, translational inhibitors, Post- translational modification of proteins. • Control of gene expression at transcription and translation level: Regulating the expression of phages, viruses, prokaryotic and eukaryotic genes, role of chromatin in gene expression and gene silencing. • Photosynthesis - Light harvesting complexes; mechanisms of electron transport; photoprotective mechanisms; CO_2 fixation-C_3, C_4 and CAM pathways. • Respiration and photorespiration: Central and peripheral metabolic pathways, electron transport and ATP synthesis; alternate oxidase; photorespiratory pathway. Fermentative pathways.
4	**Cell communication and cell signaling:** • Host parasite interaction: Recognition and entry processes of different pathogens like bacteria, viruses into animal and plant host cells. Alteration of host cell behavior by pathogens, virus-induced cell transformation, pathogen-induced diseases in animals and plants, cell-cell fusion in both normal and abnormal cells. • Cell signaling: Hormones and their receptors, cell surface receptor, signaling through G-protein coupled receptors, signal transduction pathways, secondary messengers, regulation of signaling pathways, two- component mechanism in bacterial and plant system, light signaling in plants, bacterial chemotaxis and quorum sensing. • Cellular communication, regulation of hematopoiesis, general principles of cell communication, cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix, integrins, neurotransmission and its regulation. • Cancer, genetic rearrangements in progenitor cells, oncogenes, tumor suppressor genes, cancer and the cell cycle, virus-induced cancer, metastasis, interaction of cancer cells with normal cells, apoptosis, therapeutic interventions of uncontrolled cell growth. • Innate and adaptive immune system cells and molecules involved in innate and adaptive immunity, antigens, antigenicity and immunogenicity. B and T cell epitopes, structure and function of antibody molecules. Generation of antibody diversity, monoclonal antibodies, antibody engineering, antigen-antibody interactions, MHC molecules, antigen processing and presentation, activation and differentiation of B and T cells, B and T cell receptors, humoral and cell- mediated immune responses, primary and secondary immune modulation, the complement system, Toll-like receptors, cell-mediated effector functions, inflammation, hypersensitivity and autoimmunity, immune response during bacterial (tuberculosis), parasitic (malaria) and viral (HIV) infections, congenital and acquired immunodeficiency's, vaccines.
5	**Developmental Biology:** • Basic concepts of development: Potency, commitment, specification, induction, competence, determination and differentiation; morphogenetic gradients, cell fate and cell lineages, stem cells, genomic equivalence and the cytoplasmic determinants, imprinting, mutants and transgenics in analysis of development • Gametogenesis, fertilization and early development: Production of gametes, cell surface molecules in sperm-egg recognition in animals, embryo sac development and double fertilization in plants; zygote formation, cleavage, blastula formation, embryonic fields, gastrulation and formation of germ layers in animals; embryogenesis, establishment of symmetry in plants; seed formation and germination. • Programmed cell death, aging and senescence
6	**Inheritance Biology:** • Mendelian principles: Dominance, segregation, independent assortment. • Concept of gene: Allele, multiple alleles, pseudo allele, complementation tests • Extensions of Mendelian principles: Codominance, incomplete dominance, gene interactions, pleiotropy, genomic imprinting, penetrance and

	expressivity, phenocopy, linkage and crossing over, sex linkage, sex limited and sex influenced characters. • Gene mapping methods: Linkage maps, tetrad analysis, mapping with molecular markers, mapping by using somatic cell hybrids, development of mapping population in plants. • Extra chromosomal inheritance: Inheritance of mitochondrial and chloroplast genes, maternal inheritance. • Microbial genetics: Methods of genetic transfers – transformation, conjugation, transduction and sex-duction, mapping genes by interrupted mating, fine structure analysis of genes. • Human genetics: Pedigree analysis, lod score for linkage testing, karyotypes, genetic disorders. • Quantitative genetics: Polygenic inheritance, heritability and its measurements, QTL mapping. • Mutation: Types, causes and detection, mutant types – lethal, conditional, biochemical, loss of function, gain of function, germinal verses somatic mutants, insertional mutagenesis. • Structural and numerical alterations of chromosomes: Deletion, duplication, inversion, translocation, ploidy and their genetic implications.
7	**Diversity of Life Forms:** • Principles & methods of taxonomy: Concepts of species and hierarchical taxa, biological nomenclature, classical & quantitative methods of taxonomy of plants, animals and microorganisms. • Levels of structural organization: Unicellular, colonial and multicellular forms. Levels of organization of tissues, organs & systems. Comparative anatomy, adaptive radiation, adaptive modifications. • Outline classification of plants, animals & microorganisms: Important criteria used for classification in each taxon. Classification of plants, animals and microorganisms. Evolutionary relationships among taxa. • Natural history of Indian subcontinent: Major habitat types of the subcontinent, geographic origins and migrations of species. Common Indian mammals and birds. Seasonality and phenology of the subcontinent. • Organisms of health & agricultural importance: Common parasites and pathogens of humans, domestic animals and crops. • Organisms of conservation concern: Rare, endangered species. Conservation strategies.
8	**Ecological Principles:** • Environment: Physical environment, biotic environment; biotic and abiotic interactions. • Habitat and Niche: Concept of habitat and niche, niche width and overlap, fundamental and realized niche, resource partitioning; character displacement. • Population ecology: Characteristics of a population, population growth curves, population regulation; life history strategies (r and K selection); concept of metapopulation – demes and dispersal, interdemic extinctions, age structured populations. • Species interactions: Types of interactions, interspecific competition, intraspecific, herbivory, carnivory. • Community Ecology: Nature of communities; community structure and attributes, levels of species diversity and its measurement; edges and ecotones. • Ecological succession: Types; mechanisms; changes involved in succession; concept of climax. • Ecosystem ecology: Ecosystem structure; ecosystem function; energy flow and mineral cycling (C, N, P); primary production and decomposition; structure and function of some Indian ecosystems: terrestrial (forest, grassland) and aquatic (fresh water, marine, estuarine). • Biogeography: Major terrestrial biomes; theory of island biogeography; biogeographical zones of india.

	• Applied Ecology: Environmental pollution; global environmental change. Biodiversity: Status, monitoring and documentation; major drivers of biodiversity change; biodiversity management approaches. • Conservation Biology: Principles of conservation, major approaches to management, Indian case studies on conservation/management strategy (Project Tiger, Biosphere reserves).
9	**Evolution and Behaviour:** • Emergence of evolutionary thoughts: Lamarck; Darwin–concepts of variation, adaptation, struggle, fitness and natural selection; Mendelism; spontaneity of mutations; evolutionary synthesis. • Origin of cells and unicellular evolution: Origin of basic biological molecules; Abiotic synthesis of organic monomers and polymers; Concept of Oparin and Haldane; Experiment of Miller (1953); The first cell; Evolution of prokaryotes; Origin of eukaryotic cells; Evolution of unicellular eukaryotes. • Paleontology and evolutionary history: The evolutionary time scale; Eras, periods and epoch; Major events in the evolutionary time scale; Origins of unicellular and multi cellular organisms; Major groups of plants and animals; Stages in primate evolution including Homo. • Molecular Evolution: Concepts of neutral evolution, molecular divergence and molecular clocks; Molecular tools in phylogeny, classification and identification; Protein and nucleotide sequence analysis; origin of new genes and proteins; Gene duplication and divergence. • Mechanisms: Population genetics – Populations, gene pool, gene frequency; Hardy-Weinberg Law; concepts and rate of change in gene frequency through natural selection, migration and random genetic drift; adaptive radiation. Isolating mechanisms; Speciation; Allopatric and sympatric, convergent evolution. Sexual selection. Co-evolution. • Brain, behavior and evolution: Approaches and methods in study of behavior; proximate and ultimate causation; altruism and evolution-group selection, kin selection, reciprocal altruism; neural basis of learning, memory, cognition, sleep and arousal; biological clocks, development of behavior; social communication; social dominance; Use of space and territoriality, mating systems; parental investment and reproductive success; parental care; aggressive behavior, habitat selection and optimality in foraging; migration, orientation and navigation; domestication and behavioral changes.
10	**Applied Biology:** • Microbial fermentation and production of small and macro molecules. • Application of immunological principles, vaccines, diagnostics. Tissue and cell culture methods for plants and animals. • Transgenic animals and plants, molecular approaches to diagnosis and strain identification. • Genomics and its application to health and agriculture, including gene therapy. • Bioresource and uses of biodiversity. • Breeding in plants and animals, including marker – assisted selection • Bioremediation and phytoremediation • Biosensors
11	**Methods in Biology:** • Molecular Biology and Recombinant DNA methods: Isolation and purification of RNA, DNA (genomic and plasmid) and proteins, different separation methods. Analysis of RNA, DNA and proteins by one- and two-dimensional gel electrophoresis, isoelectric focusing gels. Molecular cloning of DNA or RNA fragments in bacterial and eukaryotic systems. Expression of recombinant proteins using bacterial, animal and plant vectors. Isolation of specific nucleic acid sequences. Generation of genomic and cDNA libraries in plasmid, phage, cosmid, BAC and YAC vectors. In vitro mutagenesis and deletion techniques, gene knock out in bacterial and eukaryotic organisms. • Protein sequencing methods, detection of post translation modification of proteins. DNA sequencing methods, strategies for genome sequencing.

	Methods for analysis of gene expression at RNA and protein level, large scale expression; micro array-based techniques. Isolation, separation and analysis of carbohydrate and lipid molecules. RFLP, RAPD and AFLP techniques. • Histochemical and Immuno-techniques: Antibody generation, detection of molecules using ELISA, RIA, western blot, immunoprecipitation, flow cytometry and immunofluorescence microscopy, detection of molecules in living cells. In situ localization by techniques such as FISH and GISH. • Biophysical Method: Molecular analysis using UV/visible, fluorescence, circular dichroism, NMR and ESR spectroscopy. Molecular structure determination using X-ray diffraction and NMR. Molecular analysis using light scattering, different types of mass spectrometry and surface plasma resonance methods. • Statistical Methods: Measures of central tendency and dispersal; probability distributions (binomial, poisson and normal); sampling distribution; difference between parametric and non-parametric statistics; confidence interval; rrrors; levels of significance; regression and correlation; t-test, analysis of variance; X2 test; Basic introduction to muetrovariate statistics, etc. • Radiolabeling techniques: Detection and measurement of different types of radioisotopes normally used in biology, incorporation of radioisotopes in biological tissues and cells, molecular imaging of radioactive material, safety guidelines. • Microscopic techniques: Visualization of cells and subcellular components by light microscopy, resolving powers of different microscopes, microscopy of living cells, scanning and transmission microscopes, different fixation and staining techniques for EM, freeze-etch and freeze- fracture methods for EM, image processing methods in microscopy. • Electrophysiological methods: Single neuron recording, patch-clamp recording, ECG, brain activity recording, lesion and stimulation of brain, pharmacological testing, PET, MRI, fMRI, CAT. • Methods in field biology: Methods of estimating population density of animals and plants, ranging patterns through direct, indirect and remote observations, sampling methods in the study of behavior, habitat characterization, ground and remote sensing methods.

Section – 2 - Weightage – 50%	
Sr. No.	**Topics**
1	**Research Aptitude -** Research: Meaning, characteristics and types; steps of research, methods of research, research ethics.
2	**Reasoning (Including Mathematical) -** Number series, letter series, codes, relationships, classification.
3	**Logical Reasoning -** Understanding the structure of arguments; evaluating and distinguishing deductive and inductive reasoning; verbal analogies: word analogy-applied analogy, Reasoning logical diagrams: simple diagrammatic relationship, multi-diagrammatic relationship; venn diagram, analytical reasoning
4	**Data Interpretation -** Sources, acquisition and interpretation of data, Quantitative and qualitative data, graphical representation and mapping of data.