



# DAV UNIVERSITY, JALANDHAR

PhD Entrance Test Syllabus

## DEPARTMENT OF BIOCHEMISTRY

### Section A (50 questions)

#### Research Methodology

**Descriptive statistics:** Definition and relevance in biological research; Measures of Central Tendency: Arithmetic Mean, median, mode, quartiles and percentiles; Measures of Dispersion: Range, variance, standard deviation, coefficient of variation; Skewness and Kurtosis. Probability Theory.

**Inferential statistics:** Hypothesis testing, Errors in Hypothesis Testing- Null Hypothesis, Alternative Hypothesis, Type I and Type II errors, Confidence Limits. Setting up of level of significance. One tailed and Two- tailed tests.

**Correlation and Regression:** Correlation coefficient ( $r$ ), properties, interpretation of  $r$ , partial and multiple correlations, linear regression: Fitting of lines of regression, regression coefficient, Bivariate and Multiple Regression.

**Parametric and Non-Parametric Statistics:** Definition, Advantages, Disadvantages, Assumptions; Parametric Tests: Student's t-test, One Way Analysis of Variance, Two Way Analysis of Variance; Non-Parametric Tests: Analysis of Variance, Chi square and Kendall Rank Correlation. Basic principles and significance of research design; Randomized Block Designs (RBD), completely randomized designs (CRD); Latin square design; Split plot design and Factorial design. Data collection, organization and interpretation. Research articles, research papers, popular research articles and reviews; difference between periodicals; journals; monographs, magazines; proceedings. Science citation index; H-index, i10 index, Impact factor calculation, Impact factor of a journal; Eigen factor, Major journal search engines. Copyright act; Academic frauds; Plagiarism; Software's to check plagiarism.

### Section B (50 questions)

#### Biochemistry

**General Biochemistry:** Classification and function of carbohydrates, proteins, lipids and nucleic acids; Carbohydrate metabolism; Lipid metabolism; Metabolism of amino acids; Enzymes. Role of major hormones and their physiology.

**Molecular Biology:** Structure and function of DNA and RNA; Replication; Transcription; Translation; Regulation of gene expression (Operon model); Genetic code; Recombinant DNA technology- R-M system, restriction endonucleases, vector systems, cDNA libraries. DNA Sequencing technologies, Polymerase Chain Reaction and its variants.

**Cell biology:** Cellular organelles- Plasma membrane, cell wall, their structural organization Mitochondria, Chloroplast; Nucleus and other organelles and their organization; Transport of nutrients, ions and macromolecules across membrane; Cell cycle – molecular events and regulation; major signaling pathways – Insulin signaling, G-protein signaling, Ras, Akt, MAP Kinases.

**Immunology:** Overview of the immune system; Cells and organs of the immune system, Antibodies; Major histocompatibility complex; T-cell receptor; The complement system.



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**Genetics:** Cell division; Basic principles of inheritance; Structure of Chromosome; Chromosomal basis of mendelism; Linkage, Crossing over and chromosome mapping; Genetics of bacteria; Mutation and DNA repair; Mitochondrial and chloroplast DNA.

**Bioanalytical techniques:** Basic principles of sedimentation, preparative centrifugation, analytical centrifugation; Adsorption chromatography, Ion-exchange chromatography, Molecular exclusion chromatography, Thin-layer chromatography, Gas chromatography, HPLC; Electrophoresis of proteins and nucleic acids, UV-Vis spectroscopy, Fluorescence spectroscopy, Circular dichroism spectroscopy, X-ray spectroscopy, ESR, NMR; Immuno precipitation, Immuno blotting; light microscope, electron microscope.

## Environmental Science

Unit 1: Fundamentals of Environmental Science, Definition, principles and scope of Environmental Science., Structure and composition of atmosphere, hydrosphere, lithosphere and biosphere. Mass and Energy transfer across the various interfaces, material balance. First and Second law of thermodynamics, heat transfer processes. Scale of Meteorology, pressure, temperature, precipitation, humidity, radiation and wind. Atmospheric stability, inversions and mixing heights, wind roses, Natural resources, conservation and sustainable development.

Unit – II: Ecology and Biodiversity

Definition, Principles and scope of ecology, Evolution, Origin of life and speciation, Ecosystems, Biodiversity, uses, threats and its conservation measures

Unit – III: Environmental Geosciences

Fundamental Concept of Environmental Geosciences, Energy budget of the earth. Earth's thermal environment and seasons. General relationship between landscape, biomes and climate. Climates of India, Indian Monsoon, El Nino, Droughts. Tropical cyclones and Western Disturbances, Earth's Processes and



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various Geological Hazards, Principles of Remote sensing and its application of Environmental Sciences, Application of GIS in Environmental Management.

### Unit – IV: Energy Resources

Solar energy, Fossil fuels Hydroelectric power, Tidal, Ocean Thermal Energy Conversion, wind, geothermal energy; nuclear energy – fission and fusion; magneto hydrodynamic power, bio-energy-energy from biomass and biogas, anaerobic digestion; energy use pattern in different parts of the world.

Environmental implication of energy use; CO<sub>2</sub> emissions, global warming; air and thermal pollution; radioactive waste and radioactivity from nuclear reactors; impacts of large-scale exploitation of Solar, Wind, Hydro and Ocean energy. Principles of Analytical Methods: Titrimetry, Gravimetry, Colourimetry, Spectrophotometry, Chromatography, Gas Chromatography, Atomic Absorption Spectrophotometry, GLC, HPLC, Electrophoresis. X – ray fluorescence, X – ray diffraction, Flame photometry.

### Unit – V: Pollution

Types, sources and consequences of Air and Water pollution, Methods of monitoring and control of air pollution SO<sub>2</sub>, NO<sub>x</sub>, CO, SPM., Acid Rain, Air Quality Standards, Physico – chemical and Bacteriological sampling and analysis of water quality. Standards, sewage and waste water treatment and recycling. Water quality standard; Physico – chemical as bacteriological sampling as analysis of soil quality.

Soil Pollution Control. Industrial waste effluents and heavy metals, their interactions with soil components. Soil micro – organisms and their functions, degradation of different insecticides, fungicides and weedicides in soil. Different kinds of synthetic fertilizers (NP & K) and their interactions with different components of soil; Sources of noise pollution, measurement of noise and Indices, effect of meteorological parameters on noise propagation. Noise exposure levels and standards. Noise control and abatement measures. Impact of noise on human health. Sources of marine pollution and control. Criteria employed for disposal of pollutants in marine system-coastal management. Radioactive and Thermal Pollution.

### Unit – VI: Current Social issues

Introduction to environmental impact analysis. Environmental impact Statement and Environmental Management Plan. EIA guidelines 1994, Notification of Government of India.

Impact Assessment Methodologies. Generalized approach to impact analysis. Procedure for reviewing Environmental impact analysis and statement. Guidelines for Environmental audit. Introduction to Environmental planning. Base line information and predictions (land, water, atmosphere, energy, etc.). Restoration and rehabilitation technologies. Landuse policy for India. Urban planning for India. Rural planning and landuse pattern. Concept and strategies of sustainable development. Cost-Benefit analysis.

Environmental priorities in India and sustainable development. Environmental Education and Awareness. Environmental Ethics and Global imperatives. Global Environmental problems- ozone depletion, global warming and climatic change. Current Environmental issue in India. Context : Narmada Dam, Tehri Dam, Almetti Dam, Soil Erosion, Formation and reclamation of Usar, Alkaline and Saline Soil. Waste lands and their reclamation. Desertification and its control. Vehicular pollution and urban air quality. Biodiversity conservation and Agenda – 21. Waste disposal, recycling and power generation, Fly ash utilization. Water Crises-Conservation of water. Environmental Hazards. Eutrophication and restoration of Indian lakes. Rain water harvesting. Wet lands conservation. Epidemiological issues (e.g., Goitre, Fluorosis, Arsenic).

### Unit – VII: Solid Waste Management and Environmental Laws



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Sources and generation of solid wastes, their characterization, chemical composition and classification. Different methods of disposal and management of solid wastes (Hospital Wastes and Hazardous Wastes) Recycling of waste material. Waste minimization technologies. Hazardous Wastes Management and Handling Rules, 1989, Resource Management, Disaster Management and Risk analysis.

Environment protection-issues and problems, International and National efforts for Environment Protection, Provision of Constitution of India regarding Environment (Article 48A and 58A).

Environmental Policy Resolution, Legislation, Public Policy Strategies in Pollution Control, Wildlife Protection Act, 1972 amended 1991, Forest Conservation Act, 1980, Indian Forests Act (Revised) 1982, Air (Prevention and Control of Pollution) Act, 1981 as amended by Amendment Act, 1987 and Rule 1982, Motor Vehicle Act, 1988, The Water (Prevention and Control of Pollution) Act, 1974 as amended up to 1988 and Rules 1975, The Environment (Protection) Act, 1986 and Rules 1986.

Scheme of labelling of environmentally friendly products (Eco mark), Public Liability Insurance Act, 1991 and Rules 1991.

### Unit – VIII: Statistical Analysis

Basic elements and tools of statistical analysis; Probability, sampling, measurement and distribution of attributes; Distribution-Normal, t and  $\chi^2$  Poisson and Binomial; Arithmetic, Geometric and Harmonic means; moments; matrices, simultaneous linear equations; tests of hypothesis and significance.

Introduction to environmental system analysis; Approaches to development of models; linear simple and multiple regression models, validation and forecasting. Models of population growth and interactions – Lotka – Volterra model, Leslie's matrix model, point source stream pollution model, box model, Gaussian plume model.

**MOLECULES AND THEIR INTERACTION RELEVANT TO BIOLOGY:** Composition, structure and function of biomolecules (carbohydrates, lipids, proteins, nucleic acids and vitamins). Stabilizing interactions (Van der Waals, electrostatic, hydrogen bonding, hydrophobic interaction, etc.). Principles of biophysical chemistry (pH, buffer, reaction kinetics, thermodynamics, colligative properties). Bioenergetics, glycolysis, oxidative phosphorylation, coupled reaction, group transfer, biological energy transducers, Principles of catalysis, enzymes and enzyme kinetics, enzyme regulation, mechanism of enzyme catalysis, isozymes, Conformation of proteins (Ramachandran plot, secondary structure, domains, motif and folds)., 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. **CELLULAR ORGANIZATION**

Membrane structure and function: Structure of model membrane, lipid bilayer and membrane protein diffusion, osmosis, ion channels, active transport, membrane pumps, mechanism of sorting and regulation of intracellular transport, electrical properties of membranes.

Structural organization and function 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: Operon, unique and repetitive DNA, interrupted genes, gene families, structure of chromatin and chromosomes, heterochromatin, euchromatin, transposons.



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Cell division and cell cycle: Mitosis and meiosis, their regulation, steps in cell cycle, regulation and control of cell cycle.

### 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, homologous and site-specific 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.

### 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, second messengers, regulation of signaling pathways.

## Zoology

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



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functions, inflammation, hypersensitivity and autoimmunity, immune response during bacterial (tuberculosis), parasitic (malaria) and viral (HIV) infections, congenital and acquired immunodeficiencies, vaccines.

### 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.

Morphogenesis and organogenesis in animals : Cell aggregation and differentiation in Dictyostelium; axes and pattern formation in Drosophila, amphibia and chick; organogenesis – vulva formation in Caenorhabditis elegans, eye lens induction, limb development and regeneration in vertebrates; differentiation of neurons, post embryonic development- larval formation, metamorphosis; environmental regulation of normal development; sex determination.

Programmed cell death, aging and senescence

### ANIMAL PHYSIOLOGY

Blood and circulation: Blood corpuscles, haemopoiesis and formed elements, plasma function, blood volume, blood volume regulation, blood groups, haemoglobin, immunity, haemostasis.

Cardiovascular System: Comparative anatomy of heart structure, myogenic heart, specialized tissue, ECG – its principle and significance, cardiac cycle, heart as a pump, blood pressure, neural and chemical regulation of all above.

Respiratory system: Comparison of respiration in different species, anatomical considerations, transport of gases, exchange of gases, waste elimination, neural and chemical regulation of respiration.

Nervous system: Neurons, action potential, gross neuroanatomy of the brain and spinal cord, central and peripheral nervous system, neural control of muscle tone and posture. Sense organs: Vision, hearing and tactile response.

Excretory system: Comparative physiology of excretion, kidney, urine formation, urine concentration, waste elimination, micturition, regulation of water balance, blood volume, blood pressure, electrolyte balance, acid-base balance. Thermoregulation: Comfort zone, body temperature – physical, chemical, neural regulation, acclimatization. Stress and adaptation, Digestive system: Digestion, absorption, energy balance, BMR. Endocrinology and reproduction: Endocrine glands, basic mechanism of hormone action, hormones and diseases; reproductive processes, gametogenesis, ovulation, neuroendocrine regulation

### INHERITANCE BIOLOGY

Mendelian principles: Dominance, segregation, independent assortment. Concept of gene: Allele, multiple alleles, pseudoallele, 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.



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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. Recombination: Homologous and non-homologous recombination including transposition.

### 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 animals: Important criteria used for classification in each taxon. Classification of animals. Evolutionary relationships among taxa. Natural history of Indian subcontinent: Major habitat types of the subcontinent, geographic origins and migrations of species. Common Indian mammals, birds. Organisms of health & agricultural importance: Common parasites and pathogens of humans, domestic animals and crops. Organisms of conservation concern: Rare, endangered species. Conservation strategies.

### ECOLOGICAL PRINCIPLES

The 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, interdemec extinctions, age structured populations.

Species Interactions: Types of interactions, interspecific competition, herbivory, carnivory, pollination, symbiosis.

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, eustarine).

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).

### EVOLUTION AND BEHAVIOUR

Emergence of evolutionary thoughts: Lamarck; Darwin–concepts of variation, adaptation, struggle, fitness and natural selection; Mendelism; Spontaneity of mutations; The evolutionary synthesis.



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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; Anaerobic metabolism, photosynthesis and aerobic metabolism.

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.

The 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; Allopatricity and Sympatricity; 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.

### APPLIED BIOLOGY:

Application of immunological principles, vaccines, diagnostics. Tissue and cell culture methods for animals. Transgenic animals Genomics and its application to health, including gene therapy. Bioresource and uses of biodiversity.

### 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, such as micro array based techniques, Isolation, separation and analysis of carbohydrate and lipid molecules, RFLP, RAPD and AFLP techniques, Histochemical and Immunotechniques: Antibody generation, Detection of molecules using ELISA, RIA, western blot, immunoprecipitation, fluocytometry and immunofluorescence microscopy, detection of molecules in living cells, in situ localization by techniques such as FISH and GISH.



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**Biophysical Methods:** 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; Errors; Levels of significance; Regression and Correlation; t-test; Analysis of variance; X<sup>2</sup> test; Basic introduction to Multivariate 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.