

# Savitribai Phule Pune University

## Syllabus for PET for PhD admission in Microbiology

### PART II: Microbiology

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*Note: For Part II (Subjective), the question paper will consist of 25 MCQs (50 Marks) based on the following syllabus.*

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#### 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 (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.
- Metabolism and regulation of carbohydrates, lipids, proteins, nucleic acids. Clinical application and Diseases induced through their metabolism.
- Vitamin Chemistry, Metabolism and clinical applications.
- Principles of catalysis, enzymes and enzyme kinetics, enzyme regulation, mechanism of enzyme catalysis, isozymes, enzyme classification, enzyme isolation, purification and characterization.
- Conformation of proteins (Ramachandran plot, secondary structure, domains, motif and folds).
- Conformation of nucleic acids (helix (A, B, Z), t-RNA, micro-RNA). I. Stability of proteins and nucleic acids.
- Computational analysis techniques of macromolecules and applications.

## 2. Cellular Organization

- **Prokaryotic and eukaryotic cell Structural organization and function of intracellular organelles** (Cell wall, nucleus, mitochondria, Golgi bodies, lysosomes, endoplasmic reticulum, peroxisomes, plastids, vacuoles, chloroplast, structure & function of cytoskeleton, motility organelles, types and mechanisms, stored bodies, magnetosomes, dormant stages in microbes).
- **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, secretory systems).
- **Organization of genes and chromosomes** (Operon, unique and repetitive DNA, interrupted genes, gene families, structure of chromatin and chromosomes, heterochromatin, euchromatin, transposons).
- **Cell division and cell cycle** (Mitosis and meiosis, their regulation, steps in cell cycle, regulation and control of cell cycle).
- **Microbial Physiology and metabolism** (Growth yield and characteristics, strategies of cell division, stress response, metabolic pathways, mode of nutrition. Virus structure, classification, multiplication and diseases induced by animal, plant and human viruses).

## 3. Fundamental Process

- **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 phage, viruses, prokaryotic and eukaryotic genes, role of chromatin in gene expression and gene silencing).

#### 4. Cell Communication and Cell Signalling

- **Host parasite interaction** Recognition and entry processes of different pathogens like bacteria, viruses into animal and plant host cells, alteration of host cell behaviour by pathogens, virus-induced cell transformation, pathogen-induced diseases in animals and plants, cell-cell fusion in both normal and abnormal cells.
- **Cell signalling** Hormones and their receptors, cell surface receptor, signalling through G-protein coupled receptors, signal transduction pathways, second messengers, regulation of signalling pathways, bacterial and plant two-component systems, light signalling in plants, bacterial chemotaxis and quorum sensing.
- **Cellular communication** Regulation of haematopoiesis, 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, tumour 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 immunodeficiencies, vaccines.

## 5. 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.
- **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.
- **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

## 6. Diversity of Life Forms

- **Principles & methods of taxonomy:** Concepts of species and hierarchical taxa, biological nomenclature, classical & quantitative methods of taxonomy of microorganisms.
- **Outline classification of microorganisms:** Important criteria used for classification in each taxon. Classification of microorganisms. Evolutionary relationships among taxa. Life in extreme environments.
- **Organisms of health & agricultural importance:** Common parasites and pathogens of humans, domestic animals and crops.

## 7. 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, interdemic 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, 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).

## 8. Applied Biology

- Basics of Microbial fermentation and production/ purification/applications of primary and secondary metabolites.
- Application of immunological principles, vaccines, diagnostics.
- Genomics and its application to health and agriculture, including gene therapy.
- Bioresource and uses of biodiversity.
- Biocontrol, Bioleaching, wastewater treatment, Bioremediation and phytoremediation
- Biosensors and Nanobiotechnology

## 9. 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, flowcytometry 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, surface plasma resonance methods and tracer techniques in biology.
- **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 Electron Microscopy (EM), freeze-etch and freeze-fracture methods for EM, image processing methods in microscopy.
- **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.

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## Syllabus for PET for PhD admission in Microbiology

### PART I: Research Methodology

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*Note: For Part I (Research Methodology), the question paper will consist of 25 MCQs (50 Marks) based on the following syllabus.*

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**1) Foundation of Research:** Meaning, Objectives, Motivation, Utility, Characteristics and Types. Characteristics of scientific methods, understanding the language of research, Concept, Construct, definition, Variable. Scientific Research Process. Steps of research, methods of research, research ethics.

**2) Problem Identification & Formulation:** Definition and formulating the research problem, Necessity of defining the problem, Importance of literature review in defining a problem. Literature survey: primary and secondary; web sources; critical literature review. Research Question - Investigation Question - Hypothesis testing - Qualities of a good hypothesis - Null hypothesis & Alternative Hypothesis.

**3) Research Design:** Concept and Importance in Research - Features of a good research design - Exploratory Research Design - Concept, Types and uses, Descriptive Research Design - concept, types and uses. Experimental Design - Concept of Independent & Dependent variables. Biased and unbiased research design. Ethics pertaining to human and animal experimentation. Bio-safety guidelines

**4) Qualitative and Quantitative Research:** Qualitative - Quantitative Research - Concept of measurement, causality, generalization, replication. Merging the two approaches. Biological data: Types of data - Qualitative data, Quantitative data

**5) Sampling, Data Collection and analysis:** Execution of the research - Observation and Collection of data - Methods of data collection, hypothesis-testing - Generalization and Interpretation. Concept of Statistical population, Sample, Sampling Frame, Sampling Error, Sample size, Non-Response. Characteristics of a good sample, sample distribution, Probability



and Probability distributions. Determining size of the sample - Practical considerations in sampling and sample size. Data analysis - Univariate analysis (frequency tables, bar charts, pie charts, percentages), Bivariate analysis - Cross tabulations and Chi-square test including testing hypothesis of association including Chi test, correlation and regression analysis.

**6) Measurement:** Concept of measurement - what is measured? Problem in measurement in research - Validity and Reliability. Levels of measurement - Nominal, Ordinal, Interval, Ratio.

**8) Interpretation of Data and Paper Writing:** Graphical interpretation of data, Layout of a Research Paper, Journals, Ethical issues related to publishing, Plagiarism and Self-Plagiarism, Impact factor of journals indexing: Scopus, Web of Science, H -index, i10 index, etc.

**10) Use of tools / techniques for referencing and writing:** methods to search required information effectively, PubMed, effective literature search using Entrez, Google Scholar. Software for paper formatting like MSOffice, software for detection of Plagiarism. Reference management software like Zotero/Mendeley/Endnote. Science image drawing software's like BioRender/Cell Illustrator/Edraw/smartdraw/chemdraw, Basics of internet and e-mailing. Reporting and Thesis writing - Structure and components of scientific reports - Types of report - Technical reports and thesis - Significance - Different steps in the preparation - Layout, Structure and Language of typical reports - Illustrations and tables - Bibliography, referencing styles and footnotes - Reproduction of published material - citation and acknowledgement - Oral presentation - Planning - Preparation - Practice - Making presentation - Use of visual aids - Importance of effective communication.

**11) Application of results and ethics:** Environmental impacts - Ethical issues - ethical committees - Commercialization - Copy right - royalty - Intellectual property rights and patent law - Falsification and verification.

**12) Reasoning and Mental ability:** Analogy, Logical reasoning and aptitude, Classification, Series, Coding-Decoding, Direction Sense, Representation Through Venn Diagrams, Mathematical Operations, Arithmetical Reasoning, Inserting the Missing Character, Number, Ranking and Time Sequence Test, Eligibility Test, Representation through Venn-diagrams, Number & symbols ordering, Comprehension questions, Statement & assumptions, Statement & conclusions, Statement & actions.

## **Books recommended**

1. Research Methodology By C R Kothari
2. Research Methodology: An Introduction By Stuart Melville and Wayne
3. Research Methodology: A Step by Step Guide for beginners By Ranjeet Kumar
4. How to Write and publish a Research Paper By Robert Day and Barbara Gastle
5. Introduction to Biostatistics and Research Methods By P S S Sunder Rao
6. Research Methodology and Scientific Writings By C George Thomas
7. Practical Research Methodology By Catherine Dawson
8. Research Methods for Science By Michael P Marder
9. Research Methodology: Principle, Methods and Practices-Joshua By O. Miluwi and Hina Rashid
10. Doing Science: Design, Analysis, and Communication of Scientific Research. By Valiela, I
11. On Being a Scientist: A Guide to Responsible Conduct in Research. Washington, D.C.: National Academies Press.
12. Experimental Design for Biologists, by David J Glass