

Department of Biotechnology

Biotechnology Syllabus for Ph.D. (PET) Entrance Exam

PART A - Research Methodology

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

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) Data Collection and analysis: Execution of the research - Observation and Collection of data - Methods of data collection, hypothesis-testing - Generalization and Interpretation.

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

7) Sampling, data collection and analysis: 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.

8) Interpretation of Data and Paper Writing: Graphical interpretation of data, Layout of a Research Paper, Journals, Ethical issues related to publishing, Plagiarism and SelfPlagiarism.

9) 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. 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 and footnotes - Reproduction of published material - citation and

acknowledgement - Oral presentation - Planning - Preparation - Practice - Making presentation
- Use of visual aids - Importance of effective communication.

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

11) 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 Venndiagrams, Number & symbols ordering, Comprehension questions, Statement & assumptions, Statement & conclusions, Statement & actions.

Books recommended

1. Research Methodology-C R Kothari
2. Research Methodology: An Introduction-Stuart Melville and Wayne
3. Practical Research Methodology-Catherine Dawson
4. Research Methods for Science Michael P Marder
5. Research Methodology: Principle, Methods and Practices-Joshua O.Miluwi and Hina Rashid
6. Research Methodology: A Step By Step Guide for beginners- Ranjeet Kumar
7. How to Write and publish a Research Paper- Seventh Edition-Robert Day And Barbara Gastle
8. Research Methodology and Scientific Writings- C George Thomas

References:

- 1) Garg, B. L.Karadia R. Agrawal, F. and Agrawal U. K., 2015. An Introduction to Research Methodology, RBSA Publishers
- 2) Kothari C. R.,2004. Research Methodology: Methods And Techniques New Age International 418p.
- 3) Sinha S. C. and Dhiman A. K., 2002. Research Methodology Ess Ess Publications 2 Columes.
- 4) Trochim W. M. K., 2005. Research Methods: The Concise Knowledge Base Atomic Dog Publishing, 270P

PART – B Biotechnology

- 1. Molecules and their Interaction Relevant to Biology** - Structure of atoms, chemical bonds, and molecules - Principles of biophysical chemistry (pH, buffer, thermodynamics, reaction kinetics, colligative properties). Composition, structure, and function of biomolecules (carbohydrates, proteins, lipids, nucleic acids, and vitamins). Principles of catalysis, enzymes and enzyme kinetics, enzyme regulation, mechanism of enzyme catalysis. Metabolism of carbohydrates, amino acids, lipids, nucleotides, and vitamins. Conformation of nucleic acids (helix (A, B, Z), micro-RNA, t-RNA). Stability of proteins and nucleic acids
- 2. Cellular Organisation** - Prokaryotic and eukaryotic cell structure; Membrane structure and function, Structural organization and function, of the intracellular organelles, Organization of genes and chromosomes, Cell division and cell cycle-Mitosis and meiosis, their regulation, control of cell cycle, and steps in the cell cycle, Microbial Physiology-Growth, yield, characteristics, stress response, strategies of cell division.
- 3. Cellular Communication and Signalling** - Host-parasite interaction-Recognition and entry processes of different pathogens like bacteria, viruses into animal and plant host cells, pathogen-induced diseases in animals and plants, alteration of host cell behavior by pathogens, virus-induced cell transformation, cell-cell fusion in both normal and abnormal cells. Cell signaling-Hormones and their receptors, regulation of signaling pathways, bacterial and plant two-component systems, light signaling in plants, cell surface receptors, signaling through G-protein coupled receptors, signal transduction pathways, second messengers, bacterial chemotaxis, and quorum sensing.
- 4. Molecular structure of genes and chromosomes-** Fundamental Process - Nucleic acid replication, transcription, translation and their regulatory mechanisms in prokaryotes and eukaryotes; Mendelian inheritance; Complementation; Linkage, genetics (plasmids, transformation, transduction, conjugation); Horizontal gene transfer and Transposable elements; Organelle DNA, Satellite-and repetitive DNAs, RNA interference for gene silencing; DNA damage and repair; Chromosomal variation; Control of gene expression at transcription and translation level. Mutations and mutagenesis.
- 5. Principles of microscopy**-light, electron, fluorescent and confocal; Centrifugation- high speed and ultra; Principles of spectroscopy-UV, visible, FTIR, Raman, MS, NMR; Principles of chromatography- ion exchange, gel filtration, affinity, GC, HPLC, Electrophoresis; Microarray.
- 6. Microbes** - Viruses- structure and classification; Microbial classification and diversity (bacterial, algal and fungal); Methods in microbiology; Kinetics of Microbial growth and nutrition; Aerobic and anaerobic respiration; Nitrogen fixation; Microbial diseases and host-pathogen interaction
- 7. Development Biology** -Basic concepts of development. Gametogenesis, fertilization, and early development. Morphogenesis and organogenesis in animals. Morphogenesis and organogenesis in plants. Programmed cell death, senescence, and aging. Micropropagation.

Meristem culture and production of virus-free plants. Anther and microspore culture. Embryo and ovary culture. Protoplast isolation. Protoplast fusion-somatic hybrids, cybrid. Synthetic seeds. In vitro germplasm conservation. Methods of gene transfer in plants. Achievements and recent developments of genetic engineering in agriculture.

8. **Plant Physiology** - Photosynthesis Light-harvesting complexes; Respiration and photorespiration –plant mitochondrial electron transport and ATP synthesis; photorespiratory pathway. Stomata and stomatal movement Nitrogen metabolism. Plant hormones. Biosynthesis, Nutrient Uptake, transport, and translocation of water through xylem and phloem; transpiration; Secondary metabolites. Stress physiology. Responses of plants to biotic (pathogen and insects) and abiotic (water, temperature, and salt) stresses.
9. **Animal Physiology** - Blood and circulation, Cardiovascular System, Respiratory system, Nervous system Neurons, Sense organs Vision, hearing, and tactile response. Excretory system – Thermoregulation, Digestive system - Digestion, energy balance, absorption, BMR. Endocrinology and reproduction-Endocrine glands, Stress and adaptation.
10. **Methods in Biotechnology** - Restriction and modification enzymes; Vectors; plasmid, bacteriophage and other viral vectors, cosmids, Ti plasmid, yeast artificial chromosome; mammalian and plant expression vectors; cDNA and genomic DNA library; cloning and expression; Transposons and gene targeting; DNA labeling; DNA sequencing; Polymerase chain reactions; DNA fingerprinting; Southern and northern blotting; RAPD, RFLP; Site-directed mutagenesis; Gene transfer technologies; Gene therapy, DNA fingerprinting
11. **Immunology** - History of Immunology; Innate, humoral and cell mediated immunity; Antigen; Antibody structure and function; Synthesis of antibody and secretion; Antigen-antibody reaction; Complement; Primary and secondary lymphoid organ; B and T cells and macrophages; Major histocompatibility complex (MHC); Antigen processing and presentation; Polyclonal and monoclonal antibody; Regulation of immune response, Hybridoma technology;
12. **Diversity of Life Form** - Principles & methods of taxonomy - Biological nomenclature, Levels of a structural organization-Unicellular, colonial, and multicellular forms. Levels of organization of tissues, organs & systems. Outline classification of plants, animals & microorganisms - Major habitat types of the Indian subcontinent, geographic origins and migrations of species. Organisms of conservation concern-Conservation strategies, Rare, endangered species.
13. **Ecological Principles** - The Environment, Habitat and Niche - Population Ecology- Species Interactions, Community Ecology, Conservation Biology, Applied Ecology & Environmental pollution; Ecological Succession BiogeographyMajor terrestrial biomes; biogeographical zones of India; Ecosystem Ecology Ecosystem structure; ecosystem function; energy flow and mineral cycling (C, N, P); structure and function of some Indian ecosystems: terrestrial (forest, grassland) and aquatic (freshwater marine, estuarine); primary production and decomposition.
14. **Evolution and Behavior** - Paleontology and Evolutionary History - emergence of the evolutionary thoughts, Darwin concepts of variation, adaptation, Mechanisms-Origin of cells and unicellular evolution - Origin of basic biological molecules; Brain, Behavior, and

- Evolution: Molecular Evolution - Concepts of neutral evolution, Molecular tools in phylogeny, classification and identification; gene duplication and divergence.
15. Major Bioinformatics resources and search tools; Sequence and structure databases; Data mining and analytical tools for genomic and proteomic studies
 16. Structure of Atom, Classification of Elements and Periodicity in Properties, Chemical Bonding and Molecular Structure, Thermodynamics, Redox Reactions, s-Block Element (Alkali and Alkaline earth metals), Hydrocarbons, Electrochemistry, Chemical Kinetics, Surface Chemistry, Haloalkanes and Haloarenes, Alcohols, Phenols and Ethers, Aldehydes, Ketones and Carboxylic Acids, Organic Compounds Containing Nitrogen
 17. Laws of Motion, Work, Energy and Power, Motion of System of Particles and Rigid Body, Gravitation, Oscillations and Waves, Electrostatics, Current Electricity, Magnetic Effects of Current and Magnetism, Electromagnetic Induction and Alternating Currents, Electromagnetic Waves, Optics, Dual Nature of Matter and Radiation, Atoms and Nuclei.
 18. A New Approach to Reasoning - Verbal, Non-Verbal and Analytical and Quantitative aptitude

Suggested Readings

1. Raven PH, Johnson GB, Losos JB & Singer SR. (2005) Biology. Tata McGraw Hill, Delhi, India.
2. Taiz L, Zeiger E (2010) Plant Physiology. Sinauer Associates Inc., USA.
3. Kotpal RL (2019), Modern Text Book of Zoology (Invertebrate and Vertebrates), Rastogi Publications
4. Stryer L, Berg J, Tymoczko J & Gatto G. (2019) Biochemistry. 9th Ed. Publisher: WH Freeman
5. Andreas Hofmann & Samuel Clokie (2018). Principles and Techniques of Biochemistry and Molecular Biology 8th Ed. Cambridge University Press.
6. Woolverton CJ, et al. (2016) Microbiology. McGraw-Hill Education.
7. Cooper, G. M., & Hausman, R. E. (2013). The Cell: a Molecular Approach (6th Ed.). Washington: ASM; Sunderland
8. Watson, J.D. (2008) Molecular Biology of the Gene (5th Ed.). Menlo Park, CA: Benjamin/Cumming
9. Pörtner, R. (2007). Animal Cell Biotechnology: Methods and Protocols. Totowa, NJ: Humana Press.
10. H.S. Chawla, (2020). Introduction to Plant Biotechnology. Oxford and IBH P Publishing Co. Pvt. Ltd. New Delhi.
11. Pierce, B. A. (2005). Genetics: a Conceptual Approach. New York: W.H. Freeman
12. Primose SB & Twyman RM. (2006). Principles of Gene Manipulation and Genomics. 7th Ed. Wiley-Blackwell Publishing.
13. Paul WE. (2012) Fundamental Immunology. Lippincott Williams & Wilkins, USA
14. Pevsner, J. (2015). Bioinformatics and Functional Genomics. Hoboken, NJ.: Wiley-Blackwell.
15. Agarwal RS (2018) Quantitative Aptitude, Logic Reasoning & Verbal Reasoning