UNIVERSITY OF MUMBAI

SYLLABUS FOR Ph.D. ENTRANCE TEST (PET) IN BIOTECHNOLOGY 2020

PAPER I: 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, t-test, z-test, ANOVA- one way and two way.

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.

9. **IPR**: Types, Copyrights in Scientific work, Patents in scientific research, Writing a patent specification, patent filing and grant, infringement. Gene patenting, Farmer's rights, Plant Breeder's rights, Traditional knowledge and protection.

10. **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.

Reference books:

1) Garg, B. L.Karadia R. Agrawal, F. and Agrawal U. K., 2002. An Introduction to Research Methodology, RBSA Publishers

2) Kothari C. R., 1990. Research Methodology: Methods and Techniques New Age International 418p.

3) Sinha S. C. and Dhiman A. K., 2002. Research Methodology Ess Publications 2 Columes.

4) Trochim W. M. K., 2005. Research Methods: The Concise Knowledge Base Atomic Dog Publishing. 270P

5) Wadehra B. L., 2000. Law Relating to Patents, Trade Marks, Copyright Design and Geographical Indications, Universal Law Publishing

6) Research Methodology: An Introduction-Stuart Melville and Wayne

7) Practical Research Methodology-Catherine Dawson

8) Research Methods for Science Michael P Marder

9) Research Methodology: Principle, Methods and Practices-Joshua O.Miluwi and Hina Rashid

10) Research Methodology: A Step by Step Guide for beginners- Ranjeet Kumar

11) How to Write and publish a Research Paper- Seventh Edition-Robert Day And Barbara Gastle

12) Introduction to Biostatistics and Research Methods- P S S Sunder Rao

13) Research Methodology and Scientific Writings- C George Thomas

PAPER II: CORE SUBJECT-BIOTECHNOLOGY

1. **Biochemistry and Metabolism:** Starch and Glycogen, Cellulose, Chitin, Glycosaminoglycans Heparin, Chondroitin sulphate, Dermatan sulphate, Keratan sulphate. Formation structure and functions of Eicosanoid: Prostaglandins and Thromboxanes. Glycoproteins (N6,O6,GPI6 linked and proteoglycans) & Glycolipids, and Lectins. Haemoglobin and Myoglobin: Structure, oxygen binding, Hill equation and Hills plot, Cooperativity, Bohr effect, Allosteric regulation: Adair Equation, Symmetry model and Sequential model. Lipoproteins: Structure, types and functions. Lipoprotein Dysfunction: Atherosclerosis, Alzheimer's Disease. PEM (Kwashiorkar and Marasmus). Diabetes: Type I, Type II, gestational. Glycogen storage disorders 6von Gierke's disease, Cori's disease, Andersen's disease, McArdle's disease. Amino acid metabolism- PKU, Alkaptonuria. Lipids- Tay-Sachs, Gaucher's disease. Nucleic acids6 Gout, Lesch6Nyhan syndrome. Role of B group Vitamins in metabolic pathways. Structure and functions of neuron, types and physiologic anatomy of the Synapse, transmission of nerve impulses, ion channels, neurotransmitters and neuropeptides, Electrical events during neuronal excitation and inhibition. Neurotoxins. Neurochemistry: Special senses6 taste, vision, odor, hearing.

2. **Immunology:** Antigen presentation. Secondary signaling, co-stimulation, Cell signaling in immune response. DC activation, B cells as APC, experimental models in APC. Complements-Lectin pathway. Peptide epitopes, T cell B cell antigenic properties, prediction of T and B cell epitopes, Generation of antibody diversity, MHC and antigen presentation6 Exogenous and Endogenous pathway, non peptide antigens. Histocompatibility Complex, Polymorphism transplantation, Chimeric peptides, polytope vaccines, Major Histocompatibility Complex, Polymorphism transplantation. Cytokines: properties, receptor, antagonists, diseases, Therapeutic use of cytokines Experimental immunology:Vaccine development (Recombinant, Combined and polyvalent vaccines), Antigen Antibody reactions in diagnostics. Cancer Immunology. Mucosal immunity, Peyer's patches, gut barriers, oral immunization, Oral tolerance, Cytotoxic response, ADCC, NK cells, CTL, Th, T regulation, Immunoregulation, anergy, tolerance, anti idiotype, Mechanisms of antiviral innate immune response.
   Autoimmunity mechanisms, altered antigens, Systemic Lupus erythematosus, Graves diseases, Rheumatoid arthritis, Myasthenia Gravis, Multiple sclerosis, animal models of autoimmunity Transplantation immunology, GvH, Immunodeficiency: phagocytic, humoral, CMI, combined HLA association with disease. Animal models and transgenic animals and their use in immunological studies, Routes of Inoculation___, Antibody engineering, Chimeric antibodies, Phage display. Cell Cytotoxicity, mixed lymphocyte reaction, Apoptosis, Cytokine expression; Cell cloning, Reporter Assays, *In–situ* gene expression techniques; Cell imaging Techniques- *In vitro* and *In vivo*; Immunoelectron microscopy; *In vivo* cell tracking techniques; Microarrays. Types of cancer, malignant transformation of cells, tumour antigens, immune response to cancer, immunotherapy. Connections of CNS to immune system and *vice versa*, Psychological

modulation of immunity, stress and immunity, implication for diseases, functional significance – inflammation and acute phase response, role of glucocorticoids, stress response, energy demand and balance

3. **Biochemical and Biophysical techniques:** AFM, Fluorescence Microscopy, Confocal microscopy, cryotomy, scanning and transmission microscopes, different fixation and staining techniques for EM, freeze6etch and freeze6 fracture methods for EM, image processing methods in microscopy, single cell imaging. Environmental SEM, and its advantages. Introduction, principle and analysis using UV/visible Spectrophotometer, fluorescence spectroscopy, circular dichroism ORD, NMR and ESR spectroscopy, Molecular structure determination using Xray diffraction, X ray crystallography and NMR, Molecular analysis using light scattering, mass spectrometry and LC6MS, GC6 MS, and surface plasma resonance methods, IR. Introduction, principle and analysis using HPTLC, HPLC, GLC, Affinity chromatography and its types IEF and 2 D electrophoresis. Applications of the above techniques. Radioisotopes techniques6 Radio assay (nature of radioactivity, units, decay, half6life, detection/measurement), scintillation counting, safety aspects and applications of radioisotopes. Antibody generation, blotting techniques, Immuno - precipitation, Flow cytometry and immunofluorescence, detection of antigens in living cells, in situ localization by techniques such as FISH and GISH

4. **Molecular Biology:** Transcription in prokaryotes and Eukaryotes, Types of RNA polymerases, Promoters, initiation, elongation, termination and anti-termination. Initiation factor, role of transcription factors, Regulation of RNA polymerase Chromatin structure and transcription. Transcription in cell organelles. RNA processing in eukaryotes: modifications, splicing and splicing machinery, processing of RNA. Editing and amplification. Translation in Prokaryotes and Eukaryotes Codon assignments, Wobble hypothesis, initiation, elongation, and termination, Modification folding and transport protein. Molecular chaperons in folding, Protein sorting and trafficking using signal proteins. DNA rearrangement, RNAi, regulation of translation. Post translational modification. Mobile DNA elements, Transposable elements in bacteria, Controlling elements in TnA and Tn 10 transposition. SINES and LINES, retrotransposons. Genomics and Proteomics: an overview - omes and omics, Concepts and applications Genome overview at the level of Chromosome (with model organisms as example); Strategies for large scale DNA sequencing- Whole genome analysis techniques, Next generation sequencing methods; Organization, structure and mapping of genomes (with model organisms as example)

5. **Bioinformatics:** Organization of biological data, databases (raw and processed), Quering in data bases. Primers in biology (Designing of primers, kinds of primers). Gene finding, motif finding and multiple sequence alignment. Protein sequence analysis (theory and algorithms). Protein structure analysis and applications. Gene expression profiling and its applications. Microarray technology and basics. Microarray analysis and organization of data, Human genome analysis Proteomics. Exploration of data bases, retrieval of desired data, BLAST etc. Gene clusters and fusions, consensus sequences, exon intron finder, sequence logo.

6. **PTC & ATC:** Introduction to primary and secondary metabolism, important pathways leading to

biosynthesis of secondary metabolites in plants, Metabolic products produced from in vitro culturing of plant cells, selection of plant cells/ tissues for production of a specific products, culture system in secondary plant product, Biosynthesis- batch, continuous cultures, immobilized plant cell, Biotransformation of precursors by cell culturing, metabolic engineering for production of secondary metabolites, Hairy root culture, elicitation. Cryopreservation -Principle and types. Germplasm conservation, Transgenic plants-Edible vaccine, Golden rice. Biology of cultured cells Culture vessels, Culture Media, Microbial contamination, cross contamination. Cryopreservation. Primary culture: Types, isolation of tissues, culturing of different cells. Cell lines: Development, Subculture and propagation, immortalization of cell line, cell line designation, selection of cell lines, routine maintenance, Cytotoxicity Transformation Culture of tumor cells.

7. **Bioprocess technology:** Strain improvement for increased yield and other desirable characteristics; Upstream processing: Media formulation, Sterilization. Bioreactor designs; classification of fermenters; Batch, fed batch and continuous; Conventional fermentation v/s biotransformation; Solid substrate, surface and submerged fermentation; Fermenter design-mechanically agitated; Pneumatic and hydrodynamic fermenters; Large scale animal and plant cell cultivation; Aeration and agitation in bioprocess; Measurement and control of bioprocess parameters; Bio separation - filtration, centrifugation, sedimentation, flocculation; Cell disruption; Liquid-liquid extraction; Purification by chromatographic techniques; Reverse osmosis and ultra-filtration; Drying; Crystallization; Storage and packaging; Treatment of effluent and its disposal; Mechanism of enzyme function and reactions in process techniques; Enzymic bioconversions e.g. starch and sugar conversion processes; High-Fructose Corn Syrup; Inter esterified fat; Hydrolyzed protein etc. and their downstream processing; baking by amylases, deoxygenation and desugaring by glucoses oxidase, beer mashing and chill proofing; cheese making by proteases and various other enzyme catalytic actions in food processing; Fermented foods and beverages; Food ingredients and additives prepared by fermentation and their purification; fermentation as method of preparing and preserving foods; Microbes and their use in pickling, producing colours and flavours, alcoholic beverages and acids; Process wastes-whey, molasses, starch substrates and other food wastes for bioconversion to useful products; Bacteriocins from lactic acid bacteria - Production and applications in food preservation.

8. **Medical Microbiology:** Chromosomal disorders- Karyotyping, G banding, Chromosome analysis, variations, chromosome painting. Infections of Respiratory tract-Pneumonia,Tuberculosis. Nosocomial- Psuedomonas. Viral infections-HIV, Hepatitis. Fungal-Candidiasis. Molecular diagnostics for Pneumonia, Tuberculosis, Pseudomonas, HIV, Hepatitis. Candidiasis. Biofilms in medicine.

9. **Developmental Biology:** Human Embryonic development: Events during fertilization, in-vitro fertilization, Zonapellucidaa, glycoprotein, Oelemma protein and their role in fertilization, sperm antigens and their functional significance. Molecular and biochemical events during sperm function. Post fertilization events: early embryonic development, establishing multi-cellularity, formation of blastula, embryonic germ layer, tracking of migrating cells. Molecular mechanism of sex hormone action and regulation of gene expression. Implantation and endometrium antigens involved in implantation. Immunology of pregnancy. Superovulation, embryo culture and embryo transfer technology. Infertility and reproductive vaccines. Frontiers in contraceptive

research. Cryopreservation of sex gametes and embryos. Ethical issues related to embryo research.

10. **Clinical studies:** Types of clinical trials, single blinding, double blinding, open access, randomized trials, and their examples, interventional study, ethics committee and its members, cross over design, etc and Institution Ethics Committee/ Independent Ethics Committee, Pre-clinical toxicology: General Principals, Systemic toxicology (single dose and repeat dose toxicity studies), Carcinogenicity, Mutagenicity, Teratogenicity, Reproductive toxicity, Local toxicity, Genotoxicity, animal toxicity requirements. New drug discovery process- purpose, main steps involved in new drug discovery, process, timelines of each step, advantages and purposes of each step, ethics in clinical research, unethical trials, thalidomide tragedy, Phase I, II, III, IV trials. Introduction and designing – various phases of clinical trials – Post marketing surveillance - methods. Medical writing – Literature search & medical articles, contract writing, publication, abstracts, bibliography, clinical study reports, principals and software in Clinical Data Management (CDM).

11. **Nanotechnology:** Introduction, synthesis of nanomaterials, biological methods, use of microbial system & plant extracts, use of proteins & templates like DNA. Characterization of nanomaterials, analysis techniques, properties of nanomechanical, optical, magnetic properties, electrical conductivity, thermal conductivity. Carbon nanotubes Nanorobotiocs devices of nature: ATP synthese, the kinen, myosin, dynein, flagella modulated motion. Nanomedicine: biopharmaceutics, implantable materials, implantable chemicals, surgical aids, diagnostic tools, nanosensors, nano scanning, nano enabled drug delivery system, nanorobotics in medicine. Application of nanomaterials in food,cosmetics, agriculture, environment management.

12. **Environmental Biotechnology:** Genetically Modified Microorganisms, examples and methods Humulin, ice minus bacteria, GM bacteria in bioremediation, use of PCR as a GMO identification tool, risks and controversies related to use of GM microorganisms. Indian GM research information system, About Indian GMO Research Information System (IGMORIS), about the website, biosafety data of any two approved genes available on the database. GE crops-Arabidopsis as a model plant for studies in GE, Protocols on food and feed safety assessment, Acute oral safety study in rats and mice, sub-chornic feeding study in rodents, Protein thermal stability, Pepsin digestibility, Livestock feeding study. Solid waste treatment, pollution indicators & biosensors, biodegradation of xenobiotics, pesticides, phytoremediation. Biodegration of waste from food, textile, petro chem , paper industries, biological detoxification, Removal of oil spillage & grease deposits.

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4. Biochemical Calculations, 2nd Ed., (1997) Segel Irvin H., Publisher: John Wiley and Sons, New York.
5. Enzymes: Biochemistry, Biotechnology & Clinical chemistry, (2001) Palmer Trevor, Publisher: Horwood Pub. Co., England.
6. Outlines of Biochemistry: 5th Edition, Erice Conn & Paul Stumpf; John Wiley and Sons, USA
7. Fundamentals of Biochemistry. 3rd Edition (2008), Donald Voet & Judith Voet , John Wiley and Sons, Inc. USA
8. Lehninger, Principles of Biochemistry. 5th Edition (2008), David Nelson & Michael Cox, W.H. Freeman and company, NY.
9. Biochemistry: 7th Edition, (2012), Jeremy Berg, Lubert Stryer, W.H.Freeman and company, NY
10. Biochemistry, L Stryer, Freeman and Co, NY
11. Biochemistry, Zubay, Addison Wesley and Co.
12. Textbook of Physiology, Guyton
13. Physiology, Berne and Levy
14. Harper's Biochemistry- 27th edition
15. Text book of Human Biochemistry- Ed. G. P. Talwar
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17. Human biochemistry – James Orten and Otto Neuhaus, 10th ed , CV Mosby co London
18. Human nutrition and dietetics-Davidson and Passmore
19. Plant physiology, Salisbury and Ross (2007) CBS publishers and distributors
20. Biochemistry and Physiology of Plant Hormones, Thomas Moore, Springer Verlag New York
21. Plant Biochemistry- Hans Walter Heldt, 3rd Edition, Elesvier Academic Press
22. Introduction to Plant Biochemistry- T.W. Goodwin and E.L. Mercer
23. Plant Physiology- Devlin, CBS Publishers
24. Plant Biochemistry- Dey, Academic Press, 1999

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2. Fundamental Immunology 5th edition (August 2003): by William E., Md. Paul (Editor) By Lippincott Williams & Wilkins Publishers
3. Essential Immunology, Ivan M. Roit (1994)– Blackwell Scientific Pub, Oxford.
4. Cellular and Molecular Immunology, 3rd ed, Abbas, Saunders; 7 edition (11 June 2011)
5. Psychoneuroimmunology, Stress, and Infection, By Herman Friedman, Thomas W. Klein, Andrea L. Friedman, CRC Press, 1996

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2. Molecular Biology of the Gene, 6th Edition (2008), James D. Watson, Pearson Education, Inc. and Dorling Kindersley Publishing, Inc. USA
3. Molecular Biology, 5th Edition (2011), Weaver R., McGraw Hill Science. USA
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6. Discovering genomics, Proteomics and Bioinformatics (2006) A. Malcoln Campbell, laurie J. Heyer Benjamin Cummings; 2nd edition

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2. Biochemical spectroscopy. Vol 46 of Methods in Enzymology. (1995) Kenneth Sauer. Academic Press, USA
3. Modern experimental biochemistry 3rd edition Publisher, USA.edition. (2000) Rodney Boyer. Prentice Hall
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2. David W. Mount, Bioinformatics : Sequence and Genome Analysis (Second Edition 2004), ColdspringHarbor Laboratory Press
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DEVELOPMENTAL BIOLOGY

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3. Dr. D R Krishna, V Klotz, Clinical Pharmacokinetics, Pub Springer Verlab
4. Williams and Wilkins, Remington Pharmaceutical Sciences, Lippincott
5. Hansten, Drug interaction, Kven Stockley
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7. Susanne Prokscha, Practical guide to clinical data management
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9. Richard Rondel, Clinical Data Management, Wiley
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