

**Department of Bioengineering
Faculty of Engineering
Integral University, Lucknow**

**SYLLABUS FOR ENTRANCE TEST TO Ph.D. PROGRAM
(BIOTECHNOLOGY)
w.e.f. June, 2020 onwards**

UNIT 1. BIOCHEMISTRY, MOLECULAR CELL BIOLOGY AND GENETICS

Structure of atoms, molecules and chemical bonds, pH, buffer, reaction kinetics, Thermodynamics, Composition, structure and function of biomolecules (carbohydrates, lipids, proteins, nucleic acids and vitamins), Bioenergetics, Enzymology, Conformation of proteins & nucleic acids (DNA & RNA), Metabolism of biomolecules.

DNA replication, mutation, repair and recombination; RNA synthesis and processing; Protein synthesis and processing; Operon, interrupted genes, structure of chromatin and chromosomes, unique and repetitive DNA, heterochromatin, euchromatin, transposons; regulation of prokaryotic and eukaryotic gene expression; role of chromatin in regulating gene expression; gene silencing.

Membrane structure and function, Structural organization and function of intracellular organelles, Cell division and Cell signaling, Hormones, cell-surface receptors, signal transduction pathways and their regulation, Cellular communication, Basic developmental biology, Cancer Biology. Mendelian principles, deviation from Mendelian inheritance, Concept of gene: (Allele, multiple alleles, pseudoallele), linkage and crossing over, gene mapping, extra chromosomal inheritance, Microbial genetics, Methods of transfer of genetic material in microbes, Human genetics: Pedigree analysis, karyotypes, genetic disorders, Structural and numerical alterations in chromosomes, Population genetics.

UNIT 2. IMMUNOLOGY AND MICROBIOLOGY

Innate and adaptive immune system, antigens, antigenicity, immunogenicity, structure and function of antibody molecules, monoclonal antibodies, antibody engineering, antigen-antibody interactions, MHC molecules, antigen processing and presentation, activation and differentiation of B and T cells, inflammation, hypersensitivity, autoimmunity, immune response during infections, congenital and acquired immunodeficiencies.

History and Scope of Microbiology, Classification systems, structural and chemical composition of cell wall, Microbial growth kinetics, Bacterial Metabolism, Fermentation and anaerobic respiration, Chemotherapeutic agents and antibiotics, Drug Resistance, Host parasite interaction, Microbial spoilage of food, Food preservation, Food borne diseases, Virology, Distinctive properties of Viruses, Viroids and Prions, SARS, Bacteriophages, Lytic and Lysogenic viral life cycles, Control of viruses, Interferon, Antiviral antibiotics.

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UNIT 3. FERMENTATION TECHNOLOGY AND BIOPROCESS ENGINEERING

History and development of fermentation industry: Introduction to submerged and solid state fermentation, primary and secondary metabolite. Raw material availability, quality, processes and pretreatment of raw materials. Media design and optimization; Microbial growth in closed, semi-open cultivation systems; Maintenance energy and yield concepts; Estimation of biomass. Sterilization: Concept and methods; Sterilization of medium; Kinetics of thermal death of microorganisms; Batch sterilization; Continuous sterilization; Sterilization of air: Filters and design of depth filters. Steady state and unsteady state Material and Energy Balance calculations of different bioprocesses such as fermentation, sterilization, filtration etc. Microbial kinetics of growth and substrate utilization; Product formation in batch, Fed batch and continuous culture; Microbial pellet formation; Kinetics and dynamics of pellet formation

UNIT 4. BIOINFORMATICS AND NANOBIO TECHNOLOGY


Nucleic acid and protein sequence/structure databases (GenBank, UniProt, PDB); data mining methods for sequence analysis (BLAST, CLUSTALW). Introduction: Introduction to nanotechnology and overview of nanoscale materials, effect of length scale on properties, introduction to bionanotechnology, challenges and opportunities associated with biology on the Nanoscale, bionanotechnology systems, biological and medical applications of Bionanomaterials. Characteristics of nanoparticles, Environmental behaviour of nanoparticles, biological activity of nanomaterial. Principles of toxicology; toxicology models, experimental toxicology studies; activation and detoxification mechanisms.

UNIT 5. PHYSIOLOGY, EVOLUTION AND ECOLOGY

Photosynthesis, Respiration, Nitrogen metabolism, Plant hormones, Sensory photobiology, Secondary metabolites, Circulatory, Cardiovascular, Respiratory, Nervous, Sensory, Excretory, Digestive, Endocrine and Reproductive Systems. Principles and methods of taxonomy, Levels of structural organization, classification of plants, animals and microorganisms, Organisms of clinical and agricultural importance, Common parasites and pathogens of humans, domestic animals and crops, Molecular Evolution, Population genetics, The Environment: biotic and abiotic interactions, Habitat and niche, Population ecology, Species interactions: Types of interactions, Community ecology, Ecological succession, Ecosystem, Biomes, Applied ecology, Conservation biology.

UNIT 6. TECHNIQUES IN BIOLOGY AND SCIENTIFIC ENGLISH

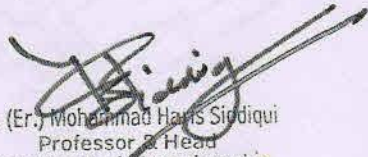
Isolation and purification of RNA, DNA and proteins and associated separation methods; one and two dimensional gel electrophoresis, isoelectric focusing; molecular cloning of DNA or RNA fragments in bacterial and eukaryotic systems; expression of recombinant proteins using bacterial, animal and plant vectors; generation of genomic and cDNA libraries, in vitro mutagenesis and deletion techniques, gene knock out in bacterial and eukaryotic organisms; protein and DNA sequencing methods, methods for analysis of gene expression at RNA and


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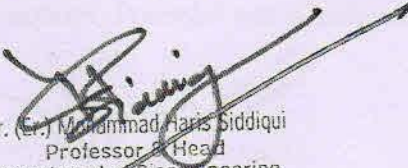
protein level, large scale expression analysis, microarray, PCR; RFLP, RAPD and AFLP techniques. Analysis of biomolecules using UV/visible, fluorescence, circular dichroism, NMR and ESR spectroscopy, structure determination using X-ray diffraction and NMR; Mass spectrometry, Antibody generation, ELISA, RIA, western blot , immunoprecipitation , flow cytometry, *in situ* localization by techniques such as FISH and GISH, Radiolabeling techniques, light and fluorescence microscopy, scanning and transmission electron microscopy. Plant and Animal tissue culture. Statistical Methods: Students t test, Chi Square Test, Probability, ANOVA, Basics of English Grammar, correct use of verbs and prepositions, Tense, Introductory knowledge of terminologies related to scientific communications: Impact Factor, Journal, Citation, Manuscript, Original Article, Review, Acknowledgements, Conflict of interests, Corresponding Author, First Author, Plagiarism.

Recommended Books:

1. Nelson & Cox, Lehninger's Principles of Biochemistry, 5th Edition
2. Harpers Biochemistry, McGraw Hill
3. Stryer, Biochemisrty, Freeman.
4. Geoffrey L. Zubay, Biochemistry.
5. Donald Voet, J.G.Voet, Biochemistry, John Willey.
6. Wilson K, Walker J, Walker JM, "Principles and Techniques of Practical Biochemistry".
7. E.P. Odum "Fundamentals of Ecology" V.B. Saunders and Co. 1974.
8. W.J. Weber "Physics-Chemical Process for water quality control, Wiley-international Ed.
9. L.L. Gaccio water and water population Handbook Marcel Dekkar, New York.
10. Pradipta Kumar Mohapatra "Textbook of Environmental Biotechnology" I.K. International Publishing House Pvt. Ltd., New Delhi.
11. Allan Scagg "Environmental Biotechnology" Oxford University Press, Canada. 2004.
12. Environmental Biotechnology by Prof. Jogdand, Himalayan publishing House, 2010.
13. Huxley TH "Evolution and ethics", Princeton University Press.
14. Goodenough U, "Genetics".
15. Gardner, M. J. Simmons, D. P. Snustad , Principles of Genetics, John Wiley & Sons, (8th Edition)
16. Tom Strachan, T. Strachan, Andrew Read, Andrew P. Read "Human Molecular Genetics"
17. William S. Klug Michael R. Cummings "Concepts of Genetics (7th Edition)"
18. B.D.Singh, Genetics, Kalyani Publications (4th Edition)
19. P.S.Verma and V.K.Agarwal, Cell Biology, Molecular Biology, Genetics, Evolution and Ecology, S.Chand Publications (4th Edition)
20. Swanson G P, Mertz & Young, "Cytogenetics".
21. Strickberger MW, "Introduction to Genetics".
22. Lewin, "Genes".
23. Freifelder DM, "Molecular Biology".
24. Brown T A, "Genomes".
25. Watson J D, "Molecular Biology of the Gene".
26. Twyman R M, "Advanced Molecular Biology".
27. Old & Primrose, "Principles of Gene Manipulation".
28. Primrose S B, "Molecular Biotechnology".
29. Cibelli J B, Robert P, Keith L, Michael C, West D, "Principles of Cloning".
30. Sambrook J, Russell DW, Sambrook J, "Molecular Cloning: A Laboratory Manual".
31. William M, O' Leary Robert, Dony Wu, "Practical Handbook of Microbiology".
32. Brown, TA, "Gene cloning: An introduction".
33. Cantor CR, Schimmel PR, "Biophysical Chemistry".
34. Joanne Willey, Linda Sherwood and Christopher J. Woolverton, "Prescott's Microbiology".


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35. Michael T. Madigan, John M. Martinko, Kelly S. Bender, Daniel H. Buckley, David A. Stahl and Thomas Brock, :Brock Biology of Microorganisms.
36. Luria & Darnell, "General Virology".
37. Pirt SJ, "Principles of Microbe and Cell Cultivation"
38. Bailey J E and Ollis DF, "Biochemical Engineering fundamentals".
39. Stanbury PF, Whitaker A, "Principles of Fermentation Technology".
40. "Principles of Cell Energetics": BIOTOL series, Butterworth - Heinemann.
41. Moser A, "Bioprocess Technology - Kinetics & Reactors".
42. Schugerl K, "Biotechnology" Vol.4 Meaning Modeling and Control.
43. Atkinson B, Mavituna F, "Biochemical Engineering and Biotechnology Handbook".
44. McCabe WL, Smith JC, Harriot P, "Unit operations of Chemical Engineering".
45. Cussler EL, "Diffusion" Cambridge University Press.
46. Doran PM, "Bioprocess Engineering Principles".
47. Pirt SJ, "Principles of Microbe and Cell Cultivation".
48. Fogler H.S. Elements of chemical reaction Engineering.
49. Levenspiel O., Chemical Reaction Engineering. 3rd edition, Wiley New York. 1992.
50. Rao D.G., Introduction to Biochemical Engineering, McGraw-Hill, 2005.
51. Villadsen, J., Nielsen, J., & Lidén, G. Bioreaction engineering principles.
52. Smith J.M., Chemical Engineering Kinetics.
53. Steinfeld, J. I., Francisco J. S., & Hase W. L. Chemical Kinetics and Dynamics.
54. Holland, C. D., & Anthony, R. G. Fundamentals of Chemical Reaction Engineering.
55. Comprehensive Biotechnology, Murray Moo-Young.
56. Microbes& Fermentation, A. Lel and Kotlers Richard J. Mickey, Oriffin publication
57. Industrial Fermentations- Leland, N.Y. Chemical publishers.
58. Prescott and Dunn's- Industrial Microbiology.
59. Prof. Dr. Christof M. Niemeyer Prof. Dr. Chad A. Mirkin, "Nanobiotechnology: Concepts, Applications and Perspectives".
60. Jesus M. de la Fuente V. Gazu, "Nanobiotechnology".
61. Baxevanis AD, Ouelette BFF; Bioinformatics: A practical Guide to the analysis of genes and proteins., Wiley 2004, ISBN: 978-0-471-47878-2
62. Stephen A., David K, Womble D; Introduction to Bioinformatics: A Theoretical and Practical Approach.
63. Harren Jhoti, Andrew R. Leach; Structure- based Drug Discovery.
64. Cynthia Gibas, Per Jambeck; Developing Bioinformatics Computer Skills: An Introduction to Software Tools for Biological Applications.
65. "Cellular & Molecular Immunology" by Abbas AK, Lichtman AH, Abbas AK, Pober JS.
66. "Immunology" by Kuby; Publisher: WH Freeman and Company.
67. "Elements of Immunology" by Fahim Halim Khan.
68. "Immunology" by Roitt, Publisher: Edinburg Mosby.
69. An introduction to Plant Tissue culture by MK Razdan. M.K. .
70. Plant Biotechnology: An Introduction to Genetic Engineering by Adrian Slater, Nigel W. Scott, Mark R. Fowler..
71. Molecular Biotechnology by Glick, B.R. and J.J. Pasternak.
72. Plant tissue culture by Bhojwani. S.S and Razdan.
73. Plant Propagation by Tissue Culture: Volume 1 & 2. EF George.
74. Plant cell culture, A Practical approach, 2nd Edition, Edited by R.A. Dixon and R.A. Gonzales.
75. R. Ian Freshney, "Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications".
76. "Animal Cell Biotechnology: Methods and Protocols" by Nigel Jenkins.
77. Arya R "Bioethics".
78. Erbisch FH and Maredia KM "Intellectual Property Rights".


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Unit 1: Bioinformatics databases and data analysis

Nucleotide and protein sequence databases: GenBank, EMBL, DDBJ, Swiss-Prot, TrEMBL, UniProt. Structural databases: RCSB PDB, MMDB, NDB. Genome databases and browsers: GOLD, MGD, Ensembl, VEGA genome browser, UCSC, Genome Browser. NCBI and its components. Secondary databases: Prosite, Prints, Pfam, InterPro. Derived databases - SCOP, CATH, FSSP, KEGG, ENZYME, LIGAND, STRING. Literature databases: PubMed, PMC, Biomed Central. Database search engines: Entrez, SRS, DBGET. Bioinformatics Resources- EBI, ExPASy, EMBOSS. Data retrieval and Data mining. Tasks in Data mining. Data warehousing, Knowledge discovery in databases.

Unit 2: Sequence analysis and algorithms

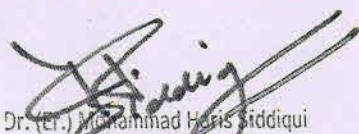
Sequence comparison, Sequence similarity and alignment. Dot plot matrix. Homologous, orthologous and xenologous sequences. Amino acid substitution matrices: PAM and BLOSUM matrices. Dynamic programming algorithms: Needleman Wunsch algorithm, Smith Waterman algorithm. Heuristic algorithms: BLAST, FASTA, concept of e-value. PSI BLAST algorithm, Multiple sequence alignment: progressive and iterative strategies, center star method, CLUSTAL, T- Coffee, PHYLIP, MEGA. Phylogenetics and phylogenetic tree: rooted and unrooted tree, Distance based methods: UPGMA, Neighbor joining, Character based methods: Maximum Parsimony and Maximum Likelihood.

Unit 3: Structural biology and analysis

Nucleic acid and Protein structures. DNA macromolecular structure, RNA folding, DNA and RNA binding proteins, Proteins: primary, secondary, tertiary and quaternary structures. Secondary structure elements: helix, beta sheets, loops, turns. Protein folding: role of chaperones and heat shock proteins. Energy based model of protein folding. Protein structure determination studies: X-ray crystallography, NMR. Protein structure prediction: need and strategies, Homology modeling method, Fold recognition, Ab-initio methods: methods and accuracies. MODELLER, Swiss Model, Threader, ROSETTA. Protein structure validation: phi and psi angles, Ramachandran plot, PROCHECK.

Unit 4: Molecular Modeling and Simulations

Introduction to molecular modeling, molecular mechanics, concepts and applications, Force fields and its concepts. Bonded and non bonded interactions. Bond bending and stretching. Hooke's law for chemical bond interactions, Coulomb's law and Lennard jones potential for electrostatic and van der waals interactions. Potential and Kinetic energy functions. Energy


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minimization. Steepest descent, conjugate gradient, Newton-Raphson method. CHARMM, AMBER force fields. Molecular dynamics: basic steps in MD, leapfrog algorithm, Verlet algorithm, periodic box, Boltzman velocity, time steps and duration of the MD run,. Visualization and analysis of MD trajectories. Applications in drug design and computational chemistry: VMD, GROMACS, Schrodinger.

Unit 5: Drug Designing and System Biology

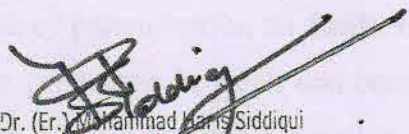
Drug & Targets: GPCR's, Aqaaporins, Ion channel protein, kinases. Target Identification and validation strategies: HTS, RNA interference, aptamers, photoaptamers. Lead Discovery and Optimization: Structure based and Ligand based drug designing. Molecular docking: concepts and implications, AUTODOCK, DOCK, HEX. Pharmacophore modeling: Training and test sets. Quantitative structure activity relationships (QSAR): Discovery studio suite, Schrodinger. Virtual screening, ADMET filtering, Drug-likeness studies. Systems Biology - objectives and applications in health and diseases. Modeling of biological process, connectivity maps: CMap and LINCS Microarrays and its applications in systems biology. Metabolic Networks, Signal Transduction Pathways, E-cell and V-cell Simulations.

Unit 6: Analytical Techniques in Biological sciences

Spectroscopy: Mass spectroscopy, MALDI-TOF, Infrared spectroscopy, NMR and ESR spectroscopy, Tandem mass spectroscopy (MS/MS) analysis, peptide fingerprinting (PMF). Electrophoresis: PAGE, Isoelectric focusing, SDS-PAGE. Southern, Northern & Western blotting techniques. Chromatography: TLC, HPLC, Gel filtration, ion-exchange and affinity chromatography. Centrifugation: Ultra centrifugation, density gradient centrifugation in isolation of cells. Microscopy: fixation, staining, phase contrast, fluorescence microscopy, SEM, TEM.

Recommended Books:

1. Fundamental Concepts of Bioinformatics - Dan E. Krane, Michael L. Raymer, Pearson education.
2. Sequence structure and Database – Des Higgins, Willice Taylor, Oxford press
3. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, by Andreas D. Baxevanis, B. F. Francis Ouellette, Wiley-Interscience
4. Sequence and Genome Analysis by David W. Mount - Cold Spring Harbor Laboratory
5. Nelson and Cox, Lehninger Principles of Biochemistry, W H Freeman & Co, ISBN: 978-0- 716-77108-1.
6. Andrew R. Leach, Molecular Modelling Principles and applications, Prentice Hall.
7. Wilkins, M.R., Williams, K.L., Appel, R.D., Hochstrasser, D.F. (Editors) Proteome Research: New Frontiers in Functional Genomics, Springer Verlag Berlin, Heidelberg.



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**SYLLABUS FOR ENTRANCE TEST TO PhD PROGRAM
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Unit 1: History of Food Preservation

Introduction and historical development of food processing and preservation. History of heat preservation, History of cold preservation, History of sterilization, History of food additives, History of food chemistry, History of supply chain, History of food laws and regulations.

Unit 2: Preservation Techniques

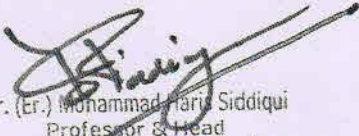
Preservation by low temperature- Low temperature storage, refrigeration and freezing. Preservation by drying; Phenomenon and methods of drying- dehydration by air drying, sun drying and freeze drying. Preservation by food additives- antibiotics, chemicals, organic acids. Preservation by radiations; Ultraviolet and ionizing irradiations. Preservation by fermentation- Definition, Advantages, disadvantages, types, equipments. Hurdle technology: concept and advantages. Intermediate moisture foods.

Unit 3: Novel Food Processing Techniques

Microwave heating- Properties, mechanism, microwave generator and microwave food application. Introduction to hydrostatic pressure technology, ohmic heating and extrusion cooking. Use of ultrasounds and magnetic fields in food processing. Application of pulse electric field in food preservation.

Unit 4: Applications of Heat Transfer

Thermal operations: Pasteurization and Sterilization - Basic concept, pasteurization of unpackaged and packaged foods, effects of pasteurization on foods. Energy equipment and rate of operations involved in process time evaluation in batch and continuous sterilization, UHT processing; aseptic packaging. Freezing: Plank's law and estimation of freezing time of foods; equipment, freeze concentration of liquid food. Rate of freezing. Concentration and Evaporation:


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Concentration of liquid foods in batch and continuous type evaporators; heat and energy balance in multiple effect evaporators.

Unit 5: Livestock Technology


Methods of slaughtering & meat processing- Pre-slaughter care, Antimortem inspection of meat animals. Methods of stunning, slaughtering and dressing of meat animals and poultry birds Post mortem examinations of meat-Rigor mortis. Factor affecting post mortem changes, properties and shelf life of meat. Poultry products- Structure, composition, nutritive value and functional properties of eggs. Grading of eggs. Factors affecting egg quality and measures of egg quality. Preservation of eggs by different methods- freezing, dehydration and coating.

Unit 6: Research Methodology

What is the meaning of research? What are the objectives of research? What are the types of research? What is the significance of research? Importance of knowing how research is done. Criteria of good research. Problems encountered by researchers in India. What is a research problem? Technique involved in defining a problem. What is a hypothesis? Basic concepts concerning the testing of hypotheses. Tests of hypotheses.

Recommended Books

1. Research methodology methods and techniques 2nd Edition written by C.R. Kothari.
2. Lawrie, R. A. 1975. Lawrie's Meat Science. 2nd Edn. Pergamon Press. Oxford UK.
3. Singh RP and Heldman DR. 1993. *Introduction to Food Engineering*. Academic Press.
4. Norman N. Potter, Joseph H. Hotchkiss , Food Science – 5th ed. Springer, 1998 – Technology & Engineering - 608 pages


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