

BHARATHIAR UNIVERSITY::COIMBATORE – 46
M.Phil / Ph.D - BIOTECHNOLOGY

PART I - SYLLABUS

(For the candidates admitted from the academic year 201819 onwards)

PAPER-I - RESEARCH METHODOLOGY

UNIT I: INTRODUCTION TO RESEARCH METHODOLOGY

What is research? Basic and applied research, Essential steps in research, Defining the research problem, Research/Experimental design; Literature collection, Literature citation, Research report: Components, Format of thesis and dissertation, Digitalization and database; Manuscript/research article, Review monographs, Bibliography and Reference, Significance of research; Plagiarism: Definition, Limitation, Software packages.

UNIT II: BIOPHYSICAL METHODS

Analysis of biomolecules using UV/Visible, fluorescence, circular dichroism, NMR and ESR spectroscopy, structure determination using x-ray diffraction and NMR; Analysis using light scattering, different type of mass spectrometry and surface plasma resonance methods.

Radiolabeling techniques: Properties of different types of radioisotopes normally used in biology, their detection and measurement; incorporation of radioisotopes in biological tissues and cells, molecular imaging of radioactive material safety guidelines.

UNIT III: MICROSCOPIC TECHNIQUES

Visualization 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.

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 such as FISH and GISH.

UNIT IV: COMPUTATIONAL METHODS

Nucleic acid and protein sequence database; data mining methods for sequence analysis, web-based tools for sequence searches motif analysis – Primer designing – Next generation sequencing analysis - Molecular phylogeny - Drug designing - High throughput screening of pharmacological applications.

UNIT V: 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; X² test; basic introduction to Multivariate statistics – Software for statistics analysis: SPSS.

References

1. C.R. Kothari, II edition (2004) Research methodology, Methods and techniques, New Age International (P) Ltd, Publishers, New Delhi.
2. Jerrod H. Zar (1999) Biostatistical analysis by, Prentice Hall International, Inc. Press, London.
3. Attwood. T.K and Parry-Smith D.J. (2002) Introduction to Bioinformatics, Pearson education Singapore.
4. Sharma. BK. Instrumental methods of chemical analysis.
5. Upadhyay, Upadhyay and Nath, Biophysical chemistry.
6. Khandpur R.S. Handbook of biomedical instrumentation, Tata Mc Graw Hill.

7. Bragal.L. Williams, A biologist guide to principle and techniques of practical biochemistry.
8. Plagiarism the internet and student learning, 2008, W. Sutherland-Smith, Routledge, UK & USA.
9. SPSS survival manual, (5th Ed), 2008, J, Pallant, McGraw-Hill Education, UK.
10. Computational methods for next generation sequencing data analysis, 2016, I, I, Mandoiu, A, 11. Zelikovsky (1st Ed), Wiley publishers, USA.
11. PCR Primer Design, 2007, A, Yuryev, Springer Science & Business Media.

PAPER-II - RECENT TRENDS IN BIOTECHNOLOGY

UNIT I: BASIC TECHNIQUES IN MOLECULAR BIOLOGY

Isolation and purification of RNA , DNA (genomic and plasmid). Analysis methods for RNA, DNA. Enzymes in recombinant DNA technology. Genomic and cDNA library construction and screening. DNA sequencing methods, strategies for genome sequencing.

UNIT II: CLONING IN MICROORGANISMS AND HIGHER ORGANISMS

Vectors in Molecular Biology. Molecular cloning of DNA or RNA fragments in Prokaryotic (E.coli, Bacillus) and eukaryotic systems - plasmid, phage, cosmid, BAC and YAC vectors. Direct and indirect gene delivery techniques. Gene transfer in plants, Expression of recombinant proteins using bacterial, animal and plant vectors. Fusion proteins.

UNIT III: GENETIC MARKERS IN MOLECULAR BIOLOGY

DNA fingerprinting, RFLP, RAPD and AFLP techniques. Somatic cell nuclear transfer, Polymerase chain reaction types and applications, DNA footprinting, Site directed mutagenesis.

UNIT IV: APPLICATIONS OF MODERN TECHNIQUES

New drugs/ Therapies for genetic diseases- combating infectious disease. Metabolic engineering, DNA vaccines. Protein sequencing methods, detection of post translation modification of proteins. Identification of protein by MALDI-TOF, yeast two and three hybrid system-phage display

UNIT V: ADVANCED TECHNIQUES IN BIOTECHNOLOGY

Microarray, Chromosome Engineering, Targeted gene replacement. Current status of stem cell research. Gene Knockout, Gene Silencing techniques (Antisense technology & RNAi).

Reference:

1. Bowtell, D and Sambrook, J. DNA Microarrays: A Molecular cloning manual. CSHL press
2. Glick, BR., Pasternak, JJ (1998) Molecular Biotechnology: Principles and Applications of recombinant DNA, ASM Press.
3. Grandi, G (2004) Genomics, Proteomics and Vaccines. Wiley press.
4. Hannon, GJ, RNAi: A guide to gene silencing. CSHL Press
5. Kirby, LT (1990) DNA finger printing: An introduction, Stockton press.
6. Lewin, B (2004). Genes VIII. Pearson Prentice Hall Press
7. Principles of genetic manipulation; Ed. Old and Primrose, 6th Edition. Blackwell Science publication

PAPER-III: 1. ANIMAL BIOTECHNOLOGY

UNIT I: BASICS OF ANIMAL CELL CULTURE

Introduction to animal tissue culture: culture media; Serum and protein free defined media and their applications. Balanced salt solutions and simple growth medium: Physical, Chemical and Metabolic functions of different constituents of culture medium; Role of carbon dioxide, serum, growth factors, glutamine in cell culture; Types of cell culture: primary and established culture; organ culture and three dimensional culture feeder layers; cell synchronization; cryopreservation. Common contaminants in animal cell culture, Containing and decontamination procedures.

UNIT II: MOLECULAR TECHNIQUES IN ANIMAL CELL CULTURE

Biology and characterization of cultured cells: tissue typing; cell-cell interaction; measuring parameters of growth; measurement of cell death; Apoptosis and its determination; cytotoxicity assays. Determination of IC₅₀ and LD₅₀. Cell transformation: physical, chemical and biological methods; Cell cloning and micromanipulation. Production and application of animal cell culture products.

UNIT III: STEM CELL BIOLOGY AND TISSUE ENGINEERING

Stem cells: characteristics and classification; stem cell niche; stem cell culture; stem cell markers. ES cells, EG cells; Adult stem cells: HSC, MSC, NSC, UCBS cells, iPS cells. Stem cell banking. Therapeutic applications: Neurodegenerative disorders, diabetes, cardiac disorders. **Tissue Engineering:** Principles of tissue engineering; biomaterials in tissue engineering; tissue engineering bioreactors. Applications: bioartificial organs-regeneration of bone, liver, epidermis and bladder. Ethical issues in stem cell research and tissue engineering.

UNIT IV: GENETICS AND IMMUNITY

Multifactorial genetic diseases: Diabetes, Rheumatoid arthritis; Cancer genetics: tumor suppressor genes, oncogenes, DNA repair genes. Gene mapping; Gene therapy; Role of epigenetics and non-coding RNAs in diseases. Immunity in healthcare: production of interferons, interleukins and vaccines through mammalian cell cultures. Hybridoma technology and its applications. Tumor immunology; transplantation immunology; autoimmune disorders; immunity to infectious agents.

UNIT V: ANIMAL MODELS OF HUMAN DISEASE

Use of disease models in healthcare research, Animals used as models for human healthcare research, Procedures and guidelines for maintenance of animals, Ethical methods of animal sacrifice and carcass disposal. Factors affecting the physiology and biochemistry of animals, Artificial methods of creating disease models- Diabetes, Cardiovascular and Cancer. Transgenics: Transgenic animal production and applications- transgenic animals as models for human disease; transgenic animals in live- stock improvement; transgenics in industry; Ethical issues in animal biotechnology.

References:

1. Animal cell culture; A practical approach, 4th Edition by Freshney, R.I. John, Wiley Publications
2. Methods in cell biology; Volume 57, Animal cell culture methods, d. Jennie P, Mather, David Barnes, Academic press
3. Mammalian cell biotechnology; A practical approach, Ed, M. Butler Oxford University press
4. Human genetics by A. Gardner, R.T. Howell and T. Davies, Scion publishing ltd. UK
5. Applied Genetics Recent Trends and Techniques, C. Emmanuel, Rev. Fr.S. Ignacimuthu S.J, S. Vincent, MJP publishers, Chennai.
6. Animal cell culture, a practical approach; Ed. John R.W. Masters, Third edition, Oxford University Press.

7. In Vitro cultivation of animal cells; Published on behalf of Open University Alkenburgerrweg 167, 6401DL Heerlen Nederland and University of Greenwich (Formerly Thales Polytechnic) Avery Way, Kent, SE9 4HB, United Kingdom
8. Immunology by Janus Kuby, 4th edition (Freeman).
9. Fundamentals of Immunology edited by William Paul. 4th edition (Lippincott Williams & Wilkins)
10. Essentials of stem biology-Robert Lanza, John Gearhart, Brigid Hogan
11. Principles of Tissue Engineering – Robert Lanza

PAPER-III: 2. PLANT MOLECULAR BIOLOGY AND BIOTECHNOLOGY

UNIT I: GENOME ORGANIZATION AND CHARACTERIZATION

Nuclear Genome, Organellar Genomes, Plant gene-genome database and its applications, Structure of Plant Gene and Gene Families. Molecular Markers: RFLP, RAPD, AFLP, SSR and SCAR. Genome mapping and applications. EST's and cDNA libraries.

UNIT II: CELL AND TISSUE CULTURE

Laboratory Organization, Media Preparations and Sterilization Techniques. Protoplast Culture, Suspension culture, Tissue Culture: Direct and Indirect Somatic Embryogenesis, Haploid Culture, Embryo Culture and Meristem Culture. Micropropagation, Direct organogenesis, Callus induction and Indirect organogenesis, Somaclonal variation, Somatic hybridization, Cryopreservation and Synthetic seeds. Secondary metabolites production and purification, Adventitious root culture, Hairy root culture.

UNIT III: PLANT GENETIC ENGINEERING

Plant Expression Vectors: Binary and Viral Vectors. Promoters, Selection markers and Reporter genes, Construction of recombinant vectors. Genetic Transformation Methods: Agrobacterium mediated and direct gene delivery systems. Chloroplast Transformation, Transient Expression systems.

UNIT IV: GENETICALLY MODIFIED PLANTS

Application of Transgenic Plants: - Bt cotton and Pest Resistance, Herbicidal Resistance, Viral Resistance, Disease Resistance, Abiotic stress resistance. Increased shelf life of flowers and fruits, Seed storage Proteins, Nitrogen fixation, Metabolic Engineering, Molecular Pharming/Farming, Gene silencing and RNAi technology, Plant genome editing- Zinc finger nuclease, TALENs, and CRISPR/Cas9.

UNIT V: PLANT BIOTECHNOLOGY INDUSTRIES AND REGULATIONS

Plant derived Products-Pharmaceutical and Industrial, Horticultural, Food Industries and GM Foods. IPR. IBSC, Biosafety, RCGM and GEAC- Guidelines by Department of Biotechnology (DBT), India.

References:

1. Maarten J. Chrispeels and David E. Sadava. Jones (2002) Plants, genes and agriculture Bartlett Publishers, 1 Exeter Plaza, Boston, USA.
2. <http://dbtbiosafety.nic.in>
3. Harvinder Singh Chawla (1998) Biotechnology in Crop Improvement IBDPublishers.
4. Donal Grierson and Convey S. V. (1988). Plant Molecular Biology, Routledge publishers
5. J Hammond (2000) Plant Biotechnology: New Products And Applications, IK International Publishers.
6. Razdan MK (2003). Introduction to Plant Tissue Culture, Oxford-IBHPublishers

7. Slater, A, Scott, N. and Fowler, M. (2003). Plant Biotechnology: The Genetic Manipulation of Plants. OxfordPress.
8. Monica A. Hughes (1999). Plant Molecular Genetics, Pearson EducationPublishers.
9. Mantel, Mathews and Mickee (1985). An introduction to genetic engineeringin plants. BlackwellPublishers.
10. Eds. Rainer Fischer and Stefan Schillberg (2004). Molecular Farming: Plant made pharmaceuticals and technicalproteins.
11. Kursad Turksen. (2016) Genome Editing. Springer International Publishing.

PAPER-III: 3. MICROBES IN BIOTECHNOLOGY

UNIT I: MICROBIAL DIVERSITY

Classification: Bacteria, Actinomycetes, Archaea, Fungi, Viruses - Bergey's system of classification - Molecular techniques for classification - Biochemical, microbiological, Chemotaxonomic parameters, 16S rRNA gene sequencing, construction of phylogenetic tree, G+C analysis, DNA-DNA hybridization. Recent trends in Diversity studies: Culture independent approach: 16S rRNA gene libraries - Microbial Community analysis (DGGE, FISH, MiSeq)

UNIT II: BIOPROCESS TECHNOLOGY AND DOWNSTREAM PROCESSING

Introduction to Bioreactors - Types: Batch, continuous and fed batch; Solid-state and submerged; Aerobic and anaerobic; Specialized reactors (fluidized, immobilized cell air-lift) - Separation of cells - flocculation, filtration - Sedimentation - Centrifugation - Disintegration: mechanical and non-mechanical - Filtration- Reverse osmosis - Extraction: two phase, organic solvents, salts - Chromatography: adsorption, ion-exchange, gel affinity – Drying and crystallization

UNIT III: MICROBES FOR SECONDARY METABOLITE PRODUCTION

Antibiotics: Definition, Discovery, classification, structure and mode of action. Biosynthesis of secondary metabolites - beta-lactam antibiotics, patulin, Aflatoxin, ergot alkaloids. Toxins: types of toxins; Fungal toxins: aromatic and phenolic toxins. Bacterial toxins: Exo and endotoxins, enterotoxins. Pigments: Melanin and carotenoids. Fungal hormones: Sterols (Achlya) and Trisporic acid (Ascomycetes). Bioluminescence in microorganisms: Mechanism and significance. **Lichens**: Usnic acid and Pulvinic acid derivatives. **Nutraceuticals**: Concept of prebiotics, probiotics and synbiotics - principle, mechanism, production and technology. Antioxidants - Omega - 3-fatty acids from algae.

UNIT IV: MICROBES IN INDUSTRIES

Microbial production of: Enzymes, Vitamins (B12, B2), Organic acids (citric acid), Alcohol (ethanol), Organic solvents (acetone, butanol), Amino acids, beverages (brandy, whisky, rum), as medicine, biopolymer. Milk products (Cheese, yoghurt) - Edible mushrooms (Oyster, paddy-straw, button), SCP (Spirulina), microbial supplements (Lactic acid bacteria).

UNIT V: MICROBES IN AGRICULTURE AND BIOREMEDIATION

Biofertilizers types: Nitrogenous (Symbiotic, Non-symbiotic), Phosphate solubilizers - Biopesticides: *Bacillus thuringiensis*, *Pseudomonas*, Viruses. Xenobiotics- microbial mechanism, microbial mining, ore leaching - Solid waste management (composting) - vermicomposting - biofuel (Algae) - oil spill remediation - Wastewater treatment: primary, secondary and tertiary (Biological), heavy metal removal - Steroid biotransformation.

References

1. Microbial Biotechnology – Fundamentals of applied Microbiology by A.N. Glazer and H. Nikaido. W.H. Freeman and company.
2. Principles of Fermentation Technology, P. F. Stanbury & A. Whitaker, Pergamon Press.
3. Microbial process Development H.W Woelle, World Scientific.
4. Biotechnology Text book of Industrial Microbiology by W. Creuger and A. Creuger. Industrial Microbiology by Casida, John Wiley and Sons Inc.
5. Industrial Microbiology by Prescott, AVI Pub. Co.
6. Biochemical Engineering Fundamentals (2nd Ed) by J.E Bailey and D. Ollis. Mc Graw Hill Book Company.
7. Bioprocess Technology: Fundamentals and Applications, KTH, Stockholm.
8. Bioprocess Engineering Basic Concepts, Shuler, M .L. and Kargi, P., Prentice Hall Engelwood Cliffs.
9. Principles of Fermentation Technology, Stanbury, P .F. and Whitaker. A. Pergamon Press, Oxford.
10. Bioreaction Engineering Principles Neilson, J . and Villadsefl. J, Plenum Press.
11. Biotechnology, Second Edition: Secondary Metabolites, 2007, K. G. Ramawat, J.M. Merillon (Eds.), CRC Press, Florida, USA.
12. Introduction to Biochemical Engineering, 2005, D. G. Rao, Tata McGraw-Hill Education.
13. Microbial Biotechnology Principles and Applications, 2008, Lee Yuan Kun, World Scientific Publishing Co. Pvt. Ltd.
14. Microbial Biotechnology – Fundamentals of Applied Microbiology (2nd Ed), 2008, A. N. Glazer, H. Nikaido, Cambridge University Press India Pvt. Ltd.

PAPER III – 4. MARINE BIOTECHNOLOGY

UNIT I

Marine ecosystem – intertidal zone, inhabitants and ecology of estuaries, salt marshes, mangrove swamps, coral reefs and the deep sea. Plankton, nekton and benthos.

UNIT II

Oceanographic instruments and general sampling procedures. Applications of ocean remote sensing, Major and minor elements in the sea water. Properties of light in sea and biological consequences, bioluminescent bacteria.

UNIT III

Culturable & Unculturable bacteria, occurrence, characteristics, characterization and exploitation. Bioactive compounds – Antimicrobials and antioxidants. Biofouling and prevention Probiotic bacteria and their importance in aquaculture. Vaccines for aquaculture. Transgenic Marine Animals.

UNIT IV

Importance of marine Algae – Micro, Macro & applications. Molecular Biology of Green mussel adhesive protein, Marine organism as a source of Polysaccharides.

UNIT V

Commercial important enzymes from marine microorganisms. Giant bacteria and their ecological significance. Marine pollution and its control.

Textbooks

1. Nair N. B. and Thampy, D. M. 1989. Text book of Marine Ecology.
2. Thurman, H. V. and Webber, H. H., 1984. Marine Biology.
3. Meadiws, P. S. and Campbell, J. J., 1988. An introduction to Marine Sciences.

References

1. Drugs from sea (2000). Fusetani, N.
2. Microbiology of deep sea hydrothermal vents (1995). Karl, D.M.
3. The search from bioactive compounds from microorganisms (1992). Omum, S.
4. Biotechnology and Biodegradation (1990). Kamely, D. Chakraborty, A. & Omenn, G.S.
5. Recent Advances in Marine Biotechnology, Vol.2 (1998). Fingerman, M., Nagabushanam, R., Thompson, M.

PAPER III – 5. NANOBIO TECHNOLOGY

UNIT I

Basic concepts of Nano science and technology - Quantum wire – Quantum well – Quantum dots. Superior properties of nano-compared with bulk materials. Introduction to nanoparticles. Use of Bio-molecules such as Proteins, DNA, RNA, Aptamers, Peptides, Antibody, Virus as nanoparticles for drug targeting and therapy.

UNIT II

Strategies for synthesis of nanoparticles: top-down & bottom-up approach. Physical, chemical and biological), Physical methods- Microwave Synthesis, Physical Vapour deposition, Laser pyrolysis. Chemical methods- Co-precipitation, Sol-gel Processing, Microemulsions.

UNIT III

Biological method- bacteria, fungi, virus, plants. Bionanostructures: Characterization of nanomaterials: SEM, Scanning Tunneling, TEM and Atomic Force Microscopy, Structural and Functional principles of bionanotechnology,

UNIT IV

Synthesis, Characterization, and Functionalization of nanoparticles for targeted Cancer Theranostics. Scope and applications of nanobiotechnology. Nanoparticles for waste water treatment and management. Nanoparticle synthesis in plants, Bacteria and yeast. microbial systems for assembly of nanostructures.

UNIT V

Biological and medical microdevices: lab on chips, organ-onchips. Biosensors (fabrication, functionalization, applications). Nanotechnology safety and the environment. Impact of nanotechnology on society and industry

Text Books

1. Lee S and Savage, LM (2010) Biological Molecules in Nanobiotechnology.
2. Shanmughavel, P. (2005). Principles of Bioinformatics, Pointer Publishers, India.

Reference Books

1. Goodsell, DS (2004) Bionanotechnology: Lessons from Nature, Wiley-Liss, Inc., NY.
2. Strocio, MA and Dutta, M (2004) Biological Nanostructures and Applications of Nanostructures in Biology: Electrical, Mechanical, and Optical properties, Kluwer Academic / Plenum Publishers, USA.
3. David E. Reisner (2009). Bionanotechnology Global prospects. CRC Press. Taylor & Francis Group 6000 Broken Sound Parkway NW, Suite 300.
4. Arthur M. Lesk, (2002). Introduction to Bioinformatics, Oxford University Press.