Syllabus for Ph.D. coursework
in
Microbiology

Department of Microbiology, School of Life Sciences
Central University of Tamil Nadu, Neelakudi
Thiruvarur, India

Department of Microbiology

About:

The Department of Microbiology (DMB) was established in 2017 with an objective of inculcating research-oriented learning aptitude to disseminate relevant scientific knowledge among student community. The priority of the department is to focus on maintaining world-class research training standards for the students to generate next generation young scientists and to facilitate their placement International and National Organizations, reputed teaching institutions and competitive biological industrial entities. The department offers a stable platform, motivation and continuous encouragement to the students for their professional advancement and personal development. The courses offered by the department encompass various areas of modern microbiology such as General Microbiology, Microbial physiology and biochemistry, Immunology, Cell biology, Molecular biology, Industrial Microbiology, Agriculture Microbiology & Plant Pathology, Bioinformatics, Biostatistics & IPR, Mycology and Virology, rDNA technology, Bacteriology & Microbial genetics, Genomics & Proteomics, Medical Microbiology & Diagnostics, Marine and Environmental microbiology, Bioanalytical techniques, Enzyme & protein technology, Research Methodology & Experimental Design, Techniques in Microbiology and Research and Publication Ethics. These chosen areas of studying are occupying the most advanced microbiological research fields and are capacitating students to evolve as highly skilled academicians. The students are empowered to emerge as valuable assets to the industrial sector and are trained for initiating start-ups and generating self-employment opportunities. The curricula aim to intertwine the benefits of both academic and research-based learning to achieve excellence in scientific studies on par with other reputed institutions in India and abroad.

The Department has established prowess in the domains of Microbial biochemistry, Yeast genetics, Mycology, Medical Microbiology, Inflammation, ER Stress, Bioprospecting, Biofertilizers, Biofuel Production, Diagnostic biosensors, Phage display, Nanoparticle, Microbial Genetics, Genome Editing, Algal Biotechnology and carbon sequestration studies. The department has dedicated teaching laboratory, Central Instrumentation and research facility and functional research laboratories.

Over the time, DMB has emerged as an efficient educator endowed with comprehensive research infrastructure and quality research plans for scientific innovative studies. We are result oriented vibrant department of CUTN, well depicted by the faculty research progress and student achievements.

Purpose: To impart knowledge and training across the different fields in Microbiology to be able to equip students for academics/industry.

Programmes offered: M.Sc. Microbiology and Doctor of Philosophy (Ph.D.)

Eligibility: Master's degree in Microbiology, Human Genetics, Nutrition and Dietetics, Botany, Zoology, Biochemistry, Biotechnology, Life Sciences, Dairy Sciences, Agriculture and Horticulture, Home Science, Fisheries Sciences, Public Health, and Allied Health Sciences from a recognized university or equivalent. Candidates should have secured a minimum of 60% marks or 6.5 CGPA (on a 10-point scale) in the qualifying degree examination for General Category, 55% marks or 6.0 CGPA (on a 10-point scale) for OBC (non-creamy layer) and 50% aggregate marks or 5.5 CGPA (on a 10-point scale) for SC/ST/PWD candidates.

Credits: The program consists of courses with a total of 16 credits.
Core Course (CC): 10 credits
Elective Course (EC): 6 credits. Students are advised take more electives in line with their research areas.

Department of Microbiology

LIST OF COURSES FOR Ph.D. MICROBIOLOGY

Core courses			
S.No.	**Course Code**	**Couse Title**	**Credits**
1	MIB3011	Research Methodology & Experimental Design	4
2	MIB3012	Techniques in Microbiology	4
3	MIB3013	Research and Publication Ethics	2

Electives			
S.No.	**Course Code**	**Couse Title**	**Credits**
1	MIB3EC1	Pharmaceutical Biotechnology	3
2	MIB3EC2	Advanced Molecular Medicine	3
3	MIB3EC3	Biomass Conversion to Biofuel Production	3
4	MIB3EC4	Bacterial Drug Resistance	3
5	MIB3EC5	Nanomaterials in Theronostic and Tissue Engineering	3
6	MIB3EC6	Yeast genetics and Molecular mechanisms	3
7	MIB3EC7	Advances in Algal Biotechnology	3

Course code: MIB3011: Research Methodology & Experimental Design

THEORY: 04 Credits: 04 hours /week

Learning Outcomes:

- To understand the methods to determine the research problem and research design
- To gain knowledge on research design and its types
- Segregate qualitative and quantitative data and understand data analysis parameters.
- Write a research report and to effectively present the data in scientific meetings.
- Gain insights into scientific writing, impact factor of journals and knowledge on plagiarism.

Unit 1 Foundations of Research:

The concept of Research, Objectives, Motivation, Research approaches and significance, Research methods vs methodology, criteria of good research, Research problem, importance of defining the problem. Identification. Formulation of Research Question – Investigation Question – Measurement Issues – Hypothesis – Qualities of a Good Hypothesis –Null Hypothesis & Alternative Hypothesis. Hypothesis Testing – Logic & Importance.

Unit 2 Research design and types:

Research Design: Concept and Importance in Research – Features of a good research design – Exploratory Research Design – concept, types and uses, Descriptive Research Designs – concept, types and uses. Sampling design, methods to select a random sample and random sampling design. Experimental Design: Concept of Independent & Dependent variables.

Unit 3 Qualitative and Quantitative Research:

Qualitative research – Quantitative research – Concept of measurement, causality, generalization, replication. Merging the two approaches. Concept of measurement– what is measured? Problems in measurement in research – Validity and Reliability. Measurement and scaling techniques. Levels of measurement – Nominal, Ordinal, Interval, Ratio. Data Preparation – Univariate analysis (frequency tables, bar charts, pie charts, percentages), Bivariate analysis – Cross tabulations and Chi-square test including testing hypothesis of association. data analysis with statistical package (Sigma STAT, SPSS for student T-test, ANOVA, etc.), hypothesis testing.

Unit 4 Interpretation of Data and Report Writing:

Data collection methods, analysis and processing of data, Meaning and Technique of interpretation; Precautions in interpretation; Significance of report writing; Different steps in writing a report; Layout of a Research report; Types of report; Mechanics of writing a research report; Precautions for writing a research report

Unit 5 Scientific Writing:

Layout of a Research Paper, Impact factor of Journals, When and where to publish? Poster preparation and Presentation, Oral presentations, Reference management, Web-based literature search engines. Plagiarism and Self-Plagiarism. Online tools to search required information effectively; Reference Management Software like Zotero/Mendeley; Software for paper formatting like LaTeX/MS Office; Software for detection of Plagiarism. scholarly publishing- IMRAD concept and design of research paper, citation and acknowledgement, plagiarism, reproducibility and accountability, Ethical issues related to publishing.

Suggested Readings:

- Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., 2002. An introduction to Research Methodology, RBSA Publishers.
- Kothari, C.R., 1990. Research Methodology: Methods and Techniques. New Age International. 418p.
- Sinha, S.C. and Dhiman, A.K., 2002. Research Methodology, Ess Ess Publications. 2 volumes.
- Trochim, W.M.K., 2005. Research Methods: the concise knowledge base, Atomic Dog Publishing. 270p.
- Wadehra, B.L. 2000. Law relating to patents, trade marks, copyright designs and geographical indications. Universal Law Publishing.

Course code: MIB3012: Techniques in Microbiology

THEORY: 04 Credits: 04 hours /week

Learning Outcomes:

- To understand the applications of various microscopic and spectroscopic techniques and their principles.
- To understand the principle, types and applications of centrifugation and chromatography techniques.
- Gain knowledge on methods of cloning, gene amplification and sequencing.
- To study different types of sequencing and gene silencing methods with their significance.
- To understand the importance and different techniques used in gene expression analysis.

Unit 1 Microscopy & Spectroscopy:

Magnification, resolving power, Principles and applications of simple, compound, dark, bright field, phase-contrast and fluorescent microscopes. Confocal laser scanning microscopy. Electron microscopy: SEM and TEM, Mechanism of image formation and contrast generation in SEM, Sample preparation methods for TEM. Spectroscopy - Electromagnetic spectrum, Beer Lambert's Law. UV/VIS Spectrophotometry, Infrared spectroscopy, FTIR, Atomic absorption spectroscopy, Electron Spin Resonance Spectroscopy techniques, Spin label and H and C NMR spectroscopy. Mass spectroscopy Fluorescent spectroscopy, Instrumentation and application of MALDI-ToF.

Unit 2 Centrifugation & Chromatographic Techniques:

Principles, Swedberg unit, sedimentation coefficient, factors affecting sedimentation rate, clearing factor, rotors, their types and maintenance, determination of molecular weight by centrifugation, types of centrifuges, density gradient centrifugation, ultracentrifuges. Introduction and types of chromatography: paper, thin layer, gas (LCMS, GC-MS), Rf value, Qualitative and preparative techniques, Gel permeation, ion exchange, HP-TLC, HPLC, FPLC and affinity chromatography and instrumentation. Applications of Chromatographic techniques in Microbiology.

Unit 3 Cloning and gene amplification techniques:

Primer design; fidelity of thermostable enzymes; DNA polymerases; types of PCR – multiplex, nested; real time PCR, touchdown PCR, hot start PCR, colony PCR, cloning of PCR products; T-vectors; proof reading enzymes; PCR based site specific mutagenesis; PCR in molecular diagnostics; viral and bacterial detection; Transformation, electroporation, transfection; construction of libraries.

Unit 4 Sequencing and gene silencing methods:

Enzymatic DNA sequencing; chemical sequencing of DNA; automated DNA sequencing; RNA sequencing; chemical synthesis of oligonucleotides; mutation detection: SSCP, DGGE, RFLP, Flow cytometry, Next-generation sequencing methods: Illumina (Solexa) sequencing, 454 Pyrosequencing, SMRT, SOLiD, Oxford Nanopore. Introduction to siRNA; siRNA technology; Micro RNA; construction of siRNA vectors; principle and application of gene silencing; gene knockouts and gene therapy; Transgenics - gene replacement; gene targeting; creation of transgenic and knock-out mice; disease model; Genome editing using CRISPR-CAS.

Unit 5 Gene expression analysis:

Isolation of mRNA and total RNA; reverse transcriptase and cDNA synthesis; cDNA and genomic libraries; construction of microarrays – genomic arrays, cDNA arrays and oligo arrays; study of protein-DNA interactions: electrophoretic mobility shift assay; DNaseI footprinting; methyl

interference assay, chromatin immunoprecipitation; protein-protein interactions using yeast two-hybrid system; phage display.

Suggested Readings:

- Friefelder. D. (1982) Physical Biochemistry, Application to Biochemistry and Molecular Biology, 2nd ed. W.H. Freemen and Company, San Fransisco.
- Griffiths, O. M. (1983). Techniques of Preparative, Zonal and Continuous Flow Ultracentrifugation.
- William, B.L. and Wilson, K. (1986). A Biologist Guide to Principles and Techniques Practical Biochemistry, 3 rd ed., Edward Arnold Publisher, Baltimore, Maryland (USA).
- Slater, R.J. (1990). Radioisotopes in Biology-A Practical Approach, Oxford University Press, New York.
- Immunology and Immunotechnology 1st Edition by Chakravarty

Course code: MIB3013: Research and Publication Ethics

THEORY – 02 Credits: (02 hours /week)

Learning Outcomes:

- To understand the importance of research ethics
- To gain knowledge on scientific misconducts and importance of intellectual honesty.
- To gain knowledge on publications ethics and common publication misconducts.
- To know about open access publication initiatives and software tools to identify predatory journals.
- To gain knowledge on publication misconduct and use of online plagiarism software tools.
- To understand the research Indexing databases, Citation databases and Research Metrics.

Unit 1	**Philosophy and ethics**

Introduction to philosophy: definition, nature and scope, concept, branches; Ethics: definition, moral philosophy, nature of moral judgements and reactions.

Unit 2	**Scientific conduct**

Ethics with respect to science and research; Intellectual honesty and research integrity; Scientific misconducts: Falsification, Fabrication and Plagiarism (FFP); Redundant Publications: duplicate and overlapping publications, salami slicing; Selective reporting and misrepresentation of data.

Unit 3	**Publication ethics**

Publication ethics: definition, introduction and importance; Best practices / standards setting initiatives and guidelines: COPE, WAME, etc.; Conflicts of interest; Publication misconduct: definition, concept, problems that lead to unethical behaviour and vice versa, types; Violation of publication ethics, authorship and contributor ship; Identification of publication misconduct, complaints and appeals; Predatory publisher and journals.

Unit 4	**Open access publishing**

Open access publications and initiatives; SHERPA/RoMEO online resource to check publisher copyright & self-archiving policies; Software tool to identify predatory publications developed by SPPU; Journal finger / journal suggestion tools viz. JANE, Elsevier Journal Finder, Springer, Journal Suggester, etc.

Unit 5	**Publication misconduct**

Group Discussion: a) Subject specific ethical issues, FFP, authorship b) Conflicts of interest c) Complaints and appeals: examples and fraud from India and abroad Software tools; Use of plagiarism software like Turnitin, Urkund and other open-source software tools.

Unit 6	**Databases and research metrics**

Databases: Indexing databases, Citation databases: Web of Science, Scopus, etc. Research Metrics: Impact Factor of journal as per Journal Citations Report, SNIP, SJR, IPP, Cite Score; Metrics: h-index, g index, i10 Index, altmetrics.

Suggested Readings:

- Nicholas H. Steneck. *Introduction* to the Responsible Conduct of Research. Office of Research Integrity. 2007. Available at: https://ori.hhs.gov/sites/default/files/rcrintro.pdf
- The Student's Guide to Research Ethics By Paul Oliver Open University Press, 2003.
- Responsible Conduct of Research By Adil E. Shamoo; David B. Resnik Oxford University Press, 2003.
- Ethics in Science Education, Research and Governance Edited by Kambadur Muralidhar, Amit Ghosh Ashok Kumar Singhvi. Indian National Science Academy, 2019. ISBN : 978-81-939482-1-7.
- Anderson B.H., Dursaton, and Poole M.: Thesis and assignment writing, Wiley Eastern 1997.
- Bijorn Gustavii: How to write and illustrate scientific papers? Cambridge University Press.
- Bordens K.S. and Abbott, B.b.: Research Design and Methods, Mc Graw Hill, 2008.
- Graziano, A., M., and Raulin, M.,L.: Research Methods – A Process of Inquiry, Sixth Edition, Pearson, 2007.

Electives
for
Ph.D. Microbiology

Elective

Course code: MIB3EC1: Pharmaceutical Biotechnology

THEORY:03: (03 hours /week)

Learning Outcomes:

- To understand the processes and mechanisms associated with anti-microbial drugs.
- To study the mechanism of antifungal agents and antifungal resistance.
- To gain knowledge on vaccine technology and types of vaccines.
- To gain knowledge on drug discovery, industrial production and manufacture of pharmaceutical drugs, their quality control and testing.
- To understand the applications of drug discovery in treating infectious diseases.

Unit 1 Antimicrobial agents:

Production of antibiotics and synthetic antimicrobial agents, (Aminoglycosides, β lactams, tetracyclines, ansamycins, macrolide antibiotics, Chloramphenicol, Sulphonamides and Quinolinone); antifungal antibiotics (Polyenes, Azole, Allylamines, 5-FC); mode of action of antibiotics, chemical disinfectants, antiseptics and preservatives.

Unit 2 Study of antifungal resistance mechanism

Mode of action of antifungals; techniques: antibiotic sensitivity assays- disc method, replica plating technique; anti-fungal sensitivity testing; antifungal resistance mechanism; molecular principles of drug targeting; assessment of a new antibiotic and testing of antimicrobial activity of a new substance; drug alternate strategy to overcome antibiotic resistance.

Unit 3 Vaccines and Biopharmaceuticals:

New vaccine technology; mRNA/DNA vaccines, vector vaccines, synthetic peptide vaccines, multivalent subunit vaccines; vaccine clinical trials; immobilization procedures for pharmaceutical applications (liposomes); macromolecular, cellular and synthetic drug carriers; biosensors in pharmaceuticals; application of microbial enzymes in pharmaceuticals.

Unit 4 Drug discovery Approaches:

Molecular docking, stimulation, and dynamic target identification; target validation, drug discovery: medium throughput, high throughput and ultrahigh throughput assay platforms; *In vitro* and *In vivo* pharmacological assays.

Unit 5 Development of drug-like compounds against infectious diseases

Drug Discovery of anti-HIV candidates; Lead Identification and optimization; economics of drug discovery; structure-related drug-like criteria of global approved drugs; rational drug design; preclinical and clinical trials.

Suggested Readings:

- Pharmaceutical Microbiology – W.B. Hugo & A.D.Russell Sixth edition. Blackwell scientific Publications.
- Quality control in the Pharmaceutical Industry - Murray S.Cooper Vol.2. Academic Press New York.
- Pharmaceutical Biotechnology by S.P.Vyas & V.K.Dixit. CBS Publishers & Distributors, New Delhi.
- Advances in Applied Biotechnology Series Vol 10, Biopharmaceuticals in transition. Industrial Biotechnology Association by Paine Webber. Gulf Publishing Company Houston

Elective

Course code: MIB3EC2: Advanced Molecular Medicine

THEORY: 03 Credits (03 hours /week)

Learning Outcomes:

- Get a basic understanding of molecular mechanisms in development of disease
- Understand how molecular/cellular biology may be used to characterise cellular processes
- Describe treatment methods available for various diseases
- Get clear knowledge on recent treatment strategies to treat human diseases
- To gain knowledge on recent advances in molecular medicine.

Unit 1	Infectious and non-infectious diseases and treatment:

Introduction, The flu, measles, HIV, strep throat, COVID-19, Cancer, inflammatory diseases, neurodegenerative diseases, autoimmune diseases, atherosclerosis, ischaemic heart disease and cerebrovascular disease, diabetes Mellitus, Asthma, allergy, Genetic disorders and inflammatory diseases of the lung, Role of endoplasmic reticulum stress in various diseases, Glia in health and disease; Research articles relevant to glial biology.

Unit 2	Disease diagnosis and drug discovery:

Detection and diagnosis of various diseases, DNA and Protein markers, Protein markers, various methods for the identification of protein markers, DNA markers, Drug design, Assay development, High-throughput compound screening, automated workstation, Cell culture in drug discovery, Research articles in disease diagnosis and drug discovery.

Unit 3	Treatment:

Monoclonal and polyclonal antibody: basics and their production, Various monoclonal antibodies in therapeutics, Cytokines: interferons, Interleukins, hormones: Androgen, estrogen and their antagonists, progesterone and other hormones, clotting factors, enzymes in treatment of diseases, current trends in treatment strategies.

Unit 4	Advanced treatment strategies:

Gene therapy: Gene delivery methods, Types of gene therapy, vectors, Drug delivery method, stem cell therapy: stem cells and their unique properties, embryonic stem cells, nuclear medicine, and various disease model for preclinical and clinical studies, Animal models for behavioural studies, clinical trials, constraints in modern technologies, future prospects.

Unit 5	Recent Trends in Molecular Medicine:

Latest research in molecular medicine, Biosensors in disease diagnosis, translational medicine, simple and advanced molecular tools in biomedical applications, Importance and applications of bioinformatics in Molecular medicine.

Suggested Readings:

- Buckingham and Flaw's, "Molecular Diagnostics: Fundamentals, Methods and Clinical Applications", F.A. DavisCompany; Firstedition, 2007.
- Jens Kurreck, Cy Aaron Stein, Molecular Medicine: An Introduction, 2016

Elective

Course code: MIB3EC3: Biomass Conversion to Biofuel Production

THEORY: 03 Credits (3hours/week)

Learning Outcomes:

- To learn about second and third-generation biofuels.
- To understand the composition of biomass and their significance in biofuel production
- To gain knowledge on biomass processing and by-product utilization.
- To gain knowledge about large-scale algal cultivation methods.
- To understand the techniques and methods involved in characterization and downstream processing.

Unit 1 Introduction and Perspectives of biofuels

Fossil versus renewable energy resources; Economic impact of biofuels; Comparison of bioenergy sources; biorefinery, biofuel production and applications, alternative energies, environmental impact of biofuel. Various generation of biofuel – first, second, third and fourth generation.

Unit 2 Biomass characterization for biofuel:

Biomass as a resource; Advantages of biomass energy among alternative sources; opportunities and challenges; Forms of biomass; Biomass properties – recalcitrant, lignin; Lignin content in various biomass; non-lignocellulosic biomass – algae and its cultivation; various generations of biofuels; microbial fuel cells.

Unit 3 Biomass processing:

Algal biomass processing; Analysis of biomass – thermochemical and biochemical; pre-treatment methods of processing; Biomass – hydrolyzation, combustion and gasification; Pyrolysis and liquefaction – fermentation; Biohydrogen and Biomethane generation; By-product utilization; process optimization; future directions on biomass energy; Industrial operation of biofuel production.

Unit 4 Biofuel production technologies:

Autotrophic production technologies – open ponds, closed PBRs, hybrid and novel systems; heterotrophic and mixotrophic production; harvesting and processing of algal biomass – harvesting technologies, processing technologies – anaerobic digestion, thermochemical conversion, solvent extraction, fermentation; challenges in large scale cultivation of algae; resource constraints for mass production of microalgae; Conversion of microbial biomass to biodiesel; Quality and economic analysis of algal biodiesel; Biohydrogen production - biophotolysis, photo fermentation, dark fermentation, combination of dark and photo fermentation and biocatalyzed electrolysis.

Unit 5	Critical Analysis of Scientific Literature:

Critical analysis of current and prior research articles on biofuels – understanding the present senecio of research in biofuels and future perspectives. Writing – review on research problems in biofuel production. Advanced techniques used in the field.

Suggested Readings:

1. Ozcan Konur. 2017. Bioenergy and Biofuels. CRC Press, Taylor & Francis Group**. ISBN 9781351228138.**
2. Rafael Luue and James Clark. 2010. Handbook of biofuels production: Processes and Technologies. Publisher Elsevier; **ISBN: 9780857090492**
3. Ramasamy, K., S. Karthikeyan and U. Sivakumar. 2016. Biocatalysts: in biomass to bioproducts. Daya Publishing House (Astral International), New Delhi. ISBN: 978-93-86071-69-9, P.264.
4. C. M. Drapcho, N. P. Nhuan, T. Walker, Biofuel Engineering Process Technology, Mc Graw Hill 2008 D. M. Mousdale, Biofuels, CRC Press 2008.

Elective

Course code: MIB3EC4: Bacterial Drug Resistance

5. J, P Sinha. 2018. Bioprospecting of Algae. Editors: MN Noor, SK Bhatnagar, Shashi Kr. Sinha. Published by: Society for plant Research India; **ISBN: 978-81-937106-0-9**

THEORY:03 Credits: (3hours/week)

Learning Outcomes:

- Understand the different types of antibiotics and their mode of action.
- Understand the phage therapy, anti-phage mutation and related fitness cost in bacteria
- Understand the research tools that help in understanding the AMR mechanisms and resistant genes.
- Understand the importance of alternative antimicrobials
- Analyse the methods to combat the AMR.

Unit 1	Antimicrobials:

History of antibiotics, classifications of antibiotics, disruption of microbiome, synthesis, actinobacteria, and other microorganisms in the production of antibiotics, different types, bacteriocin, mechanism of action, and their applications. Antifungal drugs. Antiviral drugs and their mechanism of action; Discussions on current status and research updates.

Unit 2	Antimicrobial Peptides and Biofilms:

Introduction to infections, the importance of infection control, defensins- antimicrobial peptides and their mechanisms of action, antimicrobial susceptibility testing, agar disk diffusion method, Minimum inhibition concentration, minimum bacterial concentration, neutralizing quorum signals, biofilm disintegration, live dead analysis (lab demonstration).

Unit 3	Anti-microbial Resistance Biology:

Introduction, AMR surveillance, and containment program of NCDC, antimicrobial Resistance formation, MDR, XDR, ESKAPE pathogens, development and causes of resistance. Resistance detection, transmission and surveillance, resistance genes, horizontal gene transfers, innate and passive immunity, CRISPR-CAS in resistance formation, clinical, research, and microbiological perspective of resistant formation. Drivers of bacterial and Fungal resistance, AMR biology, resistant candidiasis, resistant aspergillosis etc. and recent research developments.

Unit 4	Phage Therapy and Phage Resistance:

Phage and phage therapy, isolation of phage, lytic and lysogenic cycles, the multiplicity of the index, phage enumeration, phage cocktails, culturing, studying the phage resistance in bacteria (bacterial immunity), fitness cost, phage combinations and recent trends.

Unit 5	AMR Tools:

Phenotypical and genotypical characterizations of resistance formation, application of NGS in studying the resistance mechanisms, mutations, AMR genes, and relevant genes. Activation and inhibition of efflux pumps, Comparison of ancestral microbe with mutant bacteria using bioinformatic tools (case study), and recent research developments.

Suggested Readings:

- Insights in Antimicrobials, Resistance & Chemotherapy: 2021 Rustam Aminov
- The Evolution of Microbial Defence Systems Against Antimicrobial Agents Archana Madhav, Robert C. Will & Ankur Mutreja. 2020.
- Influence of Abiotic Factors in the Emergence of Antibiotic Resistance Sanjucta Dutta & T. Ramamurthy, 2020.

Elective

Course code: MIB3EC5: Nanomaterials in Theronostic and Tissue Engineering

THEORY: 03 Credits: (3hours/week)

Learning Outcomes:

- Understand the concept of nanotechnology and synthesis of nanoparticles.
- Understand the characterization techniques and their principles
- Understand the applications of nanomaterials in tissue engineering scaffold preparation.
- Understand the application of nanomaterials in developing diagnostic biosensors, imaging.
- Understand the use of nano drug delivery and nanocomposites in therapy.

Unit 1	Concept of Nanotechnology:

Introduction to nanotechnology, basics and concepts. Synthesis of nanomaterials (bio, physical and chemical), Bottom-up and top-down approaches, electrospinning, green synthesis, biosynthesis of nanomaterials, Carbon nanotubes and nanowires, Chemical vapor deposition, etching, plasma treatment, ball milling; discussions on recent research develpoments.

Unit 2	Applications of nano-Biomolecules:

Bionanomaterials and characterization. DNA nanotechnology, glyco, lipid and protein nanotechnology, Bio-nanomachines, Carbon nanotube, and bio-applications. Nanomaterials and biosystems interaction. Biomimetics design, hydrogels, swelling properties, Nanobiomechanics of living cells, Multi-functional nanozymes, and analysis of current status.

Unit 3	Diagnostics Nanomaterials:

Nanomaterials in diagnostics, biosensors and therapies. Protein and Virus based biologically directed/ self-assembled nanobiomaterials (SAM). Nanomaterials for cancer diagnosis, Nano artificial cells, Nanotechnology in organ printing, Biochips, Microarrays, BioMEMs, Molecular Imaging, Use of nanotubes, quantum dots, polymeric conjugates, Dendritic nanostructures, Fe/Au Nanoshell for tumor-targeted imaging, Discussions on recent research updates.

Unit 4	Therapeutic Nanomaterials:

Nanobiomolecules delivery and therapy, crossing the blood-brain barrier, bioconjugation and biocompatibility, cell repair machines, nano drug delivery vehicles and carriers. Bioconjugation of nanomaterials with antibodies, drug molecules, phage etc. and current trends.

Unit 5	**Nanomaterials in Tissue Engineering**:

Natural and synthetic polymers and their application in tissue engineering, Polymeric scaffolds, Nanoengineered hydrogels, fabrication, 2D and 3D scaffolds, immune responses to biomaterials, cell migration and differentiation, and polymeric nanocomposites. Microporous beads, PLGA microspheres, injectable thermosensitive gels. Nano and microfiber scaffolds, drug release kinetics. Nanoscaffolds in plant grafting; An analysis of the current developments.

Suggested Readings:

- Nanobiotechnology: Concepts, Applications and Perspectives. Christof M. Niemeyer. 2004
- Nanobiotechnology Microbes and Plant Assisted Synthesis of Nanoparticles, Mechanisms and Applications. 2021
- Applications of Nanobiotechnology. Margarita Stoytcheva & Roumen Zlatev. 2020

Elective

Course code: MIB3EC6: Yeast genetics and Molecular mechanisms

THEORY: 03 credits: (03 hours /week)

Learning Outcomes:

- The student will be able to classify/identify yeast and to understand the ultrastructure of yeast cells.
- The student will be able to learn the basics of yeast growth/culture techniques and yeast metabolism.
- The students will get an overview of yeast genetics and will learn about genetic engineering strategies in yeast.
- The students will gain perspective on usage of yeast as Model organism to address different scientific questions.
- The students will apply the knowledge to understand the applications of yeast in industry and research.

Unit 1	**Cell Biology of Yeast**

Yeast cells and cell organelles, Different kinds of yeasts, Yeast growth and division: budding and cell elongation; Characteristics of brewing yeasts; Genetic characteristics; Differentiation of brewing yeast strains; Characterisation and distinguishing of yeast strains. Yeast Cellular architecture, Yeast Genome organization, Yeast cell cycle and study of yeast cell cycle mutants.

Unit 2	**Yeast Metabolism and Molecular Biology**

Factors affecting yeast growth: oxygen, vitamins, ions (phosphorous, hydrogen, sodium, magnesium, calcium, potassium) and Carbohydrate/sugar uptake; Overview of yeast metabolism; Fermentation; Pasteur Effect; Crabtree effect; Biochemical mechanisms resulting in flavour compounds: alcohols, esters and carbonyls. Yeast Molecular techniques – Cloning vectors. Yeast strains and genetic backgrounds, Selection markers in yeast, Gene families involved in yeast cellular dynamics, Yeast Transport system

Unit 3	Yeast genetics and genomics

Yeast Genetic structures and functions, Yeast mating types; Mating type switching; Yeast evolution; Yeast transformation and genome engineering; Tetrad, random spore and molecular analysis of meiotic segregation and recombination; Yeast gene expression system, Saccharomyces Genome Database (SGD) and PomBase.

Unit 4	Yeast as model organism and applications in Industry

Homology between yeast and human, yeast genome sequence, human disease genes in yeast, Ageing in yeast, understanding cancer using yeast, yeast proteome, Yeast cellular dynamics, Yeast Genome and Post Genome Projects, Molecular signalling cascades in yeast, Function and biogenesis of yeast cell organelles, Future of yeast in research; Yeasts in biotechnology, Yeast propagation from pure cultures; Wild yeasts; Determining pitch rate, viability and vitality; Yeast storage; Flocculation mechanisms; Assessing flocculation and sedimentation; Adhesion and sedimentation; Yeast harvesting; Benefits of genetically modifying yeast for the brewing industry.

Unit 5	Landmark studies in yeast

a) Nurse P. and Thuriaux P. 1980. Regulatory genes controlling mitosis in the fission yeast Schizosaccharomyces pombe;
b) Mizushima N., Noda T., Yoshimori T., Tanaka Y., Ishii T., George M.D., Klionsky D.J., Ohsumi M., and Ohsumi Y. 1998.
c) A protein conjugation system essential for autophagy; Hiller M.M., Finger A., Schweiger M., and Wolf D.H. 1996.
d) ER degradation of a misfolded luminal protein by the cytosolic ubiquitin-proteasome pathway; Schleyer M. and Neupert W. 1985.
e) Transport of proteins into mitochondria: Translocational intermediates spanning contact sites between outer and inner membranes;
f) Lew D.J. and Reed S.I. 1993. Morphogenesis in the yeast cell cycle: Regulation by Cdc28 and cyclins
g) Strathern J., Hicks J., and Herskowitz I. 1981. Control of cell type in yeast by the mating type locus: The α1-α2 hypothesis
h) Lundblad V. and Szostak J.W. 1989. A mutant with a defect in telomere elongation leads to senescence in yeast
i) Tzagoloff A., Akai A., Needleman R.B., and Zulch G. 1975. Assembly of the mitochondrial membrane system. Cytoplasmic mutants of Saccharomyces cerevisiae with lesions in enzymes of the respiratory chain and in the mitochondrial ATPase

Suggested Readings:

- "Getting Started with Yeast" By Fred Sherman (2003)
- Yeast Genetics: Methods and Protocols by Jeffery S Smith and Daniel J Burke
- Yeast: Molecular and Cell Biology (2nd Edition) by Horst Feldmann
- https://www.pombase.org/
- https://www.yeastgenome.org/
- Landmark Papers in Yeast Biology; Edited by Patrick L, David S and Michael NH (2006)

Elective

Course code: MIB3EC7: Advances in Algal Biotechnology

THEORY: 03 credits: (03 hours /week)

Learning Outcomes:

- Understand the algal classification and cultivations methods.
- Gain in depth knowledge on algal primary and secondary metabolites and their industrial importance.
- To study about the marine algal resources and their significance
- Learn the conservation and control method for algae.
- Gain knowledge on algal stress responses and genetic engineering techniques for algae.

Unit 1	Cultivation techniques of algae:

Theory of endosymbiosis with respect to chloroplast evolution in algae. Isolation, purification and culturing of algae, cryopreservation, Algal growth curve; Culture medium for fresh water and marine algae; Nutrient uptake models (Michaelis - Menten and Monod, Droop models), types of movements in algae, indoor cultivation methods and scaling up.

Unit 2	Algal Metabolites and industrial importance:

Primary and secondary metabolites of fresh water and marine algae; Extraction of bioactive compounds from algae and their commercial importance; Microalgae in Human welfare: Nutraceuticals, Pharmaceuticals, Biofertilizers, Bio-fuel, bioplastics; Remote sensing strategy for the study of algal monitoring, Carbon sequestration by algae, Algae as bioindicators, Bioluminescent algae; Applications of bioengineering of microalgae in industrial productions

Unit 3	Conservation and control methods:

Secondary metabolites from microalgae as chemical defense, Algal toxins and their consequences

on aquatic environments and trophic level, Distribution of economically important algae in India, Algal genetic resource centres, culture collections and their importance; Methodological strategies for conservation of algae, Algae as pollution indicators, chemical methods of controlling algae, physical methods of controlling algae, biological methods of controlling algae.

Unit 4	**Abiotic stresses and genetic engineering:**

Algae in extreme environments, Survival mechanisms in extremophilic algae, abiotic stresses in algae; *Chlamydomonas reinhardtii* as model organism, Genome editing tools for algae, Random mutagenesis, Targeted gene modifications, Genome shuffling and evolutionary engineering; Algae specific databases and plasmids; Application of synthetic biology in algae; Limitations and controversies on transgenic microalgae for large-scale productions.

Unit 5	**Progress in algal research:**

Updates on algal taxonomy techniques, Photosynthesis, chloroplast, mitochondrial research; transcription & translation studies; algal abiotic stress response studies, updates on genetic engineering approaches and metabolite production.

Suggested Readings:

- Phycology (4th Edition) R.L. Lee, Cambridge University Press, 2008
- Barsanti, laura and paolo gualtieri 2005 Algae-Anatomy, Biochemistry and Biotechnology. Taylor & Francis, London, New York.
- Algae- Anatomy, Biochemistry and biotechnology-L. Barsanti& P. Gualtieri. Taylor & Francis,2006
- Andersen RA (2005). Algal Culturing Techniques. Physiological Society of America. ElsevierAcademic Press, USA.