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 and Enzyme & protein technology. 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 14 credits.
Core Course (CC): 10 credits
Elective Course (EC): 4 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	MBD 101	Research Methodology & Experimental Design	4
2	MBD 102	Techniques in Microbiology	4
3	MBD 103	Research and Publication Ethics	2

Electives			
S.No.	**Course Code**	**Couse Title**	**Credits**
1	DME 001	Pharmaceutical Microbiology	2
2	DME 002	Molecular Medicine	2
3	DME 003	Bio-Inoculants Production Technology	2
4	DME 004	Biofuel Production	2
5	DME 005	Antimicrobials & AMR	2
6	DME 006	Nanobiotechnology	2
7	DME 007	Yeast Biology	2
8	DME 008	Algal Biotechnology	2

Course code: MBD 101: Research Methodology & Experimental Design

THEORY: 04 Credits: 04 hours /week

Learning Outcomes:

- To understand some basic concepts of research methodologies and to design appropriate research objectives.
- To study research design and their types.
- To segregate qualitative and quantitative data and to understand parameters for data analysis.
- To gain knowledge on data analysis using statistical tools.
- To write a research report and to effectively present the data in scientific meetings.
- To gain insights of scientific writing, impact factor of journals and gain knowledge on plagiarism.
- To gain knowledge on different online tools available for reference management and plagiarism detection.
- To understand the implications of Intellectual Property Rights (IPR) and ownership of research data.

Unit 1 Foundations of Research:

Meaning, Objectives, Motivation, Utility. Concept of theory, empiricism, deductive and inductive theory. Characteristics of scientific method – Understanding the language of research – Concept, Construct, Definition, Variable. Research Process. Problem Identification & Formulation – 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. 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. Levels of measurement – Nominal, Ordinal, Interval, Ratio.

Unit 4 Data Analysis:

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 statically package (Sigma STAT, SPSS for student T-test, ANOVA, etc.), hypothesis testing.

Unit 5 Interpretation of Data and Report writing:

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 6 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.

Unit 7 Use of tools / techniques for Research:

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.

Unit 8	IPR- intellectual property rights:

Patent law, commercialization, copy right, royalty, trade related aspects of intellectual property rights (TRIPS); 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: MBD 102: Techniques in Microbiology

THEORY: 04 Credits: 04 hours /week

Learning Outcomes:

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

Unit 1 Microscopy:

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.

Unit 2 Spectroscopy:

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 3 Centrifugation 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.

Unit 4 Chromatographic techniques:

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 5 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 6 Sequencing 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.

Unit 7 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.

Unit 8	Gene silencing techniques:

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.

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: MBD 103: 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.

Elective

Course code: DME 001: Pharmaceutical Microbiology

THEORY - 02: (02 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.

Unit 1 Antibiotics and synthetic antimicrobial agents:

Production of antibiotics and synthetic antimicrobial agents, (Aminoglycosides, β lactams, tetracyclines, ansamycins, macrolide antibiotics, Chloramphenicol, Sulphonamides and Quinolinone antimicrobial agents, Antifungal antibiotics (Polyenes, Azole, Allylamines, 5-FC). Mode of action of antibiotics, and Peptide antibiotics, Chemical disinfectants, antiseptics and preservatives.

Unit 2 Antifungals:

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 Manufacturing procedures and in process control of pharmaceuticals and vaccine:

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 In silico pharmacology and drug discovery:

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. Case study: 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.

Elective

Course code: DME 002: Molecular Medicine

THEORY - 02: (02 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

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.

Unit 2 Disease diagnosis and drug discovery:

Detection and diagnosis of various diseases, DNA and Protein markers, Methods for the identification of markers, Drug design, High-throughput compound screening, Cell culture in drug discovery.

Unit 3 Treatment:

Monoclonal Antibody, interferons, Interleukins, hormones, clotting factors, enzymes in treatment of diseases.

Unit 4 Advanced treatment strategies:

Gene therapy, Gene delivery methods, Drug delivery method, stem cell therapy, nuclear medicine, and various animal model of diseases, clinical trials, constraints in modern technologies, future prospects.

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: DME 003: Bio-Inoculants Production Technology

THEORY: 02 Credit: 02 hours /week

Learning Outcomes:

- To give students an idea on biofertilizers preparation.
- To learn the types of biofertilizers and how they can be produced and used for various crops.
- To gain knowledge on strain improvement, strain preservation and mass production of bio-inoculants.
- To understand the importance of quality control and biosafety measures in bio-inoculant production and storage.

Unit 1 Introduction:

Bioinoculants- various types- biofertilizer, bio manures and biopesticides-their importance in sustainable agriculture - organic farming and environmental health Historical development of Bioinoculants technology -bioinoculants technology development in India. Biofertilizers-broad grouping of biofertilizers - dinitrogen fixers, phosphorous solubilizers and P-mobilizers. Nitrogen fixing microorganisms. Novel bioinoculants.

Unit 2 Types of biotertilizer:

Diazotrophic bacteria and BGA-symbiotic- associative symbiotic and non- symbiotic groups. Phosphorous solubilization by microorganism like bacteria and fungi - their importance in agriculture, mechanism of P-solubilization in soil ecosystem. Bacterial and fungal genera involved in P-solubilization –isolation, screening and testing the efficiency. Phosphorous mobilization by ecto- and endomycorrhizal fungi - their importance in forestry and agriculture. Mechanism of P mobilization and solubilization by AM fungi- isolation, screening and testing the efficiency.

Unit 3 Strain Improvement:

Strain improvement in bioinoculants-need- various techniques - selection, mutation, in vitro and *in-vivo* recombination technologies for improving the efficiency of bioinoculants strains-preservation of mother culture in low temperature, liquid nitrogen and dehydrated forms. Mass-multiplication of bioinoculants-laboratory level-pilot plant and industrial scale fermentation-design of fermentors-designing media for mass multiplication of bioinoculants.

Unit 4 Quality control:

Development of carrier-based inoculants and storage under low temperature- importance of shelf life-methods for increasing shelf life using various low-cost carrier materials. *In-vivo* mass production technology for AM fungi multiplication. Importance of quality control in bio-inoculants BIS specifications – microbial load in the bio-inoculants at production, storage and farmers holdings-biosafety measures on non- targeted microorganism and animals.

Suggested Readings:

- Rangaswamy,G.and Bagyaraj, D.J. 1992. Agricultural Microbiology, Asia Publishing House,New Delhi.
- Subba Rao, N.S.1999. Soil Microorganisms and plant Growth. Oxford and IBH, New Delhi.
- Bikas, R.P and Santi, M.M. 2005. Recent Trends in Biofertilizers, I K International Publishing House Pvt. Ltd, New Delhi

Elective

Course code: DME 004: Biofuel Production

THEORY: 02 Credit: 02 hours /week

Learning Outcomes:

- To learn about second and third-generation biofuels.
- 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 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 2 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 3 Algal biofuels 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.

Unit 4 Downstream processing:

Lipid extraction by different methods, factors influencing lipid content of microalgae, Qualitative and quantitative analysis of lipid by GC-MS: transesterification of fatty acids, TGA analysis, Algal biodiesel quality standards and economics, Gravimetric separation, media enrichment; advanced methods – micromanipulation, flow cytometry and other methods, Nile red staining, spectrofluorometry.

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.
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**

Elective

Course code: DME 005: Antimicrobials & AMR

THEORY - 02: (02 hours /week)

Learning Outcomes:

- Understand the different antimicrobials and their mode of action.
- To understand the concept of phage therapy and mechanism of antifungal agents.
- Understand the research tools that help in understanding the AMR mechanisms.
- Analyse the methods to combat the AMR

Unit 1	Antimicrobials:

Introduction, infections, 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). 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.

Unit 2	Bacteriophage and antifungal drugs:

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. Antifungal drugs.

Unit 3	Anti-microbial Resistance and 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.

Unit 4	AMR Tools:

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

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: DME 006: Nanobiotechnology

THEORY - 02: (02 hours /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.
- To study the importance of nanomaterials in diagnostics and therapy.

Unit 1	**Concepts of Nanobiotechnology**

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.

Unit 2	**Nano-biomolecules**:

Bionanomaterials and characterization. DNA nanotechnology, glyco, lipid and protein nanotechnology, Bio-nanomachines, Carbon nanotube and its bio-applications.

Unit 3	**Nanomaterials in tissue engineering**:

Metallic, Metal oxide-based, Ceramic, semiconducting, organic-inorganic hybrid, silica-based, polymeric nanocomposites. Tissue engineering, Biomimetics design, hydrogels, Polymeric scaffolds, Nanoengineered hydrogels, swelling properties, Nanobiomechanics of living cells, Multi-functional nanozymes.

Unit 4	**Nanomaterials in diagnostics and therapeutics:**

Nanomaterials in diagnostics, biosensors and therapies Nanomaterials in drug delivery, Nanomaterials for cancer diagnosis, Nanomaterials for cancer therapy, Nanotechnology in tissue engineering, Nano artificial cells, Nanotechnology in organ printing, Biochips, Cancer therapy using nanomedicine- Use of nanotubes, quantum dots, polymeric conjugates, Dendritic nanostructures, Fe/Au Nanoshell for tumor-targeted imaging, nanocarrier, crossing the blood-brain barrier.

Suggested Readings:

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

Elective

Course code: DME 007: Yeast Biology

THEORY: 02 credits: (02 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 apply the knowledge to understand the applications of yeast in industry and research.

Unit 1	**Basics of yeast biology**

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.

Unit 2	**Yeast growth and metabolism**:

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.

Unit 3	**Yeast genetics and genomics**

Yeast mating types; Mating type switching; Yeast evolution; Yeast transformation and genome engineering; Tetrad, random spore and molecular analysis of meiotic segregation and recombination; Introduction to Saccharomyces Genome Database (SGD) and PomBase.

Unit 4	**Yeast applications**

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; Using yeast to model human diseases.

Suggested Readings:

- "Getting Started with Yeast" By Fred Sherman (2003)
- Yeast Genetics: Methods and Protocols by Jeffery S Smith and Daniel J Burke
- https://www.pombase.org/
- https://www.yeastgenome.org/

Elective

Course code: DME 008: Algal Biotechnology

THEORY: 02 Credits: 02 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.
- Learn the conservation and control method for algae.
- Gain knowledge on algal stress responses and genetic engineering techniques for algae.

Unit 1 Classification and cultivation of algae:

Characteristic features and classification 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 Chemical composition and industrial importance of algae:

Primary and secondary metabolites of algae; Extraction of bioactive compounds from algae and their commercial importance; Algal immobilization and its applications. Microalgae in Human welfare – Nutraceuticals; Pharmaceuticals; Biofertilizers; Bio-fuel, bioplastics; CO2 sequestration and pollution control. Applications of bioengineering of microalgae in industrial productions. Limitations and controversies on transgenic microalgae for large-scale 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 Algal stress responses 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.

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. Elsevier Academic Press, USA.