Curriculum for Master of Science
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, Cell & Molecular Biology, Recombinant DNA & Protein technology, Immunology & Virology, Food & Industrial Microbiology, Bioinformatics, Biostatistics & IPR, Medical Microbiology & Diagnostics, Bacteriology, Mycology & Microbial Genetics, Agriculture Microbiology & Plant Pathology, Genomics & Proteomics, Marine & Environmental microbiology, Bioanalytical techniques. 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: Bachelor'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 total of 92 credit courses and a 2 credit value added course.
Core Course (CC): 71 credits (46 credit Core Courses + 13 Credits Discipline Specific Elective + 12 Credits lab practical).
Project Work & Dissertation: Compulsory, with 12 credits in Semester IV to impart research training.
Open elective: 3 Credits (Offered by various departments of CUTN)
Training: 4 Credits
Soft Skills: 2 Credits
Value added Course: 2 Credits

Students are advised to take more electives in line with CSIR-UGC, DBT-JRF, ICAR and ICMR syllabi which would help them to secure JRF fellowship

LIST OF COURSES FOR M.Sc. MICROBIOLOGY

Semester I: Core & Lab Courses (23 Credits)			
S.No.	**Course Code**	**Couse Title**	**Credits**
1	MIB2011	General Microbiology	4
2	MIB2012	Microbial physiology &Biochemistry	4
3	MIB2013	Cell & Molecular Biology	4
4	MIB2014	Immunology & Virology	4
5	MIB2015	Recombinant DNA & Protein Technology	3
6	MIB2016	Practical I	2
7	MIB2017	Practical II	2

Semester II: Core courses, lab courses, Training, Open Elective + Value added Course (VAC) (23+2 Credits)			
S.No.	**Course Code**	**Couse Title**	**Credits**
1	MIB2021	Food & Industrial Microbiology	3
2	MIB2022	Bioinformatics, Biostatistics & IPR	3
3	MIB2023	Medical Microbiology & Diagnostics	3
4	MIB2024	Bacteriology, Mycology & Microbial Genetics	3
5	MIB2025	Practical III	2
6	MIB2026	Practical IV	2
7	MIBOE01	Open Elective	3
8	MIB2027	Training	4
9	MIB2028	VAC	2

Semester III: Core, lab courses, Discipline Specific Elective & Soft Skills (25 Credits)			
S.No.	**Course Code**	**Couse Title**	**Credits**
1	MIB2031	Agricultural Microbiology & Plant Pathology	3
2	MIB2032	Genomics & Proteomics	4
3	MIB2033	Marine & Environmental microbiology	4
4	MIB2034	Bioanalytical techniques	4
6	MIB2035	Practical V	2
7	MIB2036	Practical VI	2
8	MIBEC01 to MIBEC06	Discipline Specific Elective	4
9	MIB2037	Soft Skills	2

Semester IV: Dissertation, Discipline Specific Elective (21 credits)			
S.No.	**Course Code**	**Couse Title**	**Credits**
1	MIB2041	Dissertation	12
2	MIBON01	Bio-Inoculants ProductionTechnology	3
3	MIBON02	Nanobiotechnology	3
4	MIBON03	Microbiome Biology	3

Electives for M.Sc. Microbiology program			
S.No.	**Course Code**	**Couse Title**	**Credits**
1	MIBEC01	Pharmaceutical Microbiology	4
2	MIBEC02	Molecular Medicine	4
3	MIBEC03	Biofuel Production	4
4	MIBEC04	Antimicrobials & AMR	4

5	MIBEC05	Yeast Biology	4
6	MIBEC06	Algal Biotechnology	4
7	MIBON01	Bio-Inoculants ProductionTechnology	3
8	MIBON02	Nanobiotechnology	3
9	MIBON03	Microbiome Biology	3

SEMESTER: I

Course code: MIB2011: General Microbiology

Theory: 04 Credits: (04 hours/week)

Learning Outcomes:

- To know the scope, history and contributions in microbiology.
- To study the microbial taxonomy and manual of systemic bacteriology.
- To understand the principles of microscopic and staining techniques.
- To study the structure and classification of prokaryotes and eukaryotes.
- To study the basic microbiology techniques and principles of sterilization, Isolation, preservation and preparation of growth medium.

Unit 1 Scope and History of Microbiology:

Scope of microbiology; ancient microbiology - Refutation of a biogenesis: Discovery of penicillin: Discovery of vaccination; One-gene one-enzyme hypothesis; Contribution of scientists – Leeuwenhoeck, Edward Jenner, Alexander Fleming, Joseph Lister, Robert Koch, Louis Pasteur, Hargobind Khorrana; Modern Microbiology; Landmark achievements in 20th century.

Unit 2 Microbial Taxonomy:

Definition and systematics; Nomenclatural rules and identification; Evolutionary relationship among the living organisms; Haeckel's three kingdom classification; Whittaker's five kingdom approach; Woese domain system; Major characteristics used in taxonomy: Morphological, physiological and metabolic, genetic and molecular taxonomy; Second edition of Bergey's manual of systematic bacteriology – characteristic features of each volume with important phyla of each.

Unit 3 Microscopy:

General principles of light microscopy - magnification, resolving power and numerical aperture; Principle and application of light, dark-field, phase contrast, differential interference contrast (DIC), fluorescence, scanning and transmission electron microscopy; scanning tunnelling microscopy; atomic force microscopy; confocal microscopy; cryoelectromicroscopy; bacterial staining.

Unit 4 Structure and functions of microbial cells:

Biology of bacteria - cell structure, size, shape, arrangement membrane, cell wall; Biology of algae and cyanobacteria, structure, physiology and classification; Biology of yeast and fungi – reproduction; mycoplasma; Prions; Virus (bacteriophages) structure - life cycle (lytic and lysogenic). Classification of extremophiles.

Unit 5 Basic microbiological techniques:

Different types of growth media (natural synthetic, complex, enriched, selective etc). Sterilization and disinfection techniques; principles and methods of sterilization - physical methods – heat, filters and radiation; chemical methods. Isolation and Preservation of microbial cultures.

Suggested Readings:

- Brock Biology of Microorganisms, 15th edition by Madigan, Bender, Buckley, Sattley and Stahl, Published by Pearson (2020).
- Prescott's Microbiology, 11th edition by Willey et. Al. Published by McGraw Hill (2019).
- Extremophiles: Microbial Life in Extreme Environments by Horikoshi and Grant, Published by Wiley (1998).
- Bergey's Manual of Systematic Bacteriology, 2nd Edition, Vol. 1, 2, 3, 4 and Springer-Verlag. New York, NY.

SEMESTER: I

Course code: MIB2012: Microbial Physiology & Biochemistry

THEORY: 04 Credits (4 hours/week)

Learning Outcomes:

- To understand the nutrient requirements and uptake mechanism in microorganisms.
- To gain knowledge on photosynthesis and inorganic metabolism
- To understand the concept of Bioenergetics and Electron transport system in microorganisms.
- To study the lipid, carbohydrate and nucleic acid metabolism in microorganisms.
- To study the metabolic regulations in microorganisms.

Unit 1 Microbial nutrition:

Microbial nutrient requirements, macro and micronutrients; nutritional classification of bacteria: phototroph, chemotroph, autotroph, heterotroph, photoautotroph, photoheterotroph, chemoautotroph, chemoheterotroph; nutritional patterns of pathogens – saprophytes, auxotroph; Transport of nutrition into the cell, passive diffusion, facilitated diffusion and active transport; Utilization of nutrients that cannot enterthe cell.

Unit 2 Photosynthesis & Inorganic Metabolism:

Characteristics and metabolism of autotrophs: Photosynthetic Bacteria and Cyanobacteria; Autotrophic CO_2 Fixation and Mechanisms of Photosynthesis, Photosystem I and II in cyanobacteria; Sulfur bacteria and the oxidation of sulfur compounds; Methanogenesis.

Unit 3 Bioenergetics & Electron transport chain:

Bioenergetics-Laws of thermodynamics, entropy, enthalpy, free energy, free energy and equilibrium constant, Gibbs free energy; coupled interconnecting reactions metabolism; ATP and other different groups of high energy phosphate compounds, Mitochondrial Electron transport chain and inhibitors of electron transport: Oxidative phosphorylation, Proton gradient generation, ATP synthase.

Unit 4 Metabolism of Biomolecules:

Metabolism of carbohydrates: EMP, Gluconeogenesis, HMP Shunt, ED pathway, Phosphoketolase and double phosphoketolase pathway. Metabolism of lipids: Oxidation of fatty acids, Ketone bodies – Formation and utilization; Biosynthesis of fatty acids- Elongation of fatty acids in cytosol, mitochondrial and microsomal, Metabolism of purines - De novo and salvage pathways for biosynthesis of Purine and pyrimidines; Degradation of purines and pyrimidines.

Unit 5 Metabolic Regulations:

Regulation through modulation of enzyme activity: fine regulation, Feedback inhibition, Enzyme activity modulation through structural changes, Phosphorylation, Adenylylation, Acetylation, Other chemical modifications, Allosteric regulation and Feedback control- Regulation of *E. coli* aspartate carbamoyltransferase.

Suggested Readings:

- Gerard J. Tortora, Berdell R. Funke, Christine L. Case. Microbiology-An Introduction. 11thedition Pearson, 2013
- Madigan MT, and Martinko JM (2014). Brock Biology of Microorganisms. 14th edition.Prentice Hall International Inc.
- Willey JM, Sherwood LM, and Woolverton CJ. (2013). Prescott's Microbiology. 9th edition.McGraw Hill Higher Education.
- Moat AG and Foster JW. (2002). Microbial Physiology. 4th edition. John Wiley & Sons.
- David White., 2007 The Physiology and Biochemistry of Prokaryotes, 3rd edn, Oxford University Press.

SEMESTER I

Course code: MIB2013: Cell and Molecular biology

THEORY: 04 Credits (04 hours/week)

Learning Outcomes:

- To understand the concept of the cell, its organelles and their function
- To understand the different cell receptors and their signal transduction.
- To understand the nucleic acids structure and replication process.
- To understand the transcription, translation and post- transcriptional modification.
- To understand the concepts of mutations and types DNA repair mechanisms.

Unit 1 Introduction to cell:

Cell theory, the architecture of cells: Emergence of modern cell biology, Structure of prokaryotic and eukaryotic cells, cell wall, cell membrane, cell organelles, organization and functions, Cell cycle events Molecular cell biology - protein structure and function, Hierarchical structure of proteins, membrane proteins, cell division.

Unit 2 Cell Signaling:

Bi-membranes and subcellular organization of prokaryotic and eukaryotic cells - cell architecture - Cell signalling – types, Chemical signals and cellular receptors, G Protein-linked receptors, Protein kinase-associated receptors, membrane and vesicular trafficking, Growth factors as messengers, Cell signals and Apoptosis, Endocystosis and exocytosis.

Unit 3 Nucleic acid Replication:

Introduction to Nucleic acid, DNA double helical structures, Chargaff's law, – Watson-Crick model, denaturation and renaturation of DNA, melting temperature (Tm), DNA quantification. **RNA** and RNA types. Molecular mechanisms and biological functions of siRNA, miRNA, Aptamers. Prokaryotic and eukaryotic DNA replication, Meselson Stahl experiment, the fidelity of replication, enzymes, and proteins involved in DNA replication.

Unit 4 Transcription and Translation:

RNA polymerase, Eukaryotic and prokaryotic transcription, and transcription factors. Post-transcriptional modification. Gene code: characteristics, deciphering the code. Wobble hypothesis tRNA structure and their role in translation, ribosomes their types and role in Protein biosynthesis: Prokaryotic and eukaryotic translation, the translational machinery. Post-transcriptional modification.

Unit 5 Mutation DNA Damage and Repair:

Molecular basis of mutation, mutation types, Ames test. Transposons (jumping genes). Causes of DNA damage (Physical and biochemical factors) and types of DNA damage, DNA repair Mechanism: Direct repair, base excision repair (BER), photoreactivation, nucleotide excision repair (NER), recombination repair mismatch repair, SOS repair.

Suggested Readings:

- "Essential Cell Biology", Albets, Bruce 5th Edition.
- "The Cell: a molecular approach" Cooper, Geoffery M. 8th Edition
- Weaver. R. F. Molecular Biology. 5th Ed. 2015. McGraw-Hill Education
- Alberts Bruce (2014) Molecular Biology of Cell (6th edition), Garland Science
- David Clark, Nanette Pazdernik, Michelle McGehee . Molecular biology.Cell Press, 2018.
- Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter. Darnell, Lodish and Baltimore. Molecular Cell Biology, 6th Ed. Garland Science
- Benjamin Lewin. Gene VIII. Pearson Education Inc. NJ, 2004

- Watson JD, Baker TA, Bell SP, Gann A, Levine M and Losick R (2008) Molecular Biology of the Gene, 6th edition, Cold Spring Harbour Laboratory Press, Pearson Publication

SEMESTER: I

Course code: MIB2014: Immunology and Virology

THEORY: 04 Credits (4 hours/week)

Learning Outcomes:

- To perceive host defence system and host-microbial interactions.
- To study the role of adaptive immunity in lymphocytes activation
- To gain knowledge of viral classification morphology and replication strategies
- To understand the mechanism of antivirals and modern approaches in viral control
- To get knowledge on different techniques in immunology and virology.

Unit 1 Innate Immunity and Recognition of Antigen

Principles of innate and adaptive immunity; Effector mechanisms – The first-lines of defense, complement system, Pattern recognition, induced innate responses to infection; Antigen recognition by B-cell and T-cell receptors; structure of antibody molecule, the interaction of antibody molecule with specific antigen and antigen recognition by T cells.

Unit 2 Adaptive Immune Response

T cell-mediated immunity; entry of naive T cells and APCs into peripheral lymphoid organs; priming of naiïve T cells by DCs; General properties of effector T cells and their cytokines; T cell-mediated cytotoxicity, macrophage activation by Th1 cells, Th2 cells, Th17 cells and Tregs; humoral Immune Response: B cell activation by helper T cells; distribution and functions of Ig classes; destruction of antibody-coated pathogens via Fc receptors; dynamics of adaptive immunity; the mucosal immune system and organization; mucosal responses to infection and regulation.

Unit 3 Definitive Properties of Viruses

History of virology; classification and nomenclature of viruses; ultrastructure, capsid symmetry and genetic materials of viruses receptor usage, entry and fusion of viruses; replication strategies of DNA and RNA viruses.

Unit 4 Antiviral strategies

Antiviral drugs, antiviral gene therapy, antiviral libraries; antiretrovirals—mechanism of action and drug resistance; modern approaches for virus control: Antisense RNA, siRNA, ribozymes,. T-phages, Baculovirus.

Unit 5 Immunotechnology and Virological Methods

Antigen-antibody interactions - Principles, types and applications of agglutination, precipitation, complement fixation, viral neutralization, immunodiffusion, immunoelectrophoresis, IgG and IgM ELISA and RIA. Monoclonal antibodies – Hybridoma technology, Chimeric, Humanised and Therapeutic neutralising antibodies; immunological methods: serotyping, immunoprecipitation, flocculation, complement fixation, tetramer technology, HLA-typing, immunoblotting, flow cytometry-based cell sorting of immune cells, cytokine arrays. Virus Haemagglutinin assay, IMAC assay, plaque assay, focus formation assay, syncytial formation and cytopathic effect assessment; isolation, purification, and cultivation: embryonated eggs, laboratory animals and cell cultures. serological methods, PCR-based assays and immunohistochemistry.

Suggested Readings:

- Janeway Immunobiology. 9th Edition. Publisher-Garland Science, 2016
- Roitt's Essential Immunology, 13th Edition, Peter J. Delves, Seamus J. Martin, Dennis R. Burton, Ivan M. Roitt 2016, Wiley-Blackwell.
- Basic Virology. Edward K. Wagner, Martinez J. Hewlett, David C. Bloom, David Camerini

- Principles of Virology, Multi-Volume, 4 or 5th Edition Jane Flint, Vincent R. Racaniello, Glenn F. Rall, Theodora Hatziioannou, Anna Marie Skalka

SEMESTER: I
Course code: MIB2015: Recombinant DNA & Protein Technology

- Principles of Molecular Virology 4th Edition, Alan J. Cann

THEORY: 03 Credits (3 hours/week)

Learning Outcomes:

- To understand the steps involved in rDNA technology.
- To get a clear picture on various cloning strategies
- To understand the expression of recombinant proteins in *E.coli*
- To explain key techniques used in rDNA technology
- To understand its applications in medical and agricultural field.

Unit 1 Introduction to recombinant DNA Technology:

Importance and outline of rDNA technology, control of gene expression in bacteria and eukaryotes, enzymes used in rDNA technology, types of vectors, vector elements, selectable markers, viral vectors, various plasmids used in cell and molecular biology research, Shuttle vectors.

Unit 2 Techniques in recombinant DNA technology:

Blotting techniques, Polymerase chain reaction (PCR) and its applications; Types of PCR and their applications, Labelling of DNA, RNA and proteins by radioactive isotopes, non-radioactive labelling, autoradiography, site-directed mutagenesis, RFLP, RAPD, AFLP, exon cloning, chromosome walking and jumping, EMSA, RNase A protection assay, DNAse I foot printing assay.

Unit 3 Cloning strategies:

Gene isolation, gene transfer techniques, genomic DNA library and cDNA library construction, partial digestion of genomic DNA, transformation, transfection, stable transfection, promoter analysis, Ligation independent cloning system, the Gateway cloning system, blue-white colony screening, Replica plating, gene expression analysis, Protein expression analysis, Posttranslational modification analysis, issues in transgene expression, DNA sequencing methods.

Unit 4 Expression of recombinant proteins:

Factors influencing the expression of recombinant proteins; purification of recombinant proteins - His-tag, GST-tag, expression of recombinant proteins – E.coli, mammalian cells, insect cells, Protein Engineering, Protein Chip technology, Cancer Proteomics, Antibody microarrays, Protein modifications, Protein structure & folding. Immunoprecipitation of proteins and protein complexes.

Unit 5 Applications of rDNA technology:

Transgenic animals, Gene therapy, Gene editing technology, agricultural and medicinal applications, commercially important transgenic plants, Therapeutic proteins used in human health care, Industrial applications, Biosafety guidelines for recombinant DNA research in India.

Suggested Readings:

- Bernard R. Glick and Jack J. Pasternak, Cherly L. Patten, Molecular Biotechnology, Principles and Applications of recombinant DNA Technology (4th edition), 2010.
- T.A. Brown, Gene Cloning and DNA Analysis: An Introduction (8th edition), 2021.
- R.W. Old and S. B.Primrose. Principles of Gene Manipulation. Blackwell Science
- Sambrook J and Russell D. W. Molecular Cloning: A laboratory Manual. Cold Spring Harbor Laboratory Press.

SEMESTER: I
Course code: MIB2016: PRACTICAL-I

Practical: 02 Credits: (04 hours /week)

1. Safety in Microbiology laboratory; microscopes – handling of light microscope
2. Micrometry – measurement of microorganisms
3. Aseptic techniques – working with equipment's and apparatus
4. Preparation of growth media for bacteria, yeast, moulds, actinobacteria and algae
5. Isolation of microorganisms by serial dilution and plating techniques
6. Purification and preservation of microorganisms
7. Staining techniques – positive, negative and differential staining
8. Turbidometry assessment of growth of bacteria and microalgae
9. Isolation of Rhizobium from root nodules and PGPR from soil
10. Morphological and Biochemical characteristics of bacteria for identification

SEMESTER: I
Course code: MIB2017: PRACTICAL-II

Practical: 02 Credits: (04 hours /week)

1. pH meter
2. Agarose Gel Electrophoresis
3. SDS-PAGE
4. RNA isolation
5. Plasmid isolation
6. Fluorescence microscope demonstration
7. Protein quantification
8. Paper chromatography
9. Quantification of eukaryotic cells using haemocytometer
10. Nuclear staining method

Suggested Readings:

- James Cappuccino and Chad Welsh, Microbiology: A Laboratory Manual, Pearson Publisher, 2019.
- Ted R. Johnson and Christine L. Case, Laboratory experiments in Microbiology, 3rd Ed., The Benjamin/Cummings Publishing Company Inc., 1992.
- Mette Ibba, Katherine Elasky, Basic and Practical Microbiology lab Manual, Cognella, Incorporated Publisher, 2018.
- Harold J. Benson, Microbiology Applications: Laboratory Manual in General Microbiology, McGraw-Hill Publisher, 2002.
- Molecular Cloning: A Laboratory Manual, Book by David W. Russell and Joseph Sambrook
- "Karp's Cell and Molecular Biology: Concepts and Experiments" 8th Edition, Gerald Karp et al.
- Advanced Analytical Techniques (Practical)

SEMESTER: II
Course code: MIB2021: Food &Industrial microbiology

Theory: 03 Credits (3hours/week)

Learning Outcomes:

- To understand the role of microbiology in the industrial aspect, food storage and packaging.
- To understand the concepts of food microbiology, food spoilage, detection and preservation.
- To gain knowledge on large scale production of microbial metabolites.
- To understand the strain development techniques for the effective production of enzymes, hormones, organic acids and vitamins
- To understand the basics of quality control norms, validation, sterility testing, GMP etc.

Unit 1	**Introduction to Food & Industrial Microbiology**

Historical account of microbes in industrial microbiology; sources and characters of industrially important microbes; their isolation, purification and maintenance; Screening of useful strains; primary screening and secondary screening; Strain improvement through random mutation and genetic engineering; types of fermentation. Microbial growth kinetics in batch, continuous and fed-batch fermentation process. Bioreactors, designs, and functional characteristics.

Unit 2	**Food spoilage, detection and Preservation**

Organisms involved in food spoilage and their significance in spoilage of different groups of foods; Detection and Enumeration of microorganisms and their products in food: Culture dependent methods - Sample collection and processing, analysis, surface testing, Direct microscopic observation, enumeration and isolation methods; Culture independent techniques - Metagenomics, Biosensor based detection of food pathogens, Nucleic-acid based methods; Immunological methods to detect food-borne pathogens; Molecular Typing and Differentiation of Food-borne Bacterial Pathogens. Food preservation: use of temperatures- Significance of psychrophilic microbes in cold-stored and frozen foods, Drying, Chemical, Modified atmosphere and Radiation.

Unit 3	**Microbial production of metabolites:**

Microbial production of Primary and secondary metabolites. Metabolic engineering, Pathways involved in secondary metabolite production, Commercial production of antibiotics with special reference to penicillin, streptomycin and their derivatives. Microbial transformations: steroids and alkaloids production. Large scale production of recombinant molecules interferon, human proteins-insulin, somatostatin, vaccines and anticancer agents.

Unit 4	**Fermented Microbial products:**

Microbiology and production of alcoholic beverages; Malt beverages, distilled beverages, wine and champagne; Pathways involved in primary metabolite production, Commercial production of organic acids like acetic, lactic, citric, and gluconic acids; Commercial production of important amino acids (glutamic acid, lysine and tryptophan), and vitamins (riboflavin and vitamin A). Industrial enzymes production: Cellulases, Xylanases, Pectinases, Amylases, Lipases and Proteases and their applications. Enzymes involved in microbial biocatalysis / transformations.

Unit 5	**Quality Assurance and Validation**

General principles of food safety risk management, Recent concerns on food safety- Safe food alternatives (Organic foods), Food safety and quality- Microbiological criteria of foods and their Significance. The HACCP and ISO systems for food safety. Regulatory practices, biosensors and

applications in Pharmaceuticals, Government regulatory practices and policies, FDA perspective.

Suggested Readings:

- Arun K. Bhunia, 2008, Foodborne Microbial Pathogens- Mechanisms and Pathogenesis, Food,
- Doyle, M. P. & Beuchat, L. R., 2007, Food Microbiology- Fundamentals and Frontiers, ASM Press.
- Quality control in the Pharmaceutical Industry - Edt. by Murray S.Cooper Vol.2. 1974, Academic Press New York.
- W. Crueger & A. Crueger (2017). Cruegers Biotechnology: A Text Book of Industrial Microbiology. Edited by K.R. Aneja. Panima Publishing Corporation.
- P.F. Stanbury, W. Whitaker & S.J. Hall (2016). Principles of Fermentation Technology. 3rd edition. Elsevier publication.
- Nduka Okafor, Benedict C. Okeke (2017). Modern Industrial Microbiology and Biotechnology. 2nd Edition: CRC Press Publishers.

SEMESTER: II
Course code: MIB2022: Bioinformatics, Biostatistics and IPR

THEORY: 03 Credits: (3 hours/week)

Learning Outcomes:

- To access different data banks and design PCR primers for gene amplification.
- To perform similarity checks between given sequences, and they can construct phylogenetic trees.
- To make better graphical representations of their results and understand the concepts of statistical significance, P Values, reproducibility, error bars etc.
- To perform basic statistical analysis of the given data set.
- To understand the components of IPR, how to file IPR, different agencies supporting IPR etc.

Unit 1 Overview of Bioinformatics & Databases:

Overview of databases in bioinformatics, modes of database search, mode of data storage (Flat file format, db-tables), flat-file formats of GenBank, Biological databases: Sequence and Structure databases – Protein Sequence databases, Nucleic Acid Sequence Databases, Pattern and motif searches, structure databases.

Unit 2 Sequence Similarities and Phylogenetic Analysis:

Pairwise alignment - Local and Global alignment concepts – Databases searches for homologous sequences - FASTA and BLAST - Multiple sequence alignment – Progressive Alignment - Clustal W, PCR primer design, Basic concepts of phylogenetic analysis, rooted/uprooted trees, approaches for phylogenetic tree construction.

Unit 3 Graphical Representation and Types of Data:

Qualitative and quantitative data, cross-sectional and time series data, discrete and continuous data, nominal, ordinal, ratio and interval scales; Presentation of data: Frequency distribution and cumulative frequency distribution, Measures of variability z-score and standard normal distribution, diagrammatic and graphical presentation of data, construction of the bar, pie diagrams, histograms, frequency polygon, and frequency curve.

Unit 4 Biostatistics:

Introduction to the t-statistic (one sample), the independent samples t-test, the dependent (paired) samples t-test, One-way ANOVA, simple linear regression analysis, Chi-Square and other non-parametric tests, introduction to multivariate analysis.: Software for Data Analysis: Introduction to the software, required data format, tables, descriptive measures, graphs and charts, presentation of tables/charts. Introduction to Graph pad PRISM and SPSS software

Unit 5 Intellectual Property Rights and Filing:

Introduction to IPR: IPR, forms of IPR, and Intellectual property protection. Concept of property with respect to intellectual creativity, Tangible and Intangible property. Copyright, trademarks, service marks, trade secret, and geographical index. Search engines for patent and prior art checks, Concepts related to patents, novelty, inventive-step, non-obviousness, utility, anticipation, etc. Type of patents. Indian patent act and foreign patents. Patentability, Patent application, Patent offices in India, forms and documents for filing, case studies Revocation of patent, Infringement (case studies), and Litigation with case studies on patent, Commercialization, and Licensing. WTO: agency controlling

trade among nations, WTO with reference to biotechnological affairs, TRIPs. WIPO, EPO, PCT.

Suggested Readings:

- Arthur. M. Lesk, Introduction to Bioinformatics, 4th Edition, 2014, Oxford University Press. K. Najarian, S.Najarian, S. Gharibzadeh, C. N. Eichelberger, Systems Biology and: A Computational Approach 1st Edition, 2009, CRC Press. ISBN: 978- 1420046502.
- Gupta SC, Kapoor VK (2014). Fundamentals of Mathematical Statistics, S Chand and sons, India
- Gupta SP (2009). Statistical Methods, 28th edition, S Chand and Sons, India.
- Intellectual Property Rights, Asha Vijay Durafe, Dhanashree K. Toradmalle. 2020. ISBN: 9789390395910.
- Law Relating to Intellectual Property Rights, VK Ahuja, 2nd Edition, Lexis Nexis (2013) ISBN: 9788180389894.

SEMESTER: II
Course code: MIB2023: Medical Microbiology & Diagnostics

THEORY: 03 Credits: (03 hours/week)

Learning Outcomes:

- To study different pathogenic bacteria and their mechanism in disease induction.
- To gain knowledge on fungal pathogenesis and diagnosis.
- To understand the molecular pathogenesis of human viruses
- To familiarise with various animal models to study the viral pathogenesis.
- To study the advanced techniques in diagnostics for microbial, viral and parasitic detection

Unit 1 Medical Bacteriology:

Staphylococcus and related organisms, Streptococcus, Enterococcus and other Gram Positive cocci, Bacillus, Listeria and Erysipelothrix, Corynebacterium and other Gram positive rods, Mycobacterium, Neisseria and related genera, Enterobacteriaceae, Vibrio and Aeromonas, Campylobacter and Helicobacter, Pseudomonas and related organisms, Haemophilus and related bacteria, Bordetella, Brucella and Francisella, Legionella, anaerobic spore-forming gram positive bacilli, anaerobic nonspore-forming Gram positive bacteria, Anaerobic Gram negative bacteria, Treponema, Borrelia and Leptospira, Mycoplasma and Ureaplasma, Rickettsia and Coxiella; role of bacteria in disease.

Unit 2 Medical Mycology:

Pathogenesis of fungal diseases; laboratory diagnosis of fungal diseases; superficial and cutaneous mycoses, subcutaneous mycoses, systemic mycoses caused by endemic dimorphic fungal pathogens; opportunistic mycoses; fungal and fungal-like infections of unusual etiology; mycotoxins and mycotoxicosis; role of fungi in disease.

Unit 3 Molecular Mechanisms of Viral pathogenesis

Human herpesviruses, Adenoviruses, Picornaviruses, Coronaviruses, Noraviruses, Paramyxoviruses, Orthomyxoviruses, Rhabdoviruses, Filoviruses, Flaviviruses, Arenaviridae, Retroviruses, Hepatitis viruses, unconventional agents and prions; mechanism of host cell damage; host cell 'shut off'; apoptosis, necrosis; alteration of signalling pathways and Cytopathic effects; emerging and reemerging virus and challenges; emerging diseases, sources and causes of emergent virus diseases.

Unit 4 Animal Models for infectious disease research

Identification, validation and development of an animal model; rodents: mouse, hamster, rats and guinea pigs: small animals: ferrets, Minks, dogs. and cats; non-human primates: rhesus monkey, green African monkey, cynomolgus Monkey (macaque); transgenic mice/genetically engineered models: knockin/knockout and humanised mouse models.

Unit 5 Techniques in diagnostics:

Microscopic examination of materials from infected Sites-culturing; biochemical profile-based microbial identification system; antimicrobial susceptibility testing methods; detection and characterization of molecular amplification Products: southern blot hybridization, restriction enzyme digest analysis and Enzyme-Linked Immunoassay (elisa), LAMP assay; Mass spectrometry based-microbial identification system; real-time detection of amplification products through fluorescence

quenching or energy transfer.

Suggested Readings:

- Murray P.R., Pfaller M.A., Tenover F.C., & Yolken R.H. 2007. Clinical Microbiology, ASM Press
- Sherris, John C, Medical Microbiology: An Introduction to Infectious Diseases, 2nd Edition
- Bauman, R.W. 2009. Microbiology: with Diseases by Body System; Benjamin Cummings
- David Wilks, Mark Farrington and David Rubenstein 2010. Infectious Diseases Manual: Blackwell Science.

SEMESTER: II

Course code: MIB2024: Bacteriology, Mycology & Microbial Genetics

- Yi-Wei Tang, Charles W. Stratton, Advanced Techniques in Diagnostic Microbiology, Volume 1: Techniques, Third edition (2018), Springer.

THEORY: 03 Credits (3hours/week)

Learning Outcomes:

- The students will learn to classify bacteria, fungi and to recognize, identify and differentiate the internal and external structures of fungal and bacterial cells.
- The students will understand the genetic organization in bacteria, learn about the bacterial genetics and mechanisms of gene transfers.
- The students learn about the principles of fungus genetics and their economic significance.
- The students will understand the principles of mutagenesis in microbes and learn about their applications in research. An overview of human microbiome will be given to the students.
- The students will apply the microbial genetics knowledge to gene manipulation and analysis strategies.

Unit 1 Introduction to Bacteriology and Mycology:

Overview of bacterial classification based on Bergey's manual of determinative bacteriology – Gram negative bacteria, Gram positive bacteria, Mycoplasmas and Archaea; Classification based on serology, Biochemistry, 16s rRNA, G+C content and Molecular tools; Bacterial ultrastructure and organelles; Staining of bacteria and organelles. General characteristics, structure and organization of fungi. Fungal reproduction - Vegetative, asexual and sexual. Adaptive & Developmental Changes: Life Cycle of myxobacteria, Aggregation and fruiting body formation. Endophytic fungi - symbiotic and opportunistic associations. Fungal ecology, distribution of yeasts and fungi. Fungal taxonomy – Criteria. Traditional, chemo and molecular taxonomy.

Unit 2 Bacterial genetics:

Organization of genetic material in bacteria; Gene transfer mechanisms: Introduction to conjugation, transformation and transduction; Recombination in bacteria; Natural transformation systems- *Streptococcus pneumoniae* and *Haemophilus influenzae*; Transfection and forced competence; Bacterial conjugation- Properties of the F plasmid, F^+ x F mating, F` x F conjugation; Transduction- Generalized and specialized transduction; Drug resistance in bacteria.

Unit 3 Fungal genetics and significance of fungi:

Fungal Genetics: Features and consequences of heterothallism, homothallism, mating types, Vegetative incompatibility, Polyploidy and aneuploidy. Neurospora- Tetrad analysis and linkage detection - 2 point and 3 point crosses – Induction of Mutations - Mitotic recombination in Neurospora – Transposable elements - Gene conversion. Yeast plasmids, Mating type genetics of yeast. Significance of Fungi: Toxigenic fungi and mycotoxins, fungi in biocontrol; Fungal metabolites and economic significance – mycotoxins, medicinal uses, biopesticides. Edible fungi – mushrooms, Mushroom poisoning.

Unit 4 Microbial genetics and Microbiome concept:

Mutations; Types of mutations; Mutagenesis – spontaneous and induced; Types of mutagens;

Applications of mutagenesis; Molecular implications of mutations – disorders, Reverse mutation, Mutant selection, Mutant enrichment, Reversions and suppression; Overview of fungal genetics and sexuality; Human microbiome: Fungal and Bacterial Human microbiomes, Microbiomes in health and disease; Cancer microbiome.

Unit 5	**Microbial genetic engineering:**

Genetic analysis of bacteria; Strain construction; Gene fusions and genetic reporters; Synthetic genes and genomes; In vitro genetic manipulations; Gene complementation and testing; Gene replacement; Cloning genes by marker rescue; Introduction to CRISPR-Cas system.

Suggested Readings:

- Molecular Genetics of Bacteria by Larry Snyder and Wendy Champness, 3rd edition; ASM press; 2007.
- Fundamental Bacterial Genetics by Nancy Trun and Janine Trempy, 1st edition; Blackwell Science Publishers; 2004.
- Modern Microbial Genetics by U.N. Streips and R.E. Yasbin, 2nd edition; Wiley Publishers; 2002.
- Microbial Genetics by Stanly R. Maloy, John E. Cronan, Jr. & David Freifelder, 2nd edition; Narosa Publishing House; 1987.
- Mehrotra RS and KR Aneja. An Introduction to Mycology, New Age Publishers
- Webster. An Introduction to Fungi, 3rd Edition, 2007
- Steven L. Stephenson (2010), The Kingdom Fungi: The Biology of Mushrooms, molds and lichens.

SEMESTER: II

Course code: MIB2028: Value Added Course in Microbiology

THEORY & PRACTICALS: 02 Credits (2hours/week)

Learning Outcomes:

- To learn the importance of budding yeast and mushroom.
- To gain knowledge and hands on training in culturing Oyster mushroom and yeast.
- To understand the importance of vitamin D
- Lab-scale production of vitamin D from yeast and *Pleurotus ostreatus* biomass
- Practical approaches in Vitamin D production.

Unit 1	**Introduction of Mushrooms**

Introduction: History, edible, and poisonous mushrooms and their nutritional and medicinal values. Taxonomy and species: distribution, and structure of various species of mushrooms.

Unit 2	**Practical Approach**

Practical approaches: Oyster mushroom *(Pleurotus ostreatus*) cultivation by bed method, polythene bag, field cultivation - Paddy straw mushroom substrate, spawning, pre-treatment of substrates. Maintenance of mushroom. Diseases - common pests, disease prevention and control measures. Processing- Blanching, freeze drying. Storage - short and long term storage.

Unit 3	**Sterols in Microorganism:**

Introduction to sterols in microorganism; Vitamin D and its importance in public health. Budding yeast and its role in food microbiology. Limitation of exploiting yeast in fermentation industry.

Unit 4	**Culturing of Budding Yeast:**

Practical approaches: Yeast (*Saccharomyces cerevisiae*) culturing, cell harvesting, extraction of lipids with organic solvents, thin-layer chromatography to check the quantity and quality of raw material for vitamin D production.

Unit 5	**Vitamin D Production:**

Practical approaches: Vitamin D production by UV irradiation of Oyster mushroom and yeast lipids. Production level, economic return. Quality analysis of the final product.

Suggested Readings:

- Gogoi R, RathaiahY, and Borah TR (2019) Mushroom Cultivation Technology, Scientific Publisher (India).
- Pesti G (2014) Mushrooms: Cultivation, Antioxidant Properties and Health Benefits, Nova Publishers.
- Gowder SJT (2017) A Critical Evaluation of Vitamin D - Clinical Overview, BoD Press.

- Boulton C, and Quain D (2013) Brewing Yeast and Fermentation, Blackwell Publishing.

SEMESTER: II

Course code: MIBOE01: Microbes in Health and Well- being

THEORY: 03 Credits (3hours/week)

Learning Outcomes:

- To acquire knowledge and gain understanding of basic concepts in microbiology and understand the origins of microbiology.
- To understand the significance of microbes in environment and to understand the role of microbes in human well being
- To gain an overview of plethora of diseases caused by pathogenic microbes in humans
- To understand the epidemiological aspects of microbial diseases in humans
- To gain knowledge in applications of microbes as nutraceuticals.

Unit 1	**Origins of Microbiology:**

Historical development of Microbiology – Theory of spontaneous generation, Biogenesis and Abiogenesis, Contribution of Indian scientists in the field of Microbiology, Fossil evidences of microorganisms, Origin of life, primitive cells and evolution of microorganisms, Overview of Prokaryotic and Eukaryotic cells.

Unit 2	**Microbes in Environment and Human microbiome**

Terrestrial environment (microflora), aquatic environment (microflora of fresh and marine habitats), atmosphere (aeromicroflora and dispersal of microbes), Extreme Habitats: extremophiles, Microbes in space, Microbes and climate change, Microbes in bioremediation, Microbiota of skin, throat, gastrointestinal tract, urogenital tract. Significance of microbiome. Normal and abnormal microflora of the human body: importance of normal microflora, normal microflora of skin, throat, gastrointestinal tract, urogenital tract, Probiotics, Prebiotics.

Unit 3	**Human diseases caused by Microbial Pathogens**

Malaria, Kala-azar – causes, symptoms, diagnosis and treatments, Brief description of the following types of mycoses and one representative disease in detail: Cutaneous mycoses- Tinea pedis (Athlete's foot), Systemic mycoses- Histoplasmosis, Opportunistic mycoses – Candidiasis, Polio, Herpes, Hepatitis, Rabies, Dengue, AIDS, Influenza (swine flu and bird flu), Ebola, Chikungunya, Japanese Encephalitis, Rota virus, Zika virus - causes, symptoms, diagnosis and treatments, Diseases caused by Streptococcus pyogenes, Haemophilus influenzae, Mycobacterium tuberculosis, Escherichia coli, Salmonella typhi, Vibrio cholerae, Helicobacter pylori.

Unit 4	**Control and Epidemiology of Microbial diseases in Humans**

Public health hygiene and communicable diseases. Survey and surveillance of microbial infections, Air borne microbial diseases, water borne microbial diseases, Food borne microbial infections,

Epidemiology of microbial infections, their detection and control, Antimicrobial resistance genes and their epidemiology, Combating infectious diseases

Unit 5	Microbial neutraceuticals:

Potential of microbes as a source of nutraceuticals/dietary supplements/functional foods/food supplements and its health benefits in relation to various health problems, microorganisms in the treatment and prevention of anaemia, obesity, diarrhoea, irritable bowel syndrome, inflammatory bowel disorders and colitis, atopic dermatitis, cancer, gluten therapy-resistant coeliac syndrome, Crohn's disease, diabetes, and allergies

Suggested Readings:

- Lund, B.M., Baird- Parker, A.C and Gould, G.W. (editors). (2000). The Microbiological Safety and Quality of Foods. Vol. 1-2. Springer, USA. 9.
- Tortora, G.J., Funke, B.R., and Case, C.L. (2016). Microbiology: An Introduction. 12th edition. Pearson Education, USA.
- Atlas, R.M. and Bartha, R. (2000). Microbial Ecology: Fundamentals and Applications. 4th edition. Benjamin Cummings, USA

SEMESTER: II

Course code: MIB2025: PRACTICAL-III

Practical: 02 Credits: (04 hours /week)

1. Isolation and identification of food –borne pathogenic bacteria from contaminated foods and dairy products.
2. Determination of quality of milk sample by methylene blue reductase test.
3. Bacteriological Examination of water quality.
4. Isolation of amylase/protease/ lipase producing microorganisms from soil
5. Production of alcohol using yeast
6. Multiple sequence alignment and Phylogenetic tree analysis.
7. Finding structural and functional motifs in proteins
8. Primer design & PCR
9. Restriction mapping & Virtual cloning
10. Network & Pathway Analysis

SEMESTER: II

Course code: MIB2026: PRACTICAL-IV

Practical: 02 Credits: (04 hours /week)

1. Isolation of free-living bacteria
2. Isolation and characterization of Plant growth promoting rhizobacteria
3. Screening Plant Growth Promoting Rhizobacteria for PGPR traits
4. Bacterial growth curve
5. Antibiotic sensitivity tests for isolated bacteria-disc method
6. Competent cell preparation
7. Transformation
8. Plasmid purification
9. Yeast Transformation
10. Selection and confirmation of transformed clones (Bacteria/Yeast)

Suggested Readings:

- Harley and Prescott (1996), Laboratory Exercises in Microbiology, McGraw Hill Higher Education, 3rd Edition
- Bull, Alan T. and Junker, Beth and Katz, Leonard and Lynd, Lee R. and Masurekar, Prakash and Reeves, Christopher D. and Zhao, Huimin, eds. (2010). Manual of Industrial Microbiology and Biotechnology, 3rd Edition. ASM Press.
- Maria S. Poptsova (2014). Genome Analysis: Current Procedures and Applications. Book: 978-1-908230-29-4. ebook: 978-1-908230-68-3. Caister Academic Press.
- "Practical Handbook of Microbiology" 4th Edition, Lorrence H Green
- Ted R. Johnson and Christine L. Case, Laboratory experiments in Microbiology, 3rd Ed., The Benjamin/Cummings Publishing Company Inc., 1992.

SEMESTER: III

Course code: MIB2031: Agricultural Microbiology & Plant Pathology

THEORY: 03 Credits (03 hours/week)

Learning Outcomes:

- To understand the importance and historic development of Agricultural Microbiology and plant Pathology.
- To understand the role of microorganisms in Bio-geo chemical cycles.
- To study different microorganisms causing plant diseases and their mechanism of pathogenesis.
- To understand the importance biocontrol agents in plant disease control.
- To gain knowledge on methods on agricultural waste management.

Unit 1	**Introduction:**

Introduction and historical development of Agricultural microbiology; Contributions of various scientists in the field of agricultural microbiology; Distribution and importance of soil microorganisms and the factors influencing the activities of soil microorganisms; Importance of soil and plant associated microbes – rhizosphere, spermosphere, phyllosphere, epiphytic and endophytes.

Unit 2	**Microorganisms role in Bio-geo chemical cycles:**

Carbon, sulphur, iron, phosphorus & nitrogen cycles; Rhizospheric microorganisms and its importance; Siderophores; PGPM-Plant growth promoting microorganisms; Plant-microbe interactions; Mechanisms of plant growth promotion. Biofertilzers – classification and importance.

Unit 3	**Plant diseases:**

Major plant disease symptoms caused by various microorganisms *viz.,* fungi, bacteria and viruses; Stages of disease development; relationship between disease cycles and factors influencing them; Mechanism of cuticle and cell wall degradation by microbes; production of secondary metabolites – fungal toxins; Plant diseases – Principles, symptoms and control; Fungal – General characteristics and different fungal diseases in plants like root rot, leaf spot, blight; Life cycle of the rice blast fungus *Magnaporthe oryzae*; Bacterial – Blight of rice and blast of rice; citrus canker – *Xanthomonas;* Viral and mycoplasma – Bud necrosis of groundnut, citrus mosaic, little leaf of brinjal, tomato leaf curl, Plant metagenomics in disease control.

Unit 4	Biological Plant Diseases Control and importance:

Principles of plant disease control; biocontrol of plant pests and diseases; Integrated pest and disease management – concepts and components; Biopesticides – *Bacillus thuringiensis, Pseudomonas syringe*; Biocontrol -by *Trichoderma,* use of Baculovirus, NPV virus, protozoa & fungi; Use of endophytic fungi as biocontrol agent against plant diseases.

Unit 5	Agro-waste management:

Recycling of agricultural wastes; biogas production; composting and vermicomposting; mushroom cultivation; biofuels and value-added products generation *via* microbes; Traditional and advanced methods of agricultural waste management.

Suggested Readings:

- Soil Microbiology by N.S. Subba Rao, 4th edition, Published by Oxford and IBH Publishing (2017)
- Soil Microbiology, Ecology and Biochemistry, 4th edition, edited by Eldor A. Paul, Published by Elsevier (2015)
- Soil Microbiology, 2nd edition by Robert L. Tate III (2000)
- Biofertilizers, volume 1: Advances in Bio-inoculants, edited by Rakshit, Meena, Parihar, Singh and Singh, Published by Elsevier (2021).

SEMESTER: III

Course code: MIB2032: Genomics & Proteomics

Learning Outcome:

Theory: 04Credits (4hours/week)

- To Understand the genome databases, genome sequencing and analysis strategies.
- To gain knowledge on Epigenetics
- To understand the concept of comparative and functional genomic approaches.
- Learn the basics of proteomic and bioinformatic tools for proteomics data analysis.
- To understand the MS based quantitative proteomics

Unit 1	Genomics and Metagenomics:

Large scale genome sequencing strategies; Genome assembly and annotation; Genome databases of Plants, animals and pathogens. Metagenomics: Gene networks: basic concepts, computational models. Microbial metagenomics; Prediction of genes, promoters, splice sites, regulatory regions: basic principles, application of methods to prokaryotic and eukaryotic genomes and interpretation of results; role of bioinformatics-OMIM database, reference genome sequence, integrated genomic maps, gene expression profiling; identification of SNPs, SNP database (DbSNP).

Unit 2	Epigenetics:

Epigenetic phenomena: heritable alternate states of gene activity, Epigenetic mechanisms regulating genome accessibility and cell differentiation. Tools for epigenetic data analysis; DNA microarray: database and basic tools, Gene Expression Omnibus (GEO), ArrayExpress, SAGE databases; DNA microarray: understanding and interpretation of microarray data, correlation of gene expression data to biological process and computational analysis tools.

Unit 3	Comparative and Functional genomics:

Comparative genomics: Basic concepts and applications; whole genome alignments: understanding the significance; Artemis, BLAST2, MegaBlast algorithms, PipMaker, applications of suffix tree in comparative genomics; Comparative genomics databases: COG, VOG; Application of sequence based and structure- based approaches to assignment of gene functions; Use of various derived

databases in function assignment; use of SNPs for identification of genetic traits.

Unit 4	Proteomics:

Protein arrays: basic principles; Computational methods for identification of polypeptides from mass spectrometry; Protein arrays: bioinformatics-based tools for analysis of proteomics data (Tools available at ExPASy Proteomics server); databases (such as InterPro) and analysis tools; Protein-protein interactions: databases such as DIP, PPI server and tools for analysis of protein-protein interactions.

Unit 5	Functional and quantitative proteomics:

Protein and peptide microarray-based technology; PCR-directed protein in situ arrays; Structural proteomics; LC-MS based proteomics: Protein MS applications – identifying unknown proteins by peptide mass fingerprinting; de novo sequencing of peptides from fragment ion spectra obtained by tandem MS.

Suggested Readings:

- Brown T.A. (2010), Gene Cloning & DNA Analysis, 6nd Edition, Wiley-Blackwell, New York.
- Bioinformatics- a Practical Guide to the Analysis of Genes and Proteins by Baxevanis, A.D.and Francis Ouellellette, B.F., Wiley India Pvt Ltd. 2009
- Primrose, S.B. and Twyman, R.M., Principles of gene manipulation and genomics. BlackwellPublishing (2006)

SEMESTER: III

Course code: MIB2033 : Marine & Environmental Microbiology

THEORY:04 Credits: (04 hours /week)

Learning Outcomes:

- To introduce marine ecosystem and associated microbial communities. To gain knowledge on seafood contamination with microbes.
- To study in detail the mechanisms employed by the extremophiles to survive in extreme environments.
- To study the interactions between microorganisms at different trophic levels and their association with surrounding abiotic factors.
- To gain knowledge on microbiology of aquatic environments and associated biogeochemical cycles
- To study the microbial communities of waste water, importance and process on waste water management. To understand the concept and importance of bioremediation and role of microbes in bioremediation.

Unit 1	Introduction to Marine Ecosystem and seafood microbiology:

Marine ecosystem: benthic & littoral zone, saltpan, mangroves and estuarine microbes; microbial loop; marine microbial communities – phytoplankton, protozoa, bacteria, fungi, and virus; Microbial endosymbionts; epiphytes; coral microbial association; sponge-microbial association. Normal genera associated with fish, food spoilage, fish & human pathogens; zoonotics – Brief account on aquaculture pathogens – Vibriosis – shrimp diseases – WSSV – MBV; Rapid diagnosis of contamination in sea foods and aquaculture products.

Unit 2	Microbes of extreme environments:

Mechanism of extremophiles – halophiles –halorhodopsin – deep sea microbes – microbes of hydrothermal vents – thermophilic, alkalophilic, osmophilic and barophilic, psychrophilic microorganisms – hyperthermophiles and halophiles –importance in biotechnology.

Unit 3	Microbial Ecology:

Interaction between abiotic and biotic factors in an ecosystem; ecological niche – limiting factor, concept of community, fluctuation and succession; Ecological pyramid; energy flow; food chain; food webs and their dynamism, stability and complexity of ecosystem; Interactions between microbes and organisms at trophic levels: commensalism, mutualism, parasitism and predation with examples; Microbial Communities: Microenvironment and niche; communities in soil, water, air; Biofilms, microbial mats and their significance. Major environmental conditions influencing microflora; Distribution of microorganisms in the aquatic environments – freshwater environment, estuaries and marine environment; Microbiology of drinking water; water pollution; purification of water for human consumption.

Unit 4	**Dynamics of Marine Microbes:**

Carbon cycle: Phototrophic microbes, the oceanic carbonate system and global warming - Nitrogen cycle: Nitrogen fixers – Iron limitation – ocean fertilization - phosphorus cycle; Decomposition of organic matter; Bioleaching and biodeteroriation of natural and synthetic materials.

Unit 5	**Microbiology of wastewater and solid waste treatment:**

Wastewater characteristics; Effluent treatment processes (like trickling filter, activated sludge, oxidative pond, anaerobic digestion and chemical disinfection); Biological, aerobic, anaerobic, primary, secondary and tertiary treatments; Activated sludge and Anaerobic digestion process. Treatment of industrial effluents by microorganisms; Factors affecting the bioremediation process; Bioremediation of toxic waste sites; Role of microbes; Microbial degradation of environmental pollutants-industrial solvents, pesticides, petroleum hydrocarbons, xenobiotics; bioremediation practices and technologies; Biofuel production from organic wastes; Bioleaching.

Suggested Readings:

- Marine Biology by Peter Castro and Michael, 10th edition by McGraw Hill (2015)
- Extremophiles: Microbial Life in Extreme Environments by Horikoshi and Grant, Published by Wiley (1998)
- Environmental Microbiology of Aquatic and Waste Systems by Nduka Okafor, Published by Springer (2011)
- Environmental Microbiology: Fund amentals and Applications: Microbial Ecology by Bertrand et al. (2015), Published by Springer Nature.

SEMESTER: III

Course code: MIB2034: Bioanalytical Techniques

THEORY: 04 Credits: (04 hours /week)

Learning Outcomes:

- To get basic knowledge of analytical techniques.
- To understand various electrophoretic techniques and its applications
- To get knowledge on chromatography, centrifugation techniques its uses
- To describe assays used in cell and molecular biology
- To understand various applications and recent trends in the field.

Unit 1	Basics in analytical techniques:

Introduction to bioanalytical techniques, Buffers and their preparation, importance of pH, concept of glass electrode and reference electrode, Microscope: The principle, resolving power, magnification and related numerical, application of microscope in analysing biological samples, Fluorescence microscope, Fluorescence spectroscopy and its applications.

Unit 2	Electrophoretic Techniques:

Electrophoresis-basic principles, Principle, procedure and applications of paper, cellulose acetate, polyacrylamide and agarose gel electrophoresis, electro-blotting, isoelectric focusing; 2D PAGE, immunoelectrophoresis, capillary electrophoresis and Pulsed Field Gel electrophoresis (PFGE), Radio isotopic techniques.

Unit 3	Centrifugation and chromatography techniques:

Principle of centrifugation, centripetal and centrifugal forces, factors affecting sedimentation rate, types of rotors, types of centrifugation and applications, Principles of adsorption, gel permeation, ion exchange and affinity chromatography, Paper and Thin Layer chromatography, Gas Chromatography and High-Performance Liquid Chromatography and their applications.

Unit 4	Bioanalytical assays:

Biomarkers assay development, validation and analysis, Biomarker testing assays, immunogenicity testing assays, Cell based proliferation and viability assays, Nitric Oxide assay, Reactive Oxygen Species detection assay, kinase assays, enzyme activity assays, ATP quantitation assay, Cytokine assays, Cell analysis – cell sorting, flow cytometry, RNA quantitation and expression assays, protein quantitation and expression assays.

Unit 5	Applications and Recent Trends:

Recent trends in Drug Discovery: High Throughput Screening, High Content Screening, Imaging instruments, cancer cell lines, primary cells, animal model, gene knockdown in drug discovery applications, Computer aided drug design, constrains in modern technologies, future prospects.

Suggested Readings:

- Andreas Hofmann and Samuel Clokie, Wilson and Walkers Principles and Techniques Of Biochemistry And Molecular Biology (2018).
- Vasudevan Ramesh, Biomolecular and Bioanalytical Techniques: Theory, Methodology and Applications (2019).

SEMESTER: III

Course code: MIB2037: Soft Skills

THEORY: 02 Credits: (02 hours /week)

Learning Outcomes:

- To understand logical reasoning and scientific thinking
- To get knowledge on time management and work ethics
- To understand basic knowledge on essay writing and scientific communication
- To prepare poster and make powerpoint presentation
- To make technical writing, basic search in pubmed, dissertation writing.

Unit 1	Logical Reasoning and Scientific thinking:

Experimental Design, Reproducibility and reliability in research, Data Interpretation – Tables, GraphPad Prism, Usage of MS word, excel, PowerPoint, Adobe Illustrator.

Unit 2	Time Management and Work ethics:

Work with different efficiencies, Team work, working environment in research laboratories, Work ethics, Work equivalence, Plaigarism, Acknowledgement, Accountability.

Unit 3	Skills for placements/Scientific communication

Essay writing, Practice and feedback, Fundamentals of Scientific communication – Written communication, Face-Face Interview, Techniques to face to face Video interviews, Mock Interview, Customizing Resume – Usage of Power Verbs, Email writing.

Unit 4	Poster and Oral presentations

Poster preparation, Powerpoint preparation, Presentation skills, Idea generation for topics of presentation, Best Practices of presentation, Grooming and body language.

Unit 5	Technical Writing

Scientific writing, Literature survey, Pubmed, Reference management, Layout of research articles, Dissertation writing.

Suggested Readings:

1. Personality Development And Soft Skills, Barun K Mitra, Second edition (2016), Oxford Press
2. Communication skills, Sanjay Kumar and Pushp Latha, Second edition (2015), Oxford Press
3. Brown, Lola (2007), Resume writing made easy, Canada, Printice hall
4. FACE, Aptipedia Aptitude Encyclopedia, 2016, 1stEdition, Wiley Publications, Delhi.
5. Mastering Ms Office, Bittu Kumar (2017), V&S publishers

SEMESTER: III

Course code: MIB2035: PRACTICAL-V

Practical: 02 Credits: (04 hours /week)

1. Direct microscopic observations and staining of fungal spores, mycelium,
2. Isolation and identification of Soil fungi,
3. Isolation and identification of endophytic fungi from plants,
4. Isolation of antibacterial/ antimycotic compounds from fungi.
5. Isolation and identifications of fungal glucosyl ceramides.
6. Virtual demonstration (as per UGC guidelines) of handling of laboratory animals,
7. Isolation of human PBMCs and lymphoproliferation assay
8. Immunoelectrophoresis and Western blotting
9. SARS-COV-2 Spike ELISA test
10. Laboratory examination and identification and biochemical tests of pus (using avirulent strain of MTCC culture) for *Staphylococcus aureus*, *Streptococcus pyogenes* and *Pseudomonas aeruginosa*.

SEMESTER: III

Course code: MIB2036: PRACTICAL-VI

Practical: 02 Credits: (04 hours /week)

1. Agarose gel electrophoresis
2. Eukaryotic DNA extraction (Teaching kits)
3. Prokaryotic DNA extraction (Teaching kits)
4. Quantification of DNA/RNA using nanodrop and determining their purity
5. Polymerase Chain Reaction
6. Study of *mitosis* in *onion root tips*.
7. Ames test
8. UV-induced mutation analysis
9. Anti-phage mutation development

10. Protein sequence extraction and multiple sequence alignment

Suggested Readings:

- Onions, A. H. S. (Agnes H. S.); Allsopp, D.;Eggins, H. O. W.;. Smith's introduction to industrial mycology
- Ellis, M. B.. (1971) Dematiaceous hyphomycetes.
- Mackie & Mccartney Practical Medical Microbiology, 14th -Edition
- Frances and John Preactical Immunology 4th-Edition
- Practical Microbiology, Prescott
- Susan Carson, Heather B miller, Scott witherow, Melissa C Srougi. Molecular biology techniques. Fourth edison, 2020.
- Stefan Surzycki. Basic Techniques in Molecular Biology (Springer Lab Manuals). Springer, 978-3540666783
- Chaithanya. KV. CELL AND MOLECULAR BIOLOGY : A Lab Manual.
- Najat Abdulrazzaq Hasan. Basic Molecular biology laboratory Manual. 2021. DOI: 10.5281/zenodo. 4541490
- Laboratory Exercises in Microbiology, Prescott H, 5th Edition

Discipline Specific Electives

For

M.Sc. Microbiology

SEMESTER V: Elective
Course code: MIBEC01: Pharmaceutical Microbiology

THEORY - 04: (04 hours /week)

Learning Outcomes:

- To understand the production processes and mechanism of action 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 acquire knowledge regarding the process of discovering and optimizing antimicrobial drugs through drug development.
- To understand the 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); mode of action of small molecule, and peptide antibiotics, assessment of a new antibiotic and testing of antimicrobial activity of a new substance; drug alternate strategy to overcome antibiotic resistance.

Unit 2	**Antifungals:**

Mode of action of antifungals (Polyenes, Azole, Allylamines, 5-FC); techniques: antibiotic sensitivity assays- disc method, replica plating technique, anti-fungal sensitivity testing; antifungal resistance mechanism; molecular principles of drug targeting.

Unit 3	**Manufacturing procedures and in process control of 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; chemical disinfectants, antiseptics and preservatives.

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; 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.

Unit 5	Microbial production and Spoilage of Pharmaceutical Products

Microbial contamination and spoilage of pharmaceutical products (sterile injectables, non-injectables, ophthalmic preparations and implants) and their sterilization; sterilization control and sterility testing (heat sterilisation, D value, z value, survival curve, Radiation, gaseous and filter sterilization); Chemical and biological indicators

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: MIBEC02: Molecular Medicine

THEORY: 04 Credits (4 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, 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.

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.

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: MIBEC03: Biofuel Production

THEORY: 04 Credits (4 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	Introduction to 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	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:

- Ozcan Konur. 2017. Bioenergy and Biofuels. CRC Press, Taylor & Francis Group**. ISBN 9781351228138.**
- Rafael Luue and James Clark. 2010. Handbook of biofuels production: Processes and Technologies. Publisher Elsevier; **ISBN: 9780857090492**
- 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.
- C. M. Drapcho, N. P. Nhuan, T. Walker, Biofuel Engineering Process Technology, Mc Graw Hill 2008 D. M. Mousdale, Biofuels, CRC Press 2008.
- 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 : MIBEC04: Antimicrobials and AMR

THEORY: 04 credits: (4 hours/week)

Learning Outcomes:

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

Unit 1	Antibiotics:

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	Antimicrobial drugs:

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). Antifungal drugs. Antiviral drugs and their mechanism of action.

Unit 3	Bacteriophage Therapy and Anti-phage Mutations:

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.

Unit 4	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.

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).

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: MIBEC05: Yeast Biology

THEORY: 04 credits (04 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	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. Yeast Cellular architecture, Yeast Genome organization

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 as model organism

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, Yeast Transport system, Yeast cell cycle and study of yeast cell cycle mutants

Unit 5	Yeast in Industry

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

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/

Elective

Course code: MIBEC06: Algal Biotechnology

THEORY: 04 credits (04 hours /week)

Learning Outcomes:

- To understand the algal classification and cultivations methods.
- To Gain in depth knowledge on algal primary and secondary metabolites and their industrial importance.
- To study the properties and applications of algae in marine environment
- To learn the conservation and control method for algae.
- To 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 chloroplastevolution 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; Applications of bioengineering of microalgae in industrial productions. Limitations andcontroversies on transgenic microalgae for large-scale productions.

Unit 3	Algae in marine environment:

Physico-chemical properties, Intertidal seaweeds, zonation patterns and factors affecting distribution of intertidal seaweeds, Remote sensing strategy for the study of algal monitoring, Carbon sequestration by algae, Algae as bioindicators, Bioluminescent algae

Unit 4	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 5	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 databasesand 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

Elective

Course code: MIBON01: Bio-Inoculants Production Technology

- Andersen RA (2005). Algal Culturing Techniques. Physiological Society of America. ElsevierAcademic Press, USA.

THEORY: 03 Credit (3 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.

Unit 2	Types of Biofertilizer:

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 fermenters-designing media for mass multiplication of bioinoculants.

Unit 4	Mass Production:

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. Noble bioinoculants production.

Unit 5	Quality Control:

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. BIS specification for biological nitrogen fixing biofertilizers – Rhizobium, Cyanobacteria, Azotobacter; BIS specification for P solubilizing and P mobilizing biofertilizers.

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
- Mahendra Rai, 2006. Handbook of Microbial Biofertilizers, CRC Press Taylor & Franscis.

Elective

Course code: MIBON02: Nanobiotechnology

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	Nanomaterials and synthesis:

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 bio-applications. Nanomaterials and biosystems interaction. Biomimetics design, hydrogels, swelling properties, Nanobiomechanics of living cells, Multi-functional nanozymes.

Unit 3	**Nanomaterials in Tissue Engineering**:

Natural and synthetic polymers and their application in tissue engineering, Polymeric scaffolds, Nanoengineered hydrogels, fabrication, immune responses to biomaterials, cell migration and differentiation, and polymeric nanocomposites.

Unit 4	**Nanomaterials in Diagnostics:**

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.

Unit 5	**Nanomaterials in Therapeutics:**

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.

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

SEMESTER:
Course code: MIBON03: Microbiome Biology

THEORY: 03 Credits: (3hours/week)

Learning Outcomes:

- To understand the concept and history of microbiome.
- To gain knowledge on different approaches in microbiome analysis.
- To understand the composition of human microbiome and its significance.
- To study the effects and correlation of microbiome in human disease
- To gain knowledge on biofilm formation and its applications in various industries.

Unit 1	**Microbiome:**

Microbiome- definition, history and perspective of microbiome, environmental genomics- microbiomes of oceans, lakhs and terrestrial ecosystems, Microbiome ecology, the fungal and viral microbiomes, Microbiome evolution. Earth Microbiome project.

Unit 2	Approaches in Micobiome analysis:

Approaches in Micobiome analysis, Metagenomics (open and closed formats), Metatranscriptomics, Pan-genomics, Epigenomics, Microfluidics technology to study the human microbiome, single cell genomics, Advance culturing techniques to study microbiomes. metagenomics of archealogical samples – Sargasso sea project – microbial phylogeography.

Unit 3	Human microbiome and disease biology:

Biodiversity and major genera of human-microbiome, human microbiome system as a "holobiont" or "superorganism", composition of specific body sites' microbiome (nose, skin, oral, urogenital, etc.) Dynamics microbiome changes from birth to death; pregnancy and the microbiome; Gut-brain conversation, obesity and gut microbiome, infectious/non-infectious diseases and gut microbiome, phylogeography of epidemics, microbiome's role in diseases such as Inflammatory bowel disease (IBD), colitis, obesity, diabetes; effects of diet on microbiome; interactions with the immune system and resistance to pathogens.

Unit 4	Animal and Plant Microbiome:

Introduction of Plant and Animal Microbiome; Microbiomes of the Different Plant Compartments (rhizosphere, phyllosphere, and endosphere), Microbiome of Food-Producing Animals (Ruminants, Poultry, Porcine Fisheries); Role of Plant Microbiome in Plant health and productivity; Role of the animal microbiome in host health and disease; Terrestrial or marine habitats and their microbial inhabitants; Microbial Diversity and biogeography in the different terrestrial or marine habitats. Introduction of Microbiome of major habitats of terrestrial (Soil) or marine (Ocean, Marine Animals) ecosystem.

Unit 5	Biofilm biology:

Biofilm – definition, cell-cell communication, extracellular polymeric substances (EPS), Formation stages – Development, Dispersal, Habitats - dental plaque, diversity and eDNA, biofilm Infectious diseases - Pseudomonas aeruginosa and Staphylococcus epidermidis, Staphylococcus aureus, Streptococcus mutans, Candida. Uses in medicine, industry, Food industry, aquaculture. Eukaryotic biofilms, biofilm as model of microbiome.

Suggested Readings:

- Angela E. Douglas (2018). Fundamentals of Microbiome Science – how microbes shape animal biology, Princeton University Press, New Jersey, United States.
- Emeran Mayer (2016). The Mind-Gut Connection: How the Astonishing Dialogue Taking Place in Our Bodies Impacts Health, Weight, and Mood. eBook, Harper Wave Books.
- Martin J. Blaser (2014). Missing Microbes: How the Overuse of Antibiotics Is Fuelling Our Modern Plagues. Harper Collins Publishers. Toronto.
- Diana Marco (2014). Metagenomics of the Microbial Nitrogen Cycle: Theory, Methods and Applications Book: 978-1-908230-48-5. ebook: 978-1-908230-60-7, Caister Academic Press.