Department of Microbiology

School of Life Sciences

Proposed Syllabus for M. Sc. Microbiology

To be effective from Academic session 2022-2023

Central University of Rajasthan

NH-8, Bandarsindri Kishangarh

305817 (Ajmer), Rajasthan

Name of Department: Department of Microbiology

Name of the Program: M. Sc. Microbiology (Two years)

A. Program Eligibility

- Bachelor's degree with Microbiology/Zoology/Botany/Life sciences/Biochemistry/Genetics/ Biotechnology/Medicine/ Pharmacy/any other discipline of Biological sciences as one of the main subjects and Chemistry as one of the optional subjects at least for One year or Two semesters with minimum 50% of marks or equivalent grade in aggregate for general category and 45% or equivalent grade for SC/ST/OBC/PWD candidates.

B. Program Objectives

- The objective of the Master's Program in Microbiology is to equip the students to gain bimolecular knowledge and analytical skills at an advanced level.
- The program emphasizes to apply knowledge acquired about prokaryotic and eukaryotic cellular processes, interaction of microorganisms among themselves, with physical and chemical agents and higher order organisms in environment and biological systems to various conditions.
- The laboratory training in addition to theory is included so that the students will acquire the skills to qualify for a broad range of positions in research, industry, consultancy, education and public administration, or for further education in a doctoral program.
- Students will be able to address broad range of fields including biopolymer chemistry, marine biochemistry, environmental biotechnology, food science, microbiology, microbial genetics, molecular biology and systems biology.

C. Program Outcomes

The Masters in Microbiology Program will address the increasing need for skilled scientific manpower with an understanding of research ethics involving microorganisms to contribute to application, advancement and impartment of knowledge in the field of microbiology and molecular biology globally. The laboratory training will empower them to prepare for careers in broad range fields.

The M. Sc. Microbiology students will have:

- State of art knowledge about various methodological and analytic approaches that are used within the specialization.
- Knowledge of the leading edge in a chosen specialized area of Microbiology, based on own research experience from a master's project and international literature.
- Can compete in national level competitive exams such as NET-JRF or GATE or International exams such as GRE-TOEFEL and can pursue career in higher studies.
- In-depth knowledge in the structure of a repertoire of microorganisms, metabolism in the cell, knowledge of the concepts of molecular genetics and biosynthesis of proteins, enzymology, physiology, microbial pathogenicity, environmental and agricultural microbiology, genetic engineering, bioengineering and a good theoretical and practical insight into methods used to obtain this knowledge.
- Demonstrate practical skills in the use of tools, technologies and methods common to microbiology, and apply the scientific method and hypothesis testing in the design and execution of experiments.
- Develop ability to independently carry out a complete scientific work process, including

the understanding of theoretical background, hypothesis generation, collection and analysis of data, and interpretation and presentation of results.

- Has high competence and multidisciplinary project experience within selected topics related to microbiology and ability to contribute in a multidisciplinary team.
- Is capable to evaluate methods and results within the field of specialization critically.
- Is able to evaluate and apply relevant theory, methods and analytic approaches within the specialized field of microbiology, including statistical methods.
- Can assess and predict the technological, ethical and social effects of their own work /disciplines and of microbiology.
- Acknowledges health, safety and environment (HSE) issues in handling chemicals and biological materials; understands the environmental impacts associated with the activity; performs risk assessments and is familiar with safety instructions in his/her subject area.
- Can communicate scientific results to the general public and experts by writing well-structured reports and contributions for scientific publications and posters, and by oral presentations.

D. Employability

- Skilled manpower suitable for academic and research institutions as technicians.
- Suitable for different government and non-governmental and private companies.
- Skilled students who can do PhD and contribute to field of Microbiology.

Course Content: M.Sc. Microbiology (Implemented from academic session 2022-2023 onwards)

Semester I

Course Code	Title of the course	Course	Course Type	Credits
MBY 401	Essentials of Prokaryotes and Eukaryotes	Core 1	T	3
MBY 402	Bioinformatics & Biotechniques	Core 2	T	3
MBY 403	Molecular Biology	Core 3	T	3
MBY 404	Immunology	Core 4	T	3
MBY 405	Biochemistry	Core 5	T	3
MBY 406	Microbial Physiology	Core 6	T	3
MBY 407	Laboratory I (Essentials of Prokaryotes and Eukaryotes, Bioinformatics & Biotechniques, Molecular Biology)	Core 7	L	3
MBY 408	Laboratory II (Immunology, Biochemistry & Microbial Physiology)	Core 8	L	3
Total Credits				**24**

Semester – II

Course Code	Title of the course	Course	Course Type	Credits
MBY409	Fundamentals of Virology & Protozoology	Core 9	T	3
MBY410	Medical Microbiology	Core 10	T	3
MBY411	Microbial Genetics and Recombinant DNA Technology	Core 12	T	3
MBY412	Laboratory -III (Virology & Protozoology, Medical Microbiology)	Core 13	L	3
MBY413	Laboratory -IV (Microbial Genetics & Recombinant DNA Technology, & Elective I)	Core 14	L	3
MBY416	Minor Project (Dissertation 1)	SEC I	Tutorial/ Laboratory	2
MBY417	Internship	SEC II	Tutorial/ Laboratory	1
MBYD-	Elective -I	DSE 1	T	3
MBYN--	Elective-NDSE-I	NDSE 1	T	3
Total Credits				24

Semester –III

Course Code	Title of the course	Course	Course Type	Credits
MBY501	Industrial Microbiology and Fermentation Technology	Core 15	T	3
MBY502	Environmental & Agriculture Microbiology	Core 16	T	3
MBY503	Food and Dairy Microbiology	Core 17	T	3
MBY 504	Laboratory-V (Industrial Microbiology and Fermentation Technology, Elective II & Elective III)	Core 18	L	3
MBY 505	Laboratory-VI (EAM, & FDM)	Core 19	L	3
MBYD--	Elective-II	DSE 2	T	3
MBYD--	Elective-III	DSE 3	T	3
MBYN--	Elective-NDSE-II	NDSE 2	T	3
Total Credits				**24**

Semester IV

Course Code	Title of the course	Course	Course Type	Credits
MBY506	Research Article Presentation	AECC/SS	Tutorial/ Presentation	3
MBY507	Major Project (Dissertation 2)	SEC 1II	Tutorial/ Laboratory	15
MBY508	Dissertation Presentation	AEEC 1	Tutorial/ Presentation	3
MBYD--	Elective IV	DSE 4	T	3
Total Credits				**24**

T: Theory Classes, L:- Laboratory Classes, SS : Self-study Course,

AECC: Ability Enhancement Credit Course, SEC: Skill Enhancement Course

List of Elective to be offered:-

(A) Discipline Specific Electives (DSE) *

MBYD01: Fungal Biotechnology and Bioprospecting
MBYD02: Bioprocess and Bioenergy
MBYD03: Pharmaceutical Microbiology
MBYD04: Petroleum Microbiology
MBYD05: Extreme Microbiology
MBYD06: Infection Biology and Vaccine Development
MBYD07: Bio-mining
MBYD08: Microbial Ecology
MBYD09: IPR and Bio-entrepreneurship
MBYD10: Metagenomics: Basics and Applications
MBYD11: One Health
MBYD12: Microbiome: Health, Disease and Medicine
MBYD13: Bioprocess Engineering
MBYD14: Infectious Diseases: Drug Discovery and Development
MBYD15: Multi-omics

(B) MOOC courses**:** - Courses may be offered by the department from the list of courses made available online before beginning of the semester as per suitability of the M. Sc. Program.
(C) Any other electives offered by the allied Departments**.**
(D)

* The subjects in the given list for DSE may change whenever required.

** The content will depend upon recent developments in the area of Microbiology.

(E) Non Discipline Specific Electives (NDSE): As offered by the other departments of the University.

S. No.	Courses Name	Course Type	No. of Course	Credits for each course	Total Credits
1.	Core Course	Theory	13	03	36
2.	Core Course	Laboratory	06	03	18
3.	DSE	Theory	04	03	12
4.	NDSE	Theory	02	03	06
5.	SEC	Tu/L	01	-	18
6.	AECC	Tu/L	02	03	06
				Total Credits	**96**

Semester- I

MBY 401 Essentials of Prokaryotes and Eukaryotes Credits 3

Course Objectives:

- Knowledge on Landmark discoveries in Microbiology and different domains classification of living organisms.
- Familiarity with general characters of prokaryotic and Eukaryotic microorganisms for conventional and molecular characterization using modern methods.
- Knowledge of cellular organization, life cycle and economic importance of prokaryotic (Eubacteria, Archaea, Cyanobacteria) and Eukaryotic (Algae, Fungi and Protozoans).

Course Outcomes:

- Understanding of basic microbial structure and similarities and differences among various groups of microorganisms such as bacteria/archaea/cyanobacteria/fungi/protozoans.
- Acquaintance on study of microbial diversity using different methods and systematics of bacteria and archaea using polyphasic approach.
- Understand the various methods for identification of isolated and uncultivable microorganisms.

Course Structure:

UNIT-I

Origin and evolution of microbial world: Pathway of discovery in Microbiology; Kingdom and domain concepts of classification; Distribution, diversity and general characteristics of Eubacteria and Archaebacteria: cell structure-essential and accessary components, nutrition, reproduction. Introduction and distinctive features of Rickettsiae, Chlamydiae, Spirochaetes, mycoplasma.

Classification of bacteria and archaea according to the Bergey's Manual of Systematic Bacteriology. Tools for Systematics: Numerical taxonomy, Phylogenetic analysis, Polyphasic approach; Modern methods of studying microbial diversity; Microbial culture collections.

Cyanobacteria: Distribution, cell structure, nutrition, morphological diversity, culturing and reproduction; Cyanobacterial bloom and cyanotoxins; Economic importance of cyanobacteria.

UNIT-II

Phycology: Distribution and salient features of algae; Classification: Criteria used in classification; Phylogeny and modern trends of classification; distinguishing characters of important groups (Chlorophyceae, Xanthophyceae, Phaeophyceae & Rhodophyceae). Culturing of algae. Algae and evolution of land plants. Range of thallus organisation; vegetative and asexual reproduction, sexual reproduction and alternation of generations; Economic importance of algae; Algal boom.

UNIT-III

Mycology: Distribution and general characters of fungi; Nutrition, Cell structures, growth and development. Origin and Phylogeny of fungi; Classification of fungi; Morphological features, reproduction and life cycles of major taxonomic groups of fungi; Heterothallism, parasexuality and heterokaryosis in fungi. Cultivation of fungi; Mycorrhizae, Economic importance of fungi

Lichens: General account, occurrence, external features, types, reproduction and ecological significance.

Suggested Readings

1. Principles of Microbiology by Ronald M. Atlas
2. Madigan MT, Martinko JM, Dunlap PV, Clark DP (2012). Brock Biology of

Microorganisms, Prentice Hall, USA.
3. Lansing M Prescott, Donald A Klein, John P Harley, Microbiology, Mc Graw Hill.
4. Michael J Pelczar, Microbiology, Tata McGraw, India.
5. Kathleen Park Talaro, Foundations in Microbiology, McGraw Hill.
6. Christiaan Hoek, David Mann, H. M. Jahns (1995). Algae: An Introduction to Phycology. Cambridge University Press
7. Constantine J. Alexopoulos, Charles W. Mims, Meredith M. Blackwell (1996). Introductory Mycology. John Wiley & Sons.
8. John Webster and Roland Weber (2007). Cambridge University Press, USA.
9. William Purvis (2000). Lichens. Smithsonian's Natural World Series.
10. D.R. Khanna (2004). Biology of Protozoa. Discovery Publishing House.
11. Mark F. Wiser. (2010). Protozoa and Human Disease. Garland Science

MBY 402 Bioinformatics and Biotechniques Credits: 3

Course Objectives:

- To learn the basics of bioinformatics and its scope
- To introduce the uses of essential bioinformatics tools and software in microbiology and other biological science fields.
- Introduction of the common and advanced Biotechniques.
- Applications of various biotechniques in microbiology and other filed of biological science.

Course Outcome:

- Understanding and uses of the common and essential bioinformatics tools.
- Principal knowledge and familiarity with the common and advanced Biotechniques.
- Designing the research plans or experimental setup in the area of biological science.
- Enable students to work efficiently in their future to pursue career opportunities.

Course Structure:

UNIT-I

Origin, History, and Introduction of Bioinformatics; Scope of Bioinformatics; Bioinformatics Resources, Databases, tools (Basic Local Alignment Search Tool, BLAST), and Software; Biological Databases; Sequence Retrieval; Sequence Alignment (Pairwise Sequence Alignment, Multiple Sequence Alignments); Structural and Functional Genome Annotation; Gene Prediction; Primer Designing; Phylogenetic Analysis; Molecular interaction networks Analysis; Bioinformatics methods for Functional genomics; MD simulation,; Microbial genome projects

UNIT-II

Basic Introduction and application of Microscopy (Light, Phase Contrast, Darkfield, Electron and Fluorescent, Confocal, and Cryo-EM), Flow cytometry (FCM), Fluorescence-activated cell sorting (FACS), Nuclear magnetic resonance (NMR), Mass spectrometry (MS), Matrix-assisted laser desorption/ionization-time of flight (MALDI-TOF) mass spectrometry, XRD Chromatography (Paper, Thin layer, Column, Liquid, Gas, and Affinity Ion Exchange); High-performance liquid chromatography (HPLC), Flow cytometry, Genome Editing Techniques, and Fluorescent Imaging (Fluorescent Probes, Immunofluorescence, Live cell Imaging)

UNIT-III

Basic Introduction and application of Nucleic acid amplification techniques (Conventional PCR, Multiplex PCR, Nested PCR, Reverse transcription polymerase chain reaction (RT-PCR), Real-time quantitative PCR (RQ-PCR), LAMP (Loop Mediated Isothermal Amplification); Nucleic acid quantification (UV Spectrophotometry/Fluorescence) and detection techniques (Gel electrophoresis, fluorescent in situ hybridization (FISH), Microarray); Nucleic acid Sequencing (First, Second, and Third Generation NGS methods), Genotyping Techniques; Gene expression techniques (Microarray, RNA-Seq)

Suggested Reading

1. Andreas D. Baxevanis, Gary D. Bader, David S. Wishart, (2020), Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins 4th Edition, Wiley publication
2. Marketa Zvelebil, Jeremy Baum (2007), Understanding Bioinformatics 1st Edition, Garland Science Publication
3. Jin Xiong, (2006), Essential Bioinformatics, 1st Edition, Cambridge University Press
4. Arthur Lesk, (2019), Introduction to Bioinformatics 5th Edition, Oxford University Press
5. Wilson And Walkers, (2018), Principles And Techniques Of Biochemistry And Molecular Biology, Eighth edition, CAMBRIDGE UNIVERSITY PRESS
6. Volodymyr Nechyporuk-Zloy, (2022), Principles of Light Microscopy: From Basic to Advanced, 1st ed. 2022 edition, Springer
7. Oksana Ableitner, (2021), Introduction to Molecular Biology: Working with DNA and RNA (essentials) 1st ed. 2021 Edition, Springer

MBY 403 Molecular Biology Credits 3

Course Objectives:

- To understand the basis structure of chromosome, structure of DNA and model
- To make student understand about the basic phenomenon of the cell and DNA replication.

Course Outcomes:

- Describe the basic fundamental process of DNA replication in prokaryotes and eukaryotes.
- Elucidate central cell biological processes and how they are regulated (for example: Transcription and Translation and its control.
- Understand how molecular cell biology forms the foundation of biotechnology.
- After course completion, students can apply the knowledge in further studies and higher education.

Course Structure:

UNIT-I

Structure of DNA and RNA: Organization of the Chromosome, Structure of Chromatin - Nucleosomes, Chromatin Domains and Isochores, Structure and Functional Organization of Centromeres and Telomeres, structure of DNA, Watson-Crick model, DNA polymorphism, Chromatin structure and remodeling, Histone code and histone modifications. DNA Supercoiling.

DNA Replication: Prokaryotic DNA Polymerase I, II and III, Eukaryotic DNA Polymerases, Fidelity and Catalytic Efficiency of DNA Polymerases, Replication Origin, Replication Mechanism Involving Leading and Lagging Strands synthesis; Problems associated with linear replicons. Mutations and Repair during replication. Recombination. PCR methods and Applications: DNA sequencing methods, di-deoxy and Chemical method.

Unit-II

Transcription: Prokaryotic RNA polymerase and sigma factors, Prokaryotic and eukaryotic promoters, Eukaryotic RNA Polymerases, Class I, II and III gene promoters, Enhancers; Prokaryotic and eukaryotic mechanism of transcription, RNA Processing: Processing, Capping, Polyadenylation and Splicing. Group I

and II Introns, Alternate Splicing. Gene Silencing and RNAi. Translation: Genetic Code, Ribosome Structure, tRNAs, Aminoacyl tRNA synthetase, Initiation, Elongation, Termination; Translational Control.

UNIT-III

Regulation of Gene Expression: Prokaryotes Operon Concept, Positive and Negative Regulation, Attenuation, Lac Operon, Catabolite Repression, Try Operon, Riboswitches. Eukaryotes - Generalized and specialized transcription factors, Transcriptional Activators and regulators. Specialized Transcriptions and Translations: Differential Gene Transcription, DNA Methylation and the Control of Transcription, Differential RNA Processing, Control of Gene Expression at the Level of Translation and microRNA in Transcriptional Gene Regulation.

Suggested Readings:-

1. Jocelyn E. Krebs, Elliott S. Goldstein and Stephen T. Kilpatrick, Lewin's Genes XII, 12th Edition, Jones and Barlett Pub., USA, 2018.
2. Watson, J. D. Tania A. Baker, Stephen P. Bell, Alexander Gann, Michael Levine, Richard Losick, Molecular Biology of the Gene, Benjamin Cummings; 6th Edition, 2007.
3. Robert F. Weaver. Molecular Biology, 4th Edition, McGraw-Hill.
4. Principles of Genetics: Snustad & Simmons
5. Principles of Genetics: Robert Tamarin
6. Genetics: Analysis and Principles: Brooker
7. Genetics: Principles and Analysis: Harlt & Jones
8. Molecular Cell Biology: Lodish
9. Molecular Biology of The Cell: 6th Edition 2014, Bruce Alberts et al Garland Science

MBY 404 Immunology Credits 3

Course Objectives

- To provide overview of immune system, antigen antibody structure and interactions.
- To develop understanding of innate and adaptive immunity along with major cells and molecules involved.
- To integrate immunology with health and enrich the knowledge for autoimmune disorders, hypersensitivity reaction.

Course Outcomes

- Upon completion students will gain knowledge of immune system, cells involved along with complement system and autoimmunity
- Develop understanding about immune system, antigen antibody interactions.
- Gain theoretical knowledge of various diseased conditions generated due to interplay of immune system components.

Course Structure:

UNIT-I

Overview of Immune System: Basic concepts of the Immune System, Cells and Organs of the Immune System, Innate Immunity (Phagocytosis, Acute and Chronic Inflammation, Complement System and functions) Adaptive Immunity (T lymphocytes, B lymphocytes receptors and signaling), Antigen, Super antigens (Types, cross-linkage with TCR and MHC-II) , Immunogens, Adjuvants, Antibodies (structure, classes and functions), antigen-antibody interactions (Antigen binding domains , antibody affinity), Types of antigen-antibody reactions.

UNIT-II

Innate and Adaptive Immunity: Antigen presentation, Antigen presenting cells, Major Histocompatibility Complex, Functions and Types of MHC molecules, MHC-Peptide interaction, CD1 molecues, Processing and presentation of antigens by MHC molecules, Cytokines classifications,

Cytokines receptors and signaling pathways, Pattern recognition receptor (Toll like receptors (TLR) and NOD-like receptors (NLR), T-Cells (Activation, Differentiation, and Memory generation,) B-Cells (Activation, Differentiation, and Memory Generation), T-Cell Activation, Differentiation, B cell response to antigens (T-dependent and T-independent).

UNIT-III

Immunology in Health and Diseases: Tolerance (Mechanism of central and peripheral tolerance), Mechanisms of apoptosis, Autoimmunity, autoimmune disorders (organ specific and systemic), Transplantation, Allergy and Hypersensitivity Reactions, Types of Hypersensitivity reactions, Immunodeficiency Disorders (Primary and acquired), Diseases of the Immune system, vaccines classifications and Immunization, Immunology of Infectious Diseases and mechanisms of immune evasion by pathogens, Cancer and Immune System; (Tumor immunity, Tumor antigens, immune responses to tumors, immune evasion by tumors) Immunotherapy, Immunodiagnostics.

Suggested Readings:-

1. Murphy, Kenneth M., Travers, Paul and Walport, Mark, Janeway's Immuno Biology, 7th Edition, Garland Science, Taylor & Francis Group, 2008.
2. Kindt, T. J.,Osborne, B. A. and Goldsby, R. A. Kuby Immunology, 6th Edition, W. H. Freeman, 2006.
3. Paul, W. E., Fundamental Immunology, 6th Edition, Lippincott Williams and Wilkins, 2008.
4. Abbas, A. K., Lichtman, A. H. and Pillai, S., Cellular and Molecular Immunology, 6th Edition, Saunders, 2007.
5. Roitt's, Essential Immunology

MBY 405 Biochemistry. Credits 3

Course Objective:

- The course learning objectives is to provide the core principles and specialized knowledge of Carbohydrates, Lipids, Proteins, Vitamins, Porphyrin, cellular transport, law of thermodynamics, Lipid and Nitrogen metabolism.
- To impart basic knowledge of enzyme kinetics, the parameters of the enzymatic reaction, mechanisms of action of enzymes and inhibitors, dependence on the temperature and pH of the enzymatic activity, knowledge of the structure of enzymes and amino acids that build active sites of enzymes

Course Outcomes:

- Overview of major bio-molecules- carbohydrates, lipids, proteins, amino acids.
- Conceptual knowledge of Proteins and its classification. Primary, secondary, super secondary, tertiary and quaternary structure. The peptide bond- Ramachandran plot
- The knowledge of vitamins, its classification, porphyrins and porphyrin ring system.
- Specify the biological significance of cellular permeability and transport process.
- Understanding the laws of thermodynamics, concepts of entropy, enthalpy and free energy changes and their application to biological systems and various biochemical studies and reactions.
- Knows the basic concepts, terms and techniques used in enzymology.
- Develop ability to link theoretical knowledge of enzymology with its practical application in industry, health care and environmental protection.

Course Structure:-

UNIT-I

Carbohydrate: Monosaccharide, Disaccharide and Polysaccharide - occurrence, structure, isolation, properties and functions of homoglycans and heteroglycans. Glycoprotein and their biological

applications. Lipid: classification, saturated and unsaturated fatty acids, phospholipids: classification, structure and functions of lipids. Amphipathic lipids: membranes, micelle.

UNIT-II

Proteins: classification of proteins on the basis of solubility and shape, structure, and biological functions. Primary structure, The peptide bond: Ramachandran plot. Secondary structure: weak interactions involved, alpha helix, beta sheet and beta turns structure. Tertiary structure: alpha and beta domains, quaternary structure. Cellular Permeability and Transport process, Bioenergetics of metabolism: oxidation–reduction reactions, coupled reactions and group transfer; enthalpy and free energy of reaction and ATP

UNIT-III

Enzymes as Biocatalysts: Principle of catalysis, Velocity, Order and Molecularity of a chemical reaction, Nomenclature and classification. Enzymes Kinetics, Enzyme Regulation, Mechanism of Enzyme catalysis, Kinetics of single and multi-substrate reaction, Michaelis-Menten equation, Kinetic parameters derivation, Lineweaver-Burk plot, Eadie Hofstsee Plot, Langmuir plot, Hans plot. Types of enzyme inhibition, reversible and irreversible, competitive inhibition, non-competitive inhibition, uncompetitive inhibition and kinetics using Enzyme mechanism: Mode of action of catalysts. Enzyme Immobilization techniques, use of immobilized enzymes in industrial and medical application.

Suggested Readings:

1. Nelson D L, Cox M. M. Lehninger s Principle of Biochemistry. 4th ed. Freeman, 2004.
2. Lansing M. Prescott. Microbiology. 5th ed. The McGraw−Hill Companies, β00β.
3. Berg, J. M., Tymoczko, J. L., Stryer, L. Biochemistry. 6th Ed. Freeman, 2006.
4. White David. Physiology and Biochemistry of Prokaryotes. 2nd ed. Oxford University Press, New York, 2000
5. G.N. Cohen (2011), Microbial Biochemistry, Second Edition, Springer Publishers
6. D. Voet, J.G.Voet, C.W. Pratt , Fundamentals of Biochemistry, 3rd Edition by. 2004, John Wiley and Sons, New York.
7. G. Zubay, Biochemistry, , 4th Edition, 1998. Brow Dubuque, Lowa,
8. L. Stryer, Biochemistry, , 5ht, Edition.2002. W.H. Freeman and Co.
9. R.K. Murray, D.K Grammer, P.A. Mayes, V.W. Rodwell, Harper's Biochemistry, 25th Edition. 2000. Appleton and Lange.

MBY 406 Microbial Physiology Credit 3

Course Objectives:

- To develop understanding about microbial metabolism, growth and energy generation.
- Gain knowledge of various fermentation pathways, microbial communication and energetics.
- Familiarize students with concepts of nitrogen and phosphate assimilation, electron transport chain and transfer of genetic information among microbial communities.

Course Outcomes:

- Acquaint with basics of metabolism and growth under normal and stressed conditions.
- Understand major fermentation, aerobic and anaerobic pathways for energy generation in microbial cells.
- Knows the concepts of microbial cross-talk.

Course Structure

UNIT-I

Introduction to Microbial Physiology, Metabolic genetic regulation, Energy, oxidation-reduction vs.

fermentation, Nitrogen assimilation; Microbial growth, Batch, Fed-batch and Continuous culture, Factors affecting microbial growth, Growth yield and characteristics, strategies of cell division, Stoichiometry of Microbial growth, Energy balance, mass balance, degree of reduction. Energetics of chemolithorophs, pH Homeostasis

UNIT-II

Regulatory systems during aerobic- anaerobic shifts, Osmotic control of gene expression, Electron transport (Respiratory pathway), regulation of nitrogen assimilation and fixation, Phosphate starvation-controlled stimulants, oxidation stress, Carbohydrate metabolism and Energy production: Glycolytic pathways, Gluconeogenesis, TCA cycle, energy production, oxidative phosphorylation.

UNIT-III

Fermentation pathways in specific group of microorganisms: Lactic acid, propionic acid, butyric acid producing fermentation; Characteristics and Metabolism of autotrophs; Biosynthesis of Fatty acids; Biosynthesis of Phospholipids, Degradation of Lipids, Endospore formation (differentiation). Bacterial Quorum sensing. Cellulose degradation, Metabolism of aromatic compounds.

Suggested Readings:

1. Albert G. Moat and John W. Foster, Microbial Physisology, Wiley-Liss, A John Wiley& Sons, Inc. Publications.
2. Roberts, K., Lewis J., Alberts B., Walter P., Johnson A., and Raff. M., Molecular Biology of the Cell, 5th Edition, Garland Publishing Inc., 2008.
3. Pollard, T. D., and Earnshaw, W. C., Cell Biology, 2nd Edition, Saunders Elsevier, 2008.
4. Gerald K., Cell and Molecular Biology, Concept and Experiment, 5th Edition, Wiley, 2007.
5. Lodish, H., Berk A., Kaiser C. A., Krieger M., Scott M.P., Bretscher A., Ploegh H., and Matsudaira P., Molecular Cell Biology, 6th Edition, Freeman, W. H. and Co., 2008.
6. James Darnell, Molecular Cell Biology, 6th Edition, W. H. Freeman & Co, 2007.

MBY 407 Laboratory I Credits 3

Course Objectives

- To understand the microbial growth kinetics and understanding different physiological phenomenon
- To deliver hands-on experience of various enzymatic assays and determination of kinetic parameters
- To give basic understanding of microbial genetic manipulations
- To understand working of different laboratory equipments used in microbiological laboratories
- To make students well verse with analytical approaches to quantify major biomolecules in the samples.

Course Outcomes

- Develop capability to quantify enzymes and determine kinetic parameters along with microbial genetic modification strategies
- Develop capability to perform different gene transfer methods in microbes
- Hand on training of the general equipments used in microbiology laboratory
- Comprehend the major spectrophotometric and titrimetric approaches of quantification in biological and environmental samples.

Course Structure:

List of Laboratory Practicals:

1. Isolation, purification, microscopic observations, and enumeration of cyanobacteria, fungi and

bacteria.
2. Bacterial and fungal staining, Motility determination.
3. BLAST analysis of DNA/protein sequence
4. Multiple Sequence alignment
5. Primer design and In-silico PCR
6. DNA amplification (PCR), quantification, and detection
7. Isolation & Quantification of Genomic DNA from Bacterial culture
8. Polymerase Chain reaction & Agarose Gel electrophoresis
9. Ligation and Cloning
10. Plasmid Isolation

MBY 408 Laboratory II Credits 3

Course Objectives:

- To impart knowledge on basic microbial isolation and identification approaches.
- Develop understanding about preparation, sterilization of microbiological media.
- Deliver knowledge on microbial quantification methods.
- To learn the techniques pertaining to amplification of biological molecules.
- To provide hands-on experience to basic immunological techniques for determination of microorganisms in biological fluids and other samples.

Course Outcomes:

- Students will develop understanding about isolation and enumeration of microorganisms from various samples.
- Microbial identification and characterization using a number of approaches will be well understood.
- Acquainted with molecular modification approaches that encompass extraction, purification, quantification and augmentation.
- Students will be able to determine and quantify presence/absence of antigens and antibodies in biological samples.

Course Structure:

List of Laboratory Practicals

1. Blood group and Rh typing.
2. Immuno-electrophoresis (Rocket Immuno-electrophoresis), Ouchterlony Double Diffusion.
3. Radial Immunodiffusion & ELISA
4. Agglutination and Immunoblotting.
5. Microbial Growth Kinetics.
6. UV Spectrophotometry.
7. Qualitative and quantitative tests for Carbohydrates- Tests for glucose/starch.
8. Qualitative and quantitative tests for amino acids/ protein.

Semester-II

MBY 409 Fundamentals of Virology & Protozoology Credits 3

Course Objectives:

- Knowledge on history, general characters of viruses and how viruses are classified on basis of architecture and genetic material.
- Discerning the plant and animal viruses and their replication strategies inside the host and also methods used in cultivation and detection of viruses.
- Comprehend the bacteriophages and other phages and their application.
- Knowledge on some common plant and animal diseases caused by different viruses, viruses transmission and control.

Course Outcomes

- Recognize characters of different types of viruses.
- Understand how viruses can be used as biotechnological tools, as cloning vectors and for gene transfer.
- Comprehend the complex interaction between viruses and host cells.
- Theoretical knowledge on techniques employed for culturing and detection of plant and animal viruses.

Course Structure:

UNIT-I

General Virology: History and origin of viruses; morphology and ultrastructure; enveloped and non-enveloped viruses; viral genomic organization; Nomenclature and classification of viruses including Baltimore classification. Attachment, entry and replication of viruses in animal and human cell; Brief account of some animal and human diseases (HIV, Hepatitis, Foot and Mouth, Oncogenic viruses); Viral pathogenesis; Prevention, treatment and control of viral diseases; virus related agents (viroid, prions).

UNIT-II

Morphology, genome organization and life cycle of Bacteriophages, Cyanophages, phycophages and mycophages; M13, Mu, and Lambda phage. Culturing of Viruses; Detection of viruses; Viral vaccines including DNA vaccines and interferons. Phage therapy, Oncogenic viruses.

Plant viruses: Classification and structure of common plant viruses. Symptoms and transmission; Pathophysiology plant viral diseases (TMV and CMV); Control and prevention of plants viral diseases.

UNIT-III

Protozoa: Classification, Morphology, reproduction, modes of nutrition, transmission, locomotory organelles and Life cycle; Cultivation of Protozoa; Life cycle and biology of Leishmania, Trichomonas, Entamoeba, Plasmodium; Detection of protozoans; Control and prevention of protozoan borne diseases; Importance of protozoa in soil and aquatic ecosystems.

Suggested Readings

1. Fields Virology Vol 1 and 2. B.N. Fields, D.M. Knipe, P.M. Howley, R.M. Chanock, J.L. Melnick,
   T.P. Monath, B. Roizman, and S.E. Straus, eds.), 3rd Edition. Lippincott-Raven, Philadelphia, PA.
2. Basic Virology Edward K. Wagner, Martinez J. Hewlett, David C. Bloom, David Camerini.
3. Virology: Principles and Applications John Carter, Venetia Saunders.
4. Principles of Virology: Molecular Biology, Pathogenesis, and Control of Animal Viruses. S. J. Flint, V. R. Racaniello, L. W. Enquist, V. R. Rancaniello, A. M. Skalka.
5. Virology Methods Manual. Brian W.J. Mahy (Editor), Hillar O. Kangro (Editor). Elsevier Science &

Technology Books.
6. Methods and Techniques in Virology. Pierre Payment, Trudel (Editor). Publisher: Marcel Dekker.
7. Black JG, 2002 Microbiology-Principles and Explorations. John Wiley & Sons Inc. New York.
8. Dimmock, N. J., Easton, A. J., and Leppard, K. N. 2001. Introduction to Modern Virology. 5th edn. Blackwell publishing, USA.
9. Flint, S.J., Enquist, L.W., Drug, R.M., Racaniello, V.R. and Skalka, A.M. 2000.
10. Principles of Virology- Molecular Biology, Pathogenesis and Control. ASM Press, Washington,D.C.

MBY 410 Medical Microbiology Credits 3

Course Objectives:

- Develop understanding about immune system, antigen antibody interactions.
- Gain theoretical knowledge of various diseased conditions generated due to interplay of immune system components.

Course Outcomes:

- Upon completion, students gained the knowledge of most common medically important organism and the infections they cause.
- Different approaches, techniques and tools used to identify pathogens and control them.
- Diagnostic approaches for microbial pathogens.
- Developing efficient vaccines and new drugs.

Course Structure

UNIT-I

Introduction to Medical Microbiology: Concept of virulence, pathogenicity, pathogenic islands, virulence factors, Koch's postulates. Host-Pathogen Interaction: Distribution and significance of normal human microbial flora, accidental pathogens, oncogenic viruses. Epidemiological principles in prevention and control of diseases; Microbial typing methods, Endemic, epidemic, pandemic and sporadic diseases; Concepts of mortality/ morbidity rates, incidence and prevalence; Communicable and non-communicable diseases; Sources and reservoirs of infection-biotic and abiotic; Modes of transmission of infections; Disease prevention and control measures; Emerging and re-emerging diseases: examples of model bacterial, viral, fungal, and parasite diseases.

UNIT-II

Infectious diseases: Risk group pathogens and biosafety levels, Study of following groups of microbial pathogens (Morphological characters, pathogenesis, diagnosis, epidemiology, prophylaxis and treatment) Bacterial- Enteric pathogens (*E. coli*, Shigella, Salmonella, Campylobacters, Vibrio), Pneumococci, Pyogenic organisms (Staphylococcus, Streptococcus), *Helicobacter pylori*, *Clostridium spp*., *Mycobacterium spp*.; Viral- HIV, Dengue, Hepatitis, flu; Fungal-Candida, Aspergillus, Cryptococococus, Microsporum; Parasite-Plasmodium, Leishmania & Entamoeba.

UNIT-III

Diagnostic Microbiology: General principles of diagnostic microbiology; Collection, transport and processing of clinical samples; Cultural, biochemical, serological and molecular methods for microbial typing; Physical, biochemical and microscopic examination of clinical samples (Blood, urine, stool etc); Isolation and identification of pathogens including *E. coli*, Salmonella spp., Klebsiella spp., Shigella spp., Staphylococcus, Streptococcus spp. from clinical samples (Blood, urine, stool, etc) Antimicrobial agents and mode of action, Antimicrobial drug susceptibility testing, Antimicrobial resistance, mechanisms of Antimicrobial resistance, Rapid detection kits.

Suggested Readings:

1. Jawetz, Melnick, & Adelberg's Medical Microbiology by Brooks GF, Butel JS, Morse SA,

Melnick JL, Jawetz E, Adelberg EA. 23rd edition. Lange Publication. 2004.
2. Cellular Microbiology by Cossart P, Boquet P, Normark S, Rappuoli R eds. 2nd edition. American Society for Microbiology Press. 2005.
3. Bacterial Pathogenesis: A molecular approach by Salyers AA and Whitt DD eds. American Society for Microbiology Press, Washington, DC USA. 2002.
4. Pathogenomics: Genome analysis of pathogenic microbes by Hacker J and Dorbindt U. ed. Wiley- VCH. 2006.
5. Molecular Microbiology: Diagnostic Principles and Practice by Persing DH, Tenover FC, Versalovic J, Tang Y, Unger ER, Relman DA, White TJ eds. American Society for Microbiology Press, 2004.
6. Infectious Disease Epidemiology: Theory and Practice by Nelson KE, Williams CM, Graham NMH eds. An Aspen Publication. 2001.
7. Plant pathology by George N. Agrios: 4th ed., Academic press, New York, 1969.
8. Plant pathology by R.S. Mehrotra: Tata McGraw –Hill publishing company limited. New Delhi.
9. Bacterial plant pathology, cell and molecular aspects by David C. Sigee, Cambridge University Press, 1993.
10. Molecular plant pathology by M. Dickinson: BIOS Scientific Publishers, London, 2003.

MBY 411 Microbial Genetics and Recombinant DNA Technology Credits 3

Course Objectives:

- To understand the mechanism of genetic transfers in microbes.
- To understand different techniques used to study the microbial genetics and utilizing the microbial phenomenon in different biotechnological applications

Course Outcomes:

- Elucidate the importance of mutations and selection of mutants.
- Understand the genetic regulatory mechanism and different mechanism of gene transfer.
- Understand to utilize artificial competency and transformation for production of recombinant genes.
- To learn about concept of recombinant DNA technology and cloning of a gene.
- After course completion, students can apply the knowledge in further studies and higher education.

Course Structure:

UNIT-I

Genetic analysis and gene transfer in bacteria: Importance and uses of mutation analysis; Types of mutations- spontaneous and induced mutagenesis; selection and isolation of mutants. Complementation and Recombination tests and gene replacements. Gene transfer: Conjugation, transformation and transduction, Molecular mechanism of gene transfers, Natural transformation and competence, DNA uptake competence systems in gram positive/negative bacteria. Artificially induced competence. Generalized versus specialized transduction T4 and lambda phage. Phase variation system in pathogenic bacteria.

UNIT-II

Techniques and enzymes in genetic recombination: restriction endonucleases, type I, II, III, , DNA ligase, Nuclease 25 (S1, BAL 31), DNA polymerase, polynucleotide kinase, phosphatase, reverse transcriptase. Properties of Plasmid vectors (pBR 322, pET28a, pGEX6P2, pMALC2X), incompatibility, isolation and purification of Plasmids, Concept of cloning and expression of gene: Restriction digestion, ligation and transformation. Vectors for library construction, Genomic DNA and cDNA libraries. Gene editing using CRISPER-Cas9, ZFN, TALEN

UNIT-III

Overexpression of recombinant proteins: Overexpression and tagging of recombinant proteins. Protein expression in *E. coli*, driven by lac, T7 and Tet-regulatable promoters. Overexpression systems in

S.cerevisiae, P.pastoris. Baculovirus overexpression system. RDT for cloning and production of interferon and insulin.

Suggested Readings:

1. Molecular Genetics of Bacteria by Larry Snyder and Wendy Champness, 3rd edition; ASM press;2007.
2. Fundamental Bacterial Genetics by Nancy Trun and Janine Trempy, 1st edition; Blackwell Science Publishers; 2004.
3. Modern Microbial Genetics by U.N. Streips and R.E. Yasbin, 2nd edition; Wiley Publishers; 2002.
4. Microbial Genetics by Stanly R. Maloy, John E. Cronan, Jr. & David Freifelder, 2nd edition; Narosa Publishing House; 1987.
5. Production of Recombinant Proteins: Novel Microbial and Eukaryotic Expression Systems by Gerd Gellison. Eiley-VCH Verlag GmbH & Co. 2004
6. Gene Cloning & DNA Analysis: An Introduction, by TA Brown, 18 th edn, Blackwell Publishing Professionals.
7. Principles of Gene Manipulations 1994 by Old and Primrose Blackwell Scientific Publications.
8. Watson, J.D. Tania A. Baker, Stephen P.Bell, et al., Molecular Biology of the Gene, Benjamin Cummings; 7th Edition, 2013.
9. Molecular Cloning: A Laboratory Manual Vol 1, 2, 3, by J Sambrook, DW Russell, Cold Spring Harbor Laboratory Press 2001
10. DNA Cloning: A Practical Approach by D.M. Glower and B.D. Hames, IRL Press, Oxford. 1995.

MBY412 Laboratory III Credits 3

Course Objectives:

- To provide exposure to design and run batch fermentation experiments for production of microbial enzymes.
- To deliver hands-on experience of various enzymatic assays and determination of kinetic parameters.
- To give basic understanding of microbial genetic manipulations with special emphasis on conjugation, transformation.

Course Outcomes:

- Students will learn about batch fermentation, designing of experiments to produce microbial metabolites and enzymes
- Develop capability to quantify enzymes and determine kinetic parameters.
- Hand on experience of different microbial genetic modification strategies.

Course Structure:

List of Laboratory Practicals:

1. Transduction by Bacteriophage & Determination of Phage Titration.
2. Diagnosis of Viral agents by Radio-immunoassays/ELISA (Demonstration).
3. Identification of Viral agents by PCR (Demonstration).
4. Identification of pathogenic bacteria by culture and biochemical methods.
5. Widal Test.
6. Antibiotic susceptibility testing.
7. Determine the minimum inhibitory concentrations (MICs) of antimicrobial agents.
8. Measuring biofilm formation by bacteria.
9. Mammalian Cell Culture

MBY 413 **Laboratory IV** **Credits 3**

Course Objectives:

- Program aims to develop students' understanding of medical microbiology with hand on experience in the isolation of the bacteria from different sources.
- It gives the knowledge about the pathogenicity, understanding the biofilm formation in bacteria, role of biofilm in pathogenicity and their antibiotics resistance pattern of pathogenic bacteria (Environmental source, Agricultural part), which is useful for public awareness.
- Understanding of application of Virus (bacteriophage) in transduction

Course Outcomes:

- Properly use aseptic techniques, including sterilization. Know General bacteriology and microbial techniques for isolation of pure cultures of bacteria.
- Learning methods for antimicrobial susceptibility testing.
- Viral Disease diagnosis tests using Radio-immunoassays/ELISA and PCR.

Course Structure:

List of laboratory practicals

1. Conjugation in E. coli
2. Transformation in E. coli.
3. Characterization of transformants.
4. Prokaryotic transformation
5. Practicals of Elective I

MBY 416 **Minor Project (Dissertation 1)** **Credits 1**

Course Objective:

- Development of proficiency of student in literature survey and defining a scientific problem

Course Outcomes:

- Collection of relevant scientific data, its interpretation, development of hypothesis and defining a problem.
- Report writing

Course Structure

- The report prepared by the student based on the literature review conducted.

Suggested Reading

- Scientific literatures available offline/online

MBY 417 **Internship** **Credits 1**

Course Objective

- The purpose of internship is to expose students to real work environment and at the same time, to gain the knowledge through though hand on observation.
- This practical training program allow students to relate theoretical knowledge with its application in the industry.

Course Outcomes

At the completion of this course, the student will be able to:

- Execute the skills in the application of theory to practical work situations.
- Apply skills and techniques directly application to their careers.

Semester- III

MBY 501 Industrial Microbiology and Fermentation Technology Credits 3

Course Objectives:

- To impart theoretical knowledge of role of microbes in industrial production of different biochemicals/bio-molecules.
- The theory syllabus covers area such as design of bioreactors, media formulations and factors affecting the industrial production of bio-chemicals along with approaches that can be used for enhanced production.
- Role of micro-organism in production of organic acids, alcohols, wine, vinegar, enzymes, vitamins, antibiotics, amino-acids and steroids.

Course Outcomes:

- Learning of different fermentation techniques, bioreactor design, inoculum development for industrial fermentations, Microbial growth and product formation kinetics, media formulation and sterilization, isolation, preservation and improvement of industrially important micro-organisms.
- Understanding of industrial production and purification of organic acids, alcohols, wine and vinegar with help of different microbes.
- Understanding of industrial production and purification of antibiotics, enzymes, amino acids and steroids.
- Understanding of different pathways followed in or by the microbes involved in production of these bio-chemicals. Method of manipulating these pathways to get desired yield.
- Understanding of application of these bio-molecules in benefit of mankind.

Course Structure:

UNIT-I

Theory and principles of industrial fermentation, Batch, fed-batch and continuous cultures, Microbial growth and product formation kinetics, media formulation and sterilization, isolation, preservation and improvement of industrially important micro-organisms, inoculum development for industrial fermentations, fermenter design, various types of fermenters used in industrial fermentation. Surface, submerged and solid-state fermentation processes.

UNIT-II

Alcohol production: Preparation of medium, Fermentation process and recovery; Production of Malt beverages: Production of Beer- malting process, mashing process and finishing; other malt products. Production of Wine: Microbial process, wine from grapes, Fermentation and recovery, types of wine-white and red wine. Microbial production of organic acids- vinegar production (substrate, microbial

processing and product recovery); Citric Acid- fermentation, recovery and uses; Lactic acid-fermentation, medium and manufacturing process, recovery and uses.

UNIT-III

Production of antibiotics-strain improvement, Penicillin- structure, production media composition and recovery; Streptomycin-structure, production media composition, and recovery, Production of Amino acids: L-Lysine production and recovery L- glutamic acid production and recovery process; Production of enzymes: Cellulase Xylanase and Lipase production, harvest, recovery and uses, Production of vitamins: Vitamin B12 (Cyanocobalamine), Riboflavin (vitamin B2) production; Biotransformation of steroids. Algal biomass cultivation, harvesting and extraction of value-added compounds, Production of lipids and carbohydrate for production of biodiesel and bioethanol

Suggested Readings

1. Bioprocess Engineering principles by Pauline M Doran, Elsevier Science and technology Books.
2. Bioprocess Engineering- Basic Concepts by Michael L Shuler and Fikret Kargi, Pearson Education, Inc.
3. Bioprocess Technology: Volume 1 by P T Kalaiselvan and I Arul Pandi MJP publisher
4. Bioprocess Engineering: Systems, Equipment and Facilities by Bjorn K. Lydersen, Nancy A. D'Elia, Kim L. Nelson, Wiley India Pvt Ltd.
5. Stanbury PF, Hall SJ, Whitaker A (1999). Principles of Fermentation Technology, Butterworth-Heinemann, 2nd edition
6. Creuger and Creuger (2001). Biotechnology- A textbook of Industrial Microbiology, Sinauer Associates, Inc
7. Waites MJ (2001). Industrial Microbiology: An Introduction, Wiley. 8. Industrial Microbiology, Prescott and Dunn

MBY 502 Environmental and Agricultural Microbiology Credits 3

Course Objectives:

- To provide students a basic understanding of environmental and agricultural microbiology including; microbial diversity in the environment in relation to environment and agricultural welfare, ecosystem wellness, microbial interactions with pollutants in the soil and environment and the fate of microbial pathogens in the environment and agricultural fields..
- Learning the basic principles of environment microbiology and be able to apply these principles to understanding and solving problems in current environmental and agricultural issues.
- Familiarize students with general principles and subject knowledge in the field of environment and agricultural microbiology.

Course Outcomes:

- Students will get the basic knowledge how to prepare and perform sampling and microbial analyses to determine the abundance, growth rate and microbial community composition together with the basic environmental parameters.
- Describe role of microorganism in recycling soil nutrients, biodegradation of complex plant polymers, sustaining and improving plant growth through improving nutrient availability, production of plant growth promoting substances and inhibiting pathogens.
- Critically discuss the need for environmental microbiology and agricultural microbiology and explain their limitations.
- Clarify application of microorganisms in varied fields of agricultural and environmental

microbiology like bioremediation, biofertilizers and waste water treatment.

- Analyse various aspects of N_2 fixation, Phosphate solubilization, PGPR, biodegradation and bioremediation mechanisms provided by microbes.

Course Structure:

UNIT-I

Soil Microbiology: Classification of soil - physical and chemical characteristics, soil as a habitat for micro-organisms, microflora of various soil types, rhizosphere and rhizoplane. Nitrogen fixation: asymbiotic and symbiotic nitrogen fixation systems, root nodulation, symbiotic bacteria (process of root nodule formation), leghemoglobin, nitrification and ammonification Aquatic Microbiology: Water ecosystems (fresh water, pond, lakes), marine habitats (estuaries, deep sea, hydrothermal vents), eutrophication, ecological implications and human health, Extreme environments and extremophilic microbes: Habitats, diversity and adaptations

UNIT- II

Aero-microbiology - droplet nuclei, aerosol, assessment of air quality, brief account of air- borne microbes – bacteria, fungi, and viruses, their diseases and preventive measures, phylloplane and phyllosphere microflora, Bio-fertilizers and Biopesticides in agriculture: Principles of crop inoculation with microbial agents, microbial inoculants and production, carriers for inoculants: types and characteristics, strain selection of bacteria, cyanobacteria and microalgae for biofertilizer production, phosphate solubilising microorganisms, AM fungi, plant growth promoting rhizobacteria, (PGPR), biocontrol agents.

UNIT-III

Microbial waste recycling: organic compost, vermicomposting, Biogas production, microbial sewage treatment, waste water treatment by microbes. sewage surveillance, Bioremediation of Xenobiotics, petroleum, oil spill, Microbial remediation of heavy metal pollution, tolerance to heavy metal by microbes, resistance developed in microbes to heavy metals, Microbial deterioration and degradation of plant food materials, leather, store and buildings materials, paper and other cellulosic materials, fuel and lubricants, metals, plastics, cosmetics, pharmaceutical products. Global warming and Climate Change.

Recommended Books:

1. Subba Rao NS (1995). Soil Microbiology, Oxford & IBH Publishing Co. Pvt. Ltd, 4th edition.
2. Rangaswami G, Bhagyaraj DJ (2001). Agricultural Microbiology, Prentice Hall of India, New Delhi, 2nd edition.
3. Dubey RC, Maheswari DK (1999). Textbook of Microbiology, S. Chand & Co. 4. Evans GM, Furlong JC (2011).
4. Environmental Biotechnology- Theory and application. Wiley-Blackwell.
5. Maier RM, Pepper IL, Gerba CP (2009). Environmental microbiology, Elsevier.
6. Osborn AM, Smith CCJ (2005). Molecular microbial ecology, Taylor & Francis US.
7. Ljungdahl LG, Adams MW, Barton LL, Ferry JG, Johnson MK (2003). Biochemistry and Physiology of Anaerobic Bacteria, Springer. 8. Madigan MT, Martinko JM, Dunlap PV, Clark DP (2012).
8. Brock Biology of Microorganisms, Prentice Hall, USA.
9. Environmental Biotechnology: Principles and Applications by Bruce E Rittmann and Perry L McCarty, McGraw-Hill International editions

MBY 503 Food and Dairy Microbiology Credits 3

Course Objectives:

- To learn about the fundamentals of food microbiology
- To learn about the characteristics of beneficial and harmful microorganisms associated with the food environment.

- To learn the basic and advanced methods/techniques used for the isolation, identification, and quantification of food microorganisms.
- To learn about laboratory practices related to food microorganisms and food safety.
- To explore the future application of fermented foods and food origin-probiotics

Course Outcome:

- Detailed knowledge and understanding of food microbes
- Laboratory training and research skills in food microbiology
- Application and problems solving skills to address the various issues related to applied food microbiology and food safety
- The scope of food microbiology and food safety

Course Structure:

UNIT I

Introduction of Food Microbiology: Scope of Food Microbiology; Role of Food Microbiologist; Basics of Food; Classification of Food by their origin and spoilage; General features and importance of Microorganisms (bacteria, fungi, protozoa, algae, and viruses) of relevance for Food; Intrinsic and Extrinsic factors that Affect Microbial Growth and Survival in Food; Isolation and Enumeration of Microbes in Food; Spores and their Importance in Food Industry; Spoilage of the different kinds of Foods; Physical and Chemical methods used for food preservation.

UNIT II

Foodborne pathogens and diseases: Characteristic of the following major foodborne pathogens: Shiga-toxin producing *E. coli* (STEC), Enterotoxigenic *E. coli* (ETEC), *Clostridium perfringens, Campylobacter, Clostridium botulinum, Vibrio, Salmonella; Staphylococcus aureus, Listeria monocytogenes, and* Norovirus; Food-Borne Infection, Food Intoxication, Bacterial Toxins and Mycotoxins in Food; Food-Borne Disease Outbreaks; Emerging and Remerging Foodborne Pathogens; Identification and characterization of Foodborne pathogens, their toxins, and spores using conventional and advanced methods.

UNIT III

Fermented Dairy and non-dairy products: Microbiology of Fermented Food, Traditional Indian Fermented Foods, Fermented Food Microbiome, Production of fermented Food (Cheese, Bread, Alcoholic beverages); Preparation and maintenance of Starter Culture Used in Food Fermentation;, Probiotics, Prebiotics, Synbiotics; Fermented foods as a source of probiotics; Single Cell protein, Enzyme from Microorganisms; Good Manufacturing Practices in Food Industry; Microbiological Standard and Criterion in Food Industry; Hazard Analysis and Critical Control points (HACCP); National and International food safety agency, organizations, guidelines and regulations.

Suggested reading:

1. Ralph Hawkins (2022) Modern Food Microbiology, First Edition, Murphy & Moore Publishing
2. Deepak Kumar Verma, Ami R. Patel, Prem Prakash Srivastav, Balaram Mohapatra, Alaa Kareem Niamah, (2021), Microbiology for Food and Health: Technological Developments and Advances, 1st edition, Apple Academic Press
3. Ahmed E. Yousef, Joy G. Waite-Cusic, Jennifer J. Perry, (2022), Analytical Food Microbiology: A Laboratory Manual, 2nd edition, Wiley
4. Michael P. Doyle, Francisco Diez-Gonzalez, Colin Hill (2019) Food Microbiology: Fundamentals and Frontiers, Fifth edition, ASM Press.
5. Kalmia E. Kniel, Thomas J. Montville, Karl R. Matthews. Food Microbiology: An Introduction, 4th Edition, ASM Press
6. Jyoti Prakash Tamang and Kasipathy Kailasapathy (2010). Fermented Foods and Beverages of the World, 1st edition, CRC Press
7. William C. Frazier, Dennis C. Westhoff, N.M. Vanitha, (2017), Food Microbiology, 5th Edition, McGraw Hill Education
8. Martin R Adams, Maurice O Moss, (2007), Food Microbiology, 3rd edition Royal Society of Chemistry
9. Dr Nigel Anelich, (2017), Methods in Food Microbiology, Agri-Horti Press

MBY 504 Laboratory V Credits 3

Course Objectives:

- To give hand on experience on isolation and characterization of microbes from different food sources, different spoiled food sources, agricultural (root nodules) and environmental samples (air water and soil).
- This paper is designed with the objective to impart hand-on experience and laboratory skills to students in area of bioprocess.
- The practical structure is designed so that students are trained to set up different fermentation processes with special emphasis on the downstream processing of bio-molecules purification and characterization.

Course Outcomes:

- Know General bacteriology and microbial techniques for isolation of pure cultures of microbes from different food, agricultural and environmental sources.
- Solid-state fermentation utilizing different agro-residues and food waste as substrates for production of different bio-molecules viz. citric acid.
- Submerged fermentation utilizing different agro-residues and food waste as substrates for production of different bio-molecules viz. citric acid.
- Comparative study of solid state and submerged fermentation with respect to yield and variation in physical parameters.
- Downstream processing of the bio-molecules and characterization such as stability at different pH and Temperature.

Course Structure:

List of laboratory practical:

1. Batch fermentation for production of microbial enzymes.
2. Solid-state fermentation for production of organic acids and study of effect of moisture content.
3. Production and estimation of citric acid (using *Aspergillus niger*) by titrimetric method.
4. Biosurfactant production.
5. Batch, fed batch and continuous culture growth kinetics studies.
6. Practical of Elective II & III

MBY 505 Laboratory VI Credits 3

Course Objectives:

- Provide idea about DNA, protein purification from samples and quantification.
- To learn the techniques pertaining to amplification of biological molecules.
- Demonstrate basic techniques used in recombinant DNA technology
- Demonstrate culture dependent studies of microbiomes, DNA molecular size determination and gel extraction

Course Outcomes:

- Capable of performing basic techniques of Molecular biology techniques.
- Capable of performing several RDT techniques.
- Capable of performing several techniques used during development of Recombinant DNA.

Course Structure:

List of laboratory practical:

1. Sampling and enumeration of food microorganisms such as lactobacillus from the different food environments.
2. Isolation and Identification of food pathogens
3. Isolation and Identification of food spoilage microorganisms
4. Culture-dependent analysis of Food Microbiome
5. Isolation and characterization of microorganisms from soil, water and air samples.
6. Isolation of halophiles/acidophiles/methanogens.
7. Isolation of Rhizobia from root nodule using Yeast Extract Agar Medium (YEMA)
8. Practical of Elective V

Semester –IV

MBY 506 Research Article Presentation Credits 3

Courses Objectives:

- This paper is designed to provide an exposure to the students about reading the different ongoing research in area of microbiology.
- The students will learn to read research paper and present in scientific platforms.

Course Outcomes:

- Searching research paper from different web sources.
- Reading research paper and making effective PowerPoint presentations.
- Understanding and Interpretation of the research articles

Course Structure:

- Scientific paper published in a respective area of research.
- Power point presentation preparation
- Oral Presentation

Suggested Reading:

- Scientific paper published in a respective area of research

MBY 507 Major Research Project (Dissertation 2) Credits 15

Course Objective:

- To develop the capability of the student to design the research problem, execute the experimentation and interprete the result on the basis of earlier research in the field.

Course Outcomes:

- Student will be able to formulate a research problem
- Student will be able to define the methodology for execution of research
- Analyzing the results, correlating it with pre-existing literature
- Development of scientific writing capabilities

Course Structure:

- Review of literature
- Problem defining
- Formulation of research methodology
- Writing protocols on the basis of methodology and performing experiments
- Interpretation of data, driving conclusions and compilation of the results

Suggested Reading:

- Scientific presentation/literatures available online

MBY 508 Dissertation Presentation Credits 3

Courses Objectives:

Presentation preparation of the different results obtained during the course of dissertation.

- This paper is designed to provide an exposure to the students about reading the different ongoing research in area of microbiology.
- The students will learn to read research paper and present in scientific platforms.
- The student will present the results of the research work to a panel for evaluation of the project.
- This course will impart proficiency of designing scientific presentation.
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Course Outcomes:

- Searching research paper from different web sources.
- Reading research paper and making PowerPoint presentations.
- Analyzing the results, correlating it with pre-existing literature
- Dissertation defence

Course Structure:

- Reading Scientific paper published in a respective area of research.

- Power point presentation preparation on the basis of experimentation
- Oral Presentation

Suggested Reading:

- Scientific paper published in a respective area of research and protocols

Course contents of Discipline Specific Electives

MBYD01 Fungal Biotechnology and Bioprospecting Credits 3

Course Objectives:

This paper is designed to provide an exposure to the students about the potential of fungi as food and in field of biotechnology as source of different enzymes, secondary metabolites, vitamins, polysaccharides, polyhydric alcohols, pigments, lipids, glycolipids, biofertilizers and biopesticides.

To understand the methods for Production of industrially important compounds from fungal source.

Course Outcomes:

Overview of fungal diversity, screening and strain improvement and development for production of different bio-molecules.

Introduction about different secondary metabolites antibiotics, organic acids, enzymes, drugs, vitamins, therapeutic peptides and pharmaceutical products, biopesticides and biofertilizers of fungal origin.

Concept of recombinant technology with special emphasis in fungal system.

Role of fungi in food and feed industries viz. edible mushrooms, different cultivation and nutritional aspects of mushrooms.

Course Structure:

UNIT-I

Fungal diversity: Different habitat and ecological groups. Screening of industrially useful fungal metabolites: Primary and secondary products of metabolism; classification of secondary metabolites; auxanography; enrichment culture, Industrial important fungal strains

UNIT-II

Fungal Biotechnology: Fungal biotechnological processes, principles of fermenter design and operation with respect to fungal process, types of fermenters used in fungal system, formulation of fermentation medium, analysis of fermentation products especially for fungal biotechnology. Fungal strain improvement: Recombinant technology composition of the different types of fungal vectors, selection markers, transformation strategies and future perspectives.

UNIT-III

Edible fungi: Mycoproteins, advancement in mushroom cultivation technology; commercial mushroom species cultivation, mushroom spawns; nutritional aspects of mushrooms. Fungi in food processing: Fungal assisted pre-treatment for ethanol production and value-added products. Fungi in agriculture applications: Fungal biofertilizers and biopesticides. Biotechnological applications of fungi and their derivatives: Production of Industrially important products from fungi-organic acids (citric acid), enzymes (amylase, protease). Fungi biomedical and pharmaceutical products: Production of antibiotics, vitamins and threptic peptides from fungi

Laboratory Practical:

1. Demonstration of Principles of fermenter design and operation.
2. Laboratory scale cultivation of mushrooms: Preparation of media for raising of pure culture, spawn preparation, compost preparation and casing
3. Isolation of fungal cultures from different sites and its bioprospecting for different biomolecule (enzymes, organic acids, antibiotics) production.
4. Screening of the agriculture waste biomass as potential carbon and nitrogen source in fungal growth.
5. Optimization of medium composition and physical parameters for organic acids/ enzymes production from fungal isolates.
6. Demonstration of the genetic transformation in fungus.

Suggested Readings:

1. Fungal Biology, 4th ed Blackwell. by Jim Deacon
2. Alexopoulos & Blackwell, Introductory Mycology, John Willey & Sons
3. B.C.Suman & V.P.Sharma, Mushroom Cultivation in India, Daya Publishing House
4. Carlos Alborto brusso, Mohamed Hijri, Mycorrhizal Biotechnology, Capital Publishing
5. D.P.Tripathi, Mushroom Cultivation. Oxford & IBH Publication Company Pvt.ltd
6. Poonam Singh & Ashok Pandey, Biotechnology for agro-Industrial residues utilisation. (2009), Springer.
7. Satyanarayana T. and Johri B.N. (2005). Microbial diversity, Current Perspectives and Potential Applications, IK international
8. Nair, L. N. (2007). Topics in Mycology and Pathology, New Central Book agency, Kolkata.
9. Oliver R. P. and Michael Schweizer (1999). Molecular Fungal Biology, CUP.
10. Berry D. R. (1988). Physiology of industrial Fungi, Blackwell Scientific Publishers.
11. Zhingiang Ann (2005). Handbook of Industrial Mycology, CRC Press.

MBYD02 Bioprocess and Bioenergy Credits 3

Course Objectives:

- Understanding of various renewable feedstocks, their availability and attributes for biofuels production.
- To provide a thorough understanding of the broad concept of generations of biofuel production from biomass and other low-cost agro-residues and biowastes, anaerobic digestion and biodiesel production.
- Analyze and design processes for biofuel production.

Course Outcomes:

- Classify and apply potential biomass feedstocks including energy crops.
- Understanding of the existing and emerging biomass to energy technologies.
- Determine potential solutions for energy needs and problems by incorporating the bioenergy technologies

Course Structure:

UNIT- I

Fundamentals of bioenergy/biofuel: Terms and concepts, origin, characteristics, advantages and disadvantages, use and cost of different types of biomass resources (renewable feedstocks): agricultural energy crops, agro-horticultural lignocellulosic residual material, other biogenous waste- production. Circular bioeconomy and sustainable bioenergy system, Current and projected future technologies for producing biofuels such as ethanol, biodiesel from oil crops, microbial fuel cells, biohydrogen.

UNIT-II

Biofuels: Biofuels generations, pre-treatment technologies, structure and function of lignocellulosic biopolymers, various types of pre-treatment technologies (Physical, mechanical, chemical, biochemical, ionic liquids etc.) bioconversion of biomass to biofuel biodiesel production; environmental impacts of biofuel production; concept of Biorefinery, value-added product generation in an integrated approach, processing of biofuel residues

UNIT- III

Anaerobic digestion process for biogas production, Inoculum- its stability and methane potential, Process

microbiology: role of microbes, types and characterization, Effect of pH, temperature, nutrients, organic loading rate (OLR) and hydraulic retention time (HRT) on biogas production from biogenous waste. Life cycle assessment of biofuels and biofuel technologies, India's energy demand and supply management, energy cropping, energy needs for the future: regional prospects and stresses, policy issues.

Laboratory Practical:

1. Assessment of the effect of severity factor on biomass degeneration.
2. Quantification of reducing sugars and lignin in biomass.
3. Pretreatment of straw and evaluation of reducing sugar generation and ethanol production.

Suggested Readings

1. Mahesh & Dayal (1992). Renewable Energy Environment and Development, Konark Publishers (P) Ltd.
2. Rao S & Parulakar BB (1994). Energy Technology, Khanna Publishers, New Delhi.
3. David N-S Hon DNS & Nobuo Shiraishi N (2000). Wood and Cellulosic Chemistry, CRC Press.
4. Sorensen B (2010) Renewable Energy, Academic Press.
5. Kasthurirangan G, van Leeuwen J, Robert C (2012). Sustainable Bioenergy and Bioproducts,

MBYD03 Pharmaceutical Microbiology Credits 3

Course Introduction: The knowledge of microbes relevant in the pharmaceutical industry is crucial for manufacturing drugs, recombinant proteins, and vaccine production. This course is designed to provide a basic and in-depth knowledge of important pharmaceutical microorganisms, microbiological methods used in the pharma industry, and pharmaceutical products produced by uses of microorganisms for creating trained pharmaceutical professionals.

Course Objectives:

- General characteristics of microorganisms relevant in the pharmaceutical industry
- Microbial control and sterilization methods used in the pharma industry
- Different microbiological methods used in the pharma industry
- Microbial products used in the pharma industry

Course Outcomes:

- Scope of microbes in the pharma sector
- Role of microbiologists in pharmaceutical industry
- Drug discovery and developments approaches
- Good Laboratory Practices (GLP) and Good Manufacturing Practices (GMP)

Course Structure:

UNIT I

Microbes and pharmaceuticals: An Introduction, importance, scope of pharmaceutical microbiology; Role of Pharmaceutical Microbiologist; Physiology and key characteristics of pharmaceutically-relevant microorganisms (Bacteria, fungi, and Virus); Extrinsic factors Affect Microbial Growth and Survival; Cultivation of Microbes; Isolation and enumeration methods of Microbes; Microbial, Identification, Characterization, and Strain Typing methods; Strain Improvement methods ; preservation methods for pure cultures; Cultivation of anaerobes; principle, procedure, and applications of the different sterilization methods; Microbial control methods

UNIT-II

Microbiological Methods in Pharmaceutical Industry: Quality control organisms Tests for sterility and preservative efficacy; Antimicrobial Effectiveness Testing; Microbial Examination of Non-Sterile Products; Sterility Testing methods; Bacterial Endotoxin Testing; Antibiotic Potency Testing; Environmental monitoring (EM) of microbiological bioburden; Antimicrobial Assay of Antibiotics, Vitamins, and Amino Acids; Good laboratory practice (GLP); Good Manufacturing Practice (GMP*)*, Hazard Analysis and Critical Control points (HACCP); National and International agency/organizations for pharmaceutical regulations

UNIT-III

Microbial Pharmaceutical products: Microbial Products as a source of pharmaceutical products: Antimicrobials, vitamins, therapeutic enzymes, vaccines, immunomodulatory drugs, anticancer drugs, recombinant proteins; Conventional to advanced approaches for Vaccine development; vaccine manufacturing; History and discovery of natural microbial products; Screening of microbial products for drug discovery; Genomics, Proteomics, and Metabolomics in drug discovery; Absorption, Distribution, Metabolism, Elimination, Toxicity (ADMET) and drug discovery; Clinical trials (Phase1, 2, 3, and 4); Human Microbiome and Pharmaceutical market, Indian Traditional Medicine System

Laboratory Practicals:

1. Cultivation of Pharmaceutically relevant Bacteria and Fungi
2. Isolation and enumeration methods of Microbes
3. Phenotypic and Molecular identification of Microbes
4. Sterility testing

Suggested Readings:

1. Sharon L. Deem, Kelly E. Lane-deGraaf, Elizabeth A. Rayhel (2018), Introduction to One Health: An Interdisciplinary Approach to Planetary Health, 1 st Edition, Wiley-Blackwell Publication
2. Ashutosh Kar (2020), Essentials of Pharmaceutical Microbiology, Second edition, New Age International Private Limited
3. G Shyam Prasad, Srisailam K (2019) Pharmaceutical Microbiology: A Laboratory manual, Pharmamed Press
4. Tim Sandle (2015), Pharmaceutical Microbiology: Essentials for Quality Assurance and Quality Control, 1st edition, Woodhead Publishing
5. Geoff Hanlon, Norman A. Hodges, (2013), Essential Microbiology for Pharmacy and Pharmaceutical Science, 1st edition, Wiley-Blackwell Publication
6. Hugo and Russell's, Stephen P. Denyer, Norman A. Hodges, Sean P. Gorman (2011), Pharmaceutical Microbiology, 8th edition Wiley-Blackwell Publication
7.

MBYD04 Petroleum Microbiology Credits 3

Course Objectives:

- To learn about the microbial communities resides in the oil reservoirs and other hydrocarbon resource environments.
- To understand how these microbial communities, impact the oil/energy production and how oil production can be made greener and sustainable by manipulating these communities.

Course Outcomes:

- Students will be able to Characterize the microbial communities in hydrocarbon resource environments.
- Can predict the positive or negative impact of the microbial communities in various petroleum fields.
- Design the microbial solutions to the microbiology related problems in the petroleum industry.

- Suggest solutions to enhance production of oil/energy by applying concepts of production related petroleum microbiology.

Course Structure:

UNIT-I

Microbiology of oil fields: Introduction to oil fields, formation of oil reservoirs, oil production, indigenous microbial communities in oil fields, microbiology and molecular biology of sulfate-reducing bacteria, hyperthermophilic and methanogenic archaea in oil fields, fermentative, iron-reducing and nitrate-reducing microorganisms.

UNIT-II

Detrimental effects of bacterial activity: Biodegradation of petroleum in subsurface geological reservoirs, reservoir souring: mechanisms and prevention, microbial control of hydrogen sulfide production in oil reservoirs, microbial corrosion in the oil industry, biofouling in the oil industry.

UNIT-III

Application of biotechnology in oil production: Microbial enhanced oil recovery: past, present and future, biotechnological upgrading of petroleum, diversity, function and biocatalytic applications of alkane oxygenase, the microbiology of marine oil spill bioremediation, metabolic indicators of anaerobic hydrocarbon biodegradation in petroleum-laden environments, unconventional gas and oil resources: shale gas, oil sands and coal bed methane (CBM).

Laboratory Practical:

1. Preparation of anaerobic medium to enrich and culture anaerobic bacteria form oil field samples
2. Evaluation of souring in oil fields using serum bottle experiment
3. Enumeration of sulfate reducing bacteria in oil field samples using MPN test.

Suggested Readings:

1. Bernard Ollivier, Mitchel Magot (2005). Petroleum Microbiology, ASM Press.
2. Corinne Whitby, Torban Lund Skovhus (2011). Applied Microbiology and molecular biology in oil field systems, Springer.
3. Larry L. Barton, W. Allan Hamilton (2007). Sulphate-Reducing Bacteria: Environmental and Engineered Systems, Cambridge University Press
4.

MBYD04 Extreme Microbiology Credits 3

Course Objectives:

- Describe different extreme environments and occurrence of organisms in such harsh conditions.
- Describing molecular approaches to explore microbial communities in extreme environments.
- Comprehend adaptations strategies of various extremophilic microorganisms.
- Microbial diversity in toxic environments.
- Knowledge about extremozymes and their application.

Course Outcomes:

- Know the types of microbial diversity flourish in extreme environments.
- Understand how organisms cope under extreme living conditions with biochemical and molecular adaption of extremphilic microorganisms.
- Understand modern techniques used for exploration of uncultivable extremophiles
- Understand potential application of extremozymes in various industries and in functional genomics.

Course Structure:

UNIT-I

Concept of extremophiles v/s conventional microbial forms & archaea, habitats in universe, eco-niches, communities and community associations, biofilms, microbial community analysis of extreme environments using various molecular approaches (DGGE, cloning and next generation sequencing, functional genomics and transcriptomics).

UNIT-II

Occurrence, Physiological features, adaptation strategies of various extremophilic microbes: a) anearobes, barophiles/ peizophiles, cryophiles & thermophiles; b) oligotrophs, osmophiles, halophiles & xerophiles; c) radiophiles, metallophiles & xenobiotic utilizers; d) alkaliphiles/ basophiles, acidophiles. Potential applications of extremophilic microbes.

UNIT-III

Microbes in toxic environments: acid mine drainage, waste containing cyanides, xenobiotics, pesticides, heavy metals and radio isotopic materials, extremozymes and their applications, field and case studies.

Laboratory Practical:

1. Conventional characterization of Extreme-tolerant heterotrophic prokaryotes.
2. Morphological characterization of cyanobacteria inhabit saline-alkaline lake.
3. Enumeration of eukaryotes thrive in extreme habitats.

Suggested Readings:

1. Brock, T. D. (1978). Thermophilic Microorganisms and Life at High Temperatures, Springer, New York.
2. Fred A Rainey and Aharon Oren (2006). Extremophiles, Academic Press.
3. Horikoshi, K. and W. D. Grant (1998). Extremophiles-Microbial Life in Extreme Environments, Wiley, New York.
4. Gerday, C. And Glansdorff, N. (2007). Physiology and biochemistry of extremophiles. Washington, DC: ASM Press.

MBYD06 Infection Biology and Vaccine Development Credits 3

Course Objectives:

- The goal of this course is to obtain a fundamental knowledge of infectious biology and pathogenicity.
- To assess the impact of environmental/climate change on the incidence, prevalence, geographical distribution, and severity of infectious diseases.
- To understand the basics of vaccines, different vaccinology approach and types of vaccines.

Course Outcomes:

- Students will have basic understanding of infectious biology and pathogenicity.
- Students will understand the concept of vaccines and vaccinology approaches.
- Student will have understanding of the immunization approaches based on types of vaccines developed eg. Whole organisms, DNA based vaccines.

Course Structure:

UNIT-I

Infection Biology: History and scope of infection biology, Neglected tropical diseases, medically significant pathogens; Symbiosis between infection and pathogenicity, Microbial surface variation, Regulation of virulence-associated genes, Mice-microbes and models of infection, Therapeutic problems

with infectious diseases: current approaches.

UNIT-II

Classical and Reverse vaccinology approaches: Historical view of classical vaccinology, Reverse vaccinology, Active and passive immunization, Vaccine design approaches, Whole-organism vaccines, purified macromolecules as vaccines, Recombinant-vector vaccines, DNA vaccines, multivalent subunit vaccines, Tools for vaccine design: Immuno-informatics tools for vaccine design, Epitope-driven approach.

UNIT-III

DNA vaccine approaches: DNA vaccines for infectious disease: introduction, immune-stimulatory activity of DNA vaccines, DNA vaccine delivery systems, physical methods, particle-mediated delivery of DNA vaccines, mRNA vaccines, Use of live viral and bacterial vectors for vaccine delivery for DNA vaccine, virus-like particle vaccines, Advantages and challenges of vaccine development: Human Papillomavirus, Influenza, Developing stable cell lines for the production of vaccine antigens. Regulation of clinical trials in vaccine development

Laboratory Practical:

1. Detection of Microbial pathogens and cell structure using differential staining procedures: capsule staining, endospore staining, acid fast staining, gram staining
2. Identification of microbial antigens by immunological techniques; ELISA, Immunoelectrophoresis
3. Identification of bacterial pathogens by molecular approaches; PCR, qPCR, western blot
4. Immunoinformatic tools for vaccine design (selection of epitopes).

Suggested Readings

1. Murphy, Kenneth M., Travers, Paul and Walport, Mark, Janeway's Immuno Biology, 7th Edition, Garland Science, Taylor & Francis Group, 2008
2. Kindt, T. J.,Osborne, B. A. and Goldsby, R. A. Kuby Immunology, 6th Edition, W. H. Freeman, 2006.
3. Jörg Hacker (Editor), Jürgen Heesemann, Molecular Infection Biology: Interactions Between Microorganisms and Cells, Publisher: Wiley-Spektrum 1st Edition, 2002
4. Feemster Kristen A, Vaccines, Publisher: Oxford, 2017
5. Igor S Lukashevich, Haval Shirwan, Novel Technologies for Vaccine Development, Publisher: Springer, 2014

MBYD07 Biomining Credit 3

Course Objectives

- To understand basic concept of Hydrometallurgy and Mineral Processing.
- To analyze and interpret various application of Microorganism in Hydrometallurgy and Mineral Processing.
- To simulate industrial application of Biohydrometallurgy with respect to leaching.
- To utilize the mineral processing application of floatation in Microbial catalysis.
- To understand the batch and column leaching for sulphide/oxide minerals with microbial processing.

Course Outcomes

- Understand basic concepts of Biohydrometallurgy and Biomineral Processing. \
- Estimate and able to understand the possibilities of utilizing microorganisms in Extractive Metallurgy and Mineral processing.
- Design experiments for scale up of the process in all kind of sulphide minerals as well as waste recycling.
- Understand the functional dynamics of the Microorganisms in mineral industry prevalent in bioheap and bio tank leaching.

Course Structure

Unit I

Extractive Metallurgy; Hydrometallurgical Phase Diagrams; Pretreatment; Leaching Theory; Leaching Reagents; Leaching Methods; Leaching Objects; Biohydrometallurgy; Solution Purification; Electrolytic Processes; Metal Recovery; Hydrometallurgical Processes; Mineral Processing; Solution equilibria of surfactants; Mineral–solution equilibria; Mineral–flotation reagent equilibria; Application of flotation agents and their structure–property relationships; Biomineral Processing applications.

Unit II

Fundamentals, microorganisms and mechanisms in Mineral Processing; Mechanisms and biochemical fundamentals of bacterial metal sulfide oxidation; Electrochemical techniques used to study bacterial-metal sulfides interactions in acidic environments; Catalytic role of silver and other ions on the mechanism of chemical and biological leaching; Recovery of zinc, nickel, cobalt and other metals by bioleaching; Bioleaching of metals in neutral and slightly alkaline environment; Bioreactors and Bioheaps; Bioleaching of sulfide minerals in continuous stirred tanks; Bioreactor design fundamentals and their application to gold mining; Airlift reactors: characterization and applications in biohydrometallurgy and Biomineral Processing; Principles, mechanisms and dynamics of chalcocite heap bioleaching; Genetics and Molecular Biology in Biomineral Processing and Biohydrometallurgy; Bioinformatics and genome biology to advance our understanding of bioleaching microorganisms; Proteomics and metaproteomics applied to biomining microorganisms; Cell-cell communication in bacteria: A promising new approach to improve bioleaching efficiency; Bioflotation and bioflocculation of relevance to minerals bioprocessing; Hydrogen sulfide removal from gaseous effluents in Biomineral Processing and Biohydrometallurgy.

Unit III

Microorganisms to Industrial Processes; Acidophile Diversity in Mineral Sulfide Oxidation; The Microbiology of Moderately Thermophilic and Transiently Thermophilic Ore Heaps; Mineral-Oxidizing Microorganisms; Bacterial Strategies for Obtaining Chemical Energy by Degrading Sulfide Minerals; Genetic and Bioinformatic Insights into Iron and Sulfur Oxidation Mechanisms of Bioleaching Organisms; Relevance of Cell Physiology and Genetic Adaptability of Biomining; The BIOX™ Process for the Treatment of Refractory Gold Concentrates; Bioleaching of a Cobalt-Containing Pyrite in Stirred Reactors; Study from Laboratory Scale to Industrial Application; Commercial Applications of Thermophile Bioleaching; Development and Current Status of Copper Bioleaching Operations in Chile: Successful Commercial Implementation; The GeoBiotics GEOCOAT® Technology – Progress and Challenges;

Whole-Ore Heap Biooxidation of Sulfidic Gold-Bearing Ores; Heap Leaching of Black Schist; Modeling and Optimization of Heap Bioleach Processes.

Laboratory Practical

1. Determination of ferrous iron, ferric iron, total iron, sulphate concentration by spectrophotometric and titrimetric methods.
2. Determination of Cu, Ni, Zn, and Fe by Atomic absorption spectroscopy.
3. Crushing and grinding of metal sulphides followed by coning and quartering and size fraction analysis.
4. Microbial viable planktonic cell count by haemocytometer.
5. Mineralogy study by X-Ray Diffraction studies.
6. Chemical, batch and fed-batch bioleaching of metal sulphides.
7. Pourbaix diagram studies for metal ions in aqueous phase using HSC.
8. Solid liquid separation techniques.
9. Solvent extraction of Copper.

Suggested Readings

1. Edgardo R. Donati and Wolfgang Sand, Germany Microbial Processing of Metal Sulfides, Springer ISBN 978-1-4020-5588-1 (HB), ISBN 978-1-4020-5589-8 (e-book)
2. D.E. Rawlings and B.D. Johnson (Eds.). Biomining, Springer, ISBN-13 987-3-540-34909-9 Springer-Verlag Berlin Heidelberg New York
3. Fathi Habashi, Handbook of Extractive Metallurgy- The Metal Industry and Ferrous Metals, Wiley VCH, Germany.
4. Chiranjib Kumar Gupta, Chemical Metallurgy: Principles and Practice. 2003 Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim, ISBN: 3-527-30376-6.
5. Christiane Dahl and Cornelius G. Friedrich, Microbial Sulfur Metabolism, 2008, ISBN-13 978-3-540-72679-1 Springer-Verlag Berlin Heidelberg New York.

MBYD08 Microbial Ecology Credits 3

Course Objectives:

- To understand basic concept in the field of microbial ecology
- To analyze and interpret various ecological and evolutionary principles
- To design experimental approaches used in the field of microbial ecology
- To critique and review arguments that researchers in microbial ecology make using evidence based approach

Course Outcomes:

- Understand basic concepts within the field of microbial ecology and environmental microbiology.
- Interpret the various ecological and evolutionary principles that impact microbes.
- Analyze and design experimental approaches used in the field of microbial ecology.
- Grasp how research in microbial ecology is conducted.
- Gain detailed knowledge about a specific aspect of the microbial ecology chosen for project/report.
- Recognize functional ubiquity and diversity observed among different microbes.
- Critique arguments that researchers in microbial ecology make based on evidence.
- Critically read and write on topics related to microbial ecology
- Comprehend how humankind may be able to manage the limited resources in a wise and sustainable fashion.

UNIT-I

Introduction to microbial ecology: overview, motivation, history, applications etc. Concepts of microbial ecology: Ecology of macro- and microorganisms: definitions, terminology, concepts. Individuals and populations: productivity, growth, distribution, activity. Communities: colonization, succession, diversity, structure. Microbial functions in ecosystems and global cycles. Phototrophy, Chemolithotrophy, anaerobic respiration (Nitrate and Sulfate reduction; Acetogenesis; Methanogenesis; Metal, Chlorate, and organic electron acceptors)

UNIT-II

Microbial interactions: Interactions of microorganisms with their physical and chemical environment. Microbial guilds and biogeochemical cycles. Interactions with the biotic environment: symbiosis, competition, parasitism and predation. Interactions within microbial communities: quorum sensing, syntrophy and antibiotics. Interactions of microorganisms with algae and plants. Interactions of microorganisms with animals and humans

UNIT-III

Methods in microbial ecology: Habitat characterization. Characterization of microbial communities: culture-based methods, biomarkers, cell stains, PCR, real-time PCR, molecular fingerprints. Characterization of microbial communities: FISH and sequencing. Activity measurements.
Ecology engineered microbial habitats: Amendments and Enrichments, Landfills, wastewater treatment reactors, Culture collections, food ecosystems, agricultural systems, aquaculture. Synthetic communities and applied microbial ecology. Evolving communities: evolutionary ecology and community stability.

Laboratory Practicals:

1. Preparation of culture medium for the growth of halophiles and thermophiles.
2. Isolation of microbes from any of the extreme environment like desert, hot springs or salt lakes
3. Isolation of *Rhizobium* sp. from root nodules of leguminous plant
4. Characterization of isolated microbes with the help of PCR based techniques

Suggested Readings:

1. Madigan MT, Martinko JM, Dunlap PV, Clark DP (2014). Brock Biology of Microorganisms, Prentice Hall, USA.
2. Larry L. Barton and Diana E. Northup (2014) Microbial Ecology
3. David L. Kirchman. Processes in Microbial Ecology, Oxford University Press
4. Recent articles/published papers published in microbial ecology journals

MBYD09 IPR and Bio-entrepreneurship Credits 3

Course Objectives:

- The overall aim of the course is to give the participants an insight into field of IPR and bioentrepreneurship
- Impart basic knowledge of intellectual property right and laws available in India.
- Describe the processes of product and service development in the life science sector as well as their similarities and differences.

Course Outcomes:

- Have knowledge on patents and property rights.
- Critically analyze the patent applications for novelty and utility.
- Well versed in writing claims for the new patent.
- Comprehend how students' research can lead to IPR in the respective field.
- Perform a basic market analysis in the life science sector Regarding judgment and approach. Analyze and

critically assess a case study

- After the course the student will have obtained skills in project management, communication and networking.

Course Structure:

UNIT-I

Definition of IPR, function and importance. Forms of protection: Copyright and related rights, Patents, Industrial Designs, Trademarks, Trade Secrets, Geographical Indicators, Semiconductor layout circuits, Plant breeder, farmer rights etc. Patentable subject matter: Novelty and Application. International conventions and Treaties (WIPO). Importance of IPR in developing world with special reference to India. IPRs in Biotechnology/Microbiology. Intellectual Property Management: Patent application process (national and International),

UNIT-II

Patent infringement, Patent Claims and Legal decision-making process. Structure of patent application including specifications, claims, prior art and patent designs. Landmark cases in Indian patent history. Guidelines for examination of biotechnology application for patent (Section 2, 3 and 10). Traditional knowledge digital library (TKDL) and Biological Diversity Act 2002.

UNIT-III

Bioentrepreneurship: Introduction and Overview of the Microbiology Industry, Translational Industry overview (include the commercialization pathways for drug, medical device, diagnostic companies) entrepreneurship/intrepreneurship Commercialization Knowledge Survey (CKS). Starting a Company Business Model (the business model canvas), Microbiology business models How to start a Startup, Exit strategies. Funding: the funding process. Financial and Economic Management.

Laboratory Practicals:

1. Learning and analysis of famous case studies in the field of patent and other IPRs.
2. Design and develop effective patent drafting skills for Indian & International patents

Suggested Readings

1. Guidelines for examination of biotechnology application for patent (2013) Office of the Controller General of Patents, Trademarks and Designs.
2. Guidelines for processing patent applications relating to traditional knowledge and biological material (2013) Office of the Controller General of Patents, Trademarks and Designs.
3. Intellectual Property Rights: Legal and Economic Challenges for Development: Cimoli
4. Indian Patent Laws: Kankanala KC, Narasani AK
5. Intellectual Property Rights: P Ganguly, Tata McGraw Hill, 2007

MBYD10 Metagenomics: Basics and Application Credits: 3

Course Objectives:

- To introduce the basics of Metagenomics and Next-Generation DNA Sequencing Technologies.
- To recognize how Metagenomics and Next-Generation DNA Sequencing Technologies have greatly revolutionized Microbiology and Biotechnology.
- To explore the application of structure and role of microbial communities in the different habitats.
- To know the basics of Metagenome Engineering and Synthetic Biology and their applications in Biotechnology.

Course Outcome:

- An understanding of Metagenomics and Next-Generation DNA Sequencing Technologies
- How Metagenomics and Next-Generation DNA Sequencing Technologies advancing Microbiology and Biotechnology.
- Perform metagenomic library preparation and selection of specific Next-Generation DNA Sequencing platforms.
- Designing the research plans or experimental setup to address the specific issues on Metagenomics

Course Structure:

UNIT-I

*Introduction of Metagenomics***:** Origin, History, and Basic Introduction of Metagenomics; Understanding Microbial Communities Using Metagenomics; Targeted metagenomics vs. Shotgun metagenomics Principle and Types of Metagenomics Library preparation; Sequencing Technologies and Platforms (second and Third Generation) for Metagenome Sequencing; Bioinformatical methods, tools, software used in Metagenome Data Analysis*;* Taxonomic and Functional annotation of metagenomic; Metabolic Pathways Construction Using Metagenome Data; Metagenome-assembled genomes (MAGs); Metatranscriptomics and Comparative metagenomics

UNIT-II

Metagenomics Applications: Study of the human, animal, plant, and other habitats-associated microbial communities using Metagenomics Approach, Bioactive Compounds (Enzymes, Antimicrobials, Anticancer Drugs, Immunomodulatory agents) Screening Methods and Approaches using Metagenome analysis of microbial communities associated with the different habitats (human and plant); Clinical Application of Metagenomics in Human Microbiome. Role of plant Metagenomics in sustainable agriculture. Role of animal Metagenomics in veterinary medicine.

UNIT-III

Metagenome Engineering: An Introduction of Genome and Metagenome Engineering; Basic principles, methods, and tools for Metagenome engineering; Genome editing tools and techniques such as CRISPR/Cas9 used to create synthetic genome; Drug Discovery from biosynthetic gene clusters using Metagenome Engineering Development of engineered microbes for disease diagnostics and therapeutics; Synthetic and Designer probiotics; Applications of engineered bacteria in vaccine designing, drug delivery, and in the industry; Biosafety and biosecurity issues, Ethical concerns related with synthetic or engineered microbes.

Laboratory Practicals:

1. Retrieval of Metagenome data such as ribosomal RNA and whole genome shotgun from biological databases
2. Bioinformatics tools and softwares used in the analysis of metagenomic data
3. Taxonomic and Functional annotation of metagenomic data
4. Biosynthetic Gene Clusters mining using the Metagenome data

Suggested Reading

1. Trevor C. Charles, Mark R. Liles, Angela Sessitsch (2017), Functional Metagenomics: Tools and Applications, 1st Edition, Springer Publication
2. Eugene Rosenberg, (2021), Microbiomes: Current Knowledge and Unanswered Questions: 2 (The Microbiomes of Humans, Animals, Plants, and the Environment) 1st ed. 2021 edition, Springer
3. Rachael E. Antwis, Xavier A. Harrison, Michael J. Cox, (2020), Microbiomes of Soils, Plants and Animals: An Integrated Approach (Ecological Reviews), Cambridge University Press
4. Robert G. Beiko, Will Hsiao, John Parkinson, (2019), Microbiome Analysis: Methods and Protocols: 1849 (Methods in Molecular Biology), 1st ed. 2018 edition

5. Nwadiuto (Diuto) Esiobu, Olawole O. Obembe, et al., (2022), Microbiomes and Emerging Applications (Multidisciplinary Applications and Advances in Biotechnology), 1st edition, CRC Press
6. Lucas J. Stal, Mariana Silvia Cretoiu, (2018), The Marine Microbiome: An Untapped Source of Biodiversity and Biotechnological Potential, 1st ed. 2016, Springer

MBYD11 One Health Credit: 3

Course Objectives:

- To introduce the basics of One Health
- An understanding of the connection between humans, animals, and the environment
- To introduce the One Health threats such as antimicrobial resistance shared by humans, animals, and the environment
- Providing examples of health challenges such as H1N1 and SARS successfully addressed through the One Health Approach

Course Outcome:

- Exploring the interconnection between humans, animals, and the environment
- How can one health approach lead to sustainable solutions to critical issues such as antimicrobial resistance, food safety, and emerging infectious disease?
- Recognize the impact of animal or environmental health on public health
- Designing a research plan on the emerging human health challenges

Course Structure:

UNIT-I

Introduction of One Health. Origin, History, and Basic Understanding of One Health Concept; Interrelationship between Human, animal, and Environment Health; Success of One Health in control emerging Infectious diseases (H1N1 &SARS) Common and Emerging Challenges (ex. COVID-19) shared by Human, Animals, and Environments; Biodiversity and its role in One Health; Ecosystem health and its relation to human and Animal Health; Animal and Human Reservoirs as a source of pathogens, Emerging and Re-emerging animal or human origin pathogens; Control of Human and Animals diseases through One Health Approach.

UNIT-II

One Health & Antimicrobial Resistance: The Role of Antimicrobials and Antimicrobial Resistance in One Health; Local and Global use of Antimicrobial in human medicine, veterinary medicine, and plant/animal agriculture. Local and Global Prevalence and Impact of Antimicrobial Resistance in Humans, Animals, Plants, and Environment. Distribution of Antimicrobial Resistant Pathogens in Humans, Animals, Plants, and Environment. Evolution and Origin of antimicrobial resistance, multi-drug resistance, and superbugs in humans, Animals, Plants, and the environment. Factors contributing to the emergence of antimicrobial resistance. Preventive and control strategies to control antimicrobial resistance through One Health approach.

UNIT-III

*One Health & Food Safety***:** Microbiology of food of animal and plant origin; Role of Food animals and plants as a reservoir of pathogens, Emerging and Re-emerging Foodborne Pathogens of animal and plant food-origin. Principals of Food Safety for the controlling the pathogens of a food animal or food plant; Plant and animal food production and manufacturing practices, Microbiology Standard and Criterion of Food of

animal and plant-origin; Food legislation and standards; Basic Issues and Emerging Trends in Food Safety; Improving Food Safety and controlling Foodborne Pathogens through One Health Approach; One Health and Sustainable Food Production and System.

Laboratory Practicals:

1. Isolation and Quantification of Microbes present in the different habitats
2. Phenotypic and molecular identification of microbes associated with the different habitats
3. In-vitro Antimicrobial Susceptibility Testing Methods
2. Isolation and identification of antibiotic-resistant bacteria from different sources

Suggested Reading

1. Ronald M. Atlas, Stanley Maloy (2020), One Health: People, Animals, and the Environment, Revised Edition, ASM Press
2. Merrilyn Walton (2019) One Planet, One Health, 1st edition, Sydney University Press
3. Joana Prata, Ana Ribeiro, Teresa Rocha-Santos (2022), One Health Integrated Approach to 21st Century Challenges to Health, 1st edition, Academic Press
4. Craig Stephen (2020). Animals, Health, and Society, 1st Edition, CRC Press
5. Sharon L. Deem, Kelly E. Lane-deGraaf, Elizabeth A. Rayhel (2018), Introduction to One Health: An Interdisciplinary Approach to Planetary Health, 1st Edition, Wiley-Blackwell Publication

MBYD12 Microbiome: health, disease and medicine Credit: 3

Course Objectives:

- Introduce basic concepts, terminology, techniques, and significance of microbiome
- Familiarize students with microbiome projects, online databases and bioinformatics tools and software used for microbiome analysis.
- To recognize how Microbiome has greatly impact on *the pharma industry*
- Biotechnology potential of microbiome

Course Outcome:

- A detailed knowledge and understanding of Microbiome field
- Designing the research plans or experimental setup to address the specific issues on Microbiome
- Enable students to work efficiently in their future to pursue career opportunities
- The scope of microbiome in *sustainable* healthcare and agriculture

UNIT-I

Human Microbiome: An Introduction to Human Microbiome and Human Microbiome Project, Structural and functional diversity of healthy human Microbiome at different major body sites (gut, oral, nasal passages, skin, gastrointestinal/urogenital tract); Role of the human microbiome in host physiology, immunity, health, and disease; Approaches and methods for study the human microbiome; Emerging culture and sequence-based technologies for human microbiome analysis; human Microbiome in disease diagnostics and therapeutics; Fecal microbiota transplantation (FMT), Human Microbiome and it's pharmaceutical and biotechnology applications.

UNIT- II

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); Sampling of plant material for rhizosphere, phyllosphere,

and endosphere microbiome analysis; Characterizing the plant microbiome using culture and metagenome-based methods; Role of Plant Microbiome in Plant health and productivity; Role of the animal microbiome in host health and disease; Antimicrobial Resistance and Animal Microbiome.

UNIT-III

Terrestrial and *Marine Microbiome:* An introduction of Earth Microbiome Project 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; Culture-dependent and -independent methods for Soil, Forest, Ocean, Marine Animals Microbiome analysis; Biotechnology Applications of Soil and Marine Microbiome; Screening approaches of Soil and Marine Microbial Communities for Natural Bioactive Compounds.

Laboratory Practicals:

1. Culture-dependent analysis of human skin microbiome
2. Culture-dependent analysis of plant microbiome
3. Culture-dependent analysis of ruminants fecal microbiome
4. An introduction of bioinformatics tools and software used for Culture dependent analysis (metagenomics) microbiome analysis

Suggested Reading

1. Eugene Rosenberg, (2021), Microbiomes: Current Knowledge and Unanswered Questions: 2 (The Microbiomes of Humans, Animals, Plants, and the Environment) 1st ed. 2021 edition, Springer

2. Rachael E. Antwis, Xavier A. Harrison, Michael J. Cox, (2020), Microbiomes of Soils, Plants and Animals: An Integrated Approach (Ecological Reviews), Cambridge University Press

3. Angela E Douglas, (2018) Fundamentals of Microbiome Science: How Microbes Shape Animal Biology, 1st edition, Princeton University Press

4. Robert G. Beiko, Will Hsiao, John Parkinson, (2019), Microbiome Analysis: Methods and Protocols: 1849 (Methods in Molecular Biology), 1st ed. 2018 edition

5. Nwadiuto (Diuto) Esiobu, Olawole O. Obembe, et al., (2022), Microbiomes and Emerging Applications (Multidisciplinary Applications and Advances in Biotechnology), 1st edition, CRC Press
6. Lucas J. Stal, Mariana Silvia Cretoiu, (2018), The Marine Microbiome: An Untapped Source of Biodiversity and Biotechnological Potential, 1st ed. 2016, Springer

MBYD13 Bioprocess Engineering Credit 3

Course objectives

- This course will allow the students to understand the principles of bioprocess engineering in a way that is accessible to Microbiology students.
- The course does not aim to transform microbiology students into bioprocess engineers, but to expose them to engineering concepts and ways of thinking.
- The student will get access to numerical problems related to industrial application using bioprocess engineering and will clear their concepts.
- Students will get access to the operational controls in microbial growth which is the fundamental and backbone of all bioprocess.

Course outcomes

- The knowledge of fermentation technology can be understood better after studying the process parameters influence on the bioprocess; hence this course would ease the fermentation technology

course.

- Acquaintance to real scale industrial operation using microbial process engineering starting from fermentation technology to waste water treatment plant and waste recycling using microbes
- Understand various approaches in process control of their experiments carried out in the practical classes.
- Strengthen thermodynamics approach in Bioprocesses of microbial origin.
- Getting scope in industries to work wherever there are full scale operations may it be enzyme production, breweries, antibiotics industries etc.

UNIT-I

Introduction to Bioengineering as an Interdisciplinary between biology and engineering; Material Balances: Material-Balance in batch and continuous process; Material Balances with Recycle; Stoichiometry of Growth and Product Formation. Energy Balances: General Energy-Balance Equations; Enthalpy Change; cooling in downstream processing; Energy-Balance Equation in Fermentation; Unsteady-State Material Balances and Energy balance equations; Unsteady-State Mass Balances; Unsteady-State Energy Balances; Fluid Flow and Mixing-Fluids in Motion; Momentum Transfer; Non-Newtonian fluids; Viscosity measurements; Rheological Properties of Fermentation Broths; Mixing in bioreactor.

UNIT-II

Heat-Transfer: Heat transfer Equipment-Bioreactor, mechanism of heat transfer, heat transfer between fluids, Application of the Design Equations; Mass Transfer: Molecular Diffusion, Diffusion in Bioprocessing, Oxygen Transfer, dissolution and solubility in bioreactors. Unit Operations in Bioprocess; Homogeneous Reactions: Batch and continuous growth, Yields in Cell growth, Cell Growth Kinetics, Kinetics of Substrate Uptake by Cell, Effect of Maintenance on Yields, Kinetics of Cell Death.

UNIT-III

Heterogeneous Reactions in Bioprocess, Concentration Gradients and Reaction Rates in Solid Catalysts, Internal Mass Transfer and Reaction, External mass transfer, Minimizing Mass-Transfer Effects, Evaluating True Kinetic Parameters, Bioreactor Engineering; Configurations-stirred tank, bubble column and air-lift reactor, Bioreactor Construction, Monitoring and Control of Bioreactors, Ideal bioreactor Operation, sterilization.

Suggested Readings

1. Bioprocess Engineering principles by Pauline M Doran, Elsevier Science and technology Books.
2. Bioprocess Engineering- Basic Concepts by Michael L Shuler and Fikret Kargi, Pearson Education, Inc.
3. Bioprocess Technology: Volume 1 by P T Kalaiselvan and I Arul Pandi MJP PUBLISHERS.
4. Bioprocess Engineering: Systems, Equipment and Facilities by Bjorn K. Lydersen, Nancy A. D'Elia, Kim L. Nelson, Wiley India Pvt Ltd.

MBYD14 Infectious Diseases: Drug discovery and Development Credits 3

Course Objectives:

- To provide an overview anti-microbial agents and different approaches to discover new drugs.
- To gain insight into post discovery processes such as in-vivo efficacy and preclinical safety studies before clinical testing.
- To provide a detailed understanding into various phases of clinical trials.
- To understand the regulatory procedures at various stages of anti-infective drug development.

Course Outcomes:

Upon completion of the course,

- Student will understand the various approaches involved in the discovery of a new anti-infective agent and steps involved in hit to lead candidate identification.
- The student will be able to evaluate the lead candidate and design a pre-clinical development pathway.
- Student will gain insight into 'first in human' introduction of a new drug candidate in various phases of clinical development.
- Student will be equipped with the complete understanding of the drug development process in general and anti-infectives in particular.
- Knowledge acquired by the student upon the completion of the course will help the student to get integrate into the research projects in the national research labs working in the area of drug discovery and pre-clinical development

Course Structure:

UNIT-I

Development of new anti-microbial agents: Historical perspective, Antibacterial drugs, Antifungal drugs, Anti-viral drugs, Anti-infective vaccines, Mechanisms of resistance and evolutionary basis of emergence of resistance, Addressing the unmet clinical need, Antimicrobial susceptibility testing, Kinetics of antimicrobial activity, Antimicrobial combinations, Preliminary ADMET studies, Different approaches to discover new antibiotics, Antibiotics drug development pathway,

UNIT-II

Non-clinical testing: Preclinical pharmacokinetics/Pharmacodynamics of anti-infective agents, Drug-drug interactions, Evaluation of antimicrobial in animal models, Investigational New Drug (IND) application, IND enabling studies: Toxicity and safety evaluation, Pre-formulation development, Formulation development, Human dose prediction. Nonclinical evaluation of vaccines.

UNIT-III

Clinical development: Key concepts of clinical trials, Phases of clinical trials (Phase 0, Phase I, Phase II, Phase III, Phase IV), Types of efficacy trials, Overview of antibacterial clinical trials, Role of biomarkers in management of antibiotic therapy, Clinical development pathway of vaccine, Drug regulatory affairs, Principles of GLP, GMP & GCP, New antimicrobial under development

Laboratory Practical:

1. Antimicrobial susceptibility testing using disk diffusion and broth dilution methods
2. Determination of bacteriostatic and bactericidal activities of antibiotics using kill kinetics assay
3. Antimicrobial combinations using checkerboard method

Suggested Readings

1. Frontiers in Clinical Drug Research (Anti Infectives) by Atta-ur-Rahman eds, by Bentham Books, 2014.
2. Antibiotics in Laboratory Medicine by Victor Lorian eds, 5th edition by Lippincott Williams & Wilkins, 2005.
3. The Pharmacological Basis of Therapeutics by Goodman & Gilman, 13th edition by McGraw-Hill Education, 2018
4. The Pharmacological Basis of Therapeutics by Goodman & Gilman, 13th edition by McGraw-Hill Education, 2018
5. Handbook of Animal Models of Infection by Oto Zak & Merle A Sande, by Academic Press, 1999
6. Guidelines on the nonclinical evaluation of vaccine adjuvants and adjuvanted vaccines-WHO Expert Committee on Biological Standardization-64th report. New Drugs and Clinical Trial rules 2019
7. Basic and Clinical Pharmacology by Bertram G. Katzung and Anthony J. eds, 12th edition by Trevor McGraw Hill. New Drugs and Clinical Trial rules 2019
8. Regulatory guidelines ICH, USFDA, Indian GCP, EMEA etc
9. Antibacterial Agents in Preclinical Development-an open access database- WHO, 2019

MBYD15 **Multi-omics** **Credits 3**

Course Objectives:

- Impart basic knowledge about genomes and proteomes and databases that store various data about genes, proteins, genomes and proteomes.
- Students would learn basic knowledge of genome sequencing, major differences between prokaryotic and eukaryotic genomes, basic proteomics and its applications.
- Students would gain skills in comparative, evolutionary and functional genomics. Students will be skilled and can work in core facilities, commercial biological and medical laboratories

Course Outcomes:

- Able to Infer the basic concepts of genomics and proteomics.
- Able to List and discuss the use of genomics, trancriptomics and proteomics in human health.
- Able to Suggest and outline solution to theoretical and experimental problems in Genomics and Proteomics field

Course Structure:

UNIT I

Genomics: Molecular mapping of genome, Genetic and physical maps, physical mapping and map –based cloning, choice of mapping population, simple sequence repeat loci, southern and fluorescence in situ hybridization for genome analysis, microcloning, molecular markers in genome analysis: RFLP, RAPD and AFLP analysis, molecular markers linked to disease resistance genes, Application of RFLP in forensic, disease prognosis, Next generation Sequencing and Applications. Metagenomics and methods of metagenomics Evolution and structure of mitochondrial genomes, mtDNA and mitochondrial diseases, epigenomic markers of epigenomics, correlated diseases and assessment of DNA modification

UNIT II

Transcriptomics: Analysis of gene expression at the level of individual gene and at global level, Concept of Reporter genes; Alkaline phosphatase, beta galactosidase, GFP, series of fluorescent genes, Northern Blot analysis, Differentia display PCR, Analysis of promoter strength, Analysis of protein-DNA and protein-protein interactions: Gel retardation assay, DNA footprinting by DNase I, DNA Microarray and applications, SAGE,

UNIT III

Proteomics: Introduction to mass spectrometry; Strategies for protein identification; Protein sequencing; Phage Display; Applications of proteome analysis to drug; Protein-protein interaction (Two hybrid interaction screening). Protein engineering; Protein chips and functional proteomics; Clinical and biomedical application of proteomics; Proteome database; yeast one-hybrid assay, ChIP-chips. Yeast two hybrids system, SPR, Co-immunoprecipitations, GST- pull-downs and Far-Westerns, Metabolomics; Assessment of different metabolites and small molecules, integration of data across multiomics layer.

Laboratory Practicals:

1. Isolation of DNA/RNA from bacterial cells.
2. Synthesis of cDNA and analysis on agarose gel
3. Purification of recombinant protein by Ni/NTA
4. SDS page analysis of purified proteins
5. Restrictive mapping experiments

Suggested Readings

1. Genome, Transcriptome and Proteome analysis by Alain Bernot. Wiley .
2. The Dictionary of Genomics, Transcriptomica and Proteomics by Guenter Kahl (Volume3)
3. Gene Cloning & DNA Analysis: An Introduction, by TA Brown, 18 th edn, Blackwell Publishing Professionals.
4. Principles and Techniques for Biochemistry and Molecular Biology by Wilson and Walker
5. Bioinformatics and Functional Genomics, by Jonathan Pevsner, 3rd edn, Wiley Blackwell

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