Department of Microbiology

School of Life Sciences

Proposed Syllabus for

M.Sc. Microbiology

(Academic session 2019-2020)

Central University of Rajasthan NH-8, Bandarsindri, Kishangarh-305817

Dist. Ajmer

Name of Department: Department of Microbiology

Name of the Program: M.Sc. Microbiology

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. Programme 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 student 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

E. Course Content : M.Sc. Microbiology (Implemented from academic session 2019- 2020 onwards)

Semester I

Course Code	Title of the course	Type of	Credits
MBY-401	Essential in Microbiology	Core	3
MBY-402	Biochemistry	Core	3
MBY-403	Bioinstrumentation and Biotechniques	Core	3
MBY-404	Microbial Physiology	Core	3
MBY-405	Molecular Biology	Core	3
MBY-406	Immunology	Core	3
MBY-407	Laboratory for Microbial Physiology, Biochemistry, Bioinstrumentation and Biotechniques	Core	3
MBY-408	Laboratory for Essential Microbiology, Molecular Biology, Immunology	Core	3
	Open Elective offered by other Departments	Soft Core	-

Total credits: 24

Semester – II

Course Code	Title of the course	Type of Course	Credits
MBY-409	Medical Microbiology	Core	3
MBY-410	Virology	Core	3
MBY-411	Enzymology	Core	3
MBY-412	Microbial Genetics	Core	3
MBY-413	Bioinformatics, IPR and Biostatistics	Core	3
MBY-414	Elective I: A. Fungal Biotechnology and Bioprospecting B. Biomass and Energy systems C. Pharmaceutical Microbiology	Elective I	3
MBY-415	Laboratory for Medical Microbiology, Virology and Bioinformatics	Core	3
MBY-416	Laboratory for Enzymology, Microbial Genetics	Core	3
MBY-417	Open Elective : Entrepreneurship and Management in Microbial Technology	Soft Core	3

Total credits: 24

Semester – III

Course Code	Title of the course	Type of Course	Credits
MBY-501	Recombinant DNA Technology	Core	3
MBY-502	Food and Dairy Microbiology	Core	3
MBY-503	Environmental and Agricultural Microbiology	Core	3
MBY-504	Emerging Concepts and Technologies in Microbiology	Core	3
MBY-505	Industrial Microbiology	Core	3
MBY-506	Elective II- A. Petroleum Microbiology B. Extreme Microbiology C. Infection Biology and Vaccine Development	Elective II	3
MBY-507	Laboratory for Food and Dairy Microbiology, Environmental and Agricultural Microbiology, Industrial Microbiology	Core	3
MBY-508	Laboratory for Emerging Concepts and Technologies in Microbiology, Recombinant DNA Technology	Core	3
	Open Elective offered by other Departments	Soft Core	-

Total credits: 24

Semester – IV

Course Code	Title of the course	Type of	Credits
MBY-509	Journal Club Presentation	Tutorial/Presentation	3
MBY-510	Review of Literature for Major project	Tutorial	3
MBY-511	Major Project (Research Dissertation)	Tutorial/Laboratory	15
MBY-512	Research Dissertation Presentation	Tutorial/Presentation	3

Total credits: 24

***Credits for open elective offered by other Department as per their syllabus**

#Open Elective are soft core which is not compulsory and will not be considered for completion of course requirement

Semester I

MBY-401 Essential in Microbiology 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).

Learning 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 unculturable microorganisms.

Course Structure

Unit I

Origin and evolution of microbial world; Pathway of discovery in Microbiology; Haeckel's three kingdom concept, Whittaker's five kingdom concept, three domain concept of Carl Woese. General characteristics of various groups of prokaryotes: bacteria including, Rickettsiae, Chlamydiae, Spirochaetes and Actinomycetes, Cyanobacteria and Mycoplasmas. Eubacteria: cell structure, nutrition, isolation and cultivation. Diversity, nutrition, ecology, significance of Gram-positive (Firmicutes, Actinobacteria) and Gram-negative [Proteobacteria (cyanobacteria, Rhizobia, methanotrophs, myxobacteria, magnetotactic bacteria), *Deinococcus-Thermus*, Spirochaetes, Bacteroidetes].

Unit II

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. Phyla of Archaea, Significance of Archaea, Evolutionary developments of Archaea, Cell structure Archaea, Metabolism and energetics of Archaea (*Thermoplasma*, *Sulfolobus*, *Pyrococcus)*. Phycology: Algal and Cyanobacterial diversity and distribution; Characteristics: cell structure, pigmentation, thallus organization, nutrition, reproduction, alternation of generations; Identification; Culturing, Classification; Phylogeny; Economic importance and applications; Phycovirus, Symbiotic associations of algae with fungi;.

Unit III

Mycology: Fungal diversity and distribution; Cell structures, growth and development, nutrition, reproduction, life cycle; Classification of fungi, Major taxonomic groups of fungi; Identification; Cultivation; Phylogeny; Yeasts: General characteristic, structure, classification, life cycles (important forms), sexual and asexual reproduction of Yeasts; Protozoa: Classification, Morphology, reproduction, modes of nutrition, modes of transmission, locomotory organelles, Life cycle, Cultivation of Protozoa. Structure and significance: *Leishmania, Trichomonas, Entamoeba, Plasmodium*

Suggested Readings

1. Madigan MT, Martinko JM, Dunlap PV, Clark DP (2012). Brock Biology of Microorganisms, Prentice Hall, USA.
2. Lansing M Prescott, Donald A Klein, John P Harley, Microbiology, Mc Graw Hill.

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

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.

Learning 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.
- Concepts of lipid and nitrogen metabolism, oxidation of fatty acid, assimilation of nitrates, ammonia assimilation.

Course Structure

Unit I

Carbohydrate: Monosaccharide, Disaccharide and Polysaccharide - occurrence, structure, isolation, properties and functions of homoglycans -starch, glycogen, cellulose, dextrin, inulin, chitins, xylans, arabinans. Occurrence, structure, properties, and functions of heteroglycans, Glycoprotein and their biological applications. Lipid: classification, saturated and unsaturated fatty acids, phospholipids: classification, structure and functions of lipids. Types and functions of microbial lipoproteins. Amphipathic lipids: membranes, micelles, emulsions and liposomes.

Unit II

Proteins: classification of proteins on the basis of solubility and shape, structure, and biological functions. Primary structure: determination of amino acid sequence of proteins. The peptide bond: Ramachandran plot. Secondary structure: weak interactions involved, alpha helix, beta sheet and beta turns structure. Super secondary structures: helix-loop-helix. Tertiary structure: alpha and beta domains, quaternary structure. Vitamins and Porphyrins: Vitamins - water soluble - thiamine, riboflavin, niacin. Porphyrins the porphyrin ring system, chlorophyll and cytochrome.

Unit III

Cellular Permeability and Transport process, Bioenergetics of metabolism: oxidation–reduction reactions, coupled reactions and group transfer; enthalpy and free energy of reaction and ATP. Lipid and Nitrogen Metabolism: Oxidation of fatty acid: β-oxidation, activation of a fatty acid, transport and steps of oxidation, α and ω oxidation.

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-403 Bioinstrumentation and Biotechniques Credits 3

Course Objectives

- Introduce the basic concept of qualitative and quantitative analysis of a given sample.
- Study various spectroscopic techniques and its instrumentation.
- Study the concept of separation science and its applications.
- Study the concept of radiochemical analysis along with industrial analyzers.

Learning Outcomes

- Define and explain various fundamentals of spectroscopy, qualitative and quantitative analysis and characterize functionalities of biomolecules by using spectroscopic techniques.
- Explain the various separation techniques and its instrumentation.
- Describe the principle and working of various radiation detectors.

Course Structure

Unit I

Microscopy: Light Microscopy: simple and compound Microscopy, Phase Contrast, Dark field, Confocal, Atomic force and Fluorescent Microscopy; Electron Microscopy: SEM, TEM, AFM Sample preparation for microscopy; Electrophoretic techniques: Principle of Electrophoresis, Agarose Gel Electrophoresis, Polyacrylamide gel electrophoresis, Counter current Electrophoresis, Immuno-Electrophoresis, Support media; Colony counter, Nephlometry, Isoelectric focussing, colorimetry, Turbidometry.

Unit II

Chromatographic techniques: Basics of Chromatography, Paper, Thin layer and Column chromatography; Protein purification; Liquid chromatography; Gas chromatography, Affinity Chromatography, Gel Filtration, Ion Exchange Chromatography. HPLC; Centrifugation techniques: Basic principle, RCF and Sedimentation Coefficient, Types of Centrifugation - High speed and Ultracentrifugation, Differential and Density-gradient centrifugation, Analytical centrifugation and applications, Factors affecting Sedimentation, Preparative and analytical centrifugation, Safety measures of centrifugation.

Unit III

Spectroscopy: Theory and applications, UV-Visible, Fluorescence, IR, FTIR, NMR, Mass spectroscopy, Raman and Atomic absorption spectroscopy; Fluorescence polarization; Radioactivity measurement: Radioactive decay, Liquid scintillation counter- Û ray detection and its applications; Use of stable isotopes in Biological sciences; Autoradiography and tracer technique. Principle of electrochemical techniques, Redox reaction measurement, pH meter and electrode; Thermal techniques: X-Ray Diffraction, Micro-array

Suggested Readings

1. Biochemistry by Lubert Stryer
2. Sharma BK, Instrument method of chemical analysis
3. DA Skoog , Instrument method of analysis
4. Plummer, An introduction to practical Biochemistry
5. Chatwal and Anand, Instrumentation
6. Principles and Techniques Of Biochemistry And Molecular Biology, Keith Wilson,
7. John Walker. Cambridge University Press India Pvt. Ltd.
8. Biochemical Techniques theory and practice : White R
9. Analytical Chemistry: Christion G. D.
10. A Biologist Guide to Principle and Techniques: Willson K. and Gounding K. H.

MBY- 404 **Microbial Physiology** **Credits 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.

Learning 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: The *E.coli* Paradigm, Metabolic genetic regulation, Energy, oxidation-reduction vs. fermentation, Nitrogen assimilation; Microbial growth: Growth cycle, continuous culture, factors affecting growth. Carbohydrate metabolism and Energy production: Glycolytic pathways, Gluconeogenesis, TCA cycle, glyoxylate cycle, energy production, oxidative phosphorylation,

Unit II

Introduction to two component system, regulatory systems during aerobic- anaerobic shifts. Osmotic control of gene expression, SOS response and Heat shock response, Electron transport (Respiratory pathway), regulation of nitrogen assimilation and fixation, Phosphate starvation-controlled stimulon, oxidation stress, The Lon system (Proteolytic control).

Unit III

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

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-405 **Molecular Biology** **Credits 3**

Course Objectives

- The objective of the course is to make student understand about the structure and function of biologically important molecules.

- Students will learn about DNA, RNA and the molecular events that govern cell functions.

Learning Outcomes

- After completing the course the students will be able to:
- Describe the structure and function of DNA and RNA in a cell.
- Elucidate central cell biological processes and how they are regulated (for example: replication and protein synthesis and gene expression).
- Explain DNA repair and recombination in terms of mutation and evolution.
- 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, Centromeres and Telomeres. Structure of DNA, Watson - Crick Model. Chromatin structure and remodeling, Histone code and histone modifications. Cell-cycle and different phases of cell cycle, controls and Check points, cyclins and cdks -types and their role

DNA Replication: Prokaryotic DNA Polymerase I, II and III, Eukaryotic DNA Polymerases, Fidelity and Catalytic Efficiency of DNA Polymerases, Okazaki Fragments, Replication Origin, Primosomes, Concurrent Replication Mechanism Involving Leading and Lagging Strands of DNA; Problems associated with linear replicons. Mutations and Repair

Unit II

Transcription: Prokaryotic RNA polymerase and sigma factors, Prokaryotic and eukaryotic promoters, Eukaryotic RNA Polymerases, Class I, II and III gene promoters, Enhancers and control regions of genes; Mechanism of transcription - Prokaryotic and eukaryotic, Transcription of protein coding genes. **RNA Processing:** Processing, Capping, Polyadenylation, Splicing. Processing of Poly A-mRNA, Group I and II Introns, Alternate Splicing, RNA editing. Non-coding RNAs

Unit III

Translation: Genetic Code, Ribosome Structure, tRNAs, Aminoacyl tRNA synthetase, Initiation, Elongation, Termination; Translational Control.

Regulation of Gene Expression: Prokarytes: Operon Concept, Positive and Negative Regulation, Attenuation, Catabolite Repression, Riboswitches. Eukaryotes - Generalized and specialized transcription factors, Transcriptional Activators and regulators.

Suggested Readings

1. Jocelyn E. Krebs, Elliott S. Goldstein and Stephen T. Kilpatrick, Lewins Genes X, 9th Edition, Jones and Barlett Pub., USA, 2011.
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: Bruce Alberts
10. Cell & Molecular Biology: Gerald Karp

MBY-406 Immunology Credits 3

Course Objective

- 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.

Learning 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 (Inflammation, Complement System, and Cells of the innate immune response) Adaptive Immunity (T lymphocytes, B lymphocytes, Antigen, Super antigens, Immunogens, Adjuvents structure and function of Antibodies, Other cells (NK Cells, macrophages etc.) and molecules such involved in the Immune response, antigen-antibody interactions - principles and applications.

Unit II

Innate and Adaptive Immunity: Antigen presentation, Antigen presenting cells, Major Histocompatibility Complex, Functions and Types of MHC molecules, interferons, Cytokines, Pattern recognition receptor (ex.Toll like receptors (TLR) and NOD-like receptors (NLR), Lymphocytes Development, Activation and Differentiation, B-Cell Activation, Differentiation, and Memory Generation, T-Cell Activation, Differentiation, and Memory, Immunological memory (Passive and Active Memory)

Unit III

Immunology in Health and Diseases: Autoimmunity, autoimmune disorders, Tolerance, and Transplantation, Allergy and Hypersensitivity Reactions, Types of Hypersensitivity reactions, Immunodeficiency Disorders, Diseases of the Immune system, vaccines and Immunization, Immunology of Infectious Diseases, Cancer and Immune System, Immunotherapy, Immunodiagnostic methodologies and techniques.

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-407 Laboratory for Microbial Physiology, Biochemistry and Bioinstrumentation and Biotechniques **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.

Learning Outcome

- 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 practical

1. Microbial Growth Kinetics
2. Conjugation in E.coli
3. Transformation in E. coli.
4. Characterization of transformant
5. Prokaryotic transformation
6. Demonstration of Microscopy, centrifugation,
7. Chromatography, NMR and XRD
8. Redox measurement and pH measurements
9. Principles of colorimetry and spectrophotometry, its calibration and estimation of O.D.
10. UV-Vis Spectrophotometry and validating the Beer-Lambert's Law.
11. Qualitative and quantitative tests for Carbohydrates- Tests for glucose/starch.
12. Qualitative and quantitative tests for amino acids/ protein..

MBY-408 Laboratory for Essential Microbiology Molecular Biology and Immunology

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.
- Provide idea about DNA, protein purification from samples and quantification.
- 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

Learning 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 practical

1. Methods of sterilization, preparation of Media: Nutrient broth, Nutrient agar, plates, slants, soft agar.
2. Pure culture technique: Streak plate, spread plate and pour plate methods.
3. Isolation, purification, microscopic observations, and enumeration of cyanobacteria, fungi and bacteria.
4. Bacterial and fungal staining, Motility determination
5. Genomic/Plasmid DNA isolation
6. Polymerase chain reaction and agarose gel electrophoresis
7. Restriction mapping
8. Cloning
9. Blood group and Rh typing
10. Immuno-electrophoresis (Rocket Immuno-electrophoresis), Ouchterlony Double Diffusion
11. Radial Immunodiffusion &ELISA
12. Agglutination and Immunoblotting

Semester II

MBY-409 **Medical Microbiology** **Credits 3**

Course Objective

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

Learning 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

Host-Pathogen Interaction: Distribution and significance of normal human microbial flora, accidental pathogens, oncogenic viruses. 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* & *Entamoeba*.

Unit II

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.

UnitT III

Epidemiology and Public Health: 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,

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-410 **Virology** **Credits 3**

Course Objective

- The course covers the following 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.

Learning 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: Brief outline on the history and discovery of viruses, nomenclature and classification of virus, morphology and ultrastructure; capsids and their arrangements; types of envelopes and their composition, Enveloped and non-enveloped viruses, Structural proteins – envelope proteins, matrix proteins and lipoproteins, Viral genomic organization, structure and replication – types of nucleic acid DNA (double stranded and single-stranded), RNA (double stranded, single stranded – positive sense and negative sense), Viral replication, virus related agents (viroids, prions), Viruses of Algae, Fungi and Cyanobacteria. Antivirals agents: Interferons

Unit II

Animal/Plant/Bacteria Viruses: Plant viruses: classification and structure of common plant viruses. Pathophysiology of common viral diseases of plants (ex TMV and CMV). Transmission of plant viral disease. Control and prevention of plants viral diseases.

Animal viruses: Classification and nomenclature of animal and human viruses. Brief account of some important animal and human disease. Prevention, treatment and control of viral diseases. Viral vaccines including DNA vaccines and interferons. Bacteriophage: Morphology, structure, genome organization and life cycle (lytic and lysogenic) of M13, Mu, and Lambda phage. Phage therapy for control of bacterial diseases.

Unit III

Cultivation and Diagnostic methods of Viruses: General methods for isolation, identification, characterization and cultivation (embryonated eggs, experimental animals, and cell cultures), Direct methods of detection – light microscopy (inclusion bodies), electron microscopy and fluorescence microscopy, serological methods - haemagglutination; complement fixation; immunofluorescence methods, ELISA and Radioimmunoassays, Western Bloting, Nucleic acid based diagnosis: Nucleic acid hybridization, polymerase chain reaction, microarray and nucleotide sequencing, Infectivity assay for animal and bacterial viruses - plaque method, LD_{50}, ID_{50}, IED_{50}

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-411 **Enzymology** **Credits 3**

Course Objective

- 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.
- To integrate the practical aspects of enzymology with the kinetic theories to provide a mechanistic overview of enzyme activity and regulation in cells.
- To develop and understanding of enzyme development and rational drug designing.

Learning Outcome

- The students will be able to make qualitative and quantitative description of the basic enzymatic phenomena and processes.
- Understand the importance of mathematical and statistical methods required for the description, interpretation of enzymatic phenomena and processes.
- 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

Enzymes as Biocatalysts: Velocity, Order and Molecularity of a chemical reaction, Kinetic equations for zero, first & second order reactions, Determination of order of the reaction, Remarkable properties of Enzymes as Catalysts, Lock and Key theory, Induced-fit hypothesis, Nomenclature and classification. Enzymes Kinetics: Kinetics of single substrate reaction, Michaelis-Menten equation, steady state kinetics, Kinetic parameters, K_m, V_{max} and K_{cat}, Lineweaver-Burk, Eadie-Hofstee plot, Hanes plot, Variations of velocity with [E], [S], pH and temperature, Bi-substrate reaction kinetics, multi-substrate reactions, Uses of kinetic studies in determining enzyme mechanism.

Unit II

Enzyme inhibition: Types of enzyme inhibition- reversible and irreversible, competitive inhibition, non- competitive inhibition, uncompetitive inhibition and kinetics using Lineweaver-Burk and Scatchard plots. Enzyme mechanism: Mode of action of catalysts, different type of catalysis, Nucleophilic, Electrophilic & Acid-Base Catalysis, Proximity and orientation effects, contributions of strain, Mechanism of action of Chymotrypsin, Ribonuclease and carboxypeptidase. Allostery: Allosteric enzymes, mechanism of allosteric interactions, subunit structures and protein assembly, symmetrical and sequential model, Hill's coefficients, Cooperativity, positive and negative Cooperativity, Allostery cooperativity in hemoglobin

Unit III

Enzymeregulation: Enzyme Regulation of Aspartic transcarbamoylase, metalloenzymes - carboxypeptidase A, Role of Zinc, Feedback inhibition. Enzyme technology: Enzyme purification and recovery, Microbial production and application of lipase, amylase and protease, Enzyme Immobilization techniques, use of immobilized enzymes in industrial processes, Enzymes in clinical diagnosis, Isozymes, Abzymes, Ribozymes, Artificial enzymes, Enzyme engineering for thermostability, directed evolution, Site directed mutagenesis.

Suggested Readings

1. P. F. Cook and W. W. Cleland, Enzyme Kinetics and Mechanism. 3rd Edition, Garland Science,2007.
2. Carnish Bowden, Fundamental of Enzyme Kinetics, 3rd Edition, Portland Press, 2004.
3. Price, N. C. & L. Stevens, Fundamentals of Enzymology, 3rd Edition, Oxford University Press, 1999.

MBY-412 Microbial Genetics Credits 3

Course objective

- To Understand the Genetic constitutents of bacteria with special emphasis on inheritance and mutations
- 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

Learning Outcomes

- Student capable of explaining process involved in genetic changes and mutations
- The identification of genetic regulatory mechanism and distinguishing different mechanism of gene regulation
- The design of different techniques based on utilizing the genetic mechansism of microbes

Course Structure

Unit I

Genetic analysis of bacteria: Importance and uses of mutation analysis. Inheritance in bacteria, types of mutations, spontaneous and induced mutagenesis, isolating mutants, selecting mutants, mutant enrichment. Reversions versus suppression. Complementation tests, recombination tests and gene replacements. Cloning genes by complementation. Cloning genes by marker rescue.

Unit II

Gene transfer by conjugation, transformation and transduction: Molecular mechanism of gene transfers by conjugation, genes and proteins involved. Regulation of gene transfer by conjugation, Hfr strains. Natural transformation and competence. Molecular basis of natural transformation: DNA uptake competence systems in gram positive and gram negative bacteria. Regulation of competence in *B. subtilis*. Importance of natural transformation. Artificially induced competence. Generalized versus specialized transduction T4 and lambda phage. Phase variation system in pathogenic bacteria.

Unit III

Overexpression of recombinant proteins: Overexpression and tagging of recombinant proteins in *E.coli*, driven by lac, T7 and Tet-regulatable promoters. Overexpression systems in *S.cerevisiae*, *P.pastoris*. Baculovirus overexpression system.

Analysis of protein-DNA and protein-protein interactions: Gel retardation assay, DNA footprinting by DNase I, yeast one-hybrid assay, ChIP-chips. Yeast two hybrids, system. Co-immunoprecipitations, pull-downs and Far-Westerns.

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.

MBY-413 Bioinformatics, IPR and Biostatistics Credits 3

Course Objectives

- Aimed to provide an overview of various bioinformatics tools, databases available and sequence analysis.
- Provide knowledge on database concept, management, retrieval along with utilization in gene and protein analysis.
- Impart basic knowledge of patenting, intellectual property rights, laws available and copyrights.
- Impart basic knowledge of statistics and tools used for several quantitative analysis in microbiology

Learning Outcomes

- Retrieve information from available databases and use them for microbial identifications and drug designing.
- Gain ability to modify gene and protein structures in simulated systems.
- Have knowledge on patents and property rights.
- Students are able to predict the significance of the biological phenomenon on the basis of available data set.

Course Structure

Unit I

Basic introduction of Bioinformatics; An overview of major bioinformatics resources; Various databases (GenBank, EMBL, DDBJ, Swissprot, Ensemble, UCSC genome browser, PlasmoDB) and bioinformatics tools; Use and application of bioinformatics in research, search and

retrieval of biological information. Searching for sequence and analysis by different database BLAST algorithm and CLUSTALW. Phylogenetic studies, alignment of sequences, gene prediction and regulation, protein classification & structure prediction. Genome analysis methods.

Unit II

Definition of IPR, function, forms of protection, importance of IPR, Patentable subject matter, Novelty, IPR and Developing World, Intellectual Property Management. International conventions and Treaties (WIPO), Introduction of Patents and patent application process (national and International), Trade Secrets, Copy Rights, Geographical Indicators, Trade Marks, PBR in UPOV, GATT and TRIPS, Patent applications- national and international, Patent infringement, Patent Claims and Legal decision-making process.

Unit III

Statistics for biologist: Introduction to Biostatistics, Frequency distribution, Variable and attribute, Line diagram, Bar diagram, Pie chart, Histogram, Mean, Median and Mode, Variance, Standard deviation, Standard error of mean, Null hypothesis, Level of significance and Probability, Student's t-test, Fisher's t- test, Chi-square test, Analysis of Variance (ANOVA).

Suggested Readings

1. Achuthsankar S Nair (2007). Computational Biology & Bioinformatics – A gentle Overview, Communications of Computer Society of India
2. Baxevanis, A.D. and Ouellette, B.F.F.(2004). Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, John Wiley & Sons
3. Intellectual Property Rights: Legal and Economic Challenges for Development: Cimoli
4. Indian Patent Laws: Kankanala KC, Narasani AK
5. P Ganguly, Intellectual Property Rights, Tata McGraw Hill, 2007
6. A Text book of Biostatistics, by A.K.Sharma, Discovery publishing house
7. Introduction to Biostatistics, By Dr. Pranab Kumar Banerjee, S. Chand Publishers

MBY-414 **Elective I** **Credits 3**

A. Fungal Biotechnology and Bioprospecting

Course Objective

- 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

Learning Outcomes

- Overview of fungal diversity, screening and strain improvement and strain development for production of different bio-molecules.
- Design of bioreactor with special emphasis on fungal systems.
- 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; habitat relationship; different ecological groups of fungi Ecotaxonomic approach in chemical screening; primary and secondary products of metabolism; Screening of industrially useful fungal metabolites;classification of secondary metabolites; primary

and secondary screening of antibiotic producers; 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 Biotechnology, formulation of fermentation medium, analysis of fermentation products especially for fungal biotechnology. Techniques for strain improvement and strain development; Recombinant technology in fungi: composition of the different types of fungal vectors, selection markers, transformation strategies, gene replacement or inactivation, applications and future perspectives

Unit III

Edible fungi; Mycoproteins. Advancement in mushroom cultivation technology; Commercial mushroom species; strain improvement and cultivation; tropical mushrooms and their cultivation; mushroom spawns; nutritional aspects of mushrooms, Fungi in food processing, Fungus for Biomass pretreatment for ethanol production.. Fungi in agriculture application: Fungal biofertilizers and biopesticides , myconematicides

Biotechnological applications of fungi and their derivatives. Production of Industrially important productsfrom fungi-organic acids (citric acid), enzymes (cellulase xylanase, amylase, protease) applications of Fungi in medical and pharmaceutical products. Production of antibiotics, drugs, vitamins and therauptic peptides from fungi.

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.

B: Biomass and energy systems

Course Objectives

- To provide a thorough 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 agri-residues and biowastes, anaerobic digestion and biodiesel production.
- To teach our students to analyze and design processes for biofuel production

Learning Outcomes

- Identify and apply potential biomass feedstocks including energy crops.
- Have an understanding of the existing and emerging biomass to energy technologies.
- Develop a critical thinking about sustainability & resilience.
- Determine potential solutions for energy needs and problems by incorporating the bioenergy technologies being explored

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 and other biogenous waste- production, availability and attributes for bioenergy production. General principles of the carbon cycle, greenhouse effect and global climate change. 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

Biofuel generations, Pretreatment technologies, structure and function of lignocellulosic biopolymers, various types of pretreatment technologies (Physical, mechanical, chemical, biochemical, ionic liquids etcetera) bioconversion of biomass to biofuel; concept of pseudo-lignin and inhibitors, biodiesel production; environmental impacts of biofuel production; concept of Biorefinery, value-added product generation in an integrated approach, processing of biofuel residues- case studies on combined heat and power (CHP) generation. The role of transgenic plants and algae.

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, Storage and stability of digestate- health and safety issues, Up-gradation of biogas to methane. 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.

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, Springer.

C. Pharmaceutical Microbiology

Course Objectives

- To Understand the basics of pharmaceutical microbiology and important microorganism playing role pharmaceutically
- To understand different products of microbial origin playing key role in pharmaceutical applications.
- To understand role of secondary metabolites in pharmaceutical industry.
- To understand good practices and regulation involved in utilizing microbial product for pharmaceutical application

Learning Outcomes

- Have basic knowledge of pharmaceutical microbiology
- Have well versed with the different microbial products used in pharmaceutical applications
- Better understanding of good laboratory practices and regulations for utilizing microbial product in pharmaceutical applications

Course Structure

Unit I

An introduction and application of pharmaceutical microbiology; Basic aspects of pharmaceutical microbiology; Biology of pharmaceutically important microorganisms: Bacteria and fungi (yeast and

molds); Study of microbial growth cycle, Microbiological growth media; Assessment of microbial growth; Isolation, identification, and characterization methods of microorganisms; Handling, cultivation, and preservation methods of microorganisms; Physical and chemical factors influencing microbial growth.

Unit II

Microbial products in pharmaceutical industry: impacts and opportunities; antibiotics, production of antibiotics antifungal agents, antiviral, antiprotozoal drugs, small molecules, growth factors, hormones, vitamins, therapeutic enzymes, recombinant proteins, immunological products and vaccines etc.; Microbial sources, contamination and spoilage of pharmaceuticals; Factors affecting microbial spoilage of pharmaceutical products; Microbial control in pharmaceutical industries; Antimicrobial resistance, Methodologies for testing of antimicrobial activity (broth-dilution methods and agar diffusion methods); Antimicrobial/preservative efficacy testing.

Unit III

Microbial production of pharmaceuticals; Primary metabolic products, Secondary metabolic products; basics of fermentation process; History and discovery of microbial natural products; Screening and development approaches for new microbial natural products; Good laboratory/manufacturing practices for pharmaceuticals production, validation and regulation; Government regulatory practices and policies for pharmaceutical industry: Food and Drug Administration (FDA), The Central Drugs Standard Control Organisation (CDSCO), the Drug Controller General of India (DCGI); patenting of pharmaceutical products

Suggested Readings

1. Geoff Hanlon & Norman A (2013). HodgesEssential Microbiology for Pharmacy and Pharmaceutical Science, Wiley-Blackwell
2. Madhu Raju Saghee , Tim Sandle , Edward C. Tidswell (2011). Microbiology and Sterility Assurance in Pharmaceuticals and Medical Devices,Business Horizons.
3. Geoff Hanlon, Norman A. Hodges (2013). Essential Microbiology for Pharmacy and Pharmaceutical Science,Wiley-Blackwell.
4. Stephen P. Denyer , Norman A. Hodges, Sean P. Gorman , Brendan F. Gilmore (2011). Hugo and Russell's Pharmaceutical Microbiology,Wiley-Blackwell.
5. Prahlad Singh Mehra (2011). A Textbook of Pharmaceutical Microbiology,I K International Publishing House.

MBY-415 Laboratories for Medical Microbiology, Virology, Bioinformatics 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 there antibiotics resistance pattern of pathogenic bacteria (Environmental source, Agricultural part), which is useful for public awareness.
- Understanding of application of Virus (bacteriophage) in transduction
- Impart basic understanding of bioinformatics approaches for bacterial/viral/fungal identifications and drug design
- Develop competence to integrate biological information with computational softwares

Learning 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 diagnonsis tests using Radio-immunoassays/ELISA and PCR
- Develop competence to retrieve information from biological databases and integrate these biological information with computational softwares.
- Learning methods for designing primers and in-silico PCR

Course Structure

List of laboratory practical

1. Identification of pathogenic bacteria by culture and biochemical methods
2. Widal Test
3. Antibiotic susceptibility testing
4. Determine the minimum inhibitory concentrations (MICs) of antimicrobial agents
5. Measuring biofilm formation by bacteria
6. Transduction by Bacteriophage & Determination of Phage Titration
7. Diagnosis of Viral agents by Radio-immunoassays/ELISA (Demonstration)
8. Identification of Viral agents by PCR (Demonstration)
9. Usage the National Center for Biotechnology Information (NCBI), European Molecular Biology Laboratory (EMBL) and other databases for biological information
10. BLAST (Basic Local Alignment Search Tool) analysis of DNA/protein sequence

11. Multiple Sequence alignment
12. Primer design and In-silico PCR

MBY-416 Laboratory Enzymology, Microbial Genetics 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.

Learning 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 along
- Hand on experience of different microbial genetic modification strategies

Course Structure

List of laboratory practical

1. Batch fermentation for production of microbial enzymes. Yield calculations and kinetics.
2. Enzymatic Assays (eg. Amylase, protease) and Yield calculations.
3. Study of factors affecting enzyme activity-substrate concentration, temperature, pH, inhibitors.
4. Determination of kinetic parameters for enzyme activity (Km & Vmax).
5. Conjugation in E.coli
6. Transformation in E. coli.
7. Characterization of transformant
8. Prokaryotic transformation

Open Elective: MBY-417: Entrepreneurship and Management in Microbial Technology

Credits 3

Course Objectives

- To understand basic of managements such as nature scope, evolution, level and components of management
- Understanding important concepts of entrepreneurship such as Planning, decision making, leadership, organizations and authority
- Understand basic requirements for establishing a bio-based startup and company

Learning Outcomes

- Imparts basic understanding and skills required for a successful entrepreneur
- Learn basic concepts of management and enterprenuerships such as planning decision making, leadership, organizations and authority
- Attains skills to manage the start-up and run an organization

Course Structure

Unit I

Understanding management and administration, Management: Nature, scope and its functional aspects/areas. Evolution of management thought: early, contemporary and modern. Roles of Management, Levels of managements. Major component of management skills; Planning: nature, purpose and importance, Types of plans, Steps in planning & planning premises, Hierarchy of plans, Components of planning, Decision making.

Unit II

Leadership Meaning and nature of directing: Understanding, Supervision, motivation Leadership styles, Motivation Theories (Abraham Maslo, Herzberg and Victor Hvrom's). Communication – Meaning and importance. Meaning and steps in controlling – Essentials of a control system – Methods of establishing control (in brief). Organisation: nature, purpose and principles of organization. Types of organization. Departmentation Committees. Centralization *Vs* Decentralization of authority and responsibility. Nature and importance of staffing–Process of Recruitment and Selection

Unit III

Structure of a Biobased technology Company. Start-up of Biobased technology Company, New Product Development. Market Research: Capital and how to source investors, Sales & Marketing Principles. Intellectual Property Principles in microbial technologies. Understanding of Government policies: . Ethical and Other Legal Issues in microbial products.

Suggested Readings

1. Naidu, NVR. (2013) Management and Entrepreneurship No eBook available I. K. International Pvt Ltd
2. Tripathi, PC., Reddy, PN. Principles of Management — Tata McGraw Hill,
3. Desai V. Dynamics of Entrepreneurial Development & Management – Vasant Desai – Himalaya Publishing House
4. Charantimath , PM. (2006) Entrepreneurship Development Pearson Education – 2006
5. Lusier R. Management Fundamentals – Concepts, Application, Skill Development Thomson
6. Robbins, S. (2003) Entrepreneurship Development Pearson Education/PHI – 17th Edition,

Semester III

MBY-501 Recombinant DNA Technology Credits 3

Course Objectives

- To familiarize the students to versatile tools and techniques employed in genetic engineering and recombinant DNA technology.
- A sound knowledge on procedural repertoire allows students to innovatively apply these in basic and applied fields of biological research.
- This course offers theoretical bases to properties and applications of versatile DNA modifying enzymes, cloning strategies, vector types, host genotype specificities for selection and screening of recombinants and/or recombinant transformants.
- Students will also be introduced to prominent nucleic acid labeling techniques. Introduction to various types of vectors viz.cloning, transformation, expression; and also vectors for genomic and cDNA library and whole genome sequencing will be provided.
- A critical appraisal of methods for site-directed mutagenesis and sequencing of cloned genomic fragments will also be covered.
- This course may be deemed as a basic course serving as a platform for introduction of more advanced cutting-edge technologies that essentially are unification of basic techniques combined in diverse forms and sequence; to be introduced later in the program.

Learning Outcomes

- Understand the difference between old biotechnology and modern biotechnology.
- Design an experiment with step-by-step instructions to address a research problem.
- Provide examples of current applications of biotechnology and advances in the different areas like medical, microbial, environmental, bioremediation, agricultural, plant, animal, and forensic.
- Provide examples on how to use microbes and mammalian cells for the production of pharmaceutical products.
- Explain the general principles of generating transgenic plants, animals and microbes.
- Technical know-how on versatile techniques in recombinant DNA technology.
- An understanding on application of genetic engineering techniques in basic and applied experimental biology.

Course Structure

Unit I

Techniques and enzymes in genetic recombination: Core techniques and essential enzymes used in recombination: restriction endonucleases, type I, II, III, recognition sequences, properties, nomenclature, classification of type II endonucleases, their activity. DNA ligase, S1 nuclease, BAL 31 nuclease, DNA polymerase, polynucleotide kinase, phosphatase, reverse transcriptase its activity and mode of action. Chemical synthesis of DNA. Restriction digestion, ligation and transformation. Properties of Plasmid, incompatibility, isolation and purification techniques,

Unit II

Plasmid vectors and their properties, pBR 322 – its construction and derivatives, single stranded plasmids, promoter probe vectors, runaway plasmid vectors. Bacteriophage lambda (λ) as a vector. Specialized cloning strategies: Expression vectors, promoter probe vectors, vectors for library construction, genomic DNA libraries, chromosome walking and jumping, cDNA libraries, short gun cloning, directed cloning, phage display. RDT for cloning and production of interferon and insulin. PCR methods and Applications: DNA sequencing methods, di-deoxy and Chemical method, Automated sequencing.

Unit III

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.

Suggested Readings

1. Principles of Gene Manipulations 1994 by Old and Primrose Blackwell Scientific Publications.
2. DNA Cloning: A Practical Approach by D.M. Glower and B.D. Hames, IRL Press, Oxford. 1995.
3. Molecular Biotechnology 2nd Edition by S.B. Primrose. Blackwell Scientific Publishers, Oxford. 1994.
4. Genetic Engineering and Introduction to Gene Analysis and Exploitation in Eukaryotes by S.M. Kingsman and A.J. Kingsman, Blackwell Scientific Publications, Oxford 1998.
5. PCR Technology - Principles and Applications for DNA Amplification by Henry A. Erlich (Ed.) Stockton Press. 1989.
6. Biotechnology: A Guide to Genetic Engineering by Peters.
7. Genetic Engineering – 2000 by Nicholl.
8. Recombinant DNA and Biotechnology: Guide for Teachers. 2nd Edition by Helen Kreuz. 2001.ASM Publications.
9. Molecular Biotechnology: Principles and Applications of Recombinant DNA. 2nd Edition. 1998 by Bernard R. Glick and Jack J. Pastemak, ASM Publications.
10. From genes to clones by Winnaker.

MBY-502 **Food and Dairy Microbiology** **Credits 3**

Course Objectives

- The course aims to provide instruction in the general principles of food microbiology.
- The course covers the biology and epidemiology of food borne microorganisms of public health significance, including bacteria, yeasts, fungi, protozoa and viruses,
- Understand food spoilage microorganisms; the microbiology of food preservation and food commodities; fermented and microbial foods; principles and methods for the microbiological examination of foods; micro biological quality control, and quality schemes.

Learning Outcomes

- Understand the principles of microorganisms during various food-processing and preservation steps.
- Comprehend the interactions between microorganisms and the food environment, and factors influencing their growth and survival.
- Understand the significance and activities of microorganisms in food.
- Recognize the characteristics of food-borne, waterborne and spoilage microorganisms, and methods for their isolation, detection and identification.
- Analyze the importance of microbiological quality control programme's in food production.
- Discuss the microbiology of different types of food commodities
- Describe the rationale for the use of standard methods and procedures for the microbiological analysis of food

Course Structure

Unit I

Food Microbiology: Micro-organisms and their importance in food microbiology–molds, yeast, bacteria, general features and classification, principles of food preservation, asepsis, control of microorganisms (anaerobic conditions, high temperature, low temperature, drying), factors influencing microbial growth in food–extrinsic and intrinsic factors, chemical preservation and food additives, canning process for heat treatment, Fermented foods. Application of microbial enzymes in food industry

Unit II

Contamination and spoilage-cereals, sugar products, vegetables, fruits, meat and meat products, fish and sea food, poultry and canned food, detection of spoilage and characterization, methods of food preservation. Food poisoning and foodborne infections; Bacterial toxins and mycotoxins in food; Quality assurance: Microbiological quality standards of food. Government regulatory practices and policies. FDA, EPA, HACCP, ISI, NABL.

Unit III

Microbiology of raw and pasteurized milk, Biochemical changes in fermented milk, Study on spoilage organisms in dairy industry, probiotics. Classification of various groups of microorganisms associated with diary industry, Acid fermented milks (Yoghurt, cultured butter milk), Starter cultures for fermented dairy products (*Streptococcus thermophilus*, *Lactobacillus bulgaricus*), Cheese production: Steps involved in manufacture of cheese, preservation, classification and nutritional aspects.

Suggested Readings

1. Frazier WC, Westhoff DC (1988). Food Microbiology, Mc Graw-Hill, New York.
2. Banwart GJ (1993). Basic food microbiology, CBS Publishers & Distributors Pvt Ltd.
3. Jay JM (1996). Modern Food Microbiology, Chapman and Hall, New York.
4. Ray B (1996). Fundamentals of Food Microbiology, CRC Press, USA.
5. Dairy Microbiology by Robinson Volume I and II
6. Applied Dairy Microbiology Edited by Elmer Marth and James Steele
7. Food Microbiology 2nd Edition by Adams
8. Fundamentals of Dairy Microbiology by Prajapati
9. The technology of Food preservation. Fourth Edition Norman W. Desrosier. CBI

MBY-503 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.
- Topics covered in detail include soil microbiology, aquatic microbiology, aero microbiology, biofertilizers and pesticides, microbial waste recycling and bioremediation etc.
- These topics were elaborated to students with their theoretical and practical use.
- The students will develop set of skills to recognise the ecological problems and critical evaluation of the human impacts on pollution, climate changes and as well as environmental protection.
- 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.
- To make students aware with current research in environmental and agricultural microbiology.

Learning 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. Microbial interactions: Symbiosis, mutualism, commensalism, amensalism, competition, antibiosis, actinorrhiza, mycorrhizal fungi and its effect on plants. Aquatic Microbiology: Water ecosystems (fresh water, pond, lakes), marine habitats (estuaries, deep sea, hydrothermal vents), eutrophication, cyanobacterial and microlagal blooms: ecological implications and human health, toxins produced by cyanobacteria and other microalgae.; Extreme environments and extremophilic microbes: Habitats, diversity, adaptations and potential applications.

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, global warming and climate change.

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. Bacterial and mycopesticides.

Unit III

Microbial waste recycling: organic compost, vermicomposting, Biogas production, microbial sewage treatment, waste water treatment by microbes. Microbial leaching and oxidation of minerals (copper bioleaching, cobalt bioleaching, Uranium bioleaching, biooxidation of gold ores, Nickel leaching, acid mine drainage) 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.

Suggested Readings

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- Theroy 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-504 Emerging Concepts and Technologies in Microbiology Credits 3

Course Objectives

- To obtain a fundamental knowledge of the basic principles of system microbiology through a series of required topics in genomics, transcriptomics, proteomics, and metabolomics, high-throughput biological techniques and bioinformatics.
- To obtain depth of knowledge in selected areas of system microbiology through advance level courses.

Learning Outcomes

- Understanding system microbiology requires all integrative omics technologies; next-generation sequencing/high-through put techniques and bioinformatics skills.
- It provide opportunities for a student to develop technical skills in next-generation sequencing including the practical application and interpretation of NGS technologies.
- Understanding the Systems Microbiology Approaches arecrucial for Modern Medical Research and Drug Development.

Course Structure

Unit I

Basic introduction of "Omics" technologies including genomics, transcriptomics (RNA-Seq), proteomics, metabolomics, metagenomics and their applications in microbiology; Basic Concepts in high throughput sequencing or Next- Generation Sequencing; Overview of main Next- Generation sequencing methods and techniques and their impacts in food-microbiology, diagnostics and public health microbiology.

Unit II

An overview of Microbial Genomics; Microbial Genome Structure and organization; Principles of microbial genomics such as sequencing, assembly, annotation of microbial genomes and its application to cultured and uncultured microbial community. A breif introduction of major bioinformatics tools and resources used in Microbial Genomics. Use and application of various bioinformatics databases and tools in Microbial Genomics, search and retrieval of biological information and databases sequence for Microbial Genomics; Microbial genome projects, Human Microbiome Project.

Unit III

An introduction of functional genomics; Resources for functional genomics; Different methodologies and techniques of functional genomics such as site-directed mutagenesis, Transposon mutagenesis, DNA sequencing, DNA microarray, RNA interference, and Chromatin immune precipitation. Genome annotation, Applications of functional genomics in vaccine and drug designing, Genome editing, tools involved in genome editing such as CRISPR/Cas9.

Suggested Readings

1. Head**,** Steven R., Ordoukhanian**,** Phillip, Salomon**,** Daniel R (2018) Next Generation Sequencing Methods and Protocol. Springer
2. Izard, Jacques., Rivera, Maria. (2014) Metagenomics for Microbiology. Elsevier
3. Kaufmann, Michael., Klinger, Claudia., Savelsbergh, Andreas. (2017) Functional Genomics Methods and Protocols. Springer

MBY-505 Industrial Microbiology Credits 3

Course Objectives

- To impart theoretical knowledge of role of microbes in industrial production of different bio-chemicals/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.

Learning 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. Basic principal of microbial fuel cells and its application .

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. Production of distilled beverages or liquors- rum, whiskey and brandy; 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 for secondary metabolite production; Penicillin-Fermentation and recovery; Tetracycline and Chloramphenicol production; Streptomycin-structure, meia composition, production and recovery, Production of Amino acids: L-Lysine production and strain improvement for lysine production; L- glutamic acid production-strain improvement for glutamic acid production and recovery process; Tryptophan production and recovery. Production of enzymes: Pectolytic enzymes-Pectinases production, harvest, recovery and uses; Invertase and Lipase production; Cellulase production and recovery; Production of vitamins: Vitamin B12 (Cyanocobalamine) production; 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 from algal biomass

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

A. Petroleum Microbiology

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.

Learning 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: Microbially enhanced oil recovery: past, present and future, biotechnological upgrading of petroleum, diversity, function and biocatalytic applications of alkane oxygenases, 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).

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.

B. Extreme Microbiology

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.

Learning 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 unculturable 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.

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.

C. Infection Biology and Vaccine Development

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

Learning 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, 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, HIV/AIDS, Influenza, Developing stable cell lines for the production of vaccine antigens

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

MBY-507 Laboratory for Food and Dairy Microbiology, Environmental and Agricultural Microbiology, Industrial Microbiology **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

Learning 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. Microbiological analysis of food
2. Isolation and enumeration of microorganisms from milk, Fruits, Vegetables and Fruit Juices
3. Isolation of pathogenic bacteria from food
4. Isolation of spoilage- associated microbes from food
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. Batch fermentation for production of microbial enzymes.
9. Solid-state fermentation for production of organic acids and study of effect of moisture content.
10. Production and estimation of citric acid (using *Aspergillus niger*) by titrimetric method
11. Biosurfactant production
12. Batch, fed batch and continuous culture growth kinetics studies

MBY-508 Laboratory for Emerging Concepts and Technologies in Microbiology, & Recombinant DNA Technology **Credits 3**

Course Objectives

- To impart hand on experience in basic technquies used in genomics, proteomics and metagenomic studies
- To demonstrate the insilico analysis for genome annotation, gene prediction and cellular co-localization.
- Demonstrate culture dependent studies of microbiomes, DNA molecular size determination and gel extraction

- Demonstrate basic techniques used in recombinant DNA technology

Learning Outcomes

- Capable of performing basic techniques of genomics, proteomics and metagenomics
- Capable of performing several in-silico analysis such as genome annotation, gene prediction and cellular co-localization
- Capable of performing several techniques used during development of Recombinant DNA.

Course Structure

List of laboratory practical

1. In silico Genome annotation
2. In silico Gene prediction
3. In silico cellular co-localization analysis
4. Search and retrieval of genomics/metagenomic data
5. Cultivation-dependent analysis of microbiome
6. DNA molecular size determinaton, Gel extraction
7. Ligation and cloning in a plasmid vector
8. Isolation of recombinant plasmid DNA, Confirmation of the insert.

MBY-509 Journal Club Presentation Credits 3

Course 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.

Learning Outcomes

- Searching research paper from different web sources.
- Reading research paper and making PowerPoint presentations.
- Giving oral presentations in front of all faculty and the students.

- Answering the question raised by the audience during and after scientific presentation.
- Overall, this course will impart proficiency of reading research articles, preparing power-point presentation and oral presentation among an audience. It will help in gaining self confidence and remove stage fear.

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-510 Review of Literature for Major Project Credits 3

Course Objectives

- This paper is designed to provide an exposure to the students about reading the different ongoing research going in specialized area of microbiology.
- The students will read different research paper to specific area which they will work during their project dissertations.

Learning Outcomes

- Searching research paper from the web sources.
- Reading research paper and knowing current status of the specialized area. This course will impart proficiency of reading research articles, gaining knowledge in area of project dissertation existing knowledge.
- Writing review of literature of their project dissertations. Will gain writing skill, referencing and citations. The skills will help the students in scientific writing and designing an experiment based on already existing literature.

Course Structure

- Scientific review and research articles published in a respective specialized area of research.
- Writing of review of literature to brush up the already existing knowledge on given area of intrest

Suggested Reading

- Scientific review and research articles published in a respective specialized area of research

MBY-511 Major Project (Research Dissertation) Credits 15

Course Objectives

- The student will be assigned a research topic based on their interest and its suitability to the assigned laboratory.
- The objective of the project is to develop a skill to independently carry out a research from designing experiment to analyzing results and presenting the result.

Learning Outcomes

- Student will be capable of designing a project. Defining objectives, develop methodology, carryout experiment, analyze the results.
- After analyzing result they will be able to write in the thesis format.
- This course will impart proficiency of designing scientific experiments and carry out those experiments.

Course Structure

- Scientific review and research articles published in a respective specialized area of research.
- Writing of review of literature to brush up the already existing knowledge on given area of interest.

Suggested Reading

- Scientific review and research articles published in a respective specialized area of research

MBY-512 Research Dissertation Presentation Credits 3

Course Objective

- The student will be present the results of the work to a panel for evaluation of the project.

Learning Outcomes

- Presentation preparation of the different results obtained during the course of project dissertation.
- Analyzing the results, correlating it with different experiment performed during the dissertation.
- This course will impart proficiency of designing scientific presentation.

Course Structure

- The dissertation report prepared by the student based on the project conducted

Suggested Reading

- Scientific presentation available online