Choice Based Credit System (CBCS)

M.Sc. MICROBIOLOGY CURRICULUM 2020-21

DEPARTMENT OF MICROBIOLOGY
TRIPURA UNIVERSITY (A Central University) SURYAMANINAGAR,
AGARTALA – 799 022 TRIPURA, INDIA

DATE OF SYLLABUS REVISION

26th September 2016

16th April 2018

19th July 2019

14th April 2021

30th June 2021

9th September 2021

Program specific Outcomes

The programme will enable the student to

- Develop an insight about the basic concepts, and practices of microbiology and its processes.
- Understand the nature and scope of different basic and applied branches of microbiology like Microscopy, Microbial Technology, Microbial ecology, Environmental microbiology, Microbial Immunology and bioinformatics
- Perform experimental procedures as per established laboratory standards in the areas of culturing, preserving and handling the microbes.
- Gain skill and training to carry out their own research work in the form of M.Sc. Project work in diverse research areas to develop confidence and analytical ability for answering a problem in real time.
- Students will develop understanding about the literature review and Scientific writing required to carry out research work in future studies.

M.Sc MICOBIOLOGY COURSE (CBCS) CURRICULUM (2020-2021)

SEMESTER I				
COURSE CODE	**COURSE TITLE**	**COURSE TYPE**	**CREDITS**	**Lecture/ Tutorial/ Practical hrs per week**
MI-701-C1	Basic Microbiologyand Microscopy	CORE	4	3L/1T
MI-702-C1	Microbial Ecology and Environmental Microbiology	CORE	4	3L/1T
MI-703-C1	Microbial Immunology	CORE	4	3L/1T
MI-704-C	Practicals.	CORE	4	8P
CSK-II	Compulsory Foundation (Soft Skills)	CF	4	3L/1T
Semester wise credits and hours of lectures			**20**	**24**
SEMESTER II				
MI-801-C1	Microbial genetics and bacterial recombination	CORE	4	3L/1T
MI-802-C1	Biochemistry and Microbial Physiology	CORE	4	3L/1T
MI-803-C1	Virology	CORE	4	3L/1T
MI-804-C	Practicals	CORE	4	8
MI-805-E2	Biophysical and biochemical methods	ELECTIVE	4	3L/1T
MI-806-E1	Microbial Bioreactors for wastewater Treatment	ELECTIVE	4	3L/1T
MI-808-E	Innovative concept Development	ELECTIVE	4	3L/1T
Semester wise credits and hours of lectures			**28**	**30**
SEMESTER III				
MI-901-C1	Tools and Techniques of Molecular Biology and Bioinformatics	CORE	4	3L/1T
MI-902-C	Practicals	CORE	4	8
MI-903E2	Fermentation Technology and Fermented Foods	ELECTIVE	4	3L/1T
MI-904-E1	Microbial Adaptation	ELECTIVE	2	
MI-905-E	Bacterial secretion system and bacterial quorum sensing	ELECTIVE	2	3L/1T
MI-905-C1	Project Work	CORE	4	3T
MI-906 E	BacteriaandChronicInfections	ELECTIVE	4	3L/1T
			20	**24**
SEMESTER IV				
MI-1001-E1	Recent trends in antimicrobial research	ELECTIVE	4	3L/1T
MI-1004-C1	Project Work	CORE	12	8
			16	**12**
Semester wise credits and hours of lectures				
In addition, a 2-credit elective course offered by other departments may be taken by the students				
Grand total of credits and hours of lecture hours			**84**	
Student have to cover 72 credits for clearing the MScCourse				

BASIC MICROBIOLOGY AND MICROSCOPYPAPER CODE:MI-701-C1
Credit: 4

Course Outcome:

- Students coming from diverse background get introduced to the three branches of microbiology namely Bacteriology, Mycology and Phycology.
- They get to understand the impact of different microscopic techniques in understanding microbial world and beyond.
- This course prepares then for getting into in-depth understanding of the subsequent papers covered in this program.

UNIT-I: BACTERIOLOGY

Bacterial cell structure and appendages: Morphological features and arrangement of bacterial cells; overview of eubacterial cell structure: Gram-positive and Gram-negative bacteria; Extracellular appendages: flagella- arrangement, basic structure and locomotive function; pili- different types, their distribution among bacteria & related functions; fimbriae- occurrence, function and features distinguishing pili and fimbriae; glycocalyx- composition and role in bacteria; and capsule-microcapsule and slime. Bacterial cell wall & cell membrane: Detailed structure of gram negative and gram positive bacterial cell wall, outer membrane lipopolysaccharide (LPS), protoplasts, sphaeroplasts, L-forms, cell wall synthesis and its inhibitors including different antibiotics; periplasm; molecular and chemical structure of cell membrane; cytoskeleton including tubulin and actin structural filaments and their role in bacteria. Bacterial cell division and reproduction: Binary fission and other forms of reproduction in bacteria; assembly, maintenance and disassembly of Z ring; endospore structure and stages involved in endospore development in Bacillus subtilis and Metabacteriumpolyspora

UNIT-II: MYCOLOGY

Classification of fungi (Oomycetes, Zygomycetes, Ascomycetes,Basidiomycetes and Deuteromycetes) and Slime molds, morphology, structure, cell differentiation, and reproduction of fungi. Hetrokaryosis, Sex hormones in fungi, physiological specialization in fungi, Mycorrhiza-ectomycorriza, endomycorrhiza and vesicular arbuscularmycorrhiza (VAM). Economic importance, Secondary metabolites from fungi: Terpenes, Nonribosomal peptides, hydrophobins, peptaibols, indole, alkaloids, detailed emphasis on polyketides.

UNIT- III PHYCOLOGY

Phycocology: General account of Diversity, distribution, nutrition, mode of reproduction, Life cycle patterns, recent status of algae (evolutionary perspective), ecological significance, phycotoxins, economic importance including role in human affairs (algal pigments, biofuels, hydrogen production, important bioactive molecules, role of algae in sustainable environment) Distribution and classification of algae, thallus organization in algae, reproduction in algae; Brief account of Chlorophyta, Bacillariophyta, Phaeophyta, Rhodophyta; Algal ecology, Algal toxins,Algal food and algalbiotechnology.

UNIT -IV: MICROSCOPY AND STAINING OF MICROORGANISMS

Microscopy: General Principles and components of simple, microscope, compound microscope, bright-field and dark-field microscope, Phase- contrast microscope, fluorescence microscope, Transmission Electron Microscope (TEM), Scanning Electron Microscope (SEM) and Atomic Force Microscope (AFM), Cytophotometry and flowcytometry Fixation and staining: Simple staining, negative staining, gram staining, acid fast staining, structural stains (Endospore, capsule and flagella).

Reference/Text Book:

1. Microbiology by Lansing M Prescott, Donald A Klein, John P Harley, McGrawHill
2. Principles of Microbiology by Ronald M. Atlas (1995), Amy McCullen
3. Microbiology: Principles and Explorations by JacquelynBlack
4. Microbiology by Michael JPelczar
5. Fundamental Principles of Bacteriology A JSalle
6. Foundations in Microbiology by Kathleen park Talaro, McGraw Hill.science
7. Microbiology: An Introduction by Gerard J Tortora, Berdell R Funke, Christine L Case,Dorling Kindersley (india) PvtLtd
8. Microbiology by Stuart Walker, W BSaunders
9. An Introduction to Microbiology by P Tauro, K KKapoor, KSYadav

MICROBIAL ECOLOGY AND ENVIRONMENTAL MICROBIOLOGY

PAPER CODE: MI-702C1
Credit: 4

Course Outcome:

- Student will have an overview of the till date developments in the field of environmental microbiology with special emphasis on the role of microbes in mitigating environment pollution. Student will have become acquainted with various cultural, biochemical and molecular techniques used in understanding microbial diversity.

- Will be knowledgeable about the diversity, adaptations and biotechnological applications of microbes of extreme environment.

- Will be able to describe the role of soil microbes in nutrient transformation, plant-microbe interactions and biotechnology. Also knows about potability of water and its quality control.

- Understands the role of microbes in management of waste plant biomass and can apply knowledge in designing microbe-based processes for pulp, textile, biofuel and animal feed production industries.

- Is able to describe the role of microbes in solid and liquid waste management, gaining knowledge of various methods employed in sewage treatment and solid waste treatment

- Understands the role of microbes in bioremediation of environmental pollutants like petroleum hydrocarbons, pesticides, plastic and electronic waste; also understands utility of microbes in mineral and oil recovery

Unit 1 Origin diversity and culturability concepts of microbes
Origin of life: A brief history of the physical origin of the Earth, Chemical and Cellular evolution; Microbial Diversification: Consequences for Earth's Biosphere; Endosymbiotic origin of eukaryotes. Significance of Biogeochemical cycles: Carbon, Nitrogen, Phosphorous, Sulphur.
Quantitative Ecology: Microbial diversity, OTU, Diversity indices (Shannon, Shimpson), Alpha and beta diversity, Richness and evenness, Samples and samplings, Concept of cultivability: Determination of total and viable microbial number, Molecular analysis of function and diversity of microbial community, Metagenomics and microbiomics.

Unit 2: Concepts of microbial ecology and microbial succession
Microbial Ecology: Basic concept of microbial Ecosystem and Biosphere, Concept of population growth and community dynamics in microbe, Development of microbial communities: r and k strategies. Physiological ecology of microorganisms: Adaptation to environmental condition, Abiotic growth limiting factors-Leibig's law of minimum, Shelford law of tolerance. Microbial community succession-biofilm communities

Unit 3 Biofertilizers
History of bio-fertilizers, sources of nitrogen and the importance of bio-fertilizers, description and characteristics of bio-fertilizers-Rhizobium, Azotobacter, Azospirillum, Blue Green Algae, Azolla, Phosphate solubilizing microorganisms, VAM. Bio-fertilizer production technology-strain selection, sterilization, growth and fermentation, standards and quality control, Bio-fertilizer application technology, constraints in the commercialization of bio-fertilizer technology

Unit 4: pollution management and Bioremediation

Water pollution and its sources: Role of organic pollutants in water, concepts of C-BOD, N-BOD and COD, Oxygen-sag curve. Treatment of waste water by aerobic and anaerobic process. Air pollution and Air borne diseases: Methods for air microflora studies Particulate matters, PAH, Fog and smog, Determination of LD50, Ames test to determine the genotoxicity of toxicants (biological assay to assess the mutagenic potential of chemical compounds) Soil pollution and management: Solid waste types, composting, landfill development, incineration methods, composting and sustainable agriculture, plastic degrading microorganisms as a tool for bioremediation, challenges in waste management Bioremediation of environmental pollutants: bioleaching, biosoption and bioaccumulation of metals from solid and liquid waste. Biodegradation and biotransformation of Xenobiotics including pesticides chlorinated and nitrated aromatic compounds, phenolic compounds, polycyclic aromatic compounds. Enzymes and metabolic pathways of degradation of xenobiotic compounds.

Reference/Text Books:

1. Maier, Pepper, Gerba. Environmental Microbiology. Academic Press.
2. Atlas, RM and Bartha, R. Microbial Ecology: Fundamentals and Applications. Pearson.
3. Schmidt and Schaechter. Topics in Ecological and Environmental Microbiology. Academic Press.
4. Environmental Microbiology by A.H. Varnam and M.G. Evans. Manson Publishing Ltd. 2000.
5. Manual of Environmental Microbiology edited by C.J. Hurst, R.L. Crawford, J.L. Garland, D.A. Lipson, A. L. Mills and L.D. Stetzenbach. 3rd edition.Blackwell Publishing. 2007.
6. Environmental Microbiology by W.D. Grant and P.E. Long. Kluwer Academic Publishers. 1981.
7. Microbiology: An environmental Perspective by P. Edmonds. Macmillan, New York. 1978.
8. Environmental Microbiology by R. Maier, I. Pepper and C. Gerba. 2nd edition.Academic Press. 2009.
9. Environmental Microbiology: Principles and Applications by P.K. Jjemba, Science Publishing Inc. 2004.
10. Advances in Applied Bioremediation by A. Singh, R.C. Kuhad and O.P. Ward. Springer. 2009.

MICROBIAL IMMUNOLOGY

PAPER CODE:MI-703-C1
Credit: 4

Course Outcome:

- Student will be able to understand the fundamental bases of immune system and immune response
- Student will be able to gather information about the structure and organization of various components of the immune system
- Student will be able to understand the genetic organization of the genes meant for expression of immune cell receptors and the bases of the generation of their diversity
- Student will be able to understand the operation and the mechanisms which underlie the immune response.
- Student will be able to apply the knowledge gained to understand the phenomena like
- Understanding host pathogen interactions which is essential in industrial as well academic research, vaccine development and therapeutics development against important human pathogens. Besides, the course is designed to cover some portions of NET exam.

UNIT 1: INTRODUCTION

Concept of Innate and Adaptive immunity, Immune dysfunction and its consequences, Immune cells and Organs**:** Immune Cells and Organs, Structure, Functions and Properties of Immune Cells - T cell, B cell, NK cell, Macrophage, Neutrophil, Eosinophil, Basophil, Dendritic cell, Structure and Functions of Immune Organs – Bone Marrow, Thymus, Lymph Node, Spleen, GALT.

UNIT 2: ANTIGENS

Antigens, Antigenicity versus Immunogenicity, Haptens, Characteristics of an antigen - Foreignness, Molecular size and Heterogeneity, T-dependent and T-independent antigens, Adjuvants. Antibodies and Humoral Immune Response: Basic structure of antibody- CDRs, Framework region, Hinge. Primary and secondary immune response, Antibody mediated effector function, Types and properties of antibodies, Monoclonal antibodies – preparation and applications, Antigen-antibody interaction – Precipitation, Agglutination, Immuno-electrophoresis, Immuno-fluorescence, ELISA.

UNIT 3: MAJOR HISTOCOMPATIBILITY COMPLEX AND CELL MEDIATED IMMUNITY

Organization and inheritance of MHC locus in humans, Structure and functions of MHC I & II molecules; Cellular expression of MHC molecules; Antigen processing and presentation (Cytosolic and Endocytic pathways); Killing mechanisms by CTL, NK cells and ADCC. Complement System**:** Components of the complement system Activation pathways (Classical, Alternative and Lectin pathways) Biological consequences of complement activation.

Unit 4. MEDICAL MICROBIOLOGY

Classification of medically important microbes, Autoimmunity, Hypersensitivity and Immunodeficiency, Different types of antigen-antibody reactions and their utilization in diagnosis in different diseases,

Reference/Text Book:

1. Campbell,N.A. and Reece, J.B. (2008) Biology 8th edition, pearson Benjamin Cummings, San Francisco.
2. Raven, P.H et al.(2006) Biology 7th edition Tata McGraw Hill Publications, NewDelhi.
3. Griffiths, A.J.F et al. (2008) Introduction to Genetic Analysis, 9th edition, W.H. Freeman &Co.NY.
4. Albert, B et al. (2008) Molecular Biology of the Cell, 8th Edition, Garland Science.NY.

PRACTICAL

PAPER CODE:MI-704C
Credit: 4
Course Outcomes:

- A Student is aware of the different sterilization techniques to be used in a microbiology laboratory and the safety procedures/practices to be followed.
- A student would know how to isolate and purify microbes as well as characterize them as per conventional methods.
- A student would learn to quantify protein and microbial cell number in solution, including determining its doubling time.
- Can find out his/her own blood group and find out the donor/recipients amongst their course mates
- Can differentiate lymphocytes, neutrophils, monocytes, eosinophils, and basophils based on morphological and staining characteristics.
- Is able to perform immune-electrophoresis, immunodiffusion assay.
- Is able to perform dot-ELISA and differentiate different types of ELISA.

Section – A Basic Microbiology

1. Laboratory safety rules in Microbiological Laboratory.
2. Preparation of culture media for growth of microorganism (Bacteria and Fungi).
3. Media, Sterilization using the autoclave.
4. Sterilization of equipment's and materials.
5. Pouring a plate and Storage of Media.
6. Inoculation and other aseptic procedure (Using a Wire loop, using a pipette, flaming the neck of bottles and test tubes).
7. Working with bacteria and yeast and obtaining mixed culture from soil (Streak plate, pour plate and Spread plate).
8. Isolation techniques and obtaining pure culture (bacteria and fungi).
9. Microbial Staining (bacteria and fungi).
10. Growth curve, measures of bacterial population by turbidometry.
11. Studying the effect of temperature and pH.
12. Determination of thermal death point and thermal death time of microorganisms.

Section-B Microbial Metabolism

1. Studies on pH titration curves of amino acids/ acetic acid and determination of pKa values and Handerson-Hasselbachequation.
2. Study of UV absorption spectra ofHemoglobin.
3. Estimation of protein by Lowry'smethod.

Section-C Microbial Immunology

1. Identification of human bloodgroups.

2. To separate serum/plasm from the bloodsample.
3. To perform total Leukocytes Count (TLC) of the given BloodSample.
4. To perform Differential Leukocytes Count (TLC) of the given BloodSample.
5. To performimmunoprecipitation.
6. To perform immunodiffusion by Ouchterlonymethod.
7. To demonstrate single radial immunodiffusion (SRID)technique.
8. To perform DotELISA.

MICOBIAL GENETICS AND BACTERIAL RECOMBINATION

PAPER CODE:MI-801C1
Credit: 4

Course Outcomes:

- Basics of microbial genetics and genetic engineering is taught to students so that they are well acquainted with the techniques used in the industry for genetic manipulations for development of different biotechnology products
- Student will be able to describe structure of DNA and RNA
- Student is able to compare and contrast the mechanisms of bacterial and eukaryotic DNA replication, DNA repair, transcription
- Student is able to explain concepts in DNA repair mechanisms, and recombination as a molecular biology tool
- Student will be able to explain various levels of gene regulation in prokaryotic system.
- Student will be familiar with the use of various cloning vectors
- Will be aware of the different bacterial and eukaryotic systems available for over expression of proteins

UNIT-I: INTRODUCTION TO MOLECULAR BIOLOGY

DNA structure, forms of DNA and DNA supercoiling; The law of DNA constancy and c-value paradox; properties of DNA-denaturation, renaturation, melting curve and hyper chromicity; DNA replication in prokaryotes: origin of replication, replication fork, leading and lagging strand, semi conservative replication, rolling circle replication, enzymes involved in prokaryotic replication and DNA proof reading. Restriction endonucleases – types, nomenclature, classification, application; DNA ligases – properties and functions, ligation techniques; DNA modifying enzymes – polymerases, DNase, RNase, polynucleotide kinases, alkaline phosphatases and terminal nucleotidyl transferase. DNA isolation, DNA polymerases

UNITII: MUTAGENESIS

Gene as unit of mutation, molecular basis of spontaneous and induced mutations and their role in evolution; Mutagens, Types of mutations, transposon mutagenesis, site-directed mutagenesis, Ames test; Environmental mutagenesis and toxicity testing.

UNIT-III: GENETIC ASPECTS OF EXTRACHROMOSOMAL ELEMENTS ANDVECTORS

Extrachromosomal elements (plasmids and bacteriophages), Plasmids as vectors for gene cloning and plasmid DNA replication; Transposons in prokaryotes and eukaryotes and their uses in genetic analyses; Life cycle of bacteriophages and their uses in microbial genetics. Cloning vehicles: Plasmids (pBR322, pUC-8, pGEM3Z and Ti plasmid), Bacteriophage (λ phage and M13 vectors), cosmids, phagemids, expression vectors, shuttle vectors, excretion vectors and Animal viral vectors; Promoter in expression vectors: Lac Z promoter, Lambda PL/ PR Promoter, T7 Promoter, Sp6 Promoter; SV-40 promoter, Cam V35s promoter and Ribosome binding sites.

UNIT-IV: BACTERIAL RECOMBINATION

Bacterial Gene Transfer: gradual development of the concept, Genetic recombination-Bacteriophages; synapsis of homologous duplexes, breakages and re-union; role of Rec A in recombination; Legitimate and illegitimate recombination gene conversion; Bacterial transformation, Host cell restriction, Transduction, complementation, Conjugation & Transfection.

Reference/ Text Book:

1. Benjamin Lewin, Gene IX, 9th Edition, Jones and Barlett Publishers, 2007.
2. J.D. Watson, N.H. Hopkins, J.W Roberts, J. A. Seitz & A.M. Weiner; Molecular Biology of the Gene, 6th Edition, Benjamin Cummings Publishing Company Inc, 2007.
3. Alberts et al; Molecular Biology of the Cell, 4th edition, Garland, 2002.
4. Molecular Genetics An Introductive Narrative by G S Stent and R Calender, San Francisco, Calif : W.H. Freeman, 1978.

BIOCHEMISTRY AND MICROBIAL PHYSIOLOGY

PAPER CODE:MI-702-C1
Credit: 4

Course Outcomes:

- Student will have gained an in-depth knowledge of primary, secondary and group translocation transport systems existing in bacteria, simultaneously learning membrane transport proteins and kinetics of solute transport.

- Will have learnt central metabolic pathways for carbon metabolism in bacteria enlisting differences with eukaryotic systems and their regulation in diverse physiological conditions.

- This allows students to apply the acquired knowledge in engineering metabolic pathways for developing industrially useful strains.

- Will have gathered understanding of inorganic and organic nitrogen assimilation and its regulation. Also knows role of glutathione in cellular redox regulation and biochemistry of glutamate overproducing strains.

- Will have learnt basic concepts of enzyme biochemistry, its kinetics and regulation.

- Will understand details of lipid and nucleotide metabolism in E. coli and its regulation

- Student will be conversant with intracellular signaling in bacteria in response to various nutritional and physiological stresses.

UNIT-I: BIOCHEMISTRY-I

Carbohydrate- Classification and properties of carbohydrates, Aerobic respiration- Glycolysis (EMPpathway), TCA-cycle with energy production, pentose-phosphate pathway, Oxidation-reduction potential and electromotive force. Photo phosphorylation; Bacterial photosynthesis; Anaerobic respiration - Utilizing NO2, Sulfur, CO2 as electron acceptors, Entner-Doudoroff pathway, Fermentation - lactic acid, ethanol and propionic acid.

UNIT-II:BIOCHEMISTRY-II

Amino acids- Structural features, classification Properties and structures of proteins including solubility and denaturation. Lipid –Classification, properties and characterization of lipids, Bacterial lipids, Major steroids and steroid derivatives of microbial origin. Enzymes: Introduction, activation energy, enzyme kinetics, significance of Km, catalytic efficiency, turnover number. Methods of plotting enzyme kinetics data: Lineweaver – Burk plot, saturation kinetics. Enzyme inhibition, models and type of inhibition.

UNIT-III: GROWTH AND TRANSPORT IN CELL

Introduction to microbial growth and cell division: Measurement of growth, growth physiology, cell division, growth yields, growth kinetics, steady state growth and continuous growth. Solute Transport: Introduction; Primary and Secondary transport; Kinetics; Membrane transport protein-Porins and aquaporins, mechanosensitive channels; ABC transporter; Group translocation PEP-PTS system; catabolite repression; inducer exclusion and inducer expulsion.

UNIT IV: PHYSIOLOGICAL ADAPTATION

Physiological Adaptation and Intracellular signalling: Introduction to two component system; response to physiological stress: aerobic-anaerobic shifts- Arc and Fnr system; osmotic homeostasis; response to nutritional stress: phosphate supply- Pho regulon; and stringent response.

Reference/Text Book:

1. Biochemistry by Geoffrey L. Zubay. 4th Edition. Brown Co, USA. 1999.
2. Microbial Physiology by A.G. Moat, J. W. Foster and M. P. Spector. 3rd Edition.John Wiley & Sons. 2002
3. Lehninger Principles of Biochemistry by D. L. Nelson and M. M. Cox.6th Edition. W. H. Freeman. 2012 4. The Physiology and Biochemistry of Prokaryotes by D. White, J. Drummond, C. Fuqua.4th Edition.Oxford University Press. 2011.
5. Microbial Biochemistry by G. N. Cohen. 2nd Edition.Springer. 2014.
6. Lippincott's Illustrated Reviews: Biochemistry edited by D. R. Ferrier. 6th Edition.Lippincott Williams & Wilkins. 2013
7. Biochemical Calculations: by Irwin H. Segel. 2nd Edition.Wiley. 2004.
8. Understanding Enzymes by T. Palmer, E.Horwood. 3rd Edition.Wiley. 1991.
9. Voet and J.G.Voet, Biochemistry, 3rd edition, John Wiley, New York, 2004.
10. A.L. Lehninger, Principles of Biochemistry, 4th edition, W.H Freeman and Company, 2004.
11. L. Stryer, Biochemistry, 5th edition, W.H. Freeman and Company, 2002.
12. Benjamin Lewin, Gene IX, 9th Edition, Jones and Barlett Publishers, 2007.
13. Watson et al., Molecular Biology of the gene 5th Edition, Pearson Prentice Hall. USA, 2003. 14. Lodish et al., Molecular cell Biology, 4th Edition, W.H. Freeman & Company, 2000.
15. Smith & Wood, Cell Biology, 2nd Edition, Chapman & Hall, London, 1996.
16. B. M. Turner, Chromatin & Gene regulation, 1st Edition, Wiley-Blackwell, 2002.
17. B Alberts, A Johnson, J Lewis. Molecular Biology of Cell. Garland Science, 2014.

VIROLOGY

PAPER CODE:MI-803C1
Credit: 4

Course Otucome:

- Basics of virus of human improtance ranging from plant to animal viruses that may affect daily life are taught. Newly emerging viruses are also discussedIs able to describe classification of viruses
- Student will be able to describe tools for studying virus structure, process of virus attachment and entry, virus assembly and release
- Student will be able to describe steps in replication of genome of RNA viruses, retroviruses, and DNA viruses
- Student will be able to describe steps in virus infection, transmission, patterns of infection, virus virulence, and host defense against virus infection
- Student will be able to describe methods of making virus vaccines and anti-viral drugs, drivers of virus evolution, and emerging viruses
- Student will be able to describe unusual infectious agents, virus mediated cellular transformation and oncogenesis
- Student will be able to describe evasion strategies used by viruses, and learn to apply their knowledge to investigate virus outbreak

UNIT 1: INTRODUCTION TO VIROLOGY:

The Big Picture of all viruses using a common strategy. Virus classification.The infectious cycle, Studying Virus infection.Koch's Postulates for viruses. Virus Genome and Genetics: Virus genome types. Double stranded DNA (dsDNA). Gapped DNA genomes.Single-stranded (ssDNA) genomes. Double stranded RNA (dsRNA). Single stranded RNA (ssRNA): (+) strand RNA. Single stranded (+) sense RNA with DNA intermediate. Single stranded RNA (-) sense. Ambisense RNA genomes.

Unit II: Virus Structure:

Metastability, The tools for viral structural biology.Helical Symmetry. Icosaheda lsymmetry.Triangulationnumber. Quasi-equivalence. Attachment and Entry.Initiation of infection.Affinity. Avidity.Cellular receptor for viruses.Getting into the Nucleus.Disassembly. RNA directed RNA synthesis, Reverse Transcription & Integration, Translation: Identification of RNA polymerase. How RNA synthesis occurs in viruses? Reverse transcriptase.Retrovirus genome organization.Steps of DNA synthesis in Retroviruses. Genomic replication of DNA viruses: Basic rules of genome replication in DNA viruses. Viral origins of DNA replication.Generic steps in Transcription. Host Polymerases. Initiation.Splicing.Alternatesplicing.PromoterStructure.Steps in Regulation of transcription.Enhancers. Virus coded transcriptional regulators. Transcriptional cascade.Export. Virus Assembly: Metastable structures. Concentrating components for assembly.Getting things to the right place. How do Virus make Sub-assemblies. Sequential and Concerted assembly. Packaging signals. Packaging of segmented genome.Acquisition of an envelope.Budding strategies.

UNIT III: VIRUS HOST INTERACTIONS AND ANTI VIRAL DRUGS

Virus Infection basics: Fundamental question of viral pathogenesis, Virion defenses to hostile

environment. Viral spread. Viremia.Determinants of tissue tropism.Virus shedding.Transmission of infection.Host defense.Innate Immune response. Virus Virulence.Toxic viral proteins. Virus induced auto-immunity. Acute Persistent Infections: General pattern of infection. Defense against the acute infection.Influenza.Polio.Measles.Rotavirus. Persistent Infection.Chronic vs. Latent Infection. Vaccines & Anti-Viral drugs: Herd Immunity. Requirement of an effective vaccine.Inactivatedvaccine.Subunit vaccines. Live attenuated vaccines. Polio eradication.Anti-Viral drugs. Search for antiviral drugs. Antiviral screening.Resistance to antiviral drugs.

UNIT IV: UNUSUAL INFICTIOUS AGENT AND INVESTIGATION OF A VIROUS OUTBREAK:

Unusual Infectious Agent: Viroids. Origin of Viroids.Satelites.Prions.Transmissible spongiform encephalopathy (TSE) caused by prions.Prion hypothesis.Prion Species barrier. Investigation of virus Outbreak: Case study of health risk associated with a virus epidemic. The origin of outbreak, the spread, the intervention strategies, public health response.

Suggested reading:

1. Principles of Virology: Molecular Biology, Pathogenesis and Control of Animal Viruses by S.J. Flint, L.W. Enquist, V.R. Racaniello, and A.M. Skalka. 2nd edition.ASM Press.2004.
2. Introduction to Modern Virology EPZ by N. Dimmock, A. Easton and K. Leppard. 5th edition. Blackwell Publishing.2005.
3. Basic Virology by Edward K. Wanger, M. Hewiett, D. Bloom and D. Camerini. 3rd edition. Blackwell Publishing.2007.
4. Principles of Molecular Virology by A.J. Cann. 3rdedition. Elsevier Academic Press.2001.

PRACTICAL

PAPER CODE:MI-804C
Credit: 4
Course Outcomes:

- Practical relevant to the theory courses are designed so as to give the students hands on experiential learning.
- The Practical are designed to understand the routine research and industrial processes as far as possible in the purview of the academic laboratory conditions.

1. Separate serum from the blood sample, Separation of serum protein by vertical gelelectrophoresis.
2. Determination of Molecular weight of Protien by Column chromatography.
3. Plasmid isolation.
4. Bacterial Transformation.
5. Genomic DNA isolation, quantification, purity analysis.
6. Study of UV absorbance spectra for Protien and DNA.
7. Polymerase chain reaction using the isolated DNA as template.
8. Agarose gel electrophoresis of PCR product.
9. Gel purification of PCR product.
10. Ligation of PCR product into plasmid Vector.
11. Preparation of competent cells by calcium chloride method.
12. Transformation of ligated product into host by heat shock method.
13. Preparation of competent cells by glycerol method.
14. Transformation of ligated product into host by Gene Pulsar (Electroporation).
15. Demonstration of α-complementation of β-galactosidase through blue white colonies.

Reference/Text Books:

1. Sambrook J, Fritsch Ef, Maniatis T. (1989). In: Molecular coloning: A Laboratory Mannual(2^{nd}ed). CSH Press,USA.
2. R.W.Old& S.B. Primrose (1990) Principles of Gene Manipulation: An Introduction to Genetic Engineering. ClackwellSciencLtd.
3. Protien purification: Principles and Practice by Robert Scopes. Springer Advanced Texts in Chemistry.1993.

BIOPHYSICAL AND BIOCHEMICAL METHODPAPER CODE:MI-805E2
Credit: 4

Course Outcomes:

- The course is to introduce the student to the variety of biophysical and biochemical techniques currently available to probe the structure and function of the biological macromolecules,

- Make student aware of the physical principles behind each technique and the instrumentation involved; make them familiar with various methods of analyzing the output data.

UNIT-I: CHROMATOGRAPHIC TECHNIQUES

Chromatography: Introduction, Principle of separation/isolation of particular substance, Basic Principle and applications: of gel filtaration chromatography, Matrix for of gel filtaration chromatography, operation of gel filtaraion chromatography, ion exchange: principle, types, parameters for choosing right matrix, applications, affinity chromatography: principle, advantages of affinity chromatography, types, choise of matrix, operation and application, gas liquid chromatography:principle, applications, high pressure/ performance liquidchromatography(HPLC).

UNIT-II: ELECTROPHORETIC TECHNIQUES

Basics of electrophoresis: electrophoretic mobility and affecting factors, Biological application and interpretation of different types of electrophoresis: PAGE, gradient gel, Agarose Gel Electrophoresis, 2D Electrophoresis, iso-electric focusing, gradient electrophoresis; pulsed field gel electrophoresis, blotting techniques:southern, northern, westrern.

UNIT-III: SPECTROSCOPIC TECNIQUES

Spectroscopy, The nature and properties of electromagnetic radiation, Electromagnetic spectrum, Principle of spectroscopy, interaction of electromagnetic radiation with matter, Energy level, molecular orbital theory, Electronic transition, chromophores, UV/Visibles spectroscopy, Beer-Lambert Law, application of UV/Visible spectroscopy, infaredspectroscophy, applications, fluorescence spectroscopy, characteristics of fluorescence, resonance energy transfer,applicatons.

UNIT-IV: FLOWCYTOMETRY

Optics: Forward Angle Light Scatter, Side Scatter Channel, Properties of FSC& SSC, fluorescence Channels, Optical Design, FSC & SSC Dot Plot, Types of Mesasurements, Flourescent Dyes and Antibodies, Fluorescence and Fluorochrome. Principles of Fluorescence, Excitation Spectra of Fluorochromes, Emission spectra,applications.

Reference/Text Book:

1. Instrumental methods of analysis. 6th edition by H.H Willard, L.L. Merrit Jr. and others. 1986.CBS Publishers anddistributors.
2. Spectroscopy. Volume 1. Edited by B.B. Straughan and S. Walker.Chapman and hallLtd.
3. Gel Electrophoresis of protiens – A practical Approach byHanes.
4. Chromatography: Concepts and Contrasts -1988 by James Miller. Jhon Wiley and Sons.Inc. , NewYork.
5. Introduction of High performance Liquid chromatography by R.J Hamilton and P.A .Sewell.
6. Spectroscopy by B.P.Straughan and S.Walker.
7. Practical aspects of gas chromatography and Mass Spectrometry 1984 by Gordon M. Message, Jhon Wiley andSons.NewYork.
8. Gel chromatography by Tibor Kremmery. WilyPublications.
9. Isotops and radiations in Biology By C.C. Thornburn, Butterworth and Co. Ltd.,London.
10. The Use of Radioactive isotopes in the life sciences by J.M.Chapman and G.Ayrey,

George Allen and Unwin Ltd.,London.
11. A.L. Lehninger, Principles of Biochemistry, 4th edition, W.H Freeman and Company,20014.
12. Alberts, AJhonson, J Lewis. Molecular, Biology of cell. Garland Science,2014.
13. Online Biophysics. V Bloomfield. Pdf. NCBIWebsite.

MICROBIAL BIOREACTOR FOR WASTE WATER TREATMENTPAPER CODE:MI-806E1
Credit: 4

Course Outcomes:

- After completing this course a student would know the factors that lead to formation of regulations for water quality management.
- The students would know the process for fresh water and wastewater treatment, with an understanding about the point of care in each case.
- The student would be trained to work in water quality assessment/water treatment facilities in industries.
- The student would have idea about the advantages and limitations of the different types of bioreactors used in water treatment.

Unit I:

History of Waste water treatment/management: Regulation of discharges to water: Clean Water Act (CWA), Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), the emergency planning and community right to know act, Pollution Prevention act 1990, an approach to problem solving: a six step method.

Unit II:

Water and Waste water characteristics: Essential Biology Concepts, Ecology, Limnology; Water supply and treatment; Physical, Chemical (inorganic, organic) and biological characteristics of waste water and Collection.

Unit III:

Waste Water Treatment-Conventional Physico Chemical Methods, Biological Methods of Treatment of Waste water; Non-potable applications of treated waste water, Case study of Waste Water Treatment with high as well as low C/N Ratio.

Unit IV:

Reactor types: suspended growth reactors; batch reactor; continuous- Flow stirred Tank Reactor; membrance reactor; rotating drum reactors; biofilm reactors; aerobic granular sludge reactor.

Reference/Text Book:

1. Environmental Engineering Principles and Practice by Richard O Mines, Jr, WileyBlackwell
2. Environmental Pollution Control Microbiology by Ross E McKinney, Marcel Dekker,Inc
3. Handbook of Water and waste water treatment plant operations, 3rd Edition by Frank R. Spellman, CRC Press, Taylor and FrancisGroup.
4. Sustainable Water Engineering Theory and Practice by Chandrappa and Das,Wiley.

5. Water Resources An integrated approach by Joseph Holden, Routledge, Taylor and FrancisGroup.

6. Drinking Water Quality Problems and Solitions, 2nd Ed, N F Gray,Cambridge.

7. Waste Water Treatment Technologies: A general Review; Economic and Social Comission for Western Asia. United Nations, New York, 2003,url:

8. Environmental Biotechnology Principles and applications. Bruce E Rittman and Perey L McCarty. TataMcGraw hill Edition (2012) ISBN.10:1-25-900288-8.

INNOVATIVE CONCEPT DEVELOPMENT

PAPER CODE:MI-808E
Credit: 4

Course outcomes:

- This course would teach a student to identify problem and solve it from an entrepreneur's perspective.
- It teaches them to analyze the patentability and the commercial value of a solution.
- It adequately trains them for better communication skills with industry interaction.

UNIT-I
What is innovation, identify customer/societal needs, design thinking skills, environmental sustainability. Identifying a problem, understanding the available solutions, developing an innovative solution.

UNIT-II
Basics of intellectual property rights; patents with reference to Life science. Drafting of patent proposals. Industrial visit/Industry interaction for problem identification, understanding skill requirement and proposing innovative solutions.

UNIT-III
Case study on technology development for i) screening of antimicrobial agents, ii) improved ecofriendly raw material production for textile and other applications, iii) conversion of waste to value added products, iv) wastewater treatment for municipal sewage and aquaculture.

UNIT-IV
Pitching of the idea: The dragonfly effect, wing 1- the single focus goal, wing 2- grab attention, wing 3- engage, wing 4- Enable action. The final story: the power of storytelling, Business Plan Development.

Internal Assessments: As per the course Instructor
Final Assessments: Presentation of the concept developed by the groups/individuals.

Reference:

1. **Purple Cow**, New Edition: Transform your Bussiness by being Remarkable: Seth Godin:Books.
2. The Pumkin Plan: A simple strategy to grow a remarkable business by MikeMichalowicz.
3. Intellectual property the law of copyrights, patents and trademarks, By Schechter, Rogher E. & Thomas, Jhon R.
4. Dragonfly effect workbook: The power of stories by Andy Smith, Barbara McCarthy and Jennifer Aaker

BACTERIA AND CHRONIC INFECTIONS

Paper Code: MICB906E
Credits:4

Course Outcomes:

- Bacterial infections that caused due to biofilms are chronic in nature and are now recognized to a big threat to human health. Understanding biofilms and associated infections, their diagnostics and treatment options gives students an idea about latest in the field of bacteriology and infections.

- Student will be introduced to bacteria and infections in general, including the difference between planktonic and biofilm growing bacteria

- Student will learn about the specific properties of biofilms and chronic infections.

- Student will Learn about Bacteria and biofilms as natural inhabitants of our body and will be discussing their role on our health.

- Student will become aware of several types of chronic infections and how biofilms are related to them

Unit1. Introduction to Infections; Properties of Biofilms and Chronic Infections

1.1 Planktonic and biofilm Growing bacteria;
1.2 Infection pathogenesis
1.3 Bacteria and Biofilms
1.4 Biofilm properties
1.5 Chronic infections–Host response part1
1.6 Chronic infections–Host response part2
1.7 Chronic infections–Treatment Failure
1.8 Chronic Infections - persistency

Unit 2. Bacteria and biofilms as natural inhabitants of our body; and biofilms in chronic infections

2.1 Introduction
2.2 Oral biofilms
2.3 Skin Microbiology
2.4 Commensal Biofilm-gutflora
2.5 Bacteria and Biofilms are ubiquitous
2.6 Cystic fibrosis
2.7 Chronic wounds
2.8 Implants
2.9 Tissue filler
2.10 Otitis Media
2.11 Intra vascular catheters

Unit3.Diagnosis and treatment of chronic infections

3.1 Diagnosis of chronic infections
3.2 Treatment of chronic infections– part1
3.3 Treatment of chronic infections – part 23.4Diagnosis in clinical Practices

Unit4.Evolutionaryperspectivesofbiofilms

4.1 Adaptation of bacteria to chronic infections
4.2 Evolution of biofilms–part1
4.3 Evolution of biofilms–part2
4.4 Adaptation and evolution in bacteria

Reference/TextBooks/Articles:

1. Tony Romeo. *Bacterial Biofilms.* Current topics in Microbiology and Immunology. Springer
2. Jean F Brisou. *Biofilms: Methods for Enzymatic release of Microorganisms*. Taylor and Francis
3. Pallaval Veera Bramhachari. *Implication of Quorum Sensing System in Biofilm Formation and Virulence.* Springer
4. Jose Luis Del Pozo (2017): *Biofilm-related disease*, Expert Review of Anti-infectiveTherapy,DOI: 10.1080/14787210.2018.1417036
5. Lebeaux D, Chauhan A, Rendueles O, Beloin C. *From in vitro to in vivo Models of Bacterial Biofilm-Related Infections.*Pathogens.2013May13;2(2):288-356.doi:10.3390/pathogens2020288.
6. Lebeaux D, Ghigo JM, Beloin C. *Biofilm-related infections: bridging the gap between clinical management and fundamental aspects of recalcitrance toward antibiotics.* Microbiol Mol BiolRev.2014Sep;78(3):510-43.doi:10.1128/MMBR.00013-14.

TOOLS AND TECHNIQUES OF MOLECULAR BIOLOGY AND BIOINFORMATICS

PAPER CODE:MI-901C1
Credit: 4
Course Outcomes:

- Student will be able to explain the structural principles governing the protein structures and their classification Identify key motifs and domains in protein structures, and their interaction with ligands or substrates;

- Student will be able to explain the basic principles of thermodynamics and their implications in biological reactions,

- Student will be able to discuss the interactions of proteins and other macromolecules along with methods for their identification,

- Student will be able to explain the basics of determination and prediction of three-dimensional structure of proteins,

- Student will be able to describe significance of studying global gene expression profile changes to get insights into and understand response of a living organism to biotic, abiotic, disease, course of development, senescence

UNIT-IIIBASICS OF DNA TECHNOLOGY

Introduction to PCR; primer designing, Types of PCR - multiplex, nested, reverse transcriptase, real time PCR, touchdown PCR, hot start PCR, colony PCR, cloning of PCR products PCR amplification of 16SrDNA,Agarose gel analysis.

UNIT-IV: MOLECULAR TOOLS AND TECHINIQUES

Transformation techniques. Genomic libraries- Isolation of genomic DNA fragments, selection of vectors, cDNA libraries and cDNA cloning, shot gun cloning, Bacterial Artificial libraries.Bacterial Transcriptome Analysis, TA cloning, Artificial chromosome vectors (YACs; BACs); Metagenomics, Primer design, AFIGE, PFGE, ARB for bacterial strain identification. Community analysis: Direct and indirect method, RAPD, RFLP, TDDG, DGGE for communityAnalysis

UNIT III: RETRIEVING INFORMATION THROUGH SEQUENCE ALIGNMENT ANDPHYLOGENETIC TREE

Database indexing and specification of search terms, the archives: nucleic acid sequence database, genome database and genomic browsers, protein sequence database, databases of structures, classification of protein structures, accuracy and precision of protein structure determination.
Submission and retrieval of Data in GenBank.Basic principle of genome assemby and annotation. Scoring matrices for nucleic acid and protein sequence analysis: PAM, BLOSSUM. Pairwise and multiple sequence analysis.Database searching using BLAST, Phylogenetic analysis.

UNIT IV: STRUCTURAL BIOINFORMATICS AND DRUG DISCOOVERY

Protein stability and folding, Sasisekharan-Ramakrishnan-Ramchandran plot, protein stability and denaturation, superposition of structures and structure alignment DALI & MUSTANG. Evolution of protein structures, protein structure prediction and modelling, prediction of protein function, divergence of function orthologues and prologues; drug discovery and development, lead compound, improving on the lead compound, Quantitative Structure Activity Relationship(QSAR) Molecular modelling in drug discovery.

Reference/ Text Book:

1. S.B. Primrose, R.M. Twyman and R.W.Old; Principles of Gene Manipulation. 6th Edition, S.B.University Press,2001.
2. J. Sambrook and D.W. Russel; Molecular Cloning: A Laboratory Manual, Vols 1-3, CSHL,2001.
3. Brown TA, Genomes, 3rd ed. Garland Science2006
4. Benjamin Lewin, Gene IX, 9th Edition, Jones and Barlett Publishers,2007.
5. J.D. Watson, N.H. Hopkins, J.W Roberts, J. A. Seitz & A.M. Weiner; Molecular Biology ofthe Gene, 6th Edition, Benjamin Cummings Publishing Company Inc,2007.
6. Alberts et al; Molecular Biology of the Cell, 4th edition, Garland,2002.
7. Molecular Genetics An Introductive Narrative by G S Stent and R Calender, San Francisco, Calif.:W.H. Freeman, 1978.
8. Introduction to Bioinformatics Arthur M. Lesk Oxford University Press (2014)ISBN978-0-19- 872467-4
9. An Introduction to R, Notes on R: A Programming Environment for Data Analysis and Graphics Version 3.3.1 (2016-06-21) by W. N. Venables, D. M. Smith and the R CoreTeam.

PRACTICALS

PAPER CODE:MI-902C
Credit: 4

Course Outcomes:

- This course covers the advanced techniques of applied microbiology and bioinformatics.
- It trains the students how to design an experiment using the techniques they have learned in the first two semesters and come up with a solution to a applied microbiology problem.
- It gives them exposure to medical microbiology as well as industrial microbiology, making them better equipped for their final semester MSc project as well as to get absorbed in industry/ research after MSc.

Section-A

1. Understanding the cultivable microbes from dental Flora.
2. Standardization of technique for sampling the dental flora
3. Growing the dental micro-flora in the selected media & determination of
(a) pre-incubation time&
(b) requisite dilution to get the CFU count and diversity estimate.
4. Isolation, purification, Characterization of dental micro-flora, & antibiotic sensitivity test.
5. In-vitro set up for testing antibiotic therapy in case of dentine tissue or teeth.
6. Visualization of the teeth surface using Scanning Electron Microscope.
7. To find out the relative proportion of Lactic Acid Bacteria from natural sources.
8. Isolation of acid producing bacterial from various natural sources like grass, intestine of fish and prawn, curd, fermented fish, bee hive, etc.
9. Characterization of isolates.
10. Testing for biofilm formation by the isolate.
11. Production of Lactic acid from whey in packed bed reactor.

Section-B

1. Gene sequence downloading from genedatabase.
2. NucleotideBLAST.
3. Comparison of gene sequence using alignmenttool.
4. Amino acid sequence of protein downloading fromdatabase.
5. ProtienBLAST.
6. Comparison Amino acid sequence of proteinusingalignmenttool.
7. Computation of instability index ofprotiens.
8. Computation of aliphatic index ofprotiens.
9. Prediction of phosphorylation sites in theprotiens.
10. Computation of hydrophobicity ofprotiens.

FERMENTATION TECHNOLOGY AND FERMENTED FOOD

PAPER CODE:MI-903E2
Credit: 4

Course Outcomes:

- Students will be able to understand the role and potential of fermented foods and the contribution of bacteria and yeast in improving the food quality and self-life after fermentation.
- They will learn how bacteria may help restore the balance of microflora in your gut, support digestive health and alleviate any digestive issues.
- They will develop understanding that when we ferment certain types of food, we help increase their health potential. This includes making the vitamins and minerals and also, they are more available for our bodies to absorb. Additionally, by boosting the beneficial bacteria in your gut, you may promote their ability to manufacture B vitamins and vitamin K.
- Students will able to have insight about the different types of fermented food of Northeast India and their places of origin and its traditional and cultural aspects.
- Students will learn about the equipment's, fermentation vessels and different tools and techniques of industrial fermentation and fermentation technology.
- Students will learn about the different fermented based industrial and pharmaceutical enzymes, organic acids, Biopolymers, amino acids, and alcohol-based products of market importance produced by fermentation technology.

UNIT I: INTRODUCTION TO FERMENTATION TECHNOLOGY

Origin and History of food fermentation; Basics of fermentation processes; Microbial culture selection for fermentation process.Media formulation, innoculum development and process optimization; Significance of substrates and starter culture; Basic requirements for fermentation and factor affecting fermentation process.Gaden's Fermentation classification, Design and operation of Fermenters, Basic concepts for selection of a reactor, Packed bed reactor, Fluidized bed reactor, Trickle bed reactor, Bubble column reactor, Scale up of Bioreactor.

UNIT II: TYPES OF FERMENTATION AND PRODUCT RECOVERY

Types of fermentation- (sub-merged/solid state, Batch /continuous fermentation);
Downstream processing.Recovery of particular matter, product isolation, distillation, centrifugation, whole booth processing, filtration, aqueous two-phase separation, solvent extraction, chromatography and electrophoresis.Bioprocess economic and Bioproduct regulation.

UNIT III: TRADITIONAL FERMENTED FOOD AND BEVERAGES

Health benefits and other significance of fermented food and beverages; traditional fermentation of Asia and North East India; Food habits and types of their fermented food; Fermented vegetable

(Fermented beans Sauerkraut, Kimchi, Pickle, bamboo shoots); Fermented soyabean products-(Temph, Tofu, Soya sauce); Fermented dairy products (Cheese, Dahi and Yogurt, Butter); Fermented baked product (bread and bakery products) Other fermented food products (Idli, Vada, Dosa, Bhatura, Dhokla); Fermented fish, meat and sausages; Fermented beverages (Sake, Rice beers, Ale, Wines).

UNIT IV: INDUSTRIAL APPLICATION OF FERMENTATION TECHNOLOGY

Fermentation process for Production of SCP; Production of Industrial alcohol (Ethanol and Butanol); Organic acids (Citric acid, Lactic acid, Glutamic acid);Amino acids (Lysine, Phenylalanine, Tryptophan);Biopolymers (Dextran, Xanthan); Antibiotics (cephalosporin's, Tetracycline's, Polyenes); Enzymes (Alpha-amylase, Lipase, Pectinases, Proteases); Vitamins (Vitamin B12 and Riboflavin); Alcoholic beverages (Toddy, Beer, Wine, Champagne, Rum, Brandy,Whisky).

Reference/Text Book:

1. Food Microbiology by William Frazier, DanniseWesthoff, McGraw-Hill.Inc.
2. Microbial Physiology and Metabolism by Caldwell D.R. 1995BrownPublishers.
3. Microbial Physiology by Moat A.G. and Foster J. W. 1999..Wiley.
4. Advances in Microbial Physiology. Volumes. Edited by By A.H. Rose. Academic Press, NewYork.
5. Principles of Fermentation Technology, 3rd Edition byStanbury& Whitaker & Hall, Butterworth- Heinemann, Elsevierscience.
6. The Art of Fermentation by SandorEllix Katz, Chelsea Green Publishing(2012).
7. Mastering Fermentation by Kate Williams, Oxfordpublishing.

MICROBIAL ADAPTATION

PAPER CODE:MI-904E1
Credit: 2

Course Outcomes:

- The course cover all tactics and strategies adopted by bacteria for their survival under stressed conditions and focused on mechanistic insights of pathogenic adaptations to host environments (acidic environment, microaerobic conditions, immune system stress, metal stress etc., modulation of host pathways by pathogens for survival, dormancy, drug tolerance and resistance, proteins for stress survival).
- This course also include different adaptation mechanisms of extremophiles to extreme environment.

UNIT-I: ADAPTATION OF EXTREM ENVIRONMENT

Adaptations to pH, Temperature adaptation, Pressure adaptation, Halophilic adaptations.

UNIT-II: PATHOGENIC ADAPTATION TO HOST ENVIRONMENT

Adaptation to acidic environment, Adaptation to Microaerobic conditions, Adaptation to immune system stress. Adaptation to Metal stress.

UNIT-III DORMANCY, DRUG TOLERANCE ANDRESISTANCE

Growth regulation by microbes, Survival and reactivation strategies of pathogens in stressthrough heterogeneous population generation, Persisters, antimicrobialresistance.

Reference:

1. Protien adaptation in Extremophiles: January 2008, Publisher: Nova Biomedical, ISBN: 1604560193.
2. Extremophiles and Their Applications in Medical Process: ISBN: 978-3-319-12808-5
3. Tuberculosis and the Tubercle Bacillus, Second Edition, ISBN:9781555819552
4. Reviews and research articles related to topics will be suggested duringcourse.

BACTERIAL SECRETION SYSTEM AND BACTERIAL QUORUM SENSING

PAPER CODE:MI-905E
Credit: 2

Course outcomes

- Secretion systems are important to understand a very common problem of antibiotic resistance. Quorum sensing helps to understand an important phenomenon of bacterial pathogenesis i.e. biofilms that are recalcitrant to antibiotics.

- Student will be able to understand different secretion systems existing in bacteria for toxins and biomolecules secretion, and their role in bacterial survival and pathogenesis.

- Student will be able to gain in-depth knowledge about density-based signal transduction in bacteria and its significance in competence, sporulation and antibiotic resistance;

- Student would know about quorum quenching and its use in developing antimicrobial tools.

UNIT-I: BACTERIAL SECRETION SYSTEM:

Introduction; Sec secretion pathway; SecB secretion Pathway; SRP pathway; Tat Pathway; Type I, Type II, Type III (T3SS; injectisome, injectosome), Type IV, Type V, Type VI; Sec A2, Sortase and Type VII secretion systems.

UNIT-II: QUORUM SENSING:

Discovery; Role in as illustrated by bioluminescence (vibrio fischeri, Vibrio harveyi); Virulence (Pseudomonous aeruginosa, Staphylococcus); Competence and Sporulation (Bacillus subtills) and antibiotic resistence in bacteria. Quorum quenching: Impact and mechanism.

Reference/Text Book:

1. Prescott's Microbiology by J. willey, L. Sherwood and C.J. Woolverton. 10th edition. McGraw Hill Education.2017.
2. Brock Biology of Microorganisms by M. Madigan, K. Bender, D. Buckley, W. Sattley, D. Stahl. 15th Edition. Pearson Education.2018.
3. Alcamo's Fundamentals of Microbiology by J.C. Pommerville. 10th Edition. Jones and Bartlett Learning.2013.
4. General Microbiology By R. Stanier, J.C. Ingraham, M. Wheelis, R. Painter. 5th Edition. Macmillan, Hampshire & London Publishers.1992.
5. Microbiology By M. Pelczer, E. Chan & R. Reid. 4th Edition. McGraw Hill Education.1998.

PROJECT WORK

PAPER CODE:MI-905C1
Credit: 4

Course Outcomes:

- Students are allotted research projects under different faculties in the department.
- Student has to carry out the literature search and propose the objectives along with the material and methods to carry out the research project.
- This course gives student hands on training on designing, planning and execution of research oriented experiments in timely manner, thus, giving them opportunity to learn meeting the deadlines.
- It enhances the critical thinking relevant to the program taught

UNIT-I PREPARATION OF SYNOPSIS

Introduction and Identification of the problem, Review of literature, Definition of the problem and logical development of a working hypothesis.

UNIT-II METHODOLOGY

Formulation of objectives and experimental design for verifying the hypothesis, standardization of methodology and modifications if any in the protocol.

UNIT-III CONDUCTING EXPERIMENTS AND REPORTING THE FINDINGS

Phase wise working for experimental findings and observation, soft copy report with statistical analysis, result and discussion of the findings, Group discussion and rectification, pre-submission through departmental seminar.

NB: Evaluation for part one will be done on:

1. ***Presentation of Synopsis its objectives, expected outcome, and methodology indetail.***
2. ***Assignment for review of literature related to proposedwork.***

RECENT TRENDS IN ANTIMICROBIAL RESEARCH

PAPER CODE:MI-1001E1
Credit: 4

- **Course Outcomes:**

- Students will able to understand why antimicrobial resistance a global concern.

- Students will also develop the understanding that the emergence and spread of drug-resistant pathogens that have acquired new resistance mechanisms, leading to antimicrobial resistance, continues to threaten our ability to treat common infections.

- Students will develop the insight that the Information obtained from antimicrobial surveillance studies is important for establishing trends in pathogen antimicrobial resistance and for identifying emerging pathogens at the national and global levels.

- Students will also have an insight that such information enables the development of targeted approaches to help control antimicrobial resistance.

- Students will able to know about the recent trends and developments in the field of antimicrobial drugs and resistant microbes.

UNIT I: ANTIMICROBIALS

An outline of the historical development of antimicrobial agents.Reasons for studying the biochemistry and molecular biology of antimicrobial compounds.Uncovering the molecular basis of antimicrobial action.Current trends in the discovery of antimicrobial drugs. Antimicrobial assays in liquid and solid media, susceptibility testing in liquid and solid media.

UNIT II :MODE OF ACTION OF ANTIMICOBIALS

Antibiotics that inhibit peptidoglycan biosynthesis.Drugs that interfere with the biosynthesis of the cell wall of mycobacteria.Fungal cell wall as a target for antimicrobial drugs.Ionophoricantibiotics.Antifungal agents that interfere with the function and biosynthesis of membrane sterols. Inhibitors of nucleic acid biosynthesis. Inhibitors of protein biosynthesis.Nitro-heterocyclic antimicrobial agents. A unique antifungal antibiotic -griseofulvin.

UNIT-III DRUG RESISTANCE

The Concept of Drug resistance, Multi Drug Resistance; Types of antimicrobial drugs and associated problems of drug Resistance.Mechanisms of bacterial resistance to host cellular and humoral defenses.

UNIT IV: MICROBIAL PATHOGENECITY AND EPIDEMIOLOGY

Virulence factors: Mechanism of adhesion, colonization and invasion of host tissues by bacterial pathogens, measurements of virulence. Microbial toxins: Characteristics, purification, Mode of action and assay (in vivo, in vitro) of diphtheria, cholera, tetanus toxins and endotoxins of Gram-negative bacteria.

Reference/Text Book:

1. Burn J. H. (1957) Principles of Therapeutics, Blackwell Scientific Pub. O. Ltd.Oxford.
2. Iyengar M. A. (1974) Pharmacology of Powdered Crude Drugs,Manipal.
3. Kokate C. K., Purohit A. P., Gokhale A. B. (2000) Pharmacology, 4 Ed.,NiraliPrakashan.
4. OsolArther (1975) Remington's Pharmaceutical Sciences, 15 Ed., Mack Pub. Co.,Pennsylvania.
5. Goldstein A., Aronow L., and Kalman S. M. (1969) Principles of Drug Action, The Basis of

Pharmacology, Harper international edition New York.
6. Satoskar R. S. & S. D. Bhandarkar (1991) Pharmacology and Pharmacotherapeutics,12Popular Prakashan,Mumbai.Ed., Vol. 1 & 2,
7. Chatwal G. P. (2003) Biopharmaceutics and Pharmacokinetics, Himalaya Publishing House,Mumbai.
8. Micheles P. S., Y. L. Khmelnitsley, J. S. Dordick and D. S. Clark, (1998), Combinatorial Biocatalysis, A Natural Approach to Drug Discovery, Trends in Biotechnol. 16,197.
9. Virulence mechanisms of bacterial pathogens (Second edition) by Roth, Bolin, Brogden Minion and Michael.
10. Medical Microbiology: AnIntroductiontoinfectiousdiseases.Sherris, JohnC,Ed,ElsevierPublication 2ndII edition.
11. Multidrug resistance. Annu Rev Biochem.2009; 78: 119–146. doi: 10.1146/annurev.biochem.78.082907.145923.

PROJECT WORK

PAPER CODE:MI-1004C1
Credit: 8

Course Outcomes:

- Student has to carry to finish the experimental part under the supervision of a mentor faculty from the department.
- Students are also sent to collaborative laboratories/Industries for successful execution of the allotted Project.
- The Projects allotted are designed by the Faculties of the Department based on their research expertise.
- This course gives student hands on training on designing, planning and execution of experiments in timely manner, thus, giving them opportunity to Learn meeting the deadlines.

UNIT-I: CONDUCTING EXPERIMENTS AND REPORTING THE FINDINGS

Phase wise working for experimental findings and observation, soft copy report with statistical analysis, result and discussion of the findings, Group discussion and rectification, pre-submission through departmental seminar.

UNIT-II: PREPARATION OF FINAL DISSERTATION

Preparation of final dissertation under the following heads and submission in hard and soft copy: Preface, Certificate, Contents, Introduction, Review of literature, Materials and methods, Experimental findings or Results, Discussion and References. Appendices- Statistical tables etc.

UNIT-III: PREPARATION OF MANUSCRIPT FOR A RESEARCH PAPER

Preparation of manuscript with reference to an International/ National journal on Science or microbiology or related to specific subject matter for publication.

NB: Evaluation for part two will be done on:

1. ***Preparation of manuscript for a research paper and its communication in ajournal***
2. ***Preparation of final dissertation***
1. ***PowerPoint Presentation of overall work of theproject***