UNIVERSITY OF KALYANI

SYLLABUS FOR MICROBIOLOGY (MAJOR)

UNDER

CURRICULUM AND CREDIT FRAMEWORK

FOR

UNDERGRADUATE PROGRAM

(WITH EFFECT FROM THE SESSION 2023-24)

University of Kalyani
Course-wise Content of the Syllabus
UG Major in Microbiology

SEMESTER-I	
COURSE CODE	**MB-M-L-01**
COURSE TITLE	**INTRODUCTION TO THE WORLD OF MICROBES (THEORY)**
CREDIT	**4**
FULL MARKS	**50**
COURSE OUTCOME	• Basic introduction to the subject is provided to students • Students will learn basic terminology related to microbiology • Students will get conceptual understanding of Microbiological world • Foundation for microbiological laboratory practice will be given to students
CONTENT	**Unit 1: Introduction, History and Scope of Microbiology-** General concept of microbes, their distribution and dimension. History and scope of microbiology as a modern science. Branches of Microbiology. Contribution of Scientists to the field of Microbiology - Antony Von Leewenhoek, Edward Jenner, Lazaro Spallanzani, Louis Pasteur, Joseph Lister, Robert Koch, Alexander Fleming and Iwanovsky. Theories of origin of life. **Unit 2: Cell organization-** Cell size, shape and arrangements, capsule, flagella and pili, Composition and detailed structure of cell envelope of gram- positive, gram- negative bacteria and archaea. Bacterial Structure, chemical composition and functions of bacterial and archaeal cell membranes, Ribosomes, cellular inclusions, nucleoid,. Plasma membrane:Structure; Cell Wall: Eukaryotic cell wall, Extracellular matrix and cell matrix interactions. Mitochondria, chloroplasts and peroxisomes. Cytoskeleton: Structure and organization of actin filaments, association of actin filaments with plasma membrane. **Unit 3: Stains and Staining Techniques-** Nature of dyes. Physical and chemical theories of staining- Stainingtechniques; principle, procedure and applications: i) Simple staining- negative staining, ii) Differential staining-Grams and acid fast staining, iii) Structural staining- cell wall, endospore, flagella and capsular staining. **Unit 4: Microbial nutrition and culture techniques-** Nutritional requirements of microorganisms -Macronutrients, micronutrients and growth factors. Nutritional types of microorganisms: Autotrophs and heterotrophs, phototrophs and chemotrophs. Physical factors affecting growth of microorganisms: Temperature, pH and Oxygen. Culture media:

	Components of media, Synthetic or defined media, Complex media, enriched media, selective media, differential media, enrichment culture media. Pure culture isolation: Streaking, serial dilution and plating methods, cultivation, maintenance and stocking of pure cultures, cultivation of anaerobic bacteria; **Unit 5: Bacterial Growth:** concept of growth of microorganisms; measurement of growth; Culture system: concept of batch and continuous culture, growth kinetics in batch system emphasizing different phases of bacterial growth, specific growth rate, growth curve, diauxic growth. Counting of bacteria -Viable count, Total count and turbidimetric estimation. **Unit 6: Sterilization and aseptic Techniques-** Definition of terms -sterilization, disinfectant, antiseptic, sanitizer, germicide, microbicidal agents, microbiostatic agents and antimicrobial agent. Evaluation of antimicrobial chemical agents -Tube dilution and agar plate techniques- well method and disk plate method. Physical methods of control - Principle, construction and application of moist heat sterilization- Boiling, Pasteurization, Fractional sterilization, Tyndallization and Moist heat under pressure- autoclave. Dry heat sterilization- Incineration and hot air oven, Filtration- membrane filter and laminar air flows, Radiation- Ionizing radiation and non-ionizing radiation. Chemical methods: Alcohol, aldehydes, phenols, halogen, metallic salts, quaternary ammonium compounds and sterilizing gases as antimicrobial agents. Selection of a chemical agent for practical applications.
COURSE CODE	**MB-M-P-01**
COURSE TITLE	**INTRODUCTION TO THE WORLD OF MICROBES (PRACTICAL)**
CREDIT	**2**
FULL MARKS	**25**
CONTENT	1. Safety measures in Laboratory. 2. Study of student microscope and research microscope -Construction, working principle, care to be taken while using the microscope. Use of oil immersion objective 3. Study of instruments - Autoclave, hot air oven, Laminar air flow bench, Inoculation chamber, inoculation loop and needle, Incubator, centrifuge, pH meter, seitz filter, colony counter, membrane filter and colorimeter/spectrophotometer. 4. Cleaning sterilization of glassware. 5. Study of aseptic and techniques -preparation of cotton plugs for test tubes and pipettes, wrapping of petriplates andpipettes. 6. Staining of bacteria - Simple staining -methylene blue staining; Gram staining. 7. Structural staining -cell wall, endospore staining and capsule staining
SUGGESTED READING	1.Wiley, J.M., Sherwood, L.M. and Woolverton, C.J. Prescott, Harley and Klein's microbiology. McGraw-Hill, New York. 2.Black, J.G. Microbiology: Principles and exploration. John Wiley and Sons, New Jersey.

	3.Pelczar, M.J., Chan, E.C.S. and Kreig, N.R. Microbiology. McGraw-Hill, New York. 4.Cappucino, J. and Sherman, N. Microbiology: A laboratory manual. Benjamin/CummingsPublishing Company, San Francisco. 5.Prescott, L.M. and Harley, J.P. Laboratory exercises in microbiology. William C. Brown,Dubuque. 6. .Aneja, K.R. Experiments in microbiology, plant pathology and biotechnology. New Age International (P) Limited, New Delhi. 7. .Kannan, K. Laboratory manual in general microbiology. Panima, New Delhi. 8. Atlas, R.M., Brown, A.E. and Parks, L.C. Laboratory manual of experimental microbiology. Mosby College Publishing Company, St. Louis. 9. Brock, T. D., Madigan, M. T., Martinko, J. M., & Parker, J. (2003). Brock biology of microorganisms. Upper Saddle River (NJ): Prentice-Hall, 2003..
COURSE CODE	**MB-SEC-T-01**
COURSE TITLE	**FOOD FERMENTATION TECHNIQUES (THEORY ONLY)**
CREDIT	**3**
FULL MARKS	**45**
COURSE OUTCOME	• Developing application skill of Microbiology in fermentation technology • Understanding the basic mechanism of production of fermented foods • Making aware of Health benefits and other commercial aspects of fermentation technology • Provide an orientation to skill based vocational learning
CONTENT	**Unit 1: Fermented Foods-** Definition, types, advantages and health benefits **Unit 2: Milk Based Fermented Foods-** Dahi, Yogurt, Buttermilk (*Chhach*) and cheese: Preparation of inoculums,types of microorganisms and production process **Unit 3: Grain Based Fermented Foods-** Soy sauce, Bread, Idli and Dosa: Microorganisms and production process **Unit 4: Vegetable Based Fermented Foods-** Pickels, Saeurkraut: Microorganisms and production process **Fermented Unit 5: Meat and Fis** Types, microorganisms involved, fermentation process **Unit 6: Probiotic Foods-** Definition, types, microorganisms and health benefits
SUGGESTED READING	1. Adams, M.R., and Moss, M.O. Food microbiology. Royal Society of Chemistry Publication, Cambridge. 2. Frazier, W.C. and Westhoff, D.C. Food microbiology. Tata McGraw Hill, New Delhi. 3. Stanbuty, P.F. and Hall, S.J. Principles of fermentation technology. Pergamon Press,Oxford. 4. Robinson, R.K. Dairy microbiology. Elsevier Applied Sciences, London. 5. James M.J. Modern food microbiology. CBS Publishers and Distributors, New Delhi.

	6. Wood, B.J. Microbiology of fermented foods. Elsevier Applied Sciences, London. 7. Ayres, J.C., Mundt, O. and Sandinee, W.E. Microbiology of foods. W.H. Freeman andCompany, New York. 8. Jay, M.J., Loessner, M.J. and Golden, D.A. Modern food microbiology. Springer Scienceand Business Media, New York. 9. Hui, Y.H., Meunier-Goddik, L., Josephsen, J., Nip, W.K. and Stanfield, P.S. Handbook offood and fermentation technology. CRC Press, Boca Raton
SEMESTER II	
COURSE CODE	**MB-M-T-02**
COURSE TITLE	**MICROBIAL SOCIETY: DIVERSITY AND SYSTEMATICS (THEORY)**
CREDIT	**4**
FULL MARKS	**50**
COURSE OUTCOME	• Student will be able to describe the fundamental concepts and terminology of taxonomic organization and parameters used in classifying bacteria, and the molecular analytic approaches used to classify diverse bacteria. • Student will be able to discuss about the use of rRNA analysis as a means of developing phylogenetic relationships. • Student will be able to describe the major groups of archaea, their stand-out physiological and structural features, as well as their ecological niches and economic significance. • Students will visualize through microscope different types of bacteria, fungi, algae • Students will learn isolation of single cell of bacteria and know preservation techniques for microbes in laboratory
CONTENT	**Unit 1: Microbial Systematics-** General account of systematics, classification and nomenclature;Classification systems-artificial or phonetic, natural and phylogenetic; Species concept in microbiology, monophyletic, paraphyletic, polyphyletic; Newer approaches for exploring non-culturable bacteria-molecular taxonomy, molecular phylogeny, molecular chronometers; Chemotaxonomy; Polyphasic taxonomy, **Unit 2: Phylogeny of prokaryons-** Diversity of more complex unicellular complex microorganisms: Monera (Prokaryote), Protista. Five kingdom domains in Whittaker's system of classification and Archaea, Bacteria and Eukarya, RNA world. Theory of endosymbiogenesis. **Unit 3: An account of prokaryons-** Brief accounts of major subgroups of these classes. The thermophlic, methanogenic and halophilic Archaea; photosynthetic bacteria, Cyanobacteria, Gram positive and Gram negative Eubacteria; including the five classes of Proteobacteria, Spirochetes and Actinomyectes.

	Unit 4: Phycology- General characteristics of algae including occurrence, thallus organization, algae cellular structure, pigments, flagella, eye spot, food reserves and vegetative, asexual and sexual reproduction, General characters of the following classes: Chlorophyta, Xanthophyta, Cyanophyta. Applications of algae in agriculture, industry, environment and food. **Unit 5: An account of eukaryotic microbes-** Fungi including Zygomycetes, Oomycetes, Ascomycetes, Basidiomycetes and Deuteromycetes (imperfect and perfect stages) and Protozoa (*Giardia*, *Entamoeba* and *Plasmodium*). **Unit 6: General Account of Virology**- Discovery of viruses, distinctive property of viruses; morphology and ultrastructure, capsids & their arrangements. Types of envelopes and their composition; viral genome – types and structures; nomenclature and classification of virus (Animal, plant, bacterial viruses). Virus related agents – viriods, prions. Structural organization of bacteriophage; Life cycle – lytic & lysogenic,
COURSE CODE	**MB-M-P-02**
COURSE TITLE	**MICROBIAL SOCIETY: DIVERSITY AND SYSTEMATICS (PRACTICAL)**
CREDIT	**2**
FULL MARKS	**25**
CONTENT	1. Preparation of culture media (Nutrient Broth and Nutrient Agar) for bacterial cultivation 2. Study of *Rhizopus*, *Penicillium*, *Aspergillus* using permanent mounts 3. Study of *Spirogyra*, *Chlamydomonas* using permanent Mounts 4. Study of *Paramecium*, *Plasmodium* using permanent mounts 5. Isolation of pure cultures of bacteria by streaking method. 6. Preservation of bacterial cultures by various techniques. 7. Estimation of CFU count by spread plate method/pour plate method.
SUGGESTED READING	1. Wiley, J.M., Sherwood, L.M. and Woolverton, C.J. Prescott, Harley and Klein's microbiology. McGraw-Hill, New York. 2. Black, J.G. Microbiology: Principles and exploration. John Wiley and Sons, New Jersey. 3. Pelczar, M.J., Chan, E.C.S. and Kreig, N.R. Microbiology. McGraw-Hill, New York. 4. Dimmoc, N.J., Easton, A.J. and Leppard, K.N. Introduction to modern virology. Wiley-Blackwell, New Jersey. 5. Primrose, S.B. Introduction to modern virology. John Wiley and Sons, New Jersey. 6. Cappucino, J. and Sherman, N. Microbiology: A laboratory manual. Benjamin/CummingsPublishing Company, San Francisco. 7. Prescott, L.M. and Harley, J.P. Laboratory exercises in microbiology. William C. Brown,Dubuque. 8. Aneja, K.R. Experiments in microbiology, plant pathology and biotechnology. New Age International (P) Limited, New Delhi.

	9. Kannan, K. Laboratory manual in general microbiology. Panima, New Delhi. 10. Atlas, R.M., Brown, A.E. and Parks, L.C. Laboratory manual of experimental microbiology. Mosby College Publishing Company, St. Louis.
COURSE CODE	**MB-SEC-T-02**
COURSE TITLE	**BIOSAFETY AND INTELLECTUAL PROPERTY RIGHTS (THEORY ONLY)**
CREDIT	**2**
FULL MARKS	**25**
COURSE OUTCOME	• To introduce basic concepts of ethics and safety that is essential for Life Science Labs. • To understand the procedures involved in protection of Intellectual property. • To give an insight into different treaties signed. • To gain knowledge about patent filing. • Developing the skill for the legal aspects of biology that can be applied in future job or research purpose
CONTENT	**Unit 1: Biosafety**- Introduction; biosafety issues in biotechnology; Biological Safety Cabinets & their types; Primary Containment for Biohazards; Biosafety Levels of Specific Microorganisms; Biosafety Guidelines: Biosafety guidelines and regulations (National and International); GMOs/LMOs- Concerns and Challenges; Role of Institutional Biosafety Committees (IBSC), RCGM, GEAC etc. for GMO applications in food and agriculture; Environmental release of GMOs **Unit 2: Introduction to Intellectual Property**- Patents, Types, Trademarks, Copyright & Related Rights, Industrial Design and Rights, Traditional Knowledge, Geographical Indications- importance of IPR – patentable and non-patentable – patenting life – legal protection of biotechnological inventions – World Intellectual Property Rights Organization (WIPO). Grant of Patent and Patenting Authorities: Types of patent applications: Ordinary, PCT, Conventional, Divisional and Patent of Addition; An introduction to Patent Filing Procedures; Patent licensing and agreement; Patent infringement- meaning, scope, litigation
SUGGESTED READING	1. World Health Organization. (2004). *Laboratory biosafety manual*. World Health Organization. 2. Richmond, J. Y., & McKinney, R. W. (2009). Biosafety in microbiological and biomedical laboratories. US Government Printing Office. 3. Chosewood, L. C., & Wilson, D. E. (2009). Biosafety in microbiological and biomedical laboratories. US Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institutes of Health. 4. Joshi, R. (2006). Biosafety and Bioethics. Gyan Publishing House. 5. Rimmer, M. (2008). *Intellectual property and biotechnology: biological inventions*. Edward Elgar Publishing. **6.** Singh, K. K. (2014). *Biotechnology and intellectual property rights: legal and social implications*. Springer.

SEMESTER III	
COURSE CODE	**MB-M-T-03**
COURSE TITLE	**MICROBES AND ENVIRONMENT (THEORY)**
CREDIT	**4**
FULL MARKS	**50**
COURSE OUTCOME	• The student will be able to recall the importance of microbes in any ecosystem with reference to nutrient cycling/ biogeochemical cycling, and biofuels and the role of microbes in mineral recovery. • The student will be able to describe BOD, COD and various methods of waste treatment (solid and liquid) utilizing diverse microorganisms. • The student will be able to describe microbial bioremediation, including petroleum products, microbial degradation of pesticides, plastics and e-waste management for a cleaner environment. • The student will be able to describe the concept of potability of water and demonstrate various tests to check the potability of given water samples. • Students will learn hands-on quality monitoring of different environment and thus understand the basics of environmental sustainability
CONTENT	**Unit 1: Microorganisms and their Habitats-** Structure and function of ecosystems, Terrestrial Environment: Soil profile and soil microflora. Aquatic Environment: Microflora of fresh water and marine habitats, Atmosphere: Aeromicroflora and dispersal of microbes, Animal Environment: Microbes in/on human body (Microbiomics) & animal (ruminants) body. Extreme Habitats: Extremophiles: Microbes thriving at high & low temperatures, pH, high hydrostatic & osmotic pressures, salinity, & low nutrient levels. **Unit 2: Biogeochemical Cycling-** Carbon cycle: Microbial degradation of cellulose, hemicelluloses, lignin and chitin, Nitrogen cycle: Nitrogen fixation, ammonification, nitrification, denitrification and nitrate reduction, Phosphorus cycle: Phosphate immobilization and solubilization, Sulphur cycle: Microbes involved in Sulphur cycle, Other elemental cycles: Iron. **Unit 3: Waste Management-** Solid Waste management: Sources and types of solid waste, Methods of solid waste disposal (composting and sanitary landfill). Liquid waste management: Composition and strength of sewage (BOD and COD), Primary, secondary (oxidation ponds, trickling filter, activated sludge process and septic tank) and tertiary sewage treatment. **Unit 4: Microbial Bioremediation-** Principles and degradation of common pesticides, organic (hydrocarbons,oil spills) and inorganic (metals) matter, biosurfactants. **Unit 5: Water Potability-** Treatment and safety of drinking (potable) water, methods to detect potability of water samples: (a) standard qualitative procedure: presumptive test/MPN test, confirmed and completed tests for faecal coliforms (b) Membrane filter technique and (c) Presence/absence tests.
COURSE CODE	**MB-M-P-03**

COURSE TITLE	**MICROBES AND ENVIRONMENT (PRACTICAL)**
CREDIT	**2**
FULL MARKS	**25**
CONTENT	1. Analysis of water quality by MPN method 2. Isolation of microbes (bacteria & fungi) from soil (28ºC & 45ºC). 3. Isolation of microbes (bacteria & fungi) from rhizosphere and rhizoplane. 4. Assessment of microbiological quality of water. 5. Determination of BOD of waste water sample.
SUGGESTED READING	1. Da Silva, N., Taniwaki, M.H., Junqueira, V.C., Silveira, N., Nascimento, M.S., Gomes, R.A.R. Microbiological examination methods of food and water: A laboratory manual.CRC Press, Boca Raton. 2. Mitchell, R. and Gu, J.D. Environmental microbiology. Wiley-Blackwell, New Jersey. 3. Maier, R., Pepper, I. and Gerba, C. Environmental microbiology. Academic Press, SanDiego. 4. Evans, G.M. and John, J.C.F. Environmental biotechnology: Theory and applications.John Wiley and Sons, New York. 5. Hurst, C.J., Crawford, R.L., Garland, J.L., Lipson, D.A., Mills, A.L. and Stetzenbach,L.D. Manual of environmental microbiology. ASM Press, Washington, D.C.
COURSE CODE	**MB-SEC-T-03**
COURSE TITLE	**MICROBES IN SUSTAINABLE AGRICULTURE AND DEVELOPMENT (THEORY ONLY)**
CREDIT	**3**
FULL MARKS	**45**
COURSE OUTCOME	• Developing application skill of microbiology in agriculture • Understanding the improving environment friendly agricultural practice • To understand skill oriented techniques to replace fossil fuel using microbe based alternative energy from agricultural waste
CONTENT	**Unit 1: Mineralization of Organic & Inorganic Matter in Soil:** Mineralization of cellulose, hemicelluloses, lignocelluloses, lignin and humus, phosphate, nitrate, silica, potassium. **Unit 2: Microbial Activity in Soil and Green House Gases:** Carbon dioxide, methane, nitrous oxide, nitric oxide – production and control. **Unit 3: Microbial Control of Soil Borne Plant Pathogens:** Biocontrol mechanisms and ways, Microorganisms used as biocontrol agents against Microbial plant pathogens, Insects, Weeds. **Unit 4: Biofertilization, Phytostimulation, Bioinsecticides:** Plant growth promoting bacteria, biofertilizers – symbiotic (*Bradyrhizobium*, *Rhizobium*, *Frankia*), Non-symbiotic (*Azospirillum*, *Azotobacter*, *Mycorrhizae*, Phosphate solubilizers, algae), Novel combination of microbes as biofertilizers, PGPRs. **Unit 5: Secondary Agriculture Biotechnology:** Biotech feed, Silage, Biomanure, biogas, biofuels – advantages and processing parameters.

SUGGESTED READING	1. Bagyaraj, D. J., & Rangaswami, G. (2007). Agricultural microbiology. PHI Learning Pvt. Ltd.. 2. Rao, N. S. (Ed.). (2016). Advances in agricultural microbiology. Elsevier. 3. Rai, M. (Ed.). (2006). Handbook of microbial biofertilizers. CRC Press. 4. Barton, L. L., & Northup, D. E. (2011). Microbial ecology. John Wiley & Sons. 5. Rastegari, A. A., Yadav, A. N., & Yadav, N. (Eds.). (2020). New and future developments in microbial biotechnology and bioengineering: trends of microbial biotechnology for sustainable agriculture and biomedicine systems: diversity and functional perspectives. Elsevier.
SEMESTER IV	
COURSE CODE	**MB-M-T-04**
COURSE TITLE	**MICROBIOLOGY IN DAILY LIFE: FOOD AND INDUSTRY (THEORY)**
CREDIT	**4**
FULL MARKS	**50**
COURSE OUTCOME	• Student will be able to evaluate the factors governing microbial growth in foods and sources of food contamination. • Student will be able to discuss the factors that govern spoilage of some common foods due to microbial activity. • Student will be able to describe various physical and chemical methods used for food preservation. • Students will be oriented to tools and techniques of different industrially important biomolecules and dairy product
CONTENT	**Unit 1: Microbial spoilage of various foods-** Intrinsic and extrinsic factors that affect growth and survival of microbes in foods, natural flora and source of contamination of foods in general. Spoilage of vegetables, fruits, meat, eggs, milk and butter, bread, canned Foods; Food-borne intoxication and infection- Botulism, aflatoxicosis, ergotism, cholera, salmonellosis. **Unit 2: Principles and methods of food preservation-** Principles, physical methods of food preservation: temperature (low, high, canning, drying), irradiation, hydrostatic pressure, high voltage pulse, microwave processing and aseptic packaging, chemical methods of food preservation: salt, sugar, organic acids, SO2, nitrite and nitrates, ethylene oxide, antibiotics and bacteriocins, Canning. **Unit 3: Fermented foods-** Dairy starter cultures, fermented dairy products: yogurt, acidophilus milk, dahi andcheese, other fermented foods: dosa, sauerkraut, soy sauce, Probiotics: Health benefits, types of microorganisms used, probiotic foods available in market. **Unit 4: Introduction to industrial microbiology-** Brief history and developments in industrial microbiology; Sources of industrially important microbes and methods for their isolation, preservation and maintenance of

	industrial strains, strain improvement, **Unit 5: Types of fermentation processes, bio-reactors and measurement of fermentation parameters-** Types of fermentation processes - Solid-state and liquid-state (stationary and submerged) fermentations; batch, fed- batch (eg. baker's yeast) and continuous fermentations. Components of a typical bio-reactor, Types of Bioreactors- Laboratory, pilot- scale and production fermenters, constantly stirred tank and air-lift fermenters, Measurement and control of fermentation parameters - pH, temperature, dissolved oxygen, foaming and aeration. **Unit 6: Down-stream processing-** Cell disruption, filtration, centrifugation, solvent extraction, precipitation, lyophilization and spray drying. **Unit 7: Microbial production of industrial products-** micro-organisms involved, media, fermentation conditions, downstream processing and uses for the production of Citric acid, ethanol, penicillin, Vitamin B12,amylase, Wine, beer, microbial biopolymers; Use of biomining and bioleaching of ores.
COURSE CODE	**MB-M-P-04**
COURSE TITLE	**MICROBIOLOGY IN DAILY LIFE: FOOD AND INDUSTRY (PRACTICAL)**
CREDIT	**2**
FULL MARKS	**25**
CONTENT	1. MBRT of milk samples and their standard plate count. 2. Isolation of any food borne bacteria from food products. 3. Isolation of spoilage microorganisms from spoiled vegetables/fruits. 4. Preparation of Yogurt/Dahi. 5. Microbial quality study of fresh salad vegetables using dilution plating technique
SUGGESTED READING	1. Adams, M.R., and Moss, M.O. Food microbiology. Royal Society of Chemistry Publication, Cambridge. 2. Frazier, W.C. and Westhoff, D.C. Food microbiology. Tata McGraw Hill, New Delhi. 3. Stanbuty, P.F. and Hall, S.J. Principles of fermentation technology. Pergamon Press,Oxford. 4. Robinson, R.K. Dairy microbiology. Elsevier Applied Sciences, London. 5. James M.J. Modern food microbiology. CBS Publishers and Distributors, New Delhi. 6. Wood, B.J. Microbiology of fermented foods. Elsevier Applied Sciences, London. 7. Ayres, J.C., Mundt, O. and Sandinee, W.E. Microbiology of foods. W.H. Freeman andCompany, New York. 8. Jay, M.J., Loessner, M.J. and Golden, D.A. Modern food microbiology. Springer Scienceand Business Media, New York. 9. Hui, Y.H., Meunier-Goddik, L., Josephsen, J., Nip, W.K. and Stanfield, P.S. Handbook offood and fermentation technology. CRC Press, Boca Raton. 10. Prescott, S. C., & Dunn, C. G. (1949). Industrial microbiology. Industrial microbiology. 11. Casida, L. E. (1968). Industrial microbiology. Industrial microbiology. 12. Verma, P. (Ed.). (2022). *Industrial microbiology and biotechnology*. Singapore: Springer.

COURSE CODE	**MB-M-T-05**
COURSE TITLE	**MICROBIAL ECOLOGY AND AGRICULTURAL MICROBIOLOGY (THEORY)**
CREDIT	**4**
FULL MARKS	**50**
COURSE OUTCOME	• The students will be able to recall the importance of microbes in different ecological niche and habitat • Students will be acquainted with environment-microbe and plant-microbe interactions and its importance • Students will be able to isolate microbe from ecologically important habitats • Role of microbes in soil fertility will be understood by both theoretical and experiential learning
CONTENT	**Unit 1: Basic concept**- Microbial ecology vs. macroecology, basic concept of ecosystem and biosphere, concept of habitat and niche, concept of population and community, Basic concept of food chain-food web and energy flow; Development of microbial communities: r and k strategies, Microbial community succession-biofilm communities. Ecology of microorganism in extreme environments (High temperature, pressure and radiation etc.); Community resistance and resilience; **Unit 2: Microbial interaction**- symbiosis, mutualism, commensalisms, competition, amensalism, synergism, parasitism and predation-mathematical model. **Unit 3: Quantitative ecology**- diversity indices, samples and samplings, concept of culturability, Determination of total and viable microbial number, molecular analysis of function and diversity of microbial community, metagenomics, measurement of microbial metabolism-stable isotope probing. **Unit 4: Plant-microbe interaction**- Useful and harmful microbes to crop growth. Microflora of rhizosphere and rhizoplane, phyllosphere and phylloplane. **Unit 5: Plant-pathogen interaction**- entry, establishment molecular mechanism of disease development (enzyme, toxin, hormone) and resistance by host (innate and inductive phytoalexin, PR-protein, control of diseases – chemical and biological; Important diseases of agricultural crops by bacteria, fungi and viruses – bacterial wilt, rust of wheat, blight of potato & CaMV and their control. **Unit 6: Microbes and crop productivity**- biofertilizers, plant growth promoting rhizobacteria and Mycorrhizal fungi; microbes in crop protection
COURSE CODE	**MB-M-P-05**
COURSE TITLE	**MICROBIAL ECOLOGY AND AGRICULTURAL MICROBIOLOGY (PRACTICAL)**
CREDIT	**2**
FULL MARKS	**25**
CONTENT	1. Isolation and enumeration of phosphate solubilizing, cellulose decomposing, free-living N_2-fixing andstarch

	hydrolyzing bacteria from different habitats (plate count method). 2. Assessment of nitrifying activity in soil. 3. Measurement of soil pH, N-content (Kjeldahl method), P-content, C-content. 4. *In vitro* study of antagonism (dual culture technique). 5. Isolation of *Rhizobium* from root nodules. **6.** Nodulation study (pot experiment)
SUGGESTED READING	1. Atlas, R.M. and Bartha, R. Microbial ecology: Fundamentals and applications. Benjamin/Cummings Science Publishing, USA. 2. Madigan, M.T., Martinko, J.M. and Parker, J. Brock biology of microorganisms. PrenticeHall, New Jersey. 3. Mitchell, R. and Gu, J.D. Environmental microbiology. Wiley-Blackwell, New Jersey.
SEMESTER V	
COURSE CODE	**MB-M-T-06**
COURSE TITLE	**FUNDAMENTAL OF LIFE PROCESS: WATER AND BIOMOLECULES (THEORY)**
CREDIT	**4**
FULL MARKS	**50**
COURSE OUTCOME	• Students will be provided interdisciplinary orientation with the basics of biochemistry • Students will learn properties of water and terminologies and parameters associated with acid, base and buffers and their biological importance • Introduction to biologically relevant molecules such as carbohydrates, proteins, vitamins, lipids will be provided • A basic concept of enzymes and their mode of actions will be learnt both qualitative and quantitative way • Students will learn hands-on to estimate different biomolecules by various methodologies
CONTENT	**Unit 1:** Structure of water, phase diagram of pure water, ionic product of water, special properties of water, buffers in animal system. Weak interactions in aqueous systems, ionization of water, Acids, bases, Arrhenius concept, proton transfer theory, Lewis concept, Lowry and Bronsted concepts. Buffers, composition, pH, pH scale, Henderson-Hasselbalch equation, titration curve of H3PO4, pK value, isoelectric pH. Buffer and its biological relevance. **Unit 2: Carbohydrates-** General properties, classification of carbohydrates, families of monosaccharides: structural concept, isomerism. Sugar derivatives, glucosamine, galactosamine, muramic acid, N-acetyl neuraminic acid. Disaccharides. Concept of reducing and non-reducing sugars. Polysaccharides- storage polysaccharides, starch and glycogen. Structural Polysaccharides- cellulose, chitin and peptidoglycan. **Unit 3: Lipids-** Fatty acids: definition, types, structures and functions, essential fatty acids. Lipid: definition, nomenclature and classification (triacylglycerols, phosphoglycerides, phosphatidylethanolamine, phosphatidylcholine, sphingosine, ceramide, sphingomyelins, cerebrosides and gangliosides) with structures and properties. Functions of lipid. Introduction of lipid micelles, monolayers, bilayers. Membrane structure. Steroids and wax. **Unit 4: Proteins-** Amino acids structure and properties. Titration curve of amino acid and its significance. Ninhydrin

	reaction. Non protein amino acids. Structure of proteins: Primary, Secondary, Tertiary and Quaternary. Peptide unit and its salient features. The alpha helix, the beta pleated sheet and their occurrence in proteins. Ramachandran plot. Human haemoglobin structure. **Unit 5: Vitamins and Enzymes-** Classification and characteristics of Vitamins with suitable examples, sources and importance. Structure of enzyme: Apoenzyme and cofactors, prosthetic group, coenzyme. Classification of enzymes, Mechanism of action of enzymes: Lock and key hypothesis, and induced Fit hypothesis, active site, specificity. Enzyme kinetics: Michaelis-Menten equation and their transformations, K_m and allosteric mechanism, specific activity, and turnover number. Factors affecting enzyme action: pH, temperature, substrate concentration, enzyme concentration, time. Enzyme inhibition and its kinetics: competitive; non-competitive, uncompetitive.
COURSE CODE	**MB-M-P-06**
COURSE TITLE	**FUNDAMENTAL OF LIFE PROCESS: WATER AND BIOMOLECULES (PRACTICAL)**
CREDIT	**2**
COURSE CODE	**25**
CONTENT	1. Concept of pH and buffers, preparation of buffers – phosphate and acetate buffer. 2. Qualitative/Quantitative tests for carbohydrates, reducing sugars, non-reducing sugars (DNS method) 3. Qualitative/Quantitative tests for proteins (Lowry method), amino acids (Ninhydrine), DNA(DPA) and RNA(Orcinol). 4. Qualitative/Quantitative assay of amylase. 5. Estimation of any one vitamin – Ascorbic acid
SUGGESTED READING	1. NELSON, L., & Cox, M. M. (2017). Lehninger Principles of Biochemistry 7th edition. 2. Voet, D., & Voet, J. G. (2010). Biochemistry. John Wiley & Sons. 3. Satyanarayana, U. (2013). Biochemistry. Elsevier Health Sciences. 4. Segel, I. H. (1991). Biochemical calculations: how to solve mathematical problems in general biochemistry. John Wiley & Sons.
COURSE CODE	**MB-M-T-07**
COURSE TITLE	**MICROBIAL GENETICS (THEORY)**
CREDIT	**4**
FULL MARKS	**50**
COURSE OUTCOME	• Explain principles/concept of Prokaryotic and Eukaryotic genetics • Provides understanding of Viral genetics and application in research. • Mutagenesis, Mutation and mutants and their understanding in microbial evolution. • Application of bacterial and eukaryotic plasmids in research.

	• Understanding of Genetic exchange phenomenon and its importance
CONTENT	**Unit 1: Genes and Mutations-** Structures of DNA and RNA/Genetic Material- DNA Structure: Miescher to Watson and Crick- historic perspective, DNA structure, Salient features of double helix, Types of DNA, Types of genetic material, denaturation and renaturation, cot curves. DNA topology – linking number, topoisomerases; Organization of DNA Prokaryotes, Viruses, Eukaryotes, RNA Structure, Organelle DNA -- mitochondria and chloroplast DNA. Mutations and mutagenesis: Definition and types of Mutations; Physical and chemical mutagens; Molecular basis of mutations; Functional mutants (loss and gain of function mutants); Uses of mutations; Reversion and suppression: True revertants; Intra- and inter-genic suppression; Ames test; Mutator genes **Unit 2: Plasmids-** Types of plasmids – F plasmid, R Plasmids, colicinogenic plasmids, Ti plasmids, linear plasmids, yeast-2 µ plasmid, Plasmid replication and partitioning, Host range, plasmid-incompatibility, plasmidamplification, Regulation of copy number, curing of plasmids **Unit 3: Mechanisms of Genetic Exchange-** Transformation - Discovery, mechanism of natural competence, Conjugation - Discovery, mechanism, Hfr and F' strains, Interrupted mating technique and time of entry mapping, Transduction - Generalized transduction, specialized transduction, LFT & HFT lysates, Mapping by recombination and co-transduction of markers **Unit 4: Phage Genetics-** Features of T4 genetics, Genetic basis of lytic *versus* lysogenic switch of phage lambda **Unit 5: Transposable elements-** Prokaryotic transposable elements – Insertion Sequences, composite and non-composite transposons, Replicative and Non replicative transposition, Mu transposon, Eukaryotic transposable elements - Yeast (Ty retrotransposon), Drosophila (P elements), Maize (Ac/Ds); Uses of transposons and transposition
COURSE CODE	**MB-M-P-07**
COURSE TITLE	**MICROBIAL GENETICS (PRACTICAL)**
CREDIT	**2**
FULL MARKS	**25**
CONTENT	1. Preparation of Master and Replica Plates 2. Study the effect of chemical and physical (UV) mutagens on bacterial cells 3. Study survival curve of bacteria after exposure to ultraviolet (UV) light *4.* Isolation of Plasmid DNA from *E.coli* 5. Study different conformations of plasmid DNA through Agarose gel electrophoresis.
SUGGESTED READING	6. Maloy, S. R., Cronan, J. E., & Freifelder, D. (1994). Microbial Genetics 2 nd Edition: illustrated. 7. Freifelder, D. M. (1987). Microbial genetics. (No Title). 8. Klug, W. S., & Cummings, M. R. (1996). Essentials of genetics (No. Ed. 2). Prentice-Hall Inc..

	9. Watson, J. D. (2004). Molecular biology of the gene. Pearson Education India. 10. Lewin, B., Krebs, J., Kilpatrick, S. T., & Goldstein, E. S. (2011). Lewin's genes X. Jones & Bartlett Learning.
Semester VI	
COURSE CODE	**MB-M-T-08**
COURSE TITLE	**IMMUNOLOGY: HOST DEFENSE VERSUS PATHOGEN (THEORY)**
CREDIT	**4**
FULL MARKS	**50**
COURSE OUTCOME	• Demonstrate and make the students aware on basic knowledge of immunological processes at a cellular and molecular level with governing principles and concepts • Introduction to the key molecules, cells (antigen, antibodies, immunoglobulin. Complement system) involved in host defence mechanism against invading pathogens • Understand the principles governing vaccination and the mechanisms of protection against infectious diseases • Understand and explain the basis of immunological tolerance, autoimmunity and transplantation • Understand and explain the basis of allergy and allergic diseases • Theory and experiential learning on different immunological techniques
CONTENT	**Unit 1: Introduction-** Fundamental concept of Innate and Adaptive immunity. Contributions of following scientists to the development of field of immunology - Edward Jenner, Louis Pasteur, Karl Landsteiner, Robert Koch, Paul Ehrlich, Elie Metchnikoff, Peter Medawar, MacFarlane Burnet and Rodney Porter **Unit 2: Immune Cells and Organs-** Structure, Functions and Properties of: Immune Cells –B cell, T cell, NKcell, Macrophage, Dendritic cell, Stem cell Immune Organs – Bone Marrow, Thymus, Lymph Node, Spleen **Unit 3: Antigens-** Characteristics of an antigen; T-dependent and T-independent antigens Concept of Epitopes, Adjuvants, Haptens, Carrier **Unit 4: Antibodies-** Types, Structure, and Functions of antibodies. Production and Clinical uses of Monoclonal antibodies **Unit 5: Major Histocompatibility Complex-** Organization of MHC locus (Mice & Human) Structure and Functions of MHC I & II molecules **Unit 6: Complement System-** Components of the Complement system. Complement Activation pathways (Classical, Alternative and Lectin pathways). Biological consequences of complement Activation

	Unit 7: Generation of Immune Response and Hypersensitive reactions - Different types of hypersensitive response; Generation of Humoral and Cell Mediated Immune Response. Antibody dependent cellular cytotoxicity (ADCC) **Unit 8: Types of Immunization-** Characteristics and functions of Active and Passive Immunization **Unit 9: Immunological Techniques-** Principles of Precipitation, Agglutination, Immunodiffusion, Immuno-electrophoresis, ELISA, ELISPOT, Western blotting, Immunofluoresence, Immunoelectron microscopy
COURSE CODE	**MB-M-P-08**
COURSE TITLE	**IMMUNOLOGY: HOST DEFENSE VERSUS PATHOGEN (PRACTICAL)**
CREDIT	**4**
FULL MARKS	**50**
CONTENT	1. Agglutination test 2. Identification of human blood groups 3. Perform immunodiffusion by Ouchterlony method **4.** Perform DOT ELISA
SUGGESTED READING	1. Kuby, J. (1997). Immunology. 2. Abul Abbas, M., Lichtman, A. H., & Pillai, S. (2021). *Cellular and Molecular Immunology, 10e, South Asia Edition-E-Book*. Elsevier Health Sciences. 3. Delves, P. J., Martin, S. J., Burton, D. R., & Roitt, I. M. (2017). *Roitt's essential immunology*. John Wiley & Sons.
COURSE CODE	**MB-M-T-09**
COURSE TITLE	**PUBLIC HEALTH AND MEDICAL MICROBIOLOGY (THEORY)**
CREDIT	**4**
FULL MARKS	**50**
COURSE OUTCOME	• Students will know about beneficial and disease-causing microbes • They will have an overview on public health, community health and clinical health system and the terminologies used in these practices (Epidemiology, pandemic, epidemic, endemic etc) • Students will be able to correlate disease symptoms with causative agent, isolate and identify pathogens. • They will gain knowledge of mechanism of action of antimicrobial drugs and prophylaxis. • Students will learn hands-on to identify bacteria by simple testing and qualitative and quantitative method to

	understand the working of antimicrobials
CONTENT	**Unit 1: Normal microflora of the human body and host pathogen interaction-** Normal microflora of skin, respiratory tract, gastrointestinal tract, urogenital tract. Host pathogen interaction: Infection, Invasion, Pathogen, Pathogenicity, Virulence, Toxigenicity, Carriers, reservoir, Opportunistic infections, Nosocomial infections, Epidemic, Endemic, Pandemic. Disease forecasting. Disease cycle. Herd immunity. Mode of entry, colonization and growth. Damage to host cell, virulence, virulence factors- exotoxins, endotoxins, neurotoxins and enzymes with special reference to Cholera toxin, enterotoxin, diphtheria toxin and tetanospasmin, Definition and differences-Public health, Clinical health, Iceberg phenomenon **Unit 2: Bacterial diseases-** Symptoms, mode of transmission, prophylaxis and control of following diseases: Respiratory Diseases: tuberculosis; Gastrointestinal Diseases: typhoid, cholera; Wound infections: tetanus; Venereal disease: Syphilis **Unit 3: Viral diseases-** Symptoms, mode of transmission, prophylaxis and control of following diseases: AIDS, Dengue, Chikungunya, Japanese Encephalitis **Unit 4: Protozoan diseases-** Symptoms, mode of transmission, prophylaxis and control of following diseases:Malaria, Kala-azar **Unit 5: Fungal diseases-** General account on transmission, symptoms and prevention of Cutaneous mycoses, Systemic mycoses, Opportunistic mycoses (Candidiasis) **Unit 6: Antimicrobial agents: General characteristics and mode of action-** Naturally produced drugs. Antibiotics produced by bacteria, actinomycetes and fungi used in chemotherapy. Classification of antibiotics on the basis of structure and mode of action. Assay of antibiotics, antibiotic spectrum Semisynthetic antibiotic. Sulfa drugs, their use and mechanism of action. Naldixic acid, nitrofurans, isonicotinic hydrazide, metronidazole; Prophylactic agents. Drug toxicity. Drug resistance – chromosomal mutation and plasmid-borne multiple drug resistance
COURSE CODE	**MB-M-P-09**
COURSE TITLE	**PUBLIC HEALTH AND MEDICAL MICROBIOLOGY (PRACTICAL)**
CREDIT	**2**
FULL MARKS	**25**
CONTENT	1. Identify bacteria (*Bacillus, Staphylococcus, E. coli, Pseudomonas,*) on the basis of cultural, morphologicaland biochemical characteristics 2. Study of composition and use of important differential media for identification of bacteria: EMB Agar,McConkey agar, Mannitol salt agar, TCBS 3. Perform antibacterial sensitivity by Agar cup method 4. Determination of minimal inhibitory concentration (MIC) of an antibiotic (Tetracycline/ Kanamycin) **5.** Determination of phenol coefficient
SUGGESTED READING	1. Al-Kobaisi, M. F. (2007). Jawetz, Melnick & Adelberg's Medical Microbiology 24th Edition. *Sultan Qaboos University Medical Journal*, *7*(3), 273-275.

	2. Greenwood, D., Slack, R. C., Peutherer, J. F., & Barer, M. R. (1997). Medical Microbiology: A Guide to Microbial Infections: Pathogenesis. *Immunity, Laboratory Diagnosis and Control, 15th Edition, Churchill Livingstne, Edinburgh, United Kingdom*, 690. 3. Levinson, W. (2008). Review of medical microbiology and immunology. *(No Title)*. 4. Ray, C. G., & Ryan, K. J. (Eds.). (2014). *Sherris medical microbiology* (pp. 579-583). New York, NY, USA: McGraw-Hill Education/Medical.
COURSE CODE	**MB-M-L-10**
COURSE TITLE	**MOLECULAR BIOLOGY (THEORY)**
CREDIT	**4**
FULL MARKS	**50**
COURSE OUTCOME	• Students will study the detailed structure of nucleic acids. • Students will learn in detail the molecular processes such as replication, transcription and translation which will provide a deeper understanding of the life process of the microbes • Students will learn fundamentals of gene regulation and its importance • Isolation of bacterial genomic DNA and estimation of nucleic acid by spectrophotometric method will be understood through experimental methods
CONTENT	**Unit 1: Structures of DNA and RNA/Genetic Material-** DNA Structure: Miescher to Watson and Crick- historic perspective, DNA structure, Salient features of double helix, Types of DNA, Types of genetic material, denaturation and renaturation, cot curves. DNA topology – linking number, topoisomerases; Organization of DNA Prokaryotes, Viruses, Eukaryotes.RNA Structure, Organelle DNA -- mitochondria and chloroplast DNA. **Unit 2: Replication of DNA (Prokaryotes and Eukaryotes**)- Bidirectional and unidirectional replication, semi-conservative, semi- discontinuous replication; Mechanism of DNA replication: Enzymes and proteins involved inDNA replication –DNA polymerases, DNA ligase, primase, telomerase – for replication of linear ends; Various modelsof DNA replication including rolling circle, D- loop (mitochondrial), Θ (theta) mode of replication and other accessory protein, Mismatch and excision repair **Unit 3: Transcription in Prokaryotes and Eukaryotes-** Transcription: Definition, difference from replication, promoter - concept and strength of promoter; RNA Polymerase and the transcription unit; Transcription in Eukaryotes: RNA polymerases, general Transcription factors **Unit 4: Post-Transcriptional Processing-** Split genes, concept of introns and exons, RNA splicing, spliceosome machinery**,** concept of alternative splicing, Polyadenylation and capping, Processing of rRNA, RNA interference: siRNA, miRNA and its significance **Unit 5: Translation (Prokaryotes and Eukaryotes)-** Translational machinery, Charging of tRNA, aminoacyl tRNA synthetases, Mechanisms of initiation, elongation and termination of polypeptides in both prokaryotes and eukaryotes, Fidelity of translation, Inhibitors of protein synthesis in prokaryotes and eukaryote

	Unit 6: Regulation of gene Expression in Prokaryotes and Eukaryotes- Principles of transcriptional regulation, regulation at initiation with examples from *lac* and *trp* operons, Sporulation in *Bacillus,* Yeast mating type switching, Changes in Chromatin Structure - DNA methylation and Histone Acetylation mechanisms.
COURSE CODE	**MB-M-P-10**
COURSE TITLE	**MOLECULAR BIOLOGY (PRACTICAL)**
CREDIT	**2**
FULL MARKS	**25**
CONTENT	1. Study of different types of DNA and RNA using micrographs and model / schematic representations 2. Study of semi-conservative replication of DNA through micrographs / schematic representations *3.* Isolation of genomic DNA from *E. coli* 4. Estimation of salmon sperm / calf thymus DNA using colorimeter (diphenylamine reagent) or UV spectrophotometer (A_{260} measurement) **5.** Estimation of RNA using colorimeter (orcinol reagent) or UV spectrophotometer (A260 measurement)
SUGGESTED READING	1. Freifelder, D. (2013). *Molecular biology*. Narosa Publishing House. 2. Lewin, B., Krebs, J., Kilpatrick, S. T., & Goldstein, E. S. (2011). *Lewin's genes X*. Jones & Bartlett Learning. 3. Alberts, B. (2017). Molecular biology of the cell. Garland science. 4. Karp, G. (2009). *Cell and molecular biology: concepts and experiments*. John Wiley & Sons. 5. Lodish, H., Berk, A., Zipursky, S. L., Matsudaira, P., Baltimore, D., & Darnell, J. (2000). Molecular cell biology 4th edition. *National Center for Biotechnology Information, Bookshelf, 9*.
SEMESTER VII	
COURSE CODE	**MB-M-T-11**
COURSE TITLE	**RECOMBINANT DNA TECHNOLOGY (THEORY)**
CREDIT	**4**
FULL MARKS	**50**
COURSE OUTCOME	• Students will be able to handle microorganisms for isolation and amplification of DNA and transform host cells. • Understanding of manipulation DNA will be developed different methods and molecular tools

	• Students will understand application of gene manipulation in different practical fields • Students will be introduced to powerful tools like PCR for DNA amplification and learn its diagnostic and research application • An overall interdisciplinary orientation for the field of biotechnology will be developed
CONTENT	**Unit 1: Introduction to Genetic Engineering-** Milestones in genetic engineering and biotechnology **Unit 2: Molecular Cloning-** Tools and Strategies; Mode of action and applications of Type I, II and III restriction endonucleases in genetic engineering; Definition and function of restriction site, linkers, adaptors, Topoisomerase, DNA ligase, Genomic library, DNA Modifying enzymes: Terminal deoxynucleotidyltransferase, kinases, phosphatise. Definition and Properties of following Cloning Vectors: pBR322, pUC8, Bacteriophage lambda, M13, Cosmids, BACs and YACs vectors, Mammalian SV40-based expression vectors **Unit 3: Methods in Molecular Cloning-** Gene delivery: Microinjection, electroporation, ballistic method (gene gun), liposome and Viral mediated delivery, *Agrobacterium* - mediated delivery. Agarose gel electrophoresis, Southern and Northernblotting, dot blot, DNA microarray analysis, SDS-PAGE and Western blotting **Unit 4: DNA Amplification and DNA sequencing-** Basic concept of PCR, RT-PCR, Real-Time PCRSanger's method of DNA Sequencing: traditional and automated sequencing. Primer walking and shotgun sequencing **Unit 5: Construction and Screening of Genomic and cDNA libraries-** Genomic and cDNA libraries: Preparation and uses, Screening of libraries: Colony hybridization and colony PCR, Chromosome walking and chromosome jumping **Unit 6: Applications of Recombinant DNA Technology-** Products of recombinant DNA technology: Insulin, hGH, Antisense molecules, GM Crops, Bt - cotton, Bt-brinjal. Gene therapy, recombinant vaccines, protein engineering and site directed mutagenesis.
COURSE CODE	**MB-M-P-11**
COURSE TITLE	**RECOMBINANT DNA TECHNOLOGY (PRACTICAL)**
CREDIT	**2**
FULL MARKS	**25**
CONTENT	1. Perform bacterial Transformation by standard method 2. Digestion of DNA using restriction enzymes and analysis by agarose gel electrophoresis 3. Ligation of DNA fragments 4. Interpretation of sequencing gel electropherograms 5. Designing of primers for DNA amplification 6. Demonstration of amplification of DNA by PCR

	7. Perform Southern blotting
SUGGESTED READING	1. Primrose, S. B., & Twyman, R. (2006). *Principles of gene manipulation and genomics*. John Wiley & Sons. 2. Brown, T. A. (2020). Gene cloning and DNA analysis: an introduction. John Wiley & Sons. 3. Reece, R. J. (2003). Analysis of genes and genomes. John Wiley & Sons.
COURSE CODE	**MB-M-T-12**
COURSE TITLE	**BIOENERGETICS AND MICROBIAL METABOLISM (THEORY)**
CREDIT	**4**
FULL MARKS	**50**
COURSE OUTCOME	• Students will gain knowledge of energy transfers and biomolecular transformations. • Students will be provided knowledge about biological membrane and its unique transport properties • Students will comprehend metabolic pathways unique to microorganisms. • Students will experience the growth of bacteria and different parameters affecting their growth through hands-on learning
CONTENT	**Unit 1: Bioenegetics-** First and second laws of Thermodynamics. Definitions of Gibb's Free Energy, enthalpy,and Entropy and mathematical relationship among them, Standard free energy change and equilibrium constant. Coupled reactions and additive nature of standard free energy change, Energy rich compounds: Phosphoenolpyruvate, 1,3- Bisphosphoglycerate, Thioesters, ATP **Unit 2: Nutrient uptake and Transport-** Passive and facilitated diffusion; Primary and secondary active transport, concept of uniport, symport and antiport; Group translocation; Iron uptake **Unit 3: Chemoheterotrophic Metabolism-** Concept of aerobic respiration, anaerobic respiration and fermentation; Sugar degradation pathways i.e. EMP, ED, Pentose phosphate pathway, TCA cycle, Electron transport chain: components of respiratory chain, comparison of mitochondrial and bacterial ETC, electron transport phosphorylation, uncouplers and inhibitors **Unit 4: Chemoheterotrophic Metabolism-** Anaerobic respiration and fermentation, Anaerobic respiration with special reference to dissimilatory nitrate reduction (Denitrification; nitrate/nitrite and nitrate/ammonia respiration; fermentative nitrate reduction); Fermentation - Alcohol fermentation and Pasteur effect; Lactate fermentation (homofermentative and heterofermentative pathways), concept of linear and branched fermentation pathways **Unit 5: Chemolithotrophic and Phototrophic Metabolism-** Introduction to aerobic and anaerobic chemolithotrophy with an example each. Hydrogen oxidation (definition and reaction) and methanogenesis (definition and reaction) Introduction to phototrophic metabolism - groups of phototrophic microorganisms, anoxygenic *vs.* oxygenic photosynthesis with reference to photosynthesis in green bacteria, purple bacteria and cyanobacteria **Unit 6: Nitrogen Metabolism** - an overview; Introduction to biological nitrogen fixation, Ammonia assimilation, Assimilatory nitrate reduction, dissimilatory nitrate reduction, denitrification

COURSE CODE	**MB-M-P-12**
COURSE TITLE	**BIOENERGETICS AND MICROBIAL METABOLISM (PRACTICAL)**
CREDIT	**2**
FULL MARKS	**25**
CONTENT	1. Study and plot the growth curve of *E. coli* by turbidometric and standard plate count methods. 2. Calculations of generation time and specific growth rate of bacteria from the graph plotted with given data 3. Effect of temperature on growth of *E. coli* 4. Effect of pH on growth of *E. coli* 5. Effect of carbon and nitrogen sources on growth of *E.coli* 6. Effect of salt on growth of *E. coli* 7. Demonstration of the thermal death time and decimal reduction time of *E. coli*
SUGGESTED READING	1. Madigan, M.T., and Martinko, J.M. (2014). Brock biology of microorganisms. PrenticeHall International Inc., New Jersey, 14th ed. 2. Moat, A.G. and Foster, J.W. (2002). Microbial physiology. John Wiley and Sons, NewYork, 4th ed. 3. Reddy, S.R. and Reddy, S.M. (2005). Microbial physiology. Scientific Publishers, India. 4. Gottschalk, G. (1986). Bacterial metabolism. Springer Verlag, New York, 2nd ed. 5. Stanier, R.Y., Ingrahm, J.I., Wheelis, M.L. and Painter, P.R. (1987). General microbiology. McMillan Press, London, 5th ed. 6. Willey, J.M., Sherwood, L.M. and Woolverton, C.J. (2013). Prescott's microbiology. McGraw Hill, New York, 9th ed.
COURSE CODE	**MB-M-T-13**
COURSE TITLE	**INSTRUMENTATION AND BIOTECHNIQUES (THEORY)**
CREDIT	**4**
FULL MARKS	**50**
COURSE OUTCOME	• Students will learn about the principle, working and applications of commonly used instruments in microbiology such as microscopy, spectrophotometry etc. • Students will also learn applications of different separation techniques such as electrophoresis, centrifugation, chromatography, etc. • Students will be able to handle, calibrate and use the instruments for different estimations and preparations
CONTENT	**Unit 1: Microscopy-** Brightfield and darkfield microscopy, Fluorescence Microscopy, Phase contrast Microscopy, Confocal Microscopy, Electron Microscopy (Scanning and Transmission Electron Microscopy) and Micrometry.

	Unit 2: Chromatography- Principles and applications of paper chromatography (including Descending and 2-D), Thin layer chromatography. Column packing and fraction collection. Gel filtration chromatography, ion exchange chromatography and affinity chromatography, GLC, HPLC. **Unit 3: Electrophoresis-** Principle and applications of native polyacrylamide gel electrophoresis, SDS-polyacrylamide gel electrophoresis, 2D gel electrophoresis, Isoelectric focusing, and Agarose gel electrophoresis. **Unit 4: Spectrophotometry-** Principle and use of study of absorption spectra of biomolecules. Analysis of biomolecules using UV and visible range. Colorimetry and turbidometry. **Unit 5: Centrifugation-** Preparative and analytical centrifugation, fixed angle and swinging bucket rotors. RCF and sedimentation coefficient, principle and application of differential centrifugation, density gradient centrifugation and isopycnic ultracentrifugation.
COURSE CODE	**MB-M-P-13**
COURSE TITLE	**INSTRUMENTATION AND BIOTECHNIQUES (PRACTICAL)**
CREDIT	**2**
FULL MARKS	**25**
CONTENT	1. Separation of mixtures by paper / thin layer chromatography. 2. Resolution and visualization of DNA by Agarose Gel Electrophoresis. 3. Separation of protein mixtures by SDS-Polyacrylamide Gel Electrophoresis (SDS-PAGE). 4. Determination of λmax for an unknown sample and calculation of extinction coefficient. 5. Separation of components of a given mixture using a laboratory scale centrifuge.
SUGGESTED READING	1. Freifelder, D. (1982). *Physical biochemistry: applications to biochemistry and molecular biology*. Macmillan. 2. Segel, I. H. (1991). Biochemical calculations: how to solve mathematical problems in general biochemistry. John 3. Upadhyay, A., Upadhyay, K., & Nath, N. (2003). Biophysical Chemistry Principles & Techniques Handbook. 4. Banerjee, P. K. (2010). *Introduction to Biophysics*. S Chand & Company Limited.
SEMESTER VIII	
COURSE CODE	**MB-M-T-14**
COURSE TITLE	**FUNDAMENTALS OF CELL BIOLOGY (THEORY ONLY)**
CREDIT	**4**
FULL MARKS	**50**

COURSE OUTCOME	• Students will gain knowledge of functioning of different part of cells and understand differences between normal and diseased cells. • Students will learn different cellular processes and signaling involved in different metabolic pathway and their implications in disease such as cancers
CONTENT	**Unit 3: Nucleus-** Nuclear envelope, nuclear pore complex and nuclear lamina Chromatin – Molecular organization, Nucleolus **Unit 4: Protein Sorting and Transport-** Ribosomes, Endoplasmic Reticulum – Structure, targeting and insertion of proteins in the ER, Protein folding, processing and quality control in ER, Smooth ER and lipid synthesis, Export of proteins and lipids from ER. Golgi Apparatus – Organization, protein glycosylation, protein sorting and export from Golgi apparatus. Lysosomes. **Unit 5: Cell Signaling-** Modes of Cell-to-Cell Signaling. Signaling molecules and their receptors. Function of cell surface receptors. Pathways of intra-cellular receptors **–** Cyclic AMP pathway, cyclic GMP and MAP kinase pathway **Unit 6: Cell Cycle, Cell Death and Cell Renewal-** Regulation of Programmed cell death. Development of cancer causes and types. Concept of stem cells- embryonic stem cell and induced pluripotent stem cells. Bacterial cell division.
SUGGESTED READING	1. Lewin, B., Krebs, J., Kilpatrick, S. T., & Goldstein, E. S. (2011). *Lewin's genes X*. Jones & Bartlett Learning. 2. Alberts, B. (2017). Molecular biology of the cell. Garland science. 3. Karp, G. (2009). *Cell and molecular biology: concepts and experiments*. John Wiley & Sons. 4. Lodish, H., Berk, A., Zipursky, S. L., Matsudaira, P., Baltimore, D., & Darnell, J. (2000). Molecular cell biology 4th edition. *National Center for Biotechnology Information, Bookshelf, 9*.
COURSE CODE	**MB-M-T-15**
COURSE TITLE	**BIOSTATISTICS (THEORY ONLY)**
CREDIT	**4**
FULL MARKS	**50**
COURSE OUTCOME	• Understand and interpret commonly reported statistical measures published in healthcare research • Analyze the different type of data using appropriate statistical software • Demonstrate a good understanding of central tendency and its measures • Explain and make them confident in understanding fundamental concepts of estimation and hypothesis testing
CONTENT	**Unit 1:** Sample and population: Sampling methods, construction of histogram, interpretation of histogram, sample mean, sample standard deviation, the normal distribution, the mean mode, median and standard deviation of the normal distribution **Unit 2:** Laws of probability, theorem of total probability. **Unit 3:** Testing of hypothesis, comparison of population means and variances- F-test, notion of confidence limit. χ^2 test,

	goodness of fit and the test of independence of two attributes; count data, examples of count data – bacterial cell count, radioactivity count, colony and plaque counts, statistical treatment to count data. **Unit 4:** Poisson distribution, standard error, confidence limits of counts; test of significance, difference of means in large samples, t-test (small samples)
SUGGESTED READING	1. Daniel, W. W., & Cross, C. L. (2017). Biostatistics: basic concepts and methodology for the health sciences. Wiley. 2. Das, D., & Das, A. (1980). Statistics in Biology & Psychology. Academic Publishers. 3. Gun, A. M., Gupta, M. K., & Dasgupta, B. (2013). Fundamentals of statistics. World Press Private. 4. Das, N. G. (2009). Statistical Methods (Volume I & II). 5. Banerjee, P. K. (2007). Introduction to biostatistics (a textbook of biometry). S. Chand Publishing.
COURSE CODE	**MB-M-T-16**
COURSE TITLE	**ISOLATION OF MICROBES FROM ENVIRONMENT: AIR, WATER, SOIL (PRACTICAL ONLY)**
CREDIT	**4**
FULL MARKS	**50**
COURSE OUTCOME	• Completely experiential learning on isolation of microbes from different environmental habitats • Qualitative and quantitative estimation of microbes from air, water, soil
CONTENT	**Unit 1: Microbial Analysis of Air -** Bioaerosol sampling, air samplers, methods of analysis, determination of CFU, culture media for bacteria and fungi, Identification of bacterial genus by simple biochemical tests (catalase, oxidase, coagulase, citrate, urease, hemolysis test and gram staining) **Unit 2: Microbiological Analysis of Water-** Sample Collection, Treatment and safety of drinking (potable) wate. Methods to detect potability of water samples: (a) standard qualitative procedure: presumptive/MPN tests, confirmed and completed tests for faecal coliforms(b)Membrane filter technique and (c) Presence/absence tests (d) BOD and COD **Unit 3: Microbiological Analysis of Soil-** Collection of soil sample, Serial dilution, Determination of CFU, Identification by simple biochemical tests (catalase, oxidase, coagulase, citrate, urease, hemolysis test and gram staining)
SUGGESTED READING	1. Kannan, K. Laboratory manual in general microbiology. Panima, New Delhi. 2. Atlas, R.M., Brown, A.E. and Parks, L.C. Laboratory manual of experimental microbiology. Mosby College Publishing Company, St. Louis. **3.** Brock, T. D., Madigan, M. T., Martinko, J. M., & Parker, J. (2003). Brock biology of microorganisms. Upper Saddle River (NJ): Prentice-Hall, 2003.
COURSE CODE	**MB-M-T-17**
COURSE TITLE	**VIROLOGY (THEORY)**
CREDIT	**4**

FULL MARKS	**50**
COURSE OUTCOME	• Students will learn about viruses and eukaryotic cell structure in detail. • Students will learn about viral diseases, their mechanism of transmission and disease progression • Students will know about role of virus in the pathogenesis of cancer • In laboratory they will be able to isolate bacteriophages from environmental sample and enumerate them
CONTENT	**Unit 1: Nature and Properties of Viruses-** Introduction: Discovery of viruses, nature and definition of viruses, general properties, concept of viroids, virusoids, satellite viruses and Prions. Theories of viral origin. Structure of Viruses: Capsid symmetry, enveloped and non-enveloped viruses. Isolation, purification and cultivation of viruses. Viral taxonomy: Classification and nomenclature of different groups of viruses **Unit 2: Bacteriophages-** Diversity, classification, one step multiplication curve, lytic and lysogenic phages (lambda phage) concept of early and late proteins, regulation of transcription in lambda phage **Unit 3: Viral Transmission, Salient features of viral nucleic acids and Replication-** Modes of viral transmission: Persistent, non-persistent, vertical and horizontal. Salient features of viral Nucleic acid : Unusual bases (TMV, T4 phage), overlapping genes (ϕX174, Hepatitis B virus), alternate splicing (HIV), terminal redundancy (T4 phage), terminal cohesive ends (lambda phage), partial double stranded genomes (Hepatitis B), long terminal repeats (retrovirus), segmented (Influenza virus), and non-segmented genomes (picornavirus), capping and tailing (TMV), Viral multiplication and replication strategies: Interaction of viruses with cellular receptors and entry of viruses. Replication strategies of viruses as per Baltimore classification (ϕX174, Retroviridae, Vaccinia, Picorna), Assembly, maturation and release of virions **Unit 4: Viruses and Cancer-** Introduction to oncogenic viruses, Types of oncogenic DNA and RNA viruses:Concepts of oncogenes and proto-oncogenes **Unit 5: Prevention & control of viral diseases-** SARS-CoV2, Structure, transmission, Rationale of vaccine design, Antiviral compounds and their mode of action, Interferon and theirmode of action. General principles of viral vaccination
COURSE CODE	**MB-M-P-17**
COURSE TITLE	**VIROLOGY (PRACTICAL)**
CREDIT	**2**
FULL MARKS	**25**
CONTENT	1. Study of the structure of important animal viruses using electron micrographs (Demonstration only) 2. Enumeration of bacteriophages (PFU) from water/sewage sample using double agar layer technique 3. Phage induction 4. Plant virus transmission by local lesion technique for assaying plant viruses (pot experiment).
SUGGESTED READING	1. Dimmoc, N.J., Easton, A.J. and Leppard, K.N. Introduction to modern virology. Wiley-Blackwell, New Jersey. 2. Primrose, S.B. Introduction to modern virology. John Wiley and Sons, New Jersey. 3. Flint, S. J., Enquist, L. W., Racaniello, V. R., & Skalka, A. M. (2004). Principles of Virology.

COURSE CODE	**MB-M-T-18**
COURSE TITLE	**MICROBIAL BIOTECHNOLOGY (THEORY)**
CREDIT	**4**
FULL MARKS	**50**
COURSE OUTCOME	• Students will be able to understand the industrial production of important microbial metabolites and products of therapeutic and industrial importance • Students will gain knowledge of isolation, maintenance, and handling of industrially important microbial cultures in laboratory settings • Students will learn application of microbes in Environmental biotechnology
CONTENT	**Unit 1: Microbial Biotechnology and its Applications-** Microbial biotechnology: Scope and its applications in human therapeutics, agriculture (Biofertilizers, PGPR, Mycorrhizae), environmental, and food technology; Use of prokaryotic and eukaryotic microorganisms in biotechnological applications; Genetically engineered microbes for industrial application: Bacteria and yeast **Unit 2: Therapeutic and Industrial Biotechnology-** Recombinant microbial production processes in pharmaceutical industries - Streptokinase, recombinant vaccines (Hepatitis B vaccine); Microbial polysaccharides and polyesters, Microbial production of bio-pesticides, bioplastics, Microbial biosensors **Unit 3: Applications of Microbes in Biotransformation-** Microbial based transformation of steroids and sterols; Bio-catalytic processes and their industrial applications: Production of high fructose syrup and production of cocoa butter substitute **Unit 4: Microbial Products and their Recovery-** Microbial product purification: filtration, ion exchange & affinity chromatography techniques; Immobilization methods and their application: Whole cell immobilization **Unit 5: Microbes for Bio-energy and Environment-** Bio-ethanol and bio-diesel production: commercial production from lignocellulosic waste and algal biomass, Biogas production: Methane and hydrogen production using microbial culture. Microorganisms in bioremediation: Degradation of xenobiotics, mineral recovery, removal of heavy metals from aqueous effluents
COURSE CODE	**MB-M-P-18**
COURSE TITLE	**MICROBIAL BIOTECHNOLOGY (PRACTICAL)**
CREDIT	**2**
FULL MARKS	**25**
CONTENT	1. Study enzyme immobilization by sodium alginate method 2. Microbial Pigment production (eg. *Pseudomonas aeruginosa*) 3. Isolation of amylase or protease producing microbes

	4. Isolation of bacteria from vermicompost **5.** Isolation of any one xenobiotic (eg Plastic, polymers, pesticides, polycyclic aromatic hydrocarbons (PAHs), pharmaceutical active compounds (PhACs), personal-care products (PCPs), phenolics, chlorinated compounds) degrading bacteria from soil
SUGGESTED READING	1. Glazer, A. N., & Nikaido, H. (2007). Microbial biotechnology: fundamentals of applied microbiology. Cambridge University Press. 2. Ahmad, I., Ahmad, F., & Pichtel, J. (Eds.). (2011). Microbes and microbial technology: agricultural and environmental applications. Springer Science & Business Media. 3. Lee, Y. K., & Anwar, A. (Eds.). (2003). Microbial biotechnology: principles and applications. World Scientific Publishing Company. 4. Casida, L. E. (1968). Industrial microbiology. Industrial microbiology.