Rev: 04

SYLLABUS

For

2 YEARS MSC MICROBIOLOGY PROGRAMME

(Revised Syllabus Approved by Academic Council)

Unveiling Excellence

Dept. of
Applied Biology

JUNE, 2019

UNIVERSITY OF SCIENCE &TECHNOLOGY, MEGHALAYA

Techno City, 9th Mile, Baridua, Ri-Bhoi, Meghalaya, 793101

Programme Specific Outcomes (PSOs) of M. Sc. Microbiology

PSO1. The objective of the Master's Programme in Microbiology is to equip the students to apply knowledge of prokaryotic and eukaryotic cellular processes, classification, interaction of microorganisms among themselves, with physical and chemical agents and higher order organisms.

PSO2. The laboratory training in addition to theory is included to prepare them for careers in the industry, agriculture, and applied research where biological system is increasingly employed.

PSO3. Basics and current molecular updates in the areas of Industrial Microbiology, Fermentation Technology, Agriculture and Environmental Microbiology are included to train the students and also sensitize them to scope for research.

PSO4. The Masters in Microbiology Programme will address the increasing need for skilled scientific manpower with an understanding of research ethics involving microorganisms to contribute to application, advancement and impartment of knowledge in the field of microbiology and molecular biology globally.

PO5. The study of Master of Microbiology will impart in-depth understanding of basic aspects of microbiological science pertaining to industrial applications that will make the students ready to contribute to:
-better awareness of the major issues at the forefront of the discipline.
-an in-depth understanding of the area of Microbiology chosen for research emphasis.
-awareness of ethical issues in Microbiology research and careers options.
-inclination towards own professional goals over a wide range of carrier options expanding from R & D, industrial or Govt. Sector or as an Entrepreneur.

SEMESTER WISE DISTRIBUTION OF COURSE

Course Code: MMB **School Code: SOBS**

SEMESTER-I

Course Code	Title	Credit	Nature of the Course	Marks Allotted		
				Internal	End Semester	Total
MMB 101	General Microbiology and Bacteriology **(CC-1)**	**4**	**T**	**30**	**70**	**100**
MMB 102	Microbial Physiology and Biochemistry **(CC-2)**	**4**	**T**	**30**	**70**	**100**
MMB 103	Bio-instrumentation **(SEC-1)**	**4**	**T**	**30**	**70**	**100**
MMB 104	Cell Biology and Genetics **(CC-3)**	**4**	**T**	**30**	**70**	**100**
MMB 105	Practical-I **(CC-4)**	**4**	**P**	**30**	**70**	**100**
Total		**20**	**-**	**150**	**350**	**500**

SEMESTER- II

Course Code	Title	Credit	Nature of the Course	Marks Allotted		
				Internal	End Semester	Total
MMB 201	Molecular Biology **(SEC-2)**	**4**	**T**	**30**	**70**	**100**
MMB 202	Microbial Genomics **(CC-5)**	**4**	**T**	**30**	**70**	**100**
MMB 203	Phycology and Mycology **(CC-6)**	**4**	**T**	**30**	**70**	**100**
MMB 204	Soil and Environmental Microbiology **(CC-7)**	**4**	**T**	**30**	**70**	**100**
MMB 205	Practical-II **(CC-8)**	**4**	**P**	**30**	**70**	**100**
Total		**20**	**-**	**150**	**350**	**500**

SEMESTER- III

Course Code	Title	Credit	Nature of the Course	Marks Allotted		
				Internal	End Semester	Total
MMB 301	Industrial Microbiology and Recombinant DNA Technology **(CC-9)**	**4**	**T**	**30**	**70**	**100**

MMB 302	Virology	**4**	**T**	**30**	**70**	**100**
MMB 303	Clinical Microbiology and Diagnostic Techniques **(CC-10)**	**4**	**T**	**30**	**70**	**100**
MMB 304	Immunology **(DSE-1)**	**4**	**T**	**30**	**70**	**100**
MMB 305	Practical-III **(CC-11)**	**4**	**P**	**30**	**70**	**100**
	Industrial Visit (as a part of Practical)					
MMB-306	Pharmacology **(MDC-1)**	**4**	**T**	**30**	**70**	**100**
Total		**20**	**-**	**150**	**350**	**500**

SEMESTER- IV

Course Code	Title	Credit	Nature of the Course	Marks Allotted		
				Internal	End Semester	Total
MMB 401	Research Methodology, Biostatistics and Bioinformatics **(DSE-2)**	**4**	**T**	**30**	**70**	**100**
MMB 402	Optional Paper **(CC-12)**	**4**	**T**	**30**	**70**	**100**
A.	Microbial Diversity					
B.	Agricultural Microbiology					
C.	Food Microbiology and Fermentation Technology					
D.	Medical Microbiology					
MMB 403	Practical on Optional Paper **(CC-13)**	**4**	**P**	**30**	**70**	**100**
MMB 404	Dissertation Work and Lab. Visit Report **(CC-14)**	**8**	**P**	**60**	**140**	**200**
HVP 740	Human Values and Professional Ethics	**NCM***	**T**	**15**	**35**	**50**
Total		**20**	**-**	**150**	**350**	**550**

***NCM: Non Credit Mendatory**

SEMESTER-I

MMB 101 General Microbiology and Bacteriology Theory Credit: 4

After successful completion, this course enables students

CO1. To explore the fascinating world of microorganism and their role (both beneficial and harmful) in day to day life. It also imparts knowledge on the various phases and contribution of different Scientists how Microbiology established itself as a separate branch of Science.

CO2. To understand the different categories of microbes and sub-microbial groups with their position in the tree of life (classification), their characteristic features and importance.

CO3. To become familiarize with the different technical aspects [isolation, cultivation, observation (microscopy), and identification] of studying microbes.

CO4. To get an insight on the existence of microbes in different spheres of the environment and how the microbes are affected/induced in these environments or *vice versa*.

CO5. To familiarize with the characteristic and structural features of bacteria as a representative type of prokaryotic cellular organism.
It also gives an insight into the various required factors (nutritional/physical) for the laboratory cultivation of bacteria.

Course Content

Unit--I: Fundamentals of Microbiology

1. Historical development of microbiology as a discipline. Spontaneous generation *vs*. Biogenesis; Microbes in nature; Role of microbes in the fields of agriculture, environment and industry (food, pharmaceuticals and others).
2. Approaches in microbial classification: Binomial Nomenclature; Haeckel's three kingdom concept; Whittaker's five kingdom and Carl Woese's three domain concept of classification.
3. General characteristics of acellulars (Viruses, Viroids, Virusoid and Prions) and cellular microorganisms (Bacteria, Algae, Fungi and Protozoa) with emphasis on their morphology, mode of reproduction and economic importance.

Unit II: Methods of studying microorganism

1. Principle and application of light (bright and dark field), phase contrast, fluorescent, electron microscope.
2. Sterilization and disinfection: Physical and chemical methods; chemotherapeutic agents and mode of action.
3. Culture Techniques- types and importance of culture media, pure culture methods, preservation of pure culture.

Unit--- III: Microorganisms and their natural habitats

1. Soil as a natural habitat of microbes. Soil microflora and their interactions in soil (symbiosis, mutualism, commensalism, competition, synergism and parasitism). Factors affecting microbial distribution in soil. Microbes in the Rhizosphere and their importance.
2. Microflora of Freshwater & Marine habitats. Factors affecting distribution of aquatic microflora. Microbial assessment of water quality and water purification. A brief account of water borne diseases in man.
3. Aeromicroflora-source and dispersal. Factors affecting distribution of aeromicroflora. Microbes in the Phyllosphere and their importance.

Unit--IV: General Bacteriology

1. Morphology and fine structure of Bacteria**:** Morphological types – size, shape and arrangements.
2. Composition and detailed structure of cell walls of archaea, Gram-positive and Gram-negative eubacteria. Effect of antibiotics and enzymes on the cell wall. Staining techniques in bacteria.
3. Structure, function and chemical composition of bacterial and archaeal cell membranes.
4. Structure and function of cell appendages and inclusions: capsule types (composition andfunction); flagella, pili or fimbrae, ribosomes, mesosomes, inclusion bodies, nucleoid, chromosome and plasmids (types of plasmids and function). Bacterial spores (Structure, stages of sporulation and regulation of spore formation).

Unit--V: Nutrition, Growth and Reproduction in Bacteria

1. Nutritional requirements in bacteria and nutritional categories.
2. Definitions of growth; Logarithmic representation of bacterial populations. Batch and continuous culture; calculation of generation time and specific growth rate. Synchronous growth. Growth curve; phases of growth. Measurement of growth and factors affecting growth.
3. Methods of reproduction in bacteria;Genetic recombination in bacteria.

Unit VI: Bacterial Systematics

1. Principle and classification of bacteria on the basis of *Bergey's manual of Determinativebacteriology*.
2. Concept of species, taxa and strain; conventional, molecular and recent approaches to polyphasic bacterial taxonomy.

Suggested Readings:

Text Books-

1. Pelczar MJ, Chan ECS and Krieg NR. (2010). *Microbiology*. 8th edition. McGraw Hill Book Company.
2. Sharma PD. (2005). *Microbiology*.4th edition (reprint). Rastogi Publication, Meerut.
3. Willey JM, Sherwood LM, and Woolverton CJ. (2008). *Prescott, Harley and Klein's Microbiology*. 8th edition. McGraw Hill Higher Education.

References-

1. Ananthanarayan R and Paniker CKJ. (2005). *Textbook of Microbiology*. 7th edition (edited by Paniker CKJ). University Press Publication.
2. Madigan MT, Martinko JM and Parker J. (2009). *Brock Biology of Microorganisms*. 12th ed. Pearson/Benjamin Cummings.
3. Tortora GJ, Funke BR and Case CL (2013). *Microbiology: An Introduction*. 11th edition. Pearson Education.
4. Atlas RM. (1997). Principles of Microbiology. 2nd edition. WM.T.Brown Publishers.
5. Srivastava S and Srivastava PS. (2003). Understanding Bacteria. Kluwer Academic Publishers, Dordrecht
6. Stanier RY, Ingraham JL, Wheelis ML and Painter PR. (2005). General Microbiology. 5th edition McMillan.

MMB 102 Microbial Physiology and Biochemistry Theory Credit: 4

After successful completion, this course enables students

CO1. To get an insight into the various biochemical principles governing the physiology of microorganisms.

CO2. To familiarize with the characteristic, types and structural features of important bio-molecules (carbohydrate, protein, lipid, amino acids) that form the building block of cellular organisms.

CO3. To develop the concept on the type, nature and other features of enzyme molecules that controls the different physiological processes of microbes and other cellular organisms.

CO4. To understand the principles of various metabolic/biochemical processes (sugar degradation, electron transport, fermentation etc.) occurring in or carried out by different microbial/ cellular systems.

CO5. To get an insight into the principles and mechanism of photosynthetic pathway carried out by various groups of bacteria and cyanobacteria.

Course Content

Unit I: Basics of Biochemistry

1. Ionization of water, Concept of pH and pK. Buffer solutions, action of buffers. Henderson-Hasselback equation. Preparation of weak acids and bases.
2. Bioenergetics: Concept of energy, First and Second Law of thermodynamics. Free Energy Change, relation between standard free energy change and equilibrium constant, exergonic and endergonic reactions.

Unit II: Biomolecules

1. Structures, properties (chemical and physical) and classification of carbohydrate, protein, amino acids, nucleic acids, and lipids.
2. Prediction of protein structure, Ramachandran plot; helix-coil transltion.

3. Enzyme nomenclature, enzyme kinetics, MM, LB, EH plots. Allosteric interactions and product inhibition. Enzyme immobilization. Co enzymes and prosthetic groups.

Unit III: Metabolism

Chemoheterotrophic Metabolism - Aerobic Respiration

1. Sugar degradation pathways i.e. EMP, ED, Pentose phosphate pathway: TCA cycle
2. Electron transport chain: components of respiratory chain, comparison of mitochondrial and bacterial ETC, electron transport phosphorylation, uncouplers and inhibitors

Chemoheterotrophic Metabolism- Anaerobic respiration and fermentation

1. Anaerobic respiration with special reference to dissimilatory nitrate reduction (Denitrification; nitrate /nitrite and nitrate/ammonia respiration; fermentative nitrate reduction)
2. Fermentation: Alcohol fermentation and Pasteur effect; Lactate fermentation (homofermentative and heterofermentative pathways); Concept of linear and branched fermentation pathways.

Unit IV: Bacterial photosynthesis

Characteristic of Photosynthetic bacteria, Phytosynthetic pigments; metabolism in Phytosynthetic bacteria; Phytosynthetic electron transport system; mechanism of photosysthesis, Dark reaction (Calvin-Benson cycle). Anoxygenic vs. oxygenic photosynthesis with reference to photosynthesis in green bacteria, purple bacteria and cyanobacteria.

Suggested Readings:

1. Albert L. Lehninger. *Principles of Biochemistry*-CBS Publishers & Distributors
2. Lubert Stryer. *Biochemistry*-Freeman International Edition.
3. Dr. A.C. Deb. *Fundamental of Biochemistry*.
4. U. Satyanarayana. *Biochemistry*-Books and Allied Pvt. Ltd.
5. Voet and Voet. *Biochemistry*-John Wiley and Sons.
6. Moat AG and Foster JW. (2002). Microbial Physiology. 4th edition. John Wiley & Sons
7. Reddy SR and Reddy SM. (2005). Microbial Physiology. Scientific Publishers India
8. Gottschalk G. (1986). Bacterial Metabolism. 2nd edition. Springer Verlag

MBT 103 Bioinstrumentation Theory Credit: 4

After successful completion, this course enables students

CO1. To develop concept on the important techniques necessary for the study and prediction of different processes occurring in microbes and other cellular organisms.

CO2. To familiarize with the importance, principle and types of chromatography and centrifugation techniques and their role in the study of biological system.

CO3. To familiarize with the importance, principle and types of electrophoretic techniques and their role in the study of biological system.

CO4. To get an insight into the concept of radioactivity and its application in biochemical and immunological processes.

CO5. To familiarize with a***dvanced techniques like*** Protein Crystallization, MALDI-TOF, Mass Spectrometry, Enzyme and Cell Immobilization which are extensively used in Industrial and R & D sectors.

Course Content

Unit I:

Basic Techniques-

1. Buffers; Methods of cell disintegration; Enzyme assays and controls; Detergents and membraneproteins; Dialysis, Ultrafiltration and other membrane techniques

Spectroscopy Techniques

2. Principles and Applications of UV, Visible Spectroscopy; Circular Dichroism; Fluorescence; Mass Spectroscopy, NMR Spectroscopy

Unit II:

Chromatography Techniques-

1. TLC and Paper chromatography; Gel permeation, Ion exchange, Hydrophobic, Reverse-phase and Affinity chromatography; HPLC and FPLC

Electrophoretic techniques-

2. Theory and application of Polyacrylamide and Agarose gel electrophoresis; Capillaryand 2D Electrophoresis

Unit III: Centrifugation

1. Basic principles & theory (RCF, Sedimentation coefficient etc); Types of centrifuge - Microcentrifuge, High speed & Ultracentrifuges; Differential & density gradient centrifugation;
2. Applications (Isolation of cell components); Analytical centrifugation; Determination of molecular weight by sedimentation velocity.

Unit IV: Radioactivity

1. Radioactive & stable isotopes; Pattern and rate of radioactive decay; Unit----s of radioactivity; Measurement of radioactivity; Geiger-Muller counter; Solid & Liquid scintillation counters (Basic principle, instrumentation & technique); Autoradiography;
2. Applications of isotopes in biochemistry; Radiotracer techniques; Radioimmunoassay

Unit V: Advanced Techniques

Protein crystallization; Theory and methods; API-electrospray and MALDI-TOF; Mass spectrometry; Enzyme and cell immobilization techniques; DNA & Peptide Synthesis.

MMB 104 Cell Biologyand Genetics Theory Credit: 4

After successful completion, this course enables students

CO1. To get an insight into the concept of prokaryotic and eukaryotic cells, and different cell organelles and functional role in cellular life.

CO2. To learn the basis of cell to cell communication in cellular life and the mechanism of cellular signaling maintained by them.

CO3. To familiarize with concept germinal cells and the events occurring during the developmental stages both in plant and animal life.

CO4. To understand the concept of gene (basic unit of genetic character) and the basic principle of genetics (inheritance of characters) as well as the concept of how mutation in gene can alter characters in an individual.

CO5. To familiarize with concept of inheritance of characters from parental line to the offspring following both Mendelian and non-Mendelian pattern.
It also gives an insight in to the different genetic diseases/disorders in man and their pattern of inheritance.

Course Content

Unit I:

1. Ultra-structure of prokaryotic and eukaryotic cells; Cell organelles structure and functions; ATP synthase and generation of ATP; Chloroplast DNA and its significance.
2. Cell communication, Cell – ECM junction, adhesion molecules; Transport of ions; Mechanism and stages of secretory pathways; Cell cycle, regulation of cell cycle.
3. Cell signaling – Cellular response to environmental signals in plants and animals; Mechanism of signal transduction.
4. Action-binding proteins and their significance; Muscle organization and function; Molecular motors; Intermediate filaments.

Unit II:

1. Potency of embryonic cells, Commitment, Specification (Autonomous and Conditional); Determination and

Differentiation; Morphogenetic gradients, Cell fate, cell lineages and development control genes in *Caenorhabditis*

2. Cellular movements and Pattern Formation – Differentiation of germ layers; Cellular polarity; Maternal gene and homeotic gene effect; Concept of embryogenesis.
3. Self-incompatibility and its genetic control; Embryo and endosperm development; Heterosis and apomixes.

Unit III: Essentials of Genetics

Genetic notations – prototypes and auxotypes; Genes as unit of mutation and recombination, molecular nature or mutation, origin of spontaneous mutation; genetic analysis of micro-organisms bacteria and yeast.

Unit IV: Mendelian genetics

1. Introduction to human genetics; Background and history. Types of genetic diseases; Role of genetics in medicine;
2. Human pedigrees; Patterns of single gene inheritance-autosomal recessive; Autosomal dominant; X linked inheritance
3. Hemoglobinopathies -Genetic disorders of hemoglobin and their diseases.

Unit V: Non-Mendelian inheritance patterns

1. Mitochondrial inheritance. Genomic imprinting: Lyon hypothesis.
2. Isodisomy; Complex inheritance
3. Genetic and environmental variation; Heritability; Twin studies. Behavioral traits; Analysis of quantitative and qualitative traits

Suggested Readings:

1. Bruce Alberts *et al*. *Molecular Biology of cell*. Garland Publications
2. Daniel. *Molecular Cell Biology*. Sceintific American Books.
3. Jack D. Bruke. *Cell Biology*. The William Twilkins Company.
4. Ambrose and Dorouthy M Hasty. *Cell Biology*. ELBS Publications.
5. Sharp. *Fundamentals of Cytology*. Mc Graw Hill Company.
6. Wilson and Marrision. *Cytology*. Reinform Publications
7. EDP Roberties and EMF Roberties. *Cell and Molecular Biology*. Sauder College.
8. Gardener EJ, Simmons MJ and Snustad DP. *Principles of Genetics*. John Wiley and Sons Publications.
9. Daniel J Fairbanks, The Continuity of Life, Brooks/Cole Pub., 1999
10. B.D. Singh Fundamentals of Genetics, Kalyani publishers, Ludhiana, ed 6th (2002)

MBT 105 Microbiology, Biochemistry and Cell Biology Practical Credit: 4

This course enhances the practical application of the concept on Microbiology, Biochemistry and Cell Biology. After successful completion, this course enables students

CO1. To understand the different phases of cell-cycle during mitosic and meiosic cell division.

CO2. To learn the principle and process for quantitative estimation (spectrophotometry) of DNA using (Diphenylamine method), RNA (Orcinol method) and protein analysis (vertical slab gel electrophoresis).

CO3. To get an insight into the laboratory techniques for the isolation and enumeration of microorganisms from fro different environmental spheres like soil, water and air with special reference to
-antibiotic producing microbes from soil
-the effect of physical factors (temperature and pH) on growth

CO4. To learn the principle and the process concerned with the study of bacteria including:
-isolating bacteria in pure cultures by streaking method
-determination of growth-phases in bacteria with the help of growth curve
-identification of unknown bacteria with the help of specific biochemical activity and staining techniques (Gram's, capsule and flagella staining)
-determination of sensitivity/resistance in bacteria against different antibiotic substances

CO5. To get an insight into the biochemical methods for the estimation of carbohydrates, proteins and amino acids- both quantitatively and qualitatively.
It also helps students to develop the idea of separation of plant pigments and amino acids using chromatographic methods of TLC/ Paper chromatography.

Course Content

Cell Biology

1. Study of mitosis and meiosis in dividing cells
2. Spectrophotometric quantification of DNA using Diphenylamine method.
3. Spectrophotometric quantification of RNA using Orcinol method.
4. Protein analysis by vertical slab gel electrophoresis and characterization by standard protein marker.

Biochemistry

1. Determination of reducing sugars by Nelson Somogye method.
2. Determination of total carbohydrate by anthrone method.
3. Determination of free acid and saponification value of oil.
4. Estimation of protein by Lowry's method.
5. Separation of pigments using paper chromatography.
6. Separation of amino acids using thin layer chromatography.

Microbiology

1. Isolation and enumeration of microorganisms from soil (rhizosphere and rhizoplane), water and air (phyllosphere and phylloplane).
2. Isolation of antibiotic producing microbes from soil.
3. Study of effect of physical factors (temperature and pH) on growth of microbes.
4. Study of bacteria:
   a) Study of bacterial growth curve.
   b) Biochemical characterization of bacteria.
   c) Staining techniques in bacteria (Gram's, capsule and flagella staining).
   d) Antibiotic sensitivity test of bacteria.

Reference:

1. S. Sadasivam and A. Manickam Biochemical Methods-, New Age International Publishers, New-Delhi.
2. Cappucino J and Sherman N. (2010). *Microbiology: A Laboratory Manual*. 9th edition. Pearson Education limited.

****

SEMESTER II

MMB 201: Molecular Biology Theory Credit: 4 Full Marks: 100

After successful completion, this course enables students

CO1. To understand the molecular basis of biological activity between biomolecules in the various systems of a cell.

CO2. To familiarize with the basics of DNA, RNA, and proteins structure and their interactions within the cell to promote growth, division and development.

CO3. To have the concept on the responses to environmental or physiological changes, or alterations of cell function brought about by mutation.

CO4. To get an insight in to the wide range of mechanisms required for gene regulation in different organisms.

CO5. To understand the molecular basis of cancer and other diseases and the pattern of interaction of animal cells with micro-organisms and viruses.
It also deals with the application of recombinant DNA techniques to problems in basic science and biotechnology.

Course Content

Unit-1: Organization of genetic materials

1. Various models to explain the structure of the nucleus and chromosomes, Special type of chromosomes: lamp brush, salivary and B chromosomes.
2. Packaging of DNA as nucleosomes in eukaryotes, Chromosomal DNA contents and Cvalue paradox. Structural changes in the chromosomes
3. Multigene families in eukaryotes; Genomic organization in prokaryotes and Archaebacteria

Unit-II: DNA replication and repair

1. Enzymes & accessory proteins involved in DNA replication
2. Replication process in prokaryotic & Eukaryotic DNA. Regulations of Eukaryotic replication
3. DNA repair: - Types of DNA Repair, Mechanism of DNA Repair

Unit-III: Transcription

1. Importance of DNA binding Proteins, RNA polymerase
2. Mechanism of Transcription in prokaryotes & Eukaryotes
3. Processing of RNA: - m-RNA processing, 5' capping, 3' polyadenylation, splicing r-RNA & t- RNA processing

Unit-IV: Translation

1. The translation machinery, role of t RNA & ribosome; Mechanism, of translation
2. Post translational modification of proteins such as phosphorylation, adenylation, acylation and glycosylation

Unit-V: Regulation & gene expression in Prokaryotes & eukaryotes

1. Operon concept (Lac operon, trp operon, his operon and arabinose operon), Structural basis of DNA-Protein interaction; Attenuation & termination
2. Gene silencing: - DNA methylation,
3. Chromatin modification & gene expression. Histone acetylation & deacetylation; Environmental regulation of gene expression

MMB 202 Microbial Genomics Theory Credit: 4

After successful completion, this course enables students

CO1. To understand the genome concept in the study of general characteristic of bacterial population focusing on the whole-genome sequencing and metagenomics for investigating microbial communities.

CO2. To get an insight in to the various tools used for studying DNA/Genes including the vectors involved in molecular cloning for genome analysis along with the concept of DNA libraries, Fluorescent in situ hybridization and Denaturing gradient gel electrophoresis.

CO3. To analyze the concept of microbial genomes, using various mapping technique such as physical and linkage mapping.

CO4. To get an insight in to the various tools involved in DNA finger printing such as RFLP, RAPD, AFLP, SSCP and SNP which finally help in studying the microbial diversity and the interrelationship between them.

CO5. To have the concept on functional genomics which helps to understand the function of genes or proteins, eventually all components of a genome of an organism which could potentially provide a more complete picture of how the genome specifies function compared to studies of single genes.

Course Content

Unit- I: Tools for studying DNA/genes: Specialized vectors and molecular cloning strategies forGenome analysis. DNA libraries, fluorescent in situ hybridization (FISH), denaturing gradient gel electrophoresis (DGGE).

Unit- II: Genomes: Size, physical structure, Whole genome shotgun sequencing, General chara-cteristics of bacterial genome, metagenomics.

Unit- III: Mapping of genome: Physical mapping strategies-PFGE, methods based on DNAhybridization, Linkage mapping strategies – mapping by conjugation and transduction.

Unit-IV: Tools for DNA Finger printing: restriction fragment length polymorphism (RFLP), randomlyamplified polymorphic DNA (RAPD), simple sequence length polymorphism (SSCP), amplified fragment length polymorphism (AFLP). Single nucleotide polymorphism (SNP).

Unit-V: Functional genomics: Genome annotation, entire genome expression analysis-microarrays, expressed sequence tags (ESTs), serial analysis of gene expression (SAGE), Proteomics.

MMB203 Phycology and Mycology Theory Credit: 4

After successful completion, this course enables students

CO1. To get an insight into the kingdom of Fungi; their taxonomic position, habitat, morphology, cellular, nutritional and reproductive features and how these features vary among different groups of fungi.

CO2. To familiarize with the specialized cellular and reproductive mechanisms like Heterothallism; Para-sexuality; Clamp-connection found within the Kingdom Fungi.

CO3. To familiarize with the important beneficial symbiotic association of fungi and their specific role in different sectors.

CO4. To understand the concept of diseases caused by fungi, different terminology associated with fungal disease and at the same time some of the important fungal diseases in plants (phyto-pathogenesis) and men (dermatophytoses/dermatomycoses).
It also gives an insight into the specific mechanism adopted by fungi for disease development (mycotoxins) and at the same it also gives an insight to the various means/approaches to combat such diseases.

CO5. To get an insight into the taxonomic position, habitat, morphology, cellular, nutritional and reproductive features of different groups of algae.
It also familiarizes students with the beneficial aspects of different algal groups.

Course Content

Unit- I: Historical development of mycology. structure and cell differentiation in fungi; Criteria for fungalclassification. Habitat, morphology and reproduction of Slime molds, Oomycetes, Zygomycotina, Ascomycotina, Basidiomycotina, Mastigomycotina and Deuteromycotina

Unit- II: Concept ofhomothallism and heterothallism in fungi; Para-sexuality and Sex hormones in fungi; Clamp-connection among basidiomycetous fungi; fungal succession on decomposing litter
Mycorrhiza: ecto-, endo- and arbuscular mycorrhiza. Role of Mycorrhiza in agriculture.
Lichens: characteristic features, types, mode of reproduction and economic importance.

Unit- III: Fungi and Plant disease – Disease symptoms; the concept of virulence and resistance,mechanical and chemical barriers of infection.
Study the pathogenesis, symptom and control of: Early and late blight of potato; loose smut of wheat, black rust of wheat, Fusarial wilt of arahar, red rot of sugarcane and damping off of seedling.

Unit- IV: Fungi and animal disease – Dermatophytes and superficial and systemic mycoses. Mycotoxins: source organism and health effects. Antifungal agents: concept and mode of action.

Unit- V: Phycology: characteristics and distribution of algae; Classification of algae; thallus organization and reproduction in algae.
Brief account (characteristic, thallus organization and mode of reproduction) of Cyanophyta, Chlorophyta, Bacillariophyta, Phaeophyta and Rhodophyta. Life-cycle pattern in algae; algal biotechnology and economic importance of algae.

MMB204 Soil and Environmental Microbiology Theory Credit: 4

After successful completion, this course enables students

CO1. To get an insight into the different sphere of the environment (soil, water and air) as microbial habitat and how the microbes are affected/induced in these environments or *vice versa*.

CO2. To understand the different types of microbial association developed in soil and how these associations affecting other cellular life in/on soil.

CO3. To develop knowledge on the application of microbes or their processes/products for developing beneficial and eco-friendly byproducts like biofertilizers, biopesticides, biopolymers, bioplastics etc.

CO4. To get an insight into how microbes affecting aquatic health and what are the different approaches for monitoring and maintaining potability of water.

CO5. To familiarize with the important environmental roles played by microbes specifically in the light of sewage treatment, litter decomposition, maintenance of soil health and at the same time in metal recovery process (bioleaching).

Course Content

Unit- I: Aero-microbiology - droplet nuclei, aerosol, assessment of air quality, brief account of air-borne microbes – bacteria, fungi, and viruses, their diseases and preventive measures; Phylloplane and Phyllosphere microflora.

Unit- II: Soil Microbiology – Classification of soil-physical and chemical characteristics, soil as a habitat for micro-organisms, microflora of various soil types, Rhizosphere and rhizoplane. Nitrogen fixation: Asymbiotic and symbiotic nitrogen fixation systems – root nodulation symbiotic bacteria (process of root nodule formation), Leghemoglobulin. Microbial interactions-symbiosis, mutualism, commensalisms, amensalism, competition, antibiosis; Actinorrhiza; Mycorrhizal fungi and its effect on plants.

Unit- III: Production of biofertilizers and biopesticides – Quality control, BIS norms of biofertilizers;Biofertilizers

(rhizobial inoculants, mass production and method of application); Biopesticides (viral, bacterial and fungal biopesticides); Biopolymers – Polyhydroxybutyrate (PHB), xantham gum.

Unit- IV: Aquatic Microbiology **–** Water ecosystems – types, fresh water (pond, lakes), marine habitats(estuaries, deep sea, hydrothermal vents); Eutrophication, food chain; potability of water, microbial assessment for water quality, water purification, physical, chemical, microbiological characteristics of sewage. Characterization of solid and liquid wastes, physical, chemical and biological (aerobic, anaerobic – primary, secondary, tertiary) treatment; Solid waste treatment; Liquid waste treatment – trickling, activated sludge, oxidation ponds. Formation of biofilm. Biomagnifications.

Unit- V: Role of microbes in environment **–** Organic matter decomposition, factors affecting litter decomposition; Biogeochemical cycling of C, N, P and S; Microbial biomass and soil fertility; Biodegradation of hydrocarbons and xenobiotics, Microbial leaching of iron and copper.

MMB-204 Practical on Theory Credit: 4

This practical course enhances the applicability of the concept on Molecular Biology, Microbial Genomics, Phycology & Mycology and Soil and Environmental Microbiology. After successful completion, this course enables students

CO1. To learn the principle and process for the isolation DNA from bacterial, plant and animal sources and their quantification using agarose gel electrophoresis

CO2. To learn the principle and process of restriction digestion analysis by agarose and polyacrylamide gel electrophoresis (over-expression of proteins by SDS-PAGE.

CO3. To learn the principle and process for the isolation and cloning of plasmid DNA and their amplification by PCR (RAPD analysis).

CO4. To understand vegetative and reproductive structures of different algal (*Nostoc, Anabaena,Oscillatoria* and *Microcystis*) and fungal (*Aspergillus, Penicillium, Fusarium* and *Alternaria*) genera through temporary and permanent slides preparation.

CO5. To learn the principle and process concerned with soil and environment including:
-isolation of root nodule bacteria (*Rhizobium*) using Yeast Extract Agar (YEMA) Medium.
-study of anatogonism of micro-organism by dual culture inoculation method (Bacterium Vs Bacterium; Bacterium Vs fungus; Fungus Vs Fungus).
-determination of dissolved oxygen (DO), BOD and COD of water (Raw/Treated/Sewage).

Course Content

Molecular Biology
1. Spectrophotometric quantification of DNA using Diphenylamine method.
2. Spectrophotometric quantification of RNA using Orcinol method.
3. Isolation and quantification of DNA from bacteria, plant and animal.
4. Agarose gel electrophoresis.
5. Protein analysis by vertical slab gel electrophoresis and characterization by standard protein marker.

Microbial Genomics
1. Restriction digestion analysis by agarose and polyacrylamide gel electrophoresis.
2. Isolation and cloning of plasmid DNA.
3. Amplification of DNA by PCR
4. RAPD analysis
5. Overexpression of proteins and analysis by SDS-PAGE
6. Purification of recombinant protein

Phycology and Mycology

1. Isolation and identification of *Aspergillus, Penicillium, Fusarium, Alternaria, Nostoc, Anabaena, Oscillatoria, Microcystis.*

Soil and Environmental Microbiology

1. Isolation of *Rhizobia* from root nodule using Yeast Extract Agar Medium (YEMA).
2. Study of anatogonism of micro-organism by dual culture inoculation method (Bacterium Vs Bacterium; Bacterium Vs fungus; Fungus Vs Fungus).
3. Determination of dissolved oxygen (DO), BOD and COD of water (Raw/Treated/Sewage).
4. Demonstration of salt tolerance level in bacteria.

SEMESTER III

MMB 301: Industrial Microbiology and Fermentation Technology THEORY
Credit: 4 Full Marks: 100

After successful completion, this course enables students

CO1. To develop idea on the sources, isolation, preservation and maintenance of industrially important microbial strains as well as their specific features.

CO2. To get an insight into the principle, types and components of a typical industrial fermentor; the basic requirement, process, measurement and control of fermentation parameters.

CO3. To understand the industrial production of alcoholic beverages, antibiotics, solvents, vitamins and industrial enzymes using microbial fermentation process with special reference to micro-organisms involved, media, fermentation conditions, downstream processing and their uses.

CO4. To have an idea on one of the important industrial process of enzyme immobilization describing the methods of immobilization and large scale applications of immobilized enzymes.

CO5. To get the basic concept of recombinant DNA technology for the genetic modification of industrially important microorganisms.
It also gives an insight in to the application of recombinant DNA technology for the production of human therapeutic agents (insulin, HGH, recombinant vaccines) and transgenic crops.

Course Content

Unit-- I: Brief History of Industrial Microbiology, suitability of microbes in industrial processes andtheir sources types of fermentation and bioreactors, Recent development in industrial microbiology, structure of fermentor, Economic aspects of fermentation processes.

Unit-- II: Isolation, selection, improvement and maintenance of industrial important strain. Metabolicpathways and metabolic control mechanisms; primary metabolites (alcohols, vitamins, enzymes and organic acids) and secondary metabolites (antibiotics and toxins); substrates for industrial fermentation

Unit-- III: Batch culture in fermentation, growth kinetics of micro-organisms, classification of fermentation process; growth and nutrient, growth and product formation, heat evolution, effect of environment (temperature, pH, high nutrient concentration), media formulation and sterilization, kinetics of thermal death of micro-organisms.

Unit-- IV: Continuous culture and scale up – Continuous culture system, productivity, productformation, power requirement oxygen transfer kinetics, foam and antifoam-instrument control, physical and chemical environment sensors.

Unit-- V: Downstream processing objectives and criteria, foam separation Precipitation methodsfiltration devices industrial scale centrifugation and cell disruption methods. liquid -liquid extraction solvent I recovery chromatography. Two phase aqueous extraction, super critical fluid extraction, ultrafiltration drying devices crystallization and whole broth processing, IPR and bioethics.

MMB302 Virology Theory Credit: 4

After successful completion, this course enables students

CO1. To get an insight into one of the most important acellular entity lying at the borderline of living and dead called virus and its allied groups including viroids, virusoids and prions.

CO2. To understand the general features morphology, ultra-structure, composition and arrangements of structural components in virus.
It also deals with the nomenclature, classification of viruses and other aspects related to virus and its allied groups.

CO3. To familiarize with the concept and important aspects (types, structural organization, multiplication cycle and therapeutic application) of bacteriophages or the virus of bacteria.

CO4. To get an insight into the cultivational, diagnostic andserological (haemagglutination, immuno-fluorescence ELISA) methods concerned with the characterization and identification of virus.

CO5. To get an insight into concept of
-plant viruses (TMV, CMV and potato virus X) and the diseases caused by them with special reference to their pathogenicity, diagnostic techniques and curative measures.
-animal viruses (Picornaviruses, Orthomixoviruses, Paramyxoviruses, Rhabdoviruses, Rotaviruses, HIV, Herpes viruses and Adenoviruses) and the diseases caused by them with special reference to their pathogenicity, diagnosis and prevention.

Course Content

Unit-I: General features, morphology of viruses - ultra structure, capsid and its arrangements, types of envelops and its composition; nomenclature and classification of viruses, Viral genomes, its type and structure; Viroids, virusoids , -brief details. prions – spread of prion diseases. Antiviral agents and interferons.

Unit-II: Bacteriophages **–** Structural organization, multiplication cycle; eclipse phase, phage production, burst size, lytic and lysogenic cycle, bacteriophage typing, application in bacterial genetics; Application of bacteriophages in health – bacteriophage therapy.

Unit-III: General methods of diagnosis and serology – Cultivation of viruses in animal inoculation,embryonated eggs, cell cultures and cell lines; Serological methods – haemagglutination, haemagglutination inhibition, complement fixation, immunofluorescent method, ELISA etc; Assay of viruses – physical and chemical methods (protein; nucleic acid and radioactive tracer, electron microscopy), infectivity assay (plaque method, end point method).

Unit-IV: Plant viruses **–** Classification and nomenclature of plant viruses; Disease symptoms – histology, physiology and cytology of plants; common viral disease of paddy, tomato and sugarcane, Type species of plant viruses (e.g. TMV, Cauliflower mosaic virus and potato virus X), transmission of plant viruses & their preservation, diagnostic techniques (serological methods, histochemical tests and fluorescent microscopy).

Unit-V: Animal viruses**–** classification and nomenclature of animal and human viruses; epidemiology, life cycle, pathogenicity, diagnosis, prevention and treatment of viruses; *RNAviruses*-Picornaviruses, Orthomixoviruses, Paramyxoviruses, Arthropod-borne viruses, Rhabdoviruses, Rotaviruses, HIV and other oncogenic viruses; *DNA viruses* – Pox viruses, Herpesviruses, Adenoviruses, Hepatitis viruses; Viral vaccines (conventional)

MMB303 Clinical Microbiology and Diagnostics Theory Credit: 4

After successful completion, this course enables students

CO1. To get an insight into the concept of association of microbes with a particular disease; various phases of host-pathogen interaction during disease development and laboratory diagnosis, management and control of microbial infections.

CO2. To understand the various stages of laboratory diagnosis of microbial infections including collection and processing of clinical specimen.

CO3. To familiarize with the different phases of microscopic and biochemical examination for the characterization and identification of clinical specimens.

CO4. To have an idea on the clinical syndromes and laboratory diagnosis of respiratory tract infections (Pharyngitis and Pneumonia); skin and soft tissue infections (Impetigo, Folliculitis, Furuncle and Carbuncle), infection of central nervous system (Meningitis and Encephalitis); gastrointestinal and urinary tract infections.

CO5. To get an insight into the safety measures in the diagnostic laboratories with special reference to epidemiology, surveillance and management and control of community and hospital infections.

Course Content

Unit-I: Host pathogen interaction: Pathogenesis of infection:colonization and invasion. Role of microbiology laboratory in the diagnosis and control of infections. Management, safety and quality control in medical microbiology laboratory.

Unit-II: Specimen collection and processing: Basic principles of specimen collection, preparation ofcontainer and swabs for collection of specimens for microbiological examination, preservation storage and transport of specimens, documentation of specimen. Microbiological examination of clinical specimens: Microscopic examination, use of colonial morphology for presumptive identification, biochemical identification of micro organisms. Immunodiagnosis of infectious diseases.

Unit-III: Clinical syndromes and their laboratory diagnosis: Upper and Lower respiratory tractinfections (Pharyngitis, otitis media, pneumonia), Skin and soft tissue infection (Impetigo, folliculitis, furuncle, carbuncle, cellulites and erysipelas), Infection of central nervous system (Meningitis and Encephalitis). Bacteremia and sepsis, Pyrexia of unknown origin (PUO).

Unit- IV: Laboratory diagnosis of clinical syndromes: Gastrointestinal infection and food poisoning,Urinary tract infections, Sexually transmitted diseases, Infection in special populations (Malignancy, AIDS, Tuberculosis and leprosy).

Unit- V: Epidemiology, surveillance and control of commUnity and hospital infections. Antimicrobialchemotherapy, emergence of drug resistance (MRSA, ESBL and MDR TB). Methods of prevention and control- isolation of patients, quarantine and incubation period of various infectious diseases. Management of patients in infectious diseases hospital.

MMB 304: Immunology Theory Credit: 4 Full Marks: 100

After successful completion, this course enables students

CO1. To familiarize with the concept of non-specific (innate) and specific (acquired) resistance mechanism developed in man against pathogens and other non-self factors which is the basis of this course.

CO2. To get an insight into the formation, types, organization and functional specificity of different cellular and organ level components conferring resistance in man.

CO3. To understand the nature, types and function of antigens that induce immunological response in man and how the product of this response (antibody, B and T cells) help in neutralizing them (agglutination and precipitation reactions).

CO4. To have the concept of different mediators/cell signaling molecules (complement, cytokines: interferons, Interleukins, heamatopoetins and chemokines) associated with immunological responses as well as their biological consequences.

CO5. To deal with the different diagnostic and serological approaches for the study of interaction between an antigen and its specific antibody including Widal Test, immunodiffusion, Immuno-electrophoresis, ELISA and RIA.
It also gives an idea on immune-disorders (hypersensitivity, autoimmune disorders, oncogenesis etc.) and induced immunity (vaccination) to overcome such abnormalities.

Course Content

Unit-I

1. Introduction: Physiology of immune system,Innate and acquired immunity.
   Clonal nature of immune response, Artificial immunity.

Unit-II

1. Cells of immune system: Lymphoid lineage (producing B and T lymphocytes) and myeloid lineage (Phagocytes: macrophages, neutrophils and eosonophils and auxillary cells; basophils, mast cells and platelets.
2. Organs of immune system: primary and secondary lymphoid organs.

Unit-III

1. Antigens: Nature, function and types (Haptens, super antigens and cluster of differentiation molecules (CDs), Processing and presentation of antigens.
2. Immunoglobulins – structure and types, Antigen antibody reactions. Major histo-compatibility complex, MHC gene organization; Class I and Class II MHC molecules, thin structure & functions.
3. B - cell and T- cell receptors, Organization of Immunoglobulin gene, Class switching.

Unit-IV

1. Complement: Pathways of complement activation; biological consequence of complement activation, Cytokines: interferences (α, β and γ), TNF, Inter leukins, heamatopoetins and chemokines.

Unit-V

1. Monoclonal antibodies–hybridoma technology; antigen–antibody reactions; agglutination reactions (Widal, haemaglutination); Precipitation reactions (immunodiffusion, Immuno-electrophoresis), Immunoblotting, ELISA, RIA; immunoelectron-microscopy.

Unit-VI

1. Immunization by vaccines: Vaccine types & functions, Immune disorder; hypersensitivity; autoimmune diseases.
2. Organs transplantation reaction; immunodeficiency, Tumour Immunology (Basic idea).

Suggested Readings:

1. Kuby J, Thomas J. Kindt, Barbara, A. Osborne Immunology, 6th Edition, Freeman,2002.
2. Janeway et al., Immunobiology, 4th Edition, Current Biology publications., 1999.Brostoff J, Seaddin JK, Male D, Roitt IM., Clinical Immunology, 6th Edition, Gower Medical Publishing, 2002.
3. Paul, Fundamental of Immunology, 4th edition, Lippencott Raven, 1999.
4. Goding, Monoclonal antibodies, Academic Press. 1985.
5. F.C. Hay, O.M.R. Westwood, Practical Immunology, 4th Edition-, Blackwell Publishing, 2002.
6. S. Hockfield, S. Carlson, C. Evans, P. Levitt, J. Pintar, L. Silberstein, Selected Methods forAntibody and Nucleic Acid probes, Volume1, Cold Spring Harbor Laboratory Press, 1993.
7. Ed Harlow, David Lane, Antibodies Laboratory Manual, Cold Spring Harbor, Laboratory Press, 1988.

MMB 305: PRCTICAL-III Credit: 4 Full Marks: 100

This practical course enhances the laboratory skill concerned with industry and diagnostic sector. After successful completion, this course enables students

CO1. To learn the microbial process for the industrial production of citric acid using *Aspergillus niger*, rifamycin using *Nocardia* strain, glutamic acid, enzyme lipase, ethanol using various Organic wastes and biofertilizers [Nitrogen fixer/Phosphate Solubilizers/ siderophore producers].

CO2. To learn the design of a batch and continuous fermenter and perform solvent extraction and metabolite analysis using a bacterial culture.

CO3. To understand the principle and process of
-blood group determination following slide agglutination test,
-blood cell count and identification following blood film preparation and

-immuno-diagnostic methods like Radial immunoassay and ELISA
It also deals with the principle and process of the immunodiffusion techniques like ODD, SRID, Immuno-electrophoresis and counter-current electrophoresis.

CO4. To isolate bacterial flora of skin by swab method and their identification on the basis of cultural, morphological and biochemical characteristics.

CO5. To understand the principle and process of antibiotic sensitivity (Kirby-Bauer method) in bacteria using minimal inhibitory concentration (MIC) of an antibiotic.

Course Content

Industrial Microbiology and Recombinant DNA Technology

1. Production and characterization of citric acid using *A. niger*.
2. Microbial production of glutamic acid and enzyme lipase.
3. Production of rifamycin using *Nocardia* strain.
4. Comparison of ethanol production using various Organic wastes /raw Material.
5. Laboratory scale production of biofertilizers [Nitrogen fixer/Phosphate Solubilizers/ siderophore producers].
6. Comparative analysis of design of a batch and continuous fermenter.
7. Solvent extraction & analysis of a metabolite from a bacterial culture.
8. Perform an enzyme assay demonstrating its hydrolytic activity (protease/peptidase/glucosidase etc.)

Immunology:

1. Preparation of blood film and identification of cells.
2. Determination of blood groups.
3. Purification of IgG from serum.
4. SGOT – PT test; agglutination.
5. Study of the immunodiffusion techniques of ODD, SRID.
6. Study of the immunological techniques of Immuno-electrophoresis, counter-current electrophoresis, ELISA.

Clinical Microbiology and Diagnostic Techniques

1. Identification of bacteria (any three of *E. coli, Salmonella, Pseudomonas, Staphylococcus, Bacillus*) using laboratory strains on the basis of cultural, morphological and biochemical characteristics.
2. Study of bacterial flora of skin by swab method
3. Perform antibacterial sensitivity by Kirby-Bauer method
4. Determination of minimal inhibitory concentration (MIC) of an antibiotic.
5. Radial immunoassay, DOT-ELISA tests (both using Kit).

SEMESTER IV

MMB 401: Research Methodology, Biostatistics and Bioinformatics Theory
Credit: 4 Full Marks: 100

After successful completion, this course enables students

CO1. To understand the concept, types and criteria of research, addressing the identification of a research problem, objectives, designs and methodology to carry out a research work.

CO2. To get the basic knowledge on qualitative research techniques and on the collection and analysis quantitative data.

CO3. To get an insight in development of hypothesis, data analysis for hypothesis-testing as well as formulation of research synopsis and report.

CO4. To familiarize with the Biostatistical tools and techniques for analyzing research outcomes thereby enabling them in justifying their findings.

CO5. To understand the basic concept of Bioinformatics; different tools and techniques associated with analysis of phylogeny and predicting the structure of different bio-elements.

Course Content

Unit-I: Fundamentals of Research Methodology

1. Definition and Objectives of Research.
   Types (Descriptive, Analytical, Applied, Fundamental, Qualitative, Quantitave, Conceptual and Empirical) and Significance of Research.
2. Research Approaches. Research Methods versus Methodology. Criteria of a Good Research.

Unit-II: Research Problem

1. Definition of Research Problem. Necessity of defining Research Problem.Techniques involved in Defining a Research Problem.

Unit-III: Research Design

1. Meaning and Need of Research Design, Important concepts related to Research Design. Features of a Good Design.

Unit-IV: Data Collection and Analysis

1. Collection of Primary Data: Observation and Interview Methods, Collection of Data through questionnaires, Collection of Secondary Data. Selection of Appropriate Methods for Data Collection. Processing and Analysis of Data; processing operations, problems in processing

Unit-V: Data Interpretation and Report Writing

1. Meaning and Importance of Interpretation.Techniques of Interpretation, Significance of Report Writing.

Unit-VI Biostatistics

1. Application of statistics in biological science; measurement of central tendency and dispersion. Mean variance, standard deviation, standard error, co-efficient of variance.
2. Concept of probability and probability laws; standard probability distribution – binomial, poisson and normal distributions.
3. Test of hypothesis. Test of significance based on z, $\chi 2$, t and F statistics; correlation and regression. Analysis of variance and co-variance; one-way and two-way ANOVA.
4. Random sampling; principles of design of experiments; CRD, RBD, LSD; transformation of data; comparison of mean.

Unit-VII: Bioinformatics and Applications

1. Concept in sequence alignment, Pairwise and Multiple sequence alignment, Phylogenetics analysis, BioEdit, ClustalW, MEGA, Restriction mapping, Genome mapping.
2. Secondary structure prediction of nucleic acids and proteins,

Homology modeling, Ramachandran plot, Visualisation of proteins 3D structure-RASMOL, Protein-protein interaction and pathways analysis.

Suggested Readings:

1. Current Protocols in Bioinformatics, Edited by A.D. Baxevanis et al, Wiley Publishers, 2005.
2. Bioinformatics by David W. Mount, Cold Spring Harbor Laboratory Press, 2001.
3. Fundamental concepts of Bioinformatics by D.E. Krane and M.L Raymer, Pearson Education, 2003.

MMB 402 Optional Paper Theory Credit: 4

MMB 402 A. Microbial Diversity

After successful completion, this course enables students

CO1. To get an insight into the diverse groups of organisms within the microbial world and the advanced strategies to classify such diverse types based on phylogeny.

CO2. To understand the different culture dependant and culture independent molecular methods for the study of microbial diversity as well as their identification.

CO3. To get an insight into the variation in metabolic pathway among different groups of microbes.

CO4. To have an idea on the various metabolic groups of microbes based on the nature of the environment and how the environmental adaptation leading to changes in their metabolic processes.

CO5. To familiarize with the concept of ecosystem in terms of microorganisms as well as the various factors affecting microbial distribution in different ecosystem and how microorganisms interact with different biotic and abiotic factors for their survival.

Course Content

Unit--II: Introduction to Microbial Diversity. Defining microbial diversity: a changing paradigm. Largescale evolution: The Big Tree. Molecular characterization of organisms. Overview of phylogenetic diversity. Principal of molecular phylogeny Methods in Taxonomy of Bacteria,Archaea and Fungi morphological Methods Chemotaxonomy. Genetic Methods Methodology of rRNA sequencing.

Unit-II: Methodology of identification of unknown pure cultures: Strategy and methods Diversity Theexpanse of microbial diversity, estimates of total number of species, measures and indices of diversity. Newer approaches for exploring unculturable bacteria from environmental samples like sewage. Culture independent molecular methods.

Unit---- III: Metabolic diversity among microorganisms: Photosynthesis; Chemolithotrophy; Hydrogen-ironnitrite-oxidizing bacteria; Nitrate and sulfate reduction; Methanogenesis and acetogenesis. Fermentations-diversity, Purple and green bacteria, cyanobacteria, acetic acid bacteria, Pseudomonads, lactic and propionic acid bacteria, endospore forming rods and cocci; Mycobacteria and Mycoplasms. Archaea: Halophiles; Methanogens; Hyperthermophilic archaea; Thermoplasma.

Unit---- IV: Introduction to microbial ecosystems Ecological niches. Interactions between microbe-microbe and microbe-host in different model systems. Food web: relation to microbes, Competition vs. succession. Predation, symbiosis and other influences on food web dynamics

MMB 402 B. Agriculture Microbiology

After successful completion, this course enables students

CO1. To have a concept on the microorganisms in agro-ecosystems and their significance in maintaining soil fertility by their biological activity (N_2 fixation, solubilization and mobilization of nutrients etc.).

CO2. To understand the chemical transformation carried out by microbes during organic matter decomposition wherein mineralization and immobilization of important nutrient occurs resulting in enhancement of soil nutrient profile.

CO3. To learn about one of the most important category of soil microbe known as PGPR (plant growth promoting rhizobacteria) and their significance in agro-ecosystems.

CO4. To get an insight into the environmental significance of microorganisms in terms of biodegradation of metal and other pollutants, bioremediation of contaminated sites and environmental monitoring (biosensors).

CO5. To familiarize with the role of microbes in the cycling (mineralization and mobilization) of nutrient elements like carbon, nitrogen, phosphorus, sulphur and iron required for a proper soil health.
It also deals with the concept of microbes as a source of bio-fuels, an alternative to non-renewable fossil fuels.

Course Content

Unit-I: Soil microorganisms in agro ecosystems: Types of microbial commUnities; soil microbial diversity: significance and conservation; effect of agricultural practices on soil organisms. Biological nitrogen-fixation: The range of nitrogen fixing organisms; mechanism of nitrogen fixation (biochemistry of nitrogenase); genetics of nitrogen-fixation; Rhizobium-Legume Association; Symplasmids, N2 fixation by non-leguminous plants.

Unit-II: Chemical transformation by microbes: Organic matter decomposition, nutrient mineralizationand immobilization; transformation of carbon and carbon compounds; availability of phosphorus, sulfur, iron and trace elements to plants; biodegradation of herbicides and pesticides. Biofertilizer: Mass cultivation of microbial inoculants; green manuring; algalization; Azolla.

Unit-III: Microbial products and plant health: PGPR (plant growth promoting rhizobacteria);significance of mycorrhizae; toxin producing microbes (antibiotics, aflatoxin, etc.); microbial herbicides; biological control. Bioindicators – their relevance and utility; Measurement of Microbial activity in environmental samples; Microbial transport and bioaugmentatin.

Unit-IV: Microorganisms and organic pollutants; Biodegradation, Bioremediation; Microorganismsand metal pollutants; Emerging Technologies in environmental microbiology and its application; Bioreporters, Biosensors, and Microprobes; Micobial Fuel Cell; Environmental Risk assessment of GMOs; IPRs.

Unit-V: Microbial transformations: The carbon cycle, The Nitrogen cycle, transformation ofphosphorus, sulphur, iron and other related transformations. Fossil fuels: coal, petroleum, natural gas, L.P.G., Introduction to Bio-fuels and energy scenario of India, Bio-diesel crops of India. In vitro technology and vegetative propagation of bio-fuel crops.

MMB 402 C. Food Microbiology and Fermentation Technology

After successful completion, this course enables students

CO1. To have an idea on the association of microbe with different food product and various strategies for preserving food from microbial spoilage.

CO2. To get an insight into the physico-chemical alteration occurring in food items due to microbial contamination that bring about spoilage of them.

CO3. To deal with food-borne infections and intoxications resulting from microbial contamination of food, the laboratory diagnosis of such food-borne infections and their preventive measures.

CO4. To have the concept on microbial fermentation and different fermented food products obtained through microbial process.
It is also concerned with pharmaco-nutritional assessment of fermented food products.

CO5. To familiarize with the industrial exploitation of different microbes for the production of single cell protein, fermented beverages, industrial enzymes and genetically modified (GM) foods.

Course Content

Unit-I: Micro-organisms and their importance in food microbiology – molds, yeast, bacteria, general features, classification; principles of food preservation; asepsis – control of micro-organisms (anaerobic conditions, high temperature, low temperature, drying); factors influencing microbial growth in food – extrinsic and intrinsic factors; chemical preservation and food additives; canning process for heat treatment.

Unit-II: Contamination and Spoilage **–** Cereals, Sugar products, vegetables, fruits, meat and meat products; milk and milk products, fish and sea food, poultry spoilage of canned food; detection of spoilage and characterization.

Unit-III: Food-borne infections and intoxications**–** bacterial: *Brucella, Bacillus, Clostridium, Escherichia, Shigella, Staphylococcus, Vibrio, Yersinia* and non-bacterial intoxication (with examples of infective and toxic types) – Protozoa, algae, fungi and viruses; food borne outbreaks– laboratory testing procedures, preventive measures, GMP and Hazard Analysis and Critical Control Point. Food control agencies and its regulations; Employee's health standards, waste treatment, disposal and quality control.

Unit-IV: Food fermentation **–** Bread, vinegar, fermented vegetables, fermented dairy products; experimental and industrial production methods; spoilage and defects of fermented dairy products; oriental fermented foods – its quality standard and control.

Unit-V: Microbial cells as food (Single cell protein), mushroom cultivation; fermented beverages –beer and wine; steroid conversion – industrial enzymes, production of amylases, proteinases, cellulases, amino acid production – glutamic acid and lysine; pickles, olives, soy sauce, genetically modified (GM) foods.

MMB 402 D. Medical Microbiology

After successful completion, this course enables students

CO1. To get an idea about the microorganisms associated with human body (skin, respiratory tract, digestive tract, urino-genital system); their source, path of entry and the infection resulted from such association.

CO2. To get an insight into the host-pathogen relationships (disease cycle), transmission of pathogens and medical diagnosis (detection of infection).
It also familiarizes with the different antimicrobial and chemotherapeutic agents, antibiotics and antiseptics with mechanism of action against targeted pathogens.

CO3. To deal with the classification, characterization, pathogenicity, symptomology, laboratory diagnosis and quarantine administration of pathogens responsible for communicable and non-communicable diseases.

CO4. To familiarize with the concept of pathogenicity, symptomology, laboratory diagnosis and quarantine administration of diseases caused by sub-bacterial agents like *Rickettsiae, Chlamydia* and *Mycoplasma.*

CO5. To have the concept of medical parasitology *i.e.* pathogenesis, transmission, disease cycle, laboratory diagnosis and treatment of diseases caused by Protozoa.

Course Content

Unit-I: Discovery of pathogenic micro-organisms; normal microflora of human body; role of resident flora. Host-parasite relationships, Infection, type and source. Disease cycle (sources of diseases, reservoirs, transmission of pathogens); Intoxications (exotoxins and endotoxins and their mechanism of action). Antimicrobial agents and antibiotics: Antiseptics, chemotherapeutic agents, effect of antibiotics on protein, nucleic acid, cellwall and cytoplasmic membrane.

Unit-II: Morphology, classification, cultural characteristics, pathogenicity and laboratory diagnosis ofStaphylococci, Streptococci, Pneumococci, Neisseriae (Gonococci and Meningococci), *Haemophilus*, *Bordetella*, *Corynebacterium*, *Clostridium*.

Unit-III: Study of Enterobacteriaceae (*E. coli, Klebsiella, Salmonella, Shigella, Proteus*), Vibrios andNonfermenting Gram negative bacilli. Emerging communicable diseases (Plague, Anthrax) - symptom, identification, monitoring and surveillance and quarantine administration.

Unit -IV: Introduction to*Mycobacteria, Brucella, Listeria, Pasturella*and Erysepelas. Spirochetes, *Rickettsiae, Chlamydia, Mycoplasma* and *Ureoplasma*.

Unit-V: Introduction to medical parasitology-classification. Pathogenesis, transmission, life cycle, labdiagnosis, treatment of Protozoa-*Entamoeba, Toxoplasma, Cryptosporidium, Leishmania,Trypanosoma, Plasmodium, Giardia, Trichomonas* and *Balantidium*.

MMB 403 Practical on Optional Paper Practical Credit: 4

This practical course is based on the Optional Papers including Microbial Diversity, Agricultural Microbiology, Food Microbiology & fermentation Technology and Medical Microbiology. After successful completion, this course enables students

CO1. To understand the specificity of microorganisms present in different environmental conditions and how these factors are affecting their phenotypic and genotypic characters.

CO2. To get an insight into the different types of microbes present in crop fields and how these microbes can be utilized in increasing crop productivity or other such aspects.

CO3. To understand the features of microbes that can be used for obtaining various industrial products and the production process of solvents, antibiotics or fermented food products using such microbes.

CO4. To familiarize with the different types of pathogenic microbes, their path of entry in human body and the various techniques to study them.

CO5. To have the concept of various laboratory methods to study the health effects of different pathogenic microbes and the use of various pharmaceutical product to inhibit them.

MMB 403 A. Microbial Diversity

1. Comprehend the ubiquitous nature of microorganisms and identify the different groups of microorganisms from different habitats.
2. Isolation and characterization of thermophiles from hot water spring.
3. Isolation and characterization of halophiles isolated from saline water.
4. Study of enzyme activity in extremophilic organisms isolated from different sources.
5. Biogenic methane production using different wastes.
6. Isolation of *Thiobacillus ferrooxidans* and *T. thiooxidans* from metal sulfides, rock coal and acid mine waters.
7. Assessment of microbial diversity in terrestrial, aquatic and aerial environment.
8. Measurement of Microorganisms using Micrometry.

MMB 403 B. Agricultural Microbiology

1. Demonstration of Winogardsky coloumn.

2. Isolation of beneficial microbes from the soil: *Rhizobium* sp., *Azotobacter* sp., *Azospirillum* sp., VAM, Cyanobacteria, Phosphobacter etc.
3. Authentication of rhizobia by biochemical and by plant infection test (tubes and Leonard jar experiment).
4. Study the growth response of crops due to biofertilizer application.
5. Compost making - testing the quality of compost made fortification of compost by inoculating beneficial microbes and rock phosphate.
6. Study on plant pathogens, collection, identification and submission.
7. Acetylene reduction assay to evaluate nitrogenase activity.
8. Visit to an institution to study use of radiotracer techniques used for plant studies.

MMB 403 C. Food Microbiology and Fermentation Technology

1. Production and estimation of lactic acid by *Lactobacillus* Sp. or *Streptococcus* Sp.
2. Production and characterization of citric acid using *A. Niger*.
3. Isolation of food poisoning bacteria from contaminated foods and dairy products
4. Extraction and detection of aflatoxin for infected foods.
6. Production of fermented milk products by *Lactobacillus acidophilus*.
7. Comparison of ethanol production using various Organic wastes /raw Material.
8. Microbial production of dextran by Leuconostoc mesenteroides.

MMB 403 D. Medical Microbiology

1. Staining methods for morphological feature of pathogenic bacteria.
   A. Differential stains – Gram stain, Ziehl Neelsen's stain for AFB
   B. Cytological stains – i) Endospore stain – Bacillus, Clostridium ii Capsule stain – positive stain
   C. Stain for Amoeba / Intestinal protozoa / Malarial parasites – Ironhaematoxylin stain, Leishman's stain, Giemsa stain.
2. Diagnostic Bacteriology : Laboratory diagnosis (isolation & identification)
   i) Pyogenic infections – Streptococci – α, β and γ haemolysis. Staphylococci – differentiation – coagulase test.
   ii) UTI infection – *E.coli, Proteus, Pseudomonas*.
3. Kirby-Bauer disc diffusion technique.
4. Dilution sensitivity test – MIC
5. Assay of amylase and protease from microbes.
6. Screening of antibiotic producing microbes.
7. Sterility testing by Bacillus stearothermophilus

MMBT 404:

Dissertation Work and lab Visit Report

Credit: 8 **Full Marks 60 + 140**

I. **Project work evaluation:** The project work will be evaluated by both external and internal examiner based on experiment designed and thesis writing.

II. **Project work seminar:** Every student has to present their work under following subheadings viz. objective, methodology, results and conclusion.

III. **Project viva voce:** Viva voce will be conducted on the basis of project work andpresentation.

IV. S**ubmission of Lab. Visit Report.**

Suggested Readings:

1. Pelczar MJ, Chan ECS and Krieg NR. (2010). *Microbiology*. 8th edition. McGraw Hill Book Company.
2. Willey JM, Sherwood LM, and Woolverton CJ. (2008). *Prescott, Harley and Klein's Microbiology*. 8th edition. McGraw Hill Higher Education.
3. Adams MR and Moss MO. (1995). *Food Microbiology*. 4th edition, New Age International (P) Limited Publishers, New Delhi, India.
4. Alexopoulos CJ, Mims CW, and Blackwell M. (1996). *Introductory Mycology*. 4th edition. John and Sons, Inc.
5. Atlas RM. (2005). *Principles of Microbiology*. 4th edition. WMT.Brown Publishers.

6. Dimmock, NJ, Easton, AL, Leppard, KN (2007). *Introduction to Modern Virology*. 6th edition (First Indian reprint 2007), Blackwell Publishing Ltd.
7. Frazier WC and Westhoff DC. (1992). *Food Microbiology*. 3rd edition. Tata McGraw-Hill Publishing Company Ltd, New Delhi, India.
8. Maier RM, Pepper IL and Gerba CP. (2009). *Environmental Microbiology*. 2nd edition, Academic Press.
9. Martin A. (1977). *An Introduction to Soil Microbiology*. 2nd edition. John Wiley & Sons Inc. New York & London.
10. Madigan MT, Martinko JM and Parker J. (2009). *Brock Biology of Microorganisms*. 12th ed. Pearson/Benjamin Cummings.
11. Stanier RY, Ingraham JL, Wheelis ML, and Painter PR. (2009). *General Microbiology*. 7th ed. McMillan.
12. Subba Rao NS. (1999). *Soil Microbiology*. 4th edition. Oxford & IBH Publishing Co. New Delhi.
13. Tortora GJ, Funke BR, and Case CL. (2013). *Microbiology: An Introduction*. 11th edition. Pearson Education.
14. Glaser A.N and Nilaido.H (1995) Microbial Biotechnology, W.H Freeman and Co.
15. Prescott and Dunn (2002) Industrial Microbiology, Agrobios (India) Publishers.
16. Crueger W. and Crueger A. (2000) *A Text of Industrial Microbiology*, 2nd Edition, PanimaPublishing Corp.
17. Stanbury P.F, Ehitaker H, Hall S.J (1997). *Priciples of Fermentation Technology*, Aditya Books (P) Ltd.
18. Joshi and Pandey. Food Fermentation – *Microbiology, Biochemistry & Technology*, Vol. I & II.
19. Vashishta BR and Sinha AK. (2008). *Fungi*. 5th edition. S. Chand and Company Ltd.
20. Vashishta BR. (2008). *Algae*. 5th edition. S. Chand and Company Limited, New Delhi
21. Bruce Alberts *et al*. *Molecular Biology of Cell*, Garland Publications
22. Sharp, *Fundamentals of Cytology*,Mc Graw Hill Company
23. EDP Roberties and EMF Roberties, *Cell Biology and Molecular Biology*, Sauder College.
24. E.J.Gardener, M.J.Simmons and D.P.Snustad, *Principles of Genetics*, John Wiley and Sons Publications.
25. Albert L. Lehninger *Principles of Biochemistry*- CBS Publishers & Distributors
26. Lubert Stryer *Biochemistry* –Freeman International Edition.
27. U. Satyanarayana *Biochemistry* Books and Allied Pvt. Ltd.
28. S. Sadasivam and A. Manickam *Biochemical Methods*-, New Age International Publishers, New-Delhi.
29. Cappucino J and Sherman N. (2010). *Microbiology: A Laboratory Manual*. 9th edition. Pearson Education limited.
30. Kuby J, Thomas J. Kindt, Barbara, A. Osborne *Immunology*, 6th Edition, Freeman,2002.
31. F.C. Hay, O.M.R. Westwood, *Practical Immunology*, 4th Edition-, Blackwell Publishing, 2002.
32. N. Trun and J. Trempy, *Fundamental Bacterial Genetics*, Blackwell publishing, 2004.
33. Campbell AM & Heyer LJ, *Discovering Genomics, Proteomics and Bioinformatics*, 2nd Edition. Benjamin Cummings 2007.
34. W.W.Daniel, *Biostatics: A foundation for analysis in the Health Science*; John Wiley.
35. Statistical methods for Agricultural workers – Panse and Sukhetme; ICAR.
36. Instrumental Methods of analysis – Willare, Mermitt & Dean.
37. SL Berger and AR Kimmel, Methods in Enzymology Vol.152, Guide to Molecular Cloning Techniques, Academic Press, Inc. San Diego, 1998.
38. P. K. Gupta, Rastogi and Co, *Elements of Biotechnology*: Meerut,2007
39. *Current Protocols in Bioinformatics*, Edited by A.D. Baxevanis et al, Wiley Publishers, 2005.
40. David W. Mount, *Bioinformatics* Cold Spring Harbor Laboratory Press, 2001.
41. Fundamental concepts of Bioinformatics by D.E. Krane and M.L Raymer, Pearson Education, 2003.
42. A.M. Campbell, *Discovering Genomics, Proteomics & Bioinfo*, C.S.H. Press, 2003.
43. Evans, G.M. and Furlong, J.C. (2003). *Environmental Biotechnology: Theory and Application*. John Wiley and Sons.
44. Nelson, G.C. (2001). *Genetically Modified Organisms in Agriculture: Economics and Politics*. Academic Press.
45. Thomas, J.A. and Fuchs, R. (2002). *Biotechnology and safety Assessment*. Academic Press.
46. Kothari, C. R. (2004), Research Methodology: Methods and Techniques, New Age International Publishers.

N.B.: the list of books is for the whole course of 2 years.