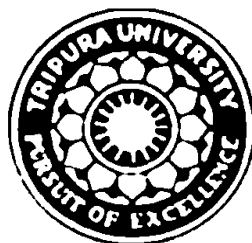


# **Choice Based Credit System (CBCS)**

## **M.Sc. MICROBIOLOGY CURRICULUM**

**2016-17**



## **DEPARTMENT OF MICROBIOLOGY**

**TRIPURA UNIVERSITY (A Central University)**

**SURYAMANINAGAR, AGARTALA – 799 022**

**TRIPURA, INDIA**

**M.Sc MICROBIOLOGY COURSE (CBCS) CURRICULUM (2015-2016)**

<b>SEMESTER I</b>				
<b>COURSE CODE</b>	<b>COURSE TITLE</b>	<b>COURSE TYPE</b>	<b>CREDITS</b>	<b>Lecture/ Tutorial/ Practical hrs per week</b>
MICB-701C	Basic Microbiology and Microbial physiology	CORE	4	3L/1T
MICB-702C	Cell biology and Biochemistry	CORE	4	3L/1T
MICB-703C	Biophysics and Instrumentation	CORE	4	3L/1T
MICB-704C	Practicals.	CORE	4	8P
	Compulsory Foundation (Soft Skills)	CF	4	3L/1T
<b>Semester wise credits and hours of lectures</b>			<b>20</b>	
<b>SEMESTER II</b>				
MICB-801C	Molecular Biology and Microbial Genetics	CORE	4	3L/1T
MICB-802C	Applied Microbiology	CORE	4	3L/1T
MICB-803C	Bioinformatics and Computational Biostatistics	CORE	4	3L/1T
MICB-804C	Practicals	CORE	4	8
MICB-805E	Microbial Ecology / Bioreactors	ELECTIVE	4	3L/1T
<b>Semester wise credits and hours of lectures</b>			<b>20</b>	
<b>SEMESTER III</b>				
MICB-901C	Tools and Techniques in Microbiology	CORE	4	3L/1T
MICB-902C	Practicals	CORE	4	8
MICB-903E	Waste Water Treatment/ Microbiology of Fermented Food and Products	ELECTIVE	4	4
MICB-904E	Basics of Statistics	ELECTIVE	4	4
MICB905C	Project Work+MOOC	CORE	3+1=4	8
<b>Semester wise credits and hours of lectures</b>			<b>20</b>	
<b>SEMESTER IV</b>				
MICB-1001E	Intellectual property Rights	ELECTIVE	4	4
MICB-1002E	Advanced Applied Microbiology/ Recent trends in Microbial Research	ELECTIVE	2	2
MICB-1003C	Project Presentation	CORE	4	8
<b>In addition a 2 credit elective course offered by other departments may be taken by the students</b>				
<b>Grand total of credits and hours of lecture hours</b>			<b>72</b>	

## **MICB-701C: BASIC MICROBIOLOGY AND MICROBIAL PHYSIOLOGY**

### **UNIT-I: BACTERIOLOGY**

Introduction to Bacteria and Bacterial structure; Cell envelope, Cytoplasmic membrane, Cell wall, Capsules, Flagella, Fimbriae, Intracellular structures, Nuclear material, Ribosome, Inclusion granules, Endospore, Bacterial slime and bio film; Fundamental of Bacterial growth, Requirements for bacterial growth, Carbon and nitrogen sources, Atmospheric conditions, pH, Growth media.

### **UNIT-II: VIROLOGY**

Brief outlines on discovery of viruses, morphology of viruses, nomenclature and classification, ultra-structure, capsid and its arrangements, types of envelopes and its composition, Viral genomes, Viroids, virusoids, cynophages and mycoviruses, prions and spread of prion diseases, Antiviral agents and interferons.

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.

Plant virology: Importance, origin, history, Symptoms of diseases; taxonomy ssrna, dsrna and DNA viruses plant virus structures; techniques used to study viral replication and genome organisation Electrophoresis, blotting, nucleic acid hybridization, cloning ; Viral genes and gene products; transmission of plant viruses: Vectors, seed, pollen, other. Disease caused by select vural groups Begomoviruses, Tospoviruses, Potyviruses, Comoviruses, other. Persistent (cryptic )plant viruses Endornaviruses, Partitiviruses; Hypovirulence; Plant molecular virology: Plant viruses as gene vectors, viral gene expression Control of viral diseases: Resistance genes, cross protection, seed treatments, cultural, transgenic

### **UNIT-III: PHYCOLOGY AND MYCOLOGY**

Distribution and classification of algae, thallus organization in algae, reproduction in algae; Brief account of Chlorophyta, Bacillariophyta, Phaeophyta, Rhodophyta; Algal ecology, Algal toxins, Algal food and algal biotechnology. History and development of mycology, General habitat, morphology and reproduction of fungi, Classification of fungi (Oomycetes, Zygomycetes, Ascomycetes, Basidiomycetes and Deuteromycetes) and Slime molds, structure and cell differentiation.

Homothallism and Heterothallism, Hetrokaryosis, Sex hormones in fungi, physiological specialization in fungi, fungal succession on decomposing litter, Mycorrhiza- ectomycorrhiza, endomycorrhiza and vesicular arbuscularmycorrhiza (VAM), Lichens- ascolichens, basidiolichens and deuteron lichens. Mycoplasma

### **UNIT-IV: BASICS OF MICROBIAL PHYSIOLOGY**

Microbial nutrition- Nutrient requirements & nutritional groups; Media Types and maintenance; Media for cultivation of bacteria, fungi and algae; Culture techniques; Anaerobic culturing methods; Synchronous, Continuous, Batch culturing methods;

Microbial growth- Definition, growth factors, generation time, growth phases; Methods of growth measurement; Enumeration of bacteria; Bacterial endospore- structure, sporulation, germination of spores.

### **Reference/Text Book:**

1. Microbiology by Lansing M Prescott, Donald A Klein, John P Harley, McGraw Hill
2. Principles of Microbiology by Ronald M. Atlas (1995), Amy Mc Cullen
3. Microbiology: Principles and Explorations by Jacquelyn Black
4. General Microbiology by Roger Y Stanier, John L Ingraham, Mark L Wheelis
5. Microbiology by Michael J Pelczar
6. Fundamental Principles of Bacteriology A J Salle
7. Foundations in Microbiology by Kathleen park Talaro, McGraw Hill. science

8. Microbiology: An Introduction by Gerard J Tortora, Berdell R Funke, Christine L Case, Dorling Kindersley (india) Pvt Ltd
9. Microbiology by Stuart Walker, W B Saunders
10. An Introduction to Microbiology by P Tauro, K K Kapoor, KS Yadav

### **MICB -702C: CELL BIOLOGY AND BIOCHEMISTRY**

#### **UNIT-I: CELL BIOLOGY-I**

Ultra structures and function of Cell wall, Plasma membrane, Membrane Transport and transporter proteins; Mitochondria (pH and electrochemical gradient), Chloroplast

#### **UNIT-II: CELL BIOLOGY -II**

ER, Golgi complex, Lysosome, Endosome, Ribosome, Centriole, Nucleus, Nuclear Transport –Import and Export of protein, Chromatin structure

Cytoskeleton – Microfilaments, Microtubules

Cell cycle and its regulation, Mitotic and meiotic cell division,

#### **UNIT-III: BIOCHEMISTRY-I**

Carbohydrate- Classification and properties of carbohydrates, Aerobic respiration- Glycolysis (EMP-pathway), TCA-cycle with energy production, pentose-phosphate pathway, Oxidation-reduction potential and electromotive force.

Photophosphorylation; Bacterial photosynthesis; Anaerobic respiration - Utilizing NO<sub>2</sub>, Sulfur, CO<sub>2</sub> as electron acceptors, Entner-Doudoroff pathway, Fermentation - lactic acid, ethanol and propionic acid.

#### **UNIT-IV: BIOCHEMISTRY-II**

Amino acids- Structural features, classification

Properties and structures of proteins including solubility and denaturation.

Lipid –Classification, properties and characterization of lipids, Bacterial lipids, Major steroids and steroid derivatives of microbial origin. Enzymes- General properties, Nomenclature and classification, Enzyme Kinetics - Michaelis-Menten equation, Enzyme Inhibition, Ribozyme and Abzyme, Applications of microbial enzymes.

#### **Reference/Text Book:**

1. Voet and J.G.Voet, Biochemistry, 3rd edition, John Wiley, New York, 2004.
2. A.L. Lehninger, Principles of Biochemistry, 4th edition, W.H Freeman and Company, 2004.
3. L. Stryer, Biochemistry, 5th edition, W.H. Freeman and Company, 2002.
4. Benjamin Lewin, Gene IX, 9th Edition, Jones and Barlett Publishers, 2007.
5. Watson et al., Molecular Biology of the gene 5th Edition, Pearson Prentice Hall. USA, 2003.
6. Lodish et al., Molecular cell Biology, 4th Edition, W.H. Freeman & Company, 2000.
7. Smith & Wood, Cell Biology, 2nd Edition, Chapman & Hall, London, 1996.
8. B. M. Turner, Chromatin & Gene regulation, 1st Edition, Wiley-Blackwell, 2002.
9. B Alberts, A Johnson, J Lewis. Molecular Biology of Cell. Garland Science, 2014.

## MICB -703C: BIOPHYSICS AND INSTRUMENTATION

### **UNIT –I: BASIC LABORATORY INSTRUMENTS**

Buffers: Henderson and Hesselbach equation, pka and pkb. Preparation of Buffers, measurement of pH, types of Electrodes.

Viscosity: specific, intrinsic and reduced viscosities, viscometers, determination of molecular size and shape through viscosity.

Osmosis: osmosis in relation to molecular size and molecular weight, osmometer, partial, specific volume and diffusion co-efficient, Dialysis, membrane filtration and its application.

Principle and working: of pH meter, Laminar-air flow. Autoclave, hot air oven, BOD, Centrifugation: Types of centrifuge machines, analytical centrifuges, differential centrifuge, and Ultracentrifuge.

### **UNIT – II: CHROMATOGRAPHIC AND ELECTROPHORETIC TECHNIQUES**

Basic principles and applications: of gel filtration chromatography, ion exchange and affinity chromatography, gas liquid chromatography (GLC), high pressure/ performance liquid chromatography (HPLC).

Basic principles of Electrophoresis and electro-focussing, theory and application of SDS- PAGE, and isoelectric focusing

### **UNIT -III: SPECTROSCOPY, RADIOGRAPHY AND TRACER TECHNIQUES**

Spectroscopic techniques: theory and applications of UV, Visible, IR, NMR, Fluorescence, Atomic Absorption, Hydrodynamic methods, Atomic absorption spectroscopy.

Principles and applications of tracer techniques in biology: Radioactive isotopes and half life of isotopes, Effect of radiation on biological system; Autoradiography, Cerenkov radiation, Liquid scintillation Spectrometry, Dosimetry, laboratory procedures and safety aspects.

### **UNIT -IV: MICROSCOPY AND STAINING OF MICROORGANISMS**

Microscopy: General Principles and components of simple, microscope, compound microscope, bright-field and dark-field microscope, Phase- contrast microscope, fluorescence microscope, Transmission Electron Microscope (TEM), Scanning Electron Microscope (SEM) and Atomic Force Microscope (AFM), Cytophotometry and flowcytometry

Fixation and staining: Simple staining, negative staining, gram staining, acid fast staining, structural stains (Endospore, capsule and flagella).

### **Reference/Text Book:**

1. Instrumental Methods of Analysis. 6th Edition by H.H. Willard, L.L. Merritt Jr. and others. 1986. CBS Publishers and Distributors.
2. Spectroscopy. Volume 1. Edited by B.B. Straughan and S. Walker. Chapman and Hall Ltd.
3. Gel Electrophoresis of Proteins- A Practical Approach by Hanes.
4. Chromatography: Concepts and Contrasts- 1988 by James Miller. John Wiley and Sons. Inc., New York.
5. Introduction to High Performance Liquid Chromatography by R. J. Hamilton and P. A. Sewell.
6. Spectroscopy by B.P. Straughan and S. Walker.
7. Practical aspects of Gas Chromatography and Mass Spectrometry 1984 by Gordon M. Message, John Wiley and Sons, New York.
8. Gel Chromatography by TiborKremmery. Wiley Publications.
9. Isotopes and radiations in Biology by C.C. Thornburn, Butterworth and Co. Ltd., London.
10. The use of radioactive isotopes in the life sciences by J.M.Chapman and G.Ayrey, George Allen and Unwin Ltd., London.
11. A.L. Lehninger, Principles of Biochemistry, 4th edition, W.H Freeman and Company, 2004.
12. Alberts, A Johnson, J Lewis. Molecular Biology of Cell. Garland Science, 2014.
13. Online Biophysics. V Bloomfield.pdf. NCBI Website.



## **MICB-704C: PRACTICAL**

1. Sterilization, disinfection, safety in microbiological laboratory.
2. Preparation of media for growth of various microorganisms.
3. Identification and culturing of various microorganisms.
4. Staining and enumeration of microorganisms.
5. Growth curve, measure of bacterial population by turbidometry and studying the effect of temperature, pH, carbon and nitrogen.
6. Assay of antibiotics production and demonstration of antibiotic resistance.
7. Isolation and screening of industrially important microorganisms.
8. Determination of thermal death point and thermal death time of microorganisms.
9. Studies on pH titration curves of amino acids/ acetic acid and determination of pKa values and Handerson-Hasselbach equation.
10. Study of UV absorption spectra of Haemoglobin.
11. Estimation of protein by Lowry's method.

### Reference/Text Book:

1. Microbiology A Laboratory Manual. 2008. 7<sup>th</sup> Edition by Cappuccino and Sherman; Pearson Education, ISBN 81-317-1437-3.

## **MICB-801C: MOLECULAR BIOLOGY AND MICROBIAL GENETICS**

### **UNIT-I: INTRODUCTION TO MOLECULAR BIOLOGY**

DNA structure, forms of DNA and DNA supercoiling; The law of DNA constancy and c-value paradox; properties of DNA-denaturation, renaturation, melting curve and hyper chromicity; DNA replication in prokaryotes: origin of replication, replication fork, leading and lagging strand, semi conservative replication, rolling circle replication, enzymes involved in prokaryotic replication and DNA proof reading.

Gene as unit of mutation, molecular basis of spontaneous and induced mutations and their role in evolution; Mutagens, Types of mutations, transposon mutagenesis, site directed mutagenesis, Ames test; Environmental mutagenesis and toxicity testing; Induction of mutation in *Neurospora crassa* and yeast, cytoplasmic inheritance and biochemical mutants.

### **UNIT-II: BACTERIAL RECOMBINATION**

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

### **UNIT-III: BASICS OF DNA TECHNOLOGY**

Introduction to genetic engineering; Restriction endonucleases – types, nomenclature, classification, application; DNA ligases – properties and functions, ligation techniques; DNA modifying enzymes – polymerases, DNase, RNase, polynucleotide kinases, alkaline phosphatases and terminal nucleotidyltransferase.

### **UNIT-IV: MOLECULAR TOOLS**

Plasmids; plasmids as vectors for gene cloning and plasmid DNA replication; Transposons in prokaryotes and eukaryotes and their uses in genetic analyses; Life cycle of bacteriophages and their uses in microbial genetics. Cloning vehicles: Plasmids (pBR322, pUC-8, pGEM3Z and Ti plasmid), Bacteriophage ( $\lambda$  phage and M13 vectors), cosmids, phagemids, expression vectors, shuttle vectors, excretion vectors and Animal viral vectors; Promoter in expression vectors: Lac Z promoter, Lambda P<sub>L</sub>/ P<sub>R</sub> Promoter, T<sub>7</sub> Promoter, Sp6 Promoter; SV-40 promoter, Cam V35s promoter and Ribosome binding sites. Transformation techniques. Genomic libraries- Isolation of genomic DNA fragments, selection of vectors, cDNA libraries and cDNA cloning, shot gun cloning, Bacterial Artificial libraries.

### **Reference/Text Books:**

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



## **MICB-802C: APPLIED MICROBIOLOGY**

### **UNIT-I: SOIL AND AGRICULTURE MICROBIOLOGY**

History of soil microbiology, Soil microbiology- Stages of Soil Formation, Soil microbes; Agriculture Practices in Stone age, Mycorrhizae, Ectomycorrhizae, Endomycorrhizae, Mycorrhizal inoculation, Horizontal vs Vertical Expansion in Agriculture (Green Revolution), Soil Analysis, Chemical fertilizer, Biofertilizer, Pesticides- classification, Mode of action, Drawbacks of chemical pesticides, Biopesticides - classification, Delta –Endotoxin of *Bacillus thuringiensis*, Three domain structure of delta-endotoxin, Mode of action, Limitation of Bt crops, Neonicotinoids-new generation of biopesticides, Mode of action of neonicotinoids, Sustainable agriculture.

### **UNIT-II: MEDICAL MICROBIOLOGY**

Classification of medically important microbes; Bacterial Genetic alterations and drug resistance; Structure and function of immune system including Immune response; Autoimmunity, Hypersensitivity and Immunodeficiency, Different types of antigen-antibody reactions and their utilization in diagnosis in different diseases, Introduction to medical mycology; Superficial & subcutaneous mycosis; Systemic & opportunistic mycosis; Introduction to parasitic diseases; Protozoan parasites of the intestines; Hospital Acquired infection control programme & biological waste management programme.

### **UNIT-III: FOOD MICROBIOLOGY**

Microorganisms important in Food Microbiology; Molds; Yeast and Yeast like fungi, Industrial Importance; Characteristics, Genera and Groups of bacteria important for food bacteriology; Factors effecting growth of microorganisms; Contamination and spoilage; Food Born Illness.

### **UNIT-IV: INDUSTRIAL MICROBIOLOGY**

Industrial Microbiology- Preview; Industrial Enzymes – Perspectives, Problem and Application; Improvement of Industrial Strains; Induced and site directed mutagenesis, Genetic variants; Protein Engineering: Principle and practice with reference to industrial enzymes; Secondary metabolites: submerged, solid state fermentation, chemostat/Continuous culture; Microbiology of food and Pharmaceuticals; Microbial production of industrial solvents; Maintenance of microbial strains: Culture Bank; Bioremediation

### **Reference/Text Books:**

1. Microbial Diversity by OladeleOgunseitan, Blackwell Publishing, 2005
2. Brock Biology of Microorganisms 11th Ed. by Madigan & Martinko, Prentice Hall, 2006.
3. Microbial Ecology 4th Ed. by Atlas & Bartha, Benjamin/Cummings, 1998.
4. Molecular Microbial Ecology by Osborn & Smith, no assigned readings, but useful background material.
5. Successful Scientific Writing: A Step by Step Guide for the Biological and Medical Sciences by Matthews & Matthews.
6. Atlas RM & Bartha R (1997) Microbial Ecology – Fundamentals and Applications
7. Kirchman DL (2008) Microbial Ecology of the Oceans
8. Barton LL & Northrup DE (2011) Microbial Ecology Wiley-Liss,
9. Begon M, Townsend CR & Harper JL (2006) Ecology – From Individuals to Ecosystems, 4th ed. (Blackwell)
10. Brock Biology of Microorganisms 11th Ed. by Madigan & Martinko, Prentice Hall, 2006.

## **MICB-803C: BIOINFORMATICS AND COMPUTATIONAL STATISTICS**

### **Unit I: Computer fundamentals.**

Computer system at a glance processor (CPU, ALU) Memory (ROM, RAM, CACHE data and address bus) Storage, Input & Output devices, Computer peripherals, Binary code and binary system, Algorithms and Flow charts, Software & Hardware, Operating systems. Application software's (Spreadsheet) Mainframe computers, Super computer, Mini and Micro computers, Workstation, Concept of multimedia and its applications. Network concepts (LAN, WAN) and its topology, Network media and hardware. Design and application of modern data communication over telephone lines and Digital telephone lines. Internet protocols HTML, SHTML, XML, WWW (World Wide Web) HTTP, SHTTP, Internet connectivity, search engines.

### **Unit II: Basics of Programming AND Retrieving Information:**

Learning PERL, Databases: contents, organisation, annotation, quality control, access, links, interoperability & data mining; Programming languages and tools, traditional programming languages, scripting languages, program libraries specialized for molecular biology; Java: computing over the web, Markup languages; Natural language processing and mining the biomedical literature, Application of text mining. Database indexing and specification of search terms, the archives: nucleic acid sequence database, genome database and genomic browsers, protein sequence database, databases of structures, classification of protein structures, accuracy and precision of protein structure determination.

### **Unit III: Sequence alignment and phylogenetic tree**

Submission and retrieval of Data in GenBank. Basic principle of genome assembly and annotation. Scoring matrices for nucleic acid and protein sequence analysis: PAM, BLOSSUM. Pairwise and multiple sequence analysis. Database searching using BLAST, Phylogenetic analysis.

Introduction to R programming, Analysis of Variance, Linear Regression, Multiple linear regression, Multiple linear regression with interaction, Polynomial Regression, Poisson Distribution, Scatter Plot, Correlation and Covariance, Stem and Leaf Plots, Box Plots, t Distribution and T score, One sample Test, Two sample test, Paired Test.

### **Unit IV: Structural Bioinformatics and Drug discovery and Computational Statistics (using R)**

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

#### Reference/Text Book:

1. Introduction to Bioinformatics Arthur M. Lesk Oxford University Press (2014) ISBN 978-0-19-872467-4
2. An Introduction to R, Notes on R: A Programming Environment for Data Analysis and Graphics Version 3.3.1 (2016-06-21) by W. N. Venables, D. M. Smith and the R Core Team.

## MICB-804C: PRACTICAL

1. Identification of human blood groups.
2. Perform Total and Differential Leukocyte Count of the given blood sample.
3. Separate serum from the blood sample. Separation of serum protein by vertical gel electrophoresis.
4. Determination of Molecular weight of Protein by Column chromatography
5. Plasmid isolation
6. Bacterial Transformation.
9. Genomic DNA isolation, quantification, purity analysis.
10. Study of UV absorbance spectra for Protein and DNA

### Reference/ Text Book:

1. Sambrook J, Fritsch EF, Maniatis T. (1989). In: *Molecular Cloning: A Laboratory Manual* (2nd ed). CSH Press, USA.
2. R.W. Old & S. B. Primrose (1990) *Principles of Gene Manipulation : An Introduction to Genetic Engineering*. Clackwell Science Ltd
3. *Protein Purification: Principles and Practice* by Robert K Scopes. Springer Advanced Texts in Chemistry. 1993.

## **MICB-805E: MICROBIAL ECOLOGY**

### **UNIT-I: BASICS OF MICROBIAL ECOLOGY**

Principles and concepts of microbial diversity - Methods of studying diversity – expansion of microbial diversity- estimates of total number of species, measures and indices of diversity-Exploitation and Conservation of microbial diversity distribution, abundance, ecological niche. Types: Bacterial, Archaeal and Eukaryal. Positive and negative roles of microbes in environment; biodegradation of recalcitrant compounds – lignin, pesticides; bioaccumulation of metals and detoxification - biopesticides; bioleaching (paper, leather, wood, textiles) and bioremediation.

### **UNIT-II: BASICS OF AERO-MICROBIAL DIVERSITY**

Aeromicrobiology: Microbes diversity in air, Determination of the microbial content of the air- Droplet nuclei, aerosol, aeroallergens; assessment of air quality (solid, liquid impingement methods); air borne transmission of microbes (viruses, bacteria and fungi), their diseases and preventive measures; Air sampling techniques, Air samples enumeration.

### **UNIT-III: BASICS OF SOIL MICROBIAL DIVERSITY**

Soil classification-physiochemical characteristics, soil microflora distribution - Factors influencing the soil microflora - Role of microorganisms in soil fertility, microbial interactions symbiosis-mutualism, commensalism, competition, synergism, amensalism, parasitism, predation - Interactions between microbes and plants - rhizosphere, phyllosphere, mycorrhizae. Microbial interactions in animals; role of biogeochemical cycles in microbial diversity (carbon, nitrogen, phosphorous and sulphur); Diversity of extremophiles.

### **UNIT-IV: AQUATIC MICROBIAL DIVERSITY**

Aquatic microbiology: Sediments, Surface water, littoral habitats; Soil and associated systems & habitats, factors influencing microflora (Minerals, pH, Organic matter, water and soil texture); altitudinal variations in microflora, Microbes associated at the interface, Microbes associated with plants, animal and insects (Symbiotic and pathogenic); Parasitic microbes, symbiotic microflora, saprophytes; Sewage treatment system (primary, secondary, tertiary and final disinfection of potable water supplies); Biological indicators of water safety and their assessment.

### **Reference/Text Book:**

1. Microbial Diversity by Oladele Ogunseitan, Blackwell Publishing, 2005
2. Brock Biology of Microorganisms 11th Ed. by Madigan & Martinko, Prentice Hall, 2006.
3. Microbial Ecology 4th Ed. by Atlas & Bartha, Benjamin/Cummings, 1998.
4. Molecular Microbial Ecology by Osborn & Smith, no assigned readings, but useful background material.
5. Successful Scientific Writing: A Step by Step Guide for the Biological and Medical Sciences by Matthews & Matthews.
6. Atlas RM & Bartha R (1997) Microbial Ecology – Fundamentals and Applications
7. Kirchman DL (2008) Microbial Ecology of the Oceans
8. Barton LL & Northrup DE (2011) Microbial Ecology Wiley-Liss,

9. Begon M, Townsend CR & Harper JL (2006) Ecology – From Individuals to Ecosystems, 4th ed. (Blackwell)

## **MICB-805E: MICROBIAL BIOREACTORS**

### **UNIT-I: MICROBIAL KINETICS**

Basic rate expressions; parameter values; basic mass balances; soluble microbial products; nutrients and electron acceptors; inhibition

### **UNIT-II: REACTORS**

Reactor types: suspended growth reactors; batch reactor ; continuous -Flow Stirred Tank Reactor with Effluent Recycle; membrane reactors; rotating drum reactors; biofilm reactors; reactor arrangements; Mass Balances ; Reactors with Recycling of Settled Cells- CSTR with Settling and Cell Recycling -Evaluation of assumptions; Engineering Design of Reactors; Reactors in series

### **UNIT-III: BIOFILM KINETICS**

Microbial aggregation; Why biofilms?; The idealized biofilm – substrate phenomenon- the biofilm itself; The steady state biofilm; The steady-State- Biofilm Solution; Estimating parameter values; average biofilm SRT; soluble microbial products and inert biomass;

### **UNIT-IV: ADVANCED MICROBIAL REACTORS FOR WASTE WATER TREATMENT**

Case study of microbial bioreactors for following types of waste water treatment: Municipal, beverage industry effluent, dairy effluent.

### **Reference/Text Book:**

1. Biochemical Engineering Fundamentals. J. Bailey and DF Ollis McGraw Hill, 2010
2. Bioreaction engineering Principles J. Nielsen and J. Villadsen, Academic Press
3. Environmental Biotechnology Principles and Applications. Bruce E Rittman and Perey L McCarty. TataMcGraw Hill Edition (2012) ISBN. 10:1-25-900288-8.



## MICB-901C: TOOLS AND TECHNIQUES IN MICROBIOLOGY

### **Unit I:**

Selective isolation of microbes: selection of medium and growth condition. Characterization of isolates: conventional and insilico techniques, DNA isolation, PCR amplification of 16SrDNA, Agarose gel analysis, AFIGE, PFGE, ARB for bacterial strain identification. Community analysis: Direct and indirect method, Shannon Diversity Index, Equitibility Index. RAPD, RFLP, TDDG, DGGE for community Analysis.

### **Unit II:**

Bacterial Draft Genome Sequence Analysis for strain identification; MAUVE Analysis, BRIG Analysis, Dot plot, Rapid Annotations using Subsystem Technology, Bacterial Transcriptome Analysis; Extracellular Enzymes; intracellular enzymes.

### **Unit III:**

TA cloning, Artificial chromosome vectors (YACs; BACs); Metagenomics, Primer design; DNA polymerases; Types of PCR - multiplex, nested, reverse transcriptase, real time PCR, touchdown PCR, hot start PCR, colony PCR, cloning of PCR products;

### **Unit IV:**

Case study of strain identification using a combination of taxonomic and insilico analysis of bacterial strains of genus *Bacillus*.

### Reference/ Text Book:

1. S.B. Primrose, R.M. Twyman and R.W.Old; Principles of Gene Manipulation. 6th Edition, S.B.University Press, 2001.
2. J. Sambrook and D.W. Russel; Molecular Cloning: A Laboratory Manual, Vols 1-3, CSHL, 2001.
3. Brown TA, Genomes, 3rd ed. Garland Science 2006
4. Aziz RK, Bartels D, Best AA, DeJongh M, Disz T, Edwards RA, Formsma K, Gerdes S, Glass EM, Kubal M, Meyer F, Olsen GJ, Olson R, Osterman AL, Overbeek RA, McNeil LK, Paarmann D, Paczian T, Parrello B, Pusch GD, Reich C, Stevens R, Vassieva O, Vonstein V, Wilke A, Zagnitko O. 2008. The RAST server: rapid annotations using subsystems technology. BMC Genomics 9:75.
5. [www.arb-home.de](http://www.arb-home.de)
6. Rang J et al Comparative analysis of genomics and proteomics in *Bacillus thuringiensis*. PLoS ONE. 2015. 10(3):e0119065

## MICB-902C: PRACTICALS

### **A) Understanding the cultivable microbes from dental Flora.**

Experiment 1:- Standardization of technique for sampling the dental flora.

Experiment 2:- Growing the dental micro-flora in the selected media & determination of

(a) pre-incubation time &

(b) requisite dilution to get the CFU count and diversity estimate.

Experiment 3:- Isolation, purification, Characterization of dental micro-flora, & antibiotic sensitivity test.

Experiment 4:- In-vitro set up for testing antibiotic therapy in case of dentine tissue or teeth.

Experiment 5:- Visualization of the teeth surface using Scanning Electron Microscope.

### **B) To find out the relative proportion of Lactic Acid Bacteria from natural sources.**

Experiment 6:- Isolation of acid producing bacterial from various natural sources like grass, intestine of fish and prawn, curd, fermented fish, bee hibe, etc

Experiment 7:-Characterization of isolates.

Experiment 8:- Testing for biofilm formation by the isolate.

Experiment 9:- Production of Lactic acid from whey in packed bed reactor.

### **References:**

- 1) Mishra, M., S. Ghosh, L.E. Alex, I. Mukherjee, T.P. Sinha, A.R. Thakur and S Ray Chaudhuri, 2012. Developing a system for antibacterial treatment of dental caries using culture based approach. OnLine J. Biol. Sci., 12: 44-53.
- 2) V Helen Shiphrah, SayantiSahu, AshokeRanjan Thakur and S RayChaudhuri. 2013 Screening of bacteria for lactic acid production from whey water. American Journal of Biochemistry and Biotechnology, 9 (2): 118-123.
- 3) Ghosh, S., G. Roy and B. Mukherjee, 2009. Dentalmold: A novel formulation to treat common dentaldisorders. AAPS Pharm. Sci. Tech., 10: 692-702.PMID: 19466555
- 4) Martín R, Soberón N, Vanechoutte M, Camino FV, Suárez JE. Characterization of indigenous vaginal lactobacilli from healthy women as probiotic candidates. International microbiology: Official journal of the Spanish Society for Microbiology. 2008;11(4):261-6.



## **MICB-903E: MICROBIOLOGY OF FERMENTED FOOD AND PRODUCTS**

**Unit I: Introduction**-Origin and History of food fermentation; Fermented foods “from art to science”; Basics of fermentation processes; Health benefits and other significances of fermented food and beverages; Fermented foods in the twenty-first century.

**Unit II: Basics of Fermentation Technology**-Types of fermentation- (sub-merged/solid state, Batch /continuous fermentation); Basic Structure of fermentors and types; Basic process and requirements for fermentation and factor affecting fermentation process; Upstream and Downstream processing of microbial products and quality control of products; Basic strain improvement process; Recent developments in fermentation technology.

**Unit III: Traditional Fermented Food and Beverages**- Tradition of fermented food and beverages of Asia and North East India; Food habits and types of their fermented food; Fermented baked product; Fermented vegetable foods- Sauerkraut, Kimchi, Pickle, bamboo shoots; Fermented soyabean products- (Temph, Tofu, Soya sauce); fermented beans; Fermented dairy products-Cheese, Dahi and Yogurt, Butter; Other fermented food products- Idli, Vada, Dosa, Bhatura, Dhokla; Fermented fish, meat and sausages; Fermented beverages- Sake, Rice beers, Ale, Wines.

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

### **Reference/Text Book:**

1. Food Microbiology by William Frazier, Dannise Westhoff, McGraw-Hill. Inc.
2. Microbial Physiology and Metabolism by Caldwell D.R. 1995Brown Publishers.
3. Microbial Physiology by Moat A.G. and Foster J. W. 1999.. Wiley.
4. Advances in Microbial Physiology. Volumes. Edited by By A.H. Rose. Academic Press, New York.
5. Principles of Fermentation Technology, 3rd Edition by Stanbury & Whitaker & Hall, Butterworth-Heinemann, Elsevier science.
6. The Art of Fermentation by SandorEllix Katz, Chelsea Green Publishing (2012).
7. Mastering Fermentation by Kate Williams, Oxford publishing.

## **MICB-903E: WASTE WATER TREATMENT**

**Unit I:** History of Waste water treatment/management: Early civilization, Middle Age, Age of Enlightenment, the industrial revolution, the progressive era, the great depression and World War II, post war era, Present day, regulation of discharges to water: Clean Water Act (CWA), Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), the emergency planning and community right to know act, Pollution Prevention act 1990, an approach to problem solving: a six step method.

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

**Unit III:** Waste Water Treatment-Conventional Physico Chemical Methods, Biological Methods of Treatment of Waste water; Non-potable applications of treated waste water, design of water treatment systems; Design of waste water treatment systems, Environmental sustainability, Environmental Public Health

### **Reference/Text Book:**

1. Environmental Engineering Principles and Practice by Richard O Mines, Jr, Wiley Blackwell
2. Environmental Pollution Control Microbiology by Ross E McKinney, Marcel Dekker, Inc
3. Handbook of Water and waste water treatment plant operations, 3<sup>rd</sup> Edition by Frank R. Spellman, CRC Press, Taylor and Francis Group.
4. Sustainable Water Engineering Theory and Practice by Chandrappa and Das, Wiley.
5. Water Resources An integrated approach by Joseph Holden, Routledge, Taylor and Francis Group.
6. Drinking Water Quality Problems and Solitions, 2<sup>nd</sup> Ed, N F Gray, Cambridge.
7. Waste Water Treatment Technologies: A general review; ECONOMIC AND SOCIAL COMMISSION FOR WESTERN ASIA. United Nations, New York, 2003, url:

## **MICB-904E: BASICS OF STATISTICS**

Types of statistical data: primary and secondary data, Classification, Tabulation and Diagrammatic representation of data, Frequency Distribution, Cumulative Distribution and their graphical representation, Histogram, Frequency Polygon, Frequency Curve and Ogive. Measures of central tendency: Arithmetic, geometric and harmonic mean, median and mode. Measures of dispersion: Mean Deviation, Variance, moments, skewness and kurtosis and their measures based on quantiles and moments.

Correlation Coefficient and its Properties, Spearman's Rank Correlation Coefficient. Correlation and Regression Analysis, Fitting of Linear equation by the principle of Least Squares. Partial and multiple correlation. Random Experiments and Random Events, Classical and Axiomatic definitions of Probability (discrete sample space only), Conditional Probability, Independence of Events and Bayes Theorem.

Random Variable and its Probability Distribution, Cumulative Distribution Function, Probability Mass Function and Probability Density Function, Mathematical Expectation, Variance and Moments, Simple Theorems including theorems on expectation and variance of a sum of random variables and expectation of product of Random Variables. Moment generating functions; characteristic functions; probability inequalities (Tchebyshef, Markov, Jensen).

Introduction of some distributions: Bernoulli, Binomial, Poisson, Geometric, Uniform, Normal, Exponential distributions. Population, sample, Statistic, standard error, estimation, confidence interval and confidence level, confidence interval estimate of proportion and mean. Hypothesis and its types, errors, critical region, level of significance, power and p-values. Test statistics: Student's t-test, Chi-square, F and Z-Statistics and their applications in testing of hypothesis. Exact and Large sample tests. Analysis of Variance. Non-parametric test - sign, median, run, Mann-Whitney test. Chi square test of goodness of fit, Chi square analysis of contingency table.

### Reference/Text Books:

- [1] Mukhopadhyay, P: Mathematical Statistics. Books and Allied (P) Ltd.
- [2] Mukhopadhyay, P: Applied Statistics. Books and Allied (P) Ltd.
- [3] Goon, A. M. ., Gupta, M. K and Dasgupta, B.: Fundamentals of Statistics; Vol. I, II
- [4] Rohatgi, V.K. and Ehsanes Saleh, A. K. Md. : An introduction to Probability and Statistics
- [5] Gupta, S.C, and Kapoor, V.K. : Fundamentals of Mathematical Statistics
- [6] Gupta, S.C, and Kapoor, V.K. : Fundamentals of Applied Statistics

## MICB-905C: PROJECT WORK

### **Unit -1 Unit -1 Preparation of synopsis**

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

### **Unit -2 Methodology**

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

### **Unit – 3 Conducting experiments and reporting the findings**

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

*NB: Evaluation for part one will be done on:*

- 1. Presentation of Synopsis its objectives, expected outcome, and methodology in detail.*
- 2. Assignment for review of literature related to proposed work.*

## **MICB-1001E: INTELLECTUAL PROPERTY RIGHTS**

**Unit I:** Intellectual Property Creation, Protection, and Management; Introduction, Definition & Function of Different IPR's, Case Studies on Why IPR's are Important, and How to Protect/Enforce Them. Trademarks; Introduction, Types of Trade Mark, Mode of Protection, Registration Procedure, Case Studies; Passing Off/Opposition/Litigation Actions, Brand and Trade Mark Valuation. Copyright; Meaning & Importance, Subject Matter & Term, Registration Procedure; Ownership, Economic/Moral Rights, Assignment, Transmission and Licensing; Performer Rights, Broadcast Reproduction Rights, Infringement of Copyright, Remedies of Infringement, Civil, Administrative;

**Unit II:** Patents: Introduction; Definition, Importance & Type of Patents; Patentable Inventions; Prior Art Search – Need and procedure; Patent Drafting/Filing – Procedure and Best Practices: Overview of Patent Filing Procedure, Who can be an Applicant?, Form of Application, Formalities to keep in mind while filing Patent Application; Publication and Examination of Applications; Representation & Pre grant Opposition; Anticipation; Secrecy of Invention; Grant of Patent; Rights of Patentee; Amendment of Application and Specifications; Restoration of Lapsed Patents; Post grant Opposition; Freedom to Operate Searches – Need and Procedure; Compulsory Licensing, Use of Inventions for Govt. Purposes & Revocation; Infringement of Patent & Remedies

**Unit III:** Designs: Introduction; Definition & Importance; Registration Procedure; Overview; Prerequisites of Registration; Application for Registration; Publication; Grant of Certificate; Copyright in Registered Designs & Duration; Cancellation of Registration; Piracy of Registered Designs and Remedies. Geographical Indication: Introduction; Definition & Importance; Registration of GI – Procedure. Plant Varieties and Farmers' Rights: Introduction, Objective and Definition; Registration of Plant Varieties: Application; Requirements for Registration; Requirements for Denomination given to Variety; Non Registerable Varieties (S. 29); Tests to be conducted; Acceptance of Application; Publication of Application; Opposition; Registration; Duration, Effect of Registration and Benefit Sharing; Farmers' Rights; Compulsory License; Plant Varieties Protection Appellate Tribunal; Infringement, Offences and Penalties. Semiconductor Integrated Circuits Layout Designs: Introduction, Importance and Definition; Importance & Definition; Registration – Procedure; Absolute Grounds for Prohibition of Registration; Objections to Acceptance; Publication of Application; Opposition; Registration.

**Unit IV:** IP Litigation: Introduction; Civil vs. Criminal Remedies – Advantages & Strategy; Filing Procedure in Various Civil Courts / High Courts; Defenses in case of Infringement Suit; Pointers Specific to Certain type Civil IP Litigation (e.g. Trademarks, Copyright, Patents etc.); Criminal Litigation; Pointers Specific to Certain type criminal IP Litigation (e.g. Trademarks, Copyright etc.) Confidential Information / Trade Secret: Introduction & Advantages; Type of CI / TS; Requirements for Consideration of Information as CI / TS; Remedies against Breach of Confidence. IP Licensing: Introduction; Meaning & Importance; Licensing vs. Assignment; Compulsory Licensing & Procedure; Strategies for successful transfer of technology. IP Valuation: Introduction; Various Methods of IP Valuation; When to use which Method? IP Due Diligence And Audit: Introduction; Procedure. IP Strategy: IP Portfolio Development Strategy; IP Litigation Strategy; IP Licensing, Tech Transfer, and Commercialization Strategy

Reference/Text Books:

1. Intellectual property counseling and litigation, Ed by Horwith&Worwitz
2. Intellectual property the law of copyrights, patents and trademarks, By Schechter, Roger E. & Thomas, John R.

## MICB-1002E: ADVANCED APPLIED MICROBIOLOGY

### **UNIT-1 Agriculture Microbiology**

**Role of microorganisms in soil fertility-** Interactions among microorganisms, mutualisms, comensalism, competition, amensalism, parasitism, predation – Interactions between microbes and plants - rhizosphere, phyllosphere, mycorrhizae. Biogeochemical - carbon cycle - role of microbes in carbon cycle- trophic relationships-mobilization and immobilisation of carbon with rhizosphere. Nitrogen cycle - mechanism of biological nitrogen fixation-ammonification-nitrification- denitrification and microorganisms involved in such processes. Phosphorous cycle - Sulphur cycle. Biofertilizer for sustainable agriculture *Rhizobium Azospirillum Azotobacter, Azolla*, applications methods of biofertilizers - significance of biofertilizers.

**Microbial interactions in animals (Fish and Shrimps)-**GI Tract microbial biodiversity, Fish probiotics, Biogeochemical cycles in terms of aquaculture,

**Pond water treatment for sustainable aquaculture-** Water pollution - sources and nature of pollutants in water - Sewage - industrial effluent - agrochemicals - Eutrophication - waterborne diseases. Potable water. Assessment of microbiological quality of water. Brief account on bioterrorism. Bioremediation, Biofloc technology

### **UNIT-II FOOD MICROBIOLOGY**

**Importance of studying food and dairy microbiology:**Primary sources of microorganisms in foods.

Factors influencing microbial growth in foods – extrinsic and intrinsic.

**Principles of food preservation:**Preservation methods - irradiations - drying, heat processing, chilling and freezing, high pressure, modification of atmosphere and chemical preservatives. Contamination, preservation and spoilage of fruits vegetables, meat, dairy, agricultural and poultry products.

**Food sanitation in food manufacture and in the retail trade:** Nutritional value of fermented foods. Food control agencies and its regulations. Bacterial pathogens such as *Brucella, Clostridium, Bacillus, E. coli, Listeria, Salmonella, Staphylococcus, Vibrio and Yersinia*.

#### **Reference/Text Books:**

1. Alexander M. (1977) Introduction to soil microbiology. John Wiley & Sons, Inc., New York.
2. EcEldowney S, Hardman DJ, Waite DJ, Waite S. (1993). Pollution: Ecology and Biotreatment – Longman Scientific Technical.
3. Dirk J, Elas V, Trevors JT, Wellington, EMH (1997) Modern Soil Microbiology, Marcel Dekker INC, New York.
4. Ramanathan, and Muthukaruppan SM (2005) Environmental Microbiology. OmSakthiPathipagam, Annamalai Nagar.
5. Andrews AT, Varley J. (1994) Biochemistry of milk products. Royal Society of Chemistry.
6. Banwart GJ. (1989), Basic food microbiology, Chapman & Hall, New York.
7. Frazier WC and Westhoff DC. (1988) Food microbiology, TATA McGraw Hill Publishing Company Ltd. New Delhi.

## MICB-1002E: RECENT TRENDS IN MICROBIAL RESEARCH

### **Unit I: Antimicrobials**

An outline of the historical development of antimicrobial agents. Reasons for studying the biochemistry and molecular biology of antimicrobial compounds. Uncovering the molecular basis of antimicrobial action. Current trends in the discovery of antimicrobial drugs. Antimicrobial assays in liquid and solid media, susceptibility testing in liquid and solid media. Antibiotics that inhibit peptidoglycan biosynthesis. Drugs that interfere with the biosynthesis of the cell wall of mycobacteria. Fungal cell wall as a target for antimicrobial drugs. Ionophoric antibiotics. Antifungal agents that interfere with the function and biosynthesis of membrane sterols. Inhibitors of nucleic acid biosynthesis. Inhibitors of protein biosynthesis. Nitroheterocyclic antimicrobial agents. A unique antifungal antibiotic- griseofulvin, antiviral agents, antiprotozoal agents. Drug transport across cell walls and membranes. Multi drug resistance.

### **Unit II: Microbial Pathogenicity and Epidemiology**

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

#### Reference/Text Book:

1. Burn J. H. (1957) *Principles of Therapeutics*, Blackwell Scientific Pub. O. Ltd. Oxford.
2. Iyengar M. A. (1974) *Pharmacology of Powdered Crude Drugs*, Manipal.
3. Kokate C. K., Purohit A. P., Gokhale A. B. (2000) *Pharmacology*, 4<sup>th</sup> Ed., NiraliPrakashan.
4. OsolArther (1975) *Remington's Pharmaceutical Sciences*, 15<sup>th</sup> Ed., Mack Pub. Co., Pennsylvania.
5. Goldstein A., Aronow L., and Kalman S. M. (1969) *Principles of Drug Action, The Basis of Pharmacology*, Harper international edition New York.
6. Satoskar R. S. & S. D. Bhandarkar (1991) *Pharmacology and Pharmacotherapeutics*, 12<sup>th</sup> Ed., Vol. 1 & 2, Popular Prakashan, Mumbai.
7. Chatwal G. P. (2003) *Biopharmaceutics and Pharmacokinetics*, Himalaya Publishing House, Mumbai.
8. Micheles P. S., Y. L. Khmel'nitsley, J. S. Dordick and D. S. Clark, (1998), *Combinatorial Biocatalysis, A Natural Approach to Drug Discovery*, Trends in Biotechnol. **16**, 197.
9. Altreuter D., and D S. Clark, (1999), *Combinatorial Biocatalysis: Taking the Lead From Nature*, Curr. Opin. Biotechnol. **10**, 130.
10. Virulence mechanisms of bacterial pathogens (Second edition) by Roth, Bolin, Brogden Minion and Michael
11. Medical Microbiology edited by Samuel Baron. Fourth edition. ( University of Texas Medical Branch of Galvesion)
12. Medical Microbiology: an Introduction to infectious diseases. Sherris, John C, Ed, Elsevier Publication II<sup>nd</sup> edition.
13. Multidrug resistance. Annu Rev Biochem. 2009 ; 78: 119-146. doi:10.1146/annurev.biochem.78.082907.145923.

## **PAPER -1003C:PROJECT WORK**

### **Unit -1 Conducting experiments and reporting the findings**

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

### **Unit – 2 Preparation of final dissertation**

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

### **Unit – 3 Preparation of manuscript for a research paper**

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

*NB: Evaluation for part two will be done on:*

- 1. Preparation of manuscript for a research paper and its communication in a journal*
- 2. Preparation of final dissertation*
- 3. PowerPoint Presentation of overall work of the project*