SHRI GURU RAM RAI UNIVERSITY

(Estd. by Govt. of Uttarakhand, vide Shri Guru Ram Rai University Act no. 03 of 2017)

Syllabus of

M.Sc. (MICROBIOLOGY)

(Two Year Course- Semester System)
Under CBCS

Effective from Academic Session
2017-2018

Master of Science (MICROBIOLOGY)-Two Year Programme- Choice Based Credit System

Admission to Master's Program in Microbiology shall be through entrance examination conducted by University/Merit of qualifying exam and the program shall be based on the choice based credit system in which credit defines the quantum of content/ syllabus prescribed for a course system and determines the number of hours of instruction per week.

The student shall be eligible for admission to a Master's Degree Program in Microbiology after he/she has successfully completed a three year undergraduate degree or earned prescribed number of credits through the examinations conducted by University as equivalent to an undergraduate degree with minimum 45% marks in undergraduate course.

Core courses prescribed for every Semester shall be mandatory for all students registered for the Master's Program in Microbiology and shall carry minimum 86 credits. There shall be Elective courses offered in semester III and IV including dissertation and shall carry a minimum of 24 credits. A self-study course would comprise of maximum 06 credits of which minimum 03 credits shall be mandatory which shall not be included while calculating grades.

The student may choose self-study course either only in one of the two semesters (III/IV). The self study course shall be based on advanced topics. As a mandate student should undergo 4-5 weeks industrial training during summer break after 2nd semester to boost up the academic knowledge and gain the industrial exposure. The industrial training would comprise of 03 credits that shall be mandatory, which shall not be included while calculating grades but will be mentioned in the award sheet.

In order to qualify for a two year master's degree, a student must acquire a minimum of 86 credits including a minimum of 24 credits in electives choosing at least two electives in Semester III/IV offered either by the parent department or other departments and one qualifying self-study course and industrial training of minimum 03 credits each.

The dissertation is a semester long elective course of 09 credits and is mandatory for every student. The dissertation would be allotted in the beginning of III Semester and candidate would submit the thesis/report during IV Semester examination. The dissertation may be in the form of a field based minor research work/ project work/ practical training. The students may complete the dissertation work in the department/ other research institutes/ industries/ hospitals, etc.

A candidate has to obtain a minimum of 40 % marks in individual paper in university examination as well as in mid term exams and 50% marks in aggregate (Two Sessional Tests marks plus End-Term Examination marks) to pass.

The 2- Year Masters Programme will have the following components:

1) Core course: Minimum 62 credits.
2) Elective course: Minimum 24 credits (Including dissertation)
3) Dissertation: 09 credits (elective) in IV Semester.
4) Self study course: Maximum 06 credits (one minimum 03 credits shall be mandatory but not to be included while calculating grades).
5) Industrial training: 03 credits (Shall be mandatory but not to be included while calculating grades).
6) Journal club 01 credit

M.Sc. Microbiology

I Semester

Sl.	Code	Paper	Credits			MM
			L	P	C	
1	MMBC101	INTRODUCTORY MICROBIOLOGY	4	0	4	100
2	MMBC102	PRINCIPLES OF BIOCHEMISTRY	4	0	4	100
3	MMBC103	CELL AND MOLECULAR BIOLOGY	4	0	4	100
4	MMBC104	MICROBIAL GENETICS	4	0	4	100
5	MMBL105	Lab Course I (Based on paper 1 & 2)	0	3	3	100
6	MMBL106	Lab Course II (Based on paper 3 & 4)	0	3	3	100
			Core Credit		22	600

II Semester

Sl.	Code	Paper	Credits			MM
			L	P	C	
1	MMBC201	MICROBIAL PHYSIOLOGY AND METABOLISM	4	0	4	100
2	MMBC202	IMMUNOLOGY	4	0	4	100
3	MMBC203	BIOLOGICAL TECHNIQUES	4	0	4	100
4	MMBC204	RECOMBINANT DNA TECHNOLOGY	4	0	4	100
5	MMBL205	Lab Course I (Based on paper 1 & 2)	0	3	3	100
6	MMBL206	Lab Course II (Based on paper 3 & 4)	0	3	3	100
			Core Credit		22	600

* 5 Week Industrial Training in Summer Break (June-July) and submission of report and presentation in III semester.

III Semester

Sl.	Code	Paper	Credits			MM
			L	P	C	
1	MMBC301	MEDICAL MICROBIOLOGY	4	0	4	100
2	MMBC302	INDUSTRIAL AND PHARMACEUTICAL MICROBIOLOGY	4	0	4	100
3	MMBE303	Elective – I (a) FOOD AND DAIRY MICROBIOLOGY (b) DRUG DESIGNING AND NANO-BIOTECHNOLOGY (C) MOLECULAR VIROLOGY AND INFECTION	4	0	4	100
4	MMBE304	Elective – II a) ENVIRONMENTAL MICROBIOLOGY b) AGRICULTURAL MICROBIOLOGY	4	0	4	100

		c) ECOSYSTEM ANALYSIS AND REMOTE SENSING				
5	MMBL305	Lab Course I (Based on paper 1 & 2)	0	3	3	100
6	MMBL306	Lab Course II (Based on Elective I & II)	0	3	3	100
7	MMBS307	Self Study A. BIOINFORMATICS& BIOLOGICAL DATA BASE B. BIOMEDICAL TECHNOLOGY	3	0	3	100
8	MMBI308	Industrial Training Report/Presentation.	03		3	
						600

Core Credit = 11 + Elective Credit = 11 Total Credit = 22 with additional 3 credits of self study& 3 credits of Industrial Training.

IV Semester

Sl.	Code	Paper	Credits			MM
			L	P	C	
1	MMBE401	DISSERTATION	0	9	9	300
2	MMBC402	EPIDEMIOLOGY	4	0	4	100
3	MMBE403	a. Beverages Biotechnology b. Bio – Entrepreneurship c Intellectual Property Rights	4	0	4	100
4	MMBL404	Lab Course based on paper (C402)	0	3	3	100
5	MMBJ405	Journal Club*	0	1		
6	MMBS406	Self Study A. INFECTION AND IMMUNITY B. RESEARCH METHODOLOGY	3	0	3	100
						600

Core Credit = 7 + Elective Credit = 13 Total Credit = 20 with additional 3 credits of self study & 01 credits of Journal club.

- Journal club will include the reading, presentation and to develop writing skills in view of thesis writing.
- The thesis evaluation will be of 180 marks and 60 marks for academic performance and 60 for presentation/viva.

Master of Science (MICROBIOLOGY) -Two Year Programme- FIRST SEM.
Choice Based Credit System
INTRODUCTORY MICROBIOLOGY
PAPER CODE: MMBC101

Lecture 4 hr/week **100 marks**

Unit I: History and Classification
Discovery of microorganisms; Conflicts over spontaneous generation; Golden era of microbiology; Kingdom classification of microorganisms: Haeckel's three kingdom concept, Whittaker's five kingdom concept, Six kingdom classification, Eight kingdom classification, Three domain concept of Carl Woese; Differences between prokaryotes and eukaryotes; Techniques used in microbial classification (Morphological, chemotaxonomic and genetic methods); Tools for systematics (Phylogenetic, numerical and polyphasic taxonomy); Scope and relevance of microbiology.

Unit II: Basics of Microbiology
Microbial nutrition; Culture media; Culture techniques for isolation of pure culture; Cultivation of aerobic and anaerobic bacteria; Preservation methods; Microbial growth: Growth curve of batch and continuous cultivation, Diauxic growth curve, Generation time, Growth kinetics, Asynchronous and synchronous growth, Measurement of growth, Factors affecting growth; Control of microbial growth: Physical and chemical agents.

Unit III: General Bacteriology
Bergey's system of bacterial classification; Brief account of Gracilicutes, Fermicutes, Mendosicutes and Tenericutes; Ultrastructure of bacterial cell: Morphology of bacteria, Structure and properties of cell wall and cell membrane, Cell wall synthesis, Capsule (Types, composition and function), Ultrastructure and functions of flagella, cilia, pili, s-layer, cytoplasmic inclusions, ribosomes and nucleoid; Bacterial reproduction

Unit IV: General Virology and mycology
Discovery of viruses; Characteristic feature of viruses, viroids, virusoids and prions; Baltimore scheme of classification; Morphology and ultrastructure: Capsids and their arrangements, Types and composition of envelopes, Viral genome (Types and structures); Isolation and cultivation of viruses , experimental animals and cell culture; Infectivity assay (Plaque method, pock method and end point methods); lytic and lysogenic cycle; Mycology: General features, Mycelial organization and structure, Nutrition, Cultivation, Reproduction, Classification (Basis and general outline), Salient features of Ascomycetes, Basidiomycetes, Zygomycetes andDeuteromycetes.

Unit V: Extremophiles
General introduction to Archae bacteria and applications Tools used for studying extremophiles, culturable and non culturable microbial diversity, Characteristic features, physiology, applications of acidophiles, alkalophiles, psychrophiles, thermophiles, barophiles, halophiles, oligotrophs, osmophiles, radiophiles, metallophiles and xerophiles.

SUGGESTED READINGS
1. Wiley, J.M., Sherwood, L.M. and Woolverton, C.J. Prescott, Harley and Klein's microbiology. McGraw-Hill, New York.

2. Black, J.G. Microbiology: Principles and exploration. John Wiley and Sons, New Jersey.
3. Madigan, M.T., Martinko, J.M. and Parker, J. Brock biology of microorganisms. Prentice Hall, New Jersey.
4. Pommerville, J.C. Alcamo's fundamentals of microbiology. Jones and Bartlett Learning, Sudbury.
5. Wheelis, M. Principles of modern microbiology. Jones and Bartlett Learning, Sudbury.
6. Stanier, R.Y., Ingraham, J.L., Wheelis, M.L. and Painter, P.R. General microbiology. MacMillan Press, London.
7. Sclegel, H.G. General microbiology. Cambridge University Press, Cambridge.
8. Pelczar, M.J., Chan, E.C.S. and Kreig, N.R. Microbiology. McGraw-Hill, New York.
9. Tiwari, S.P., Sharma, R. and Singh, R.K. Recent advances in microbiology. Nova Science, New York.
10. Topley, W.W.C., Wilson, S.G.S. and Parker, M.T. Topley and Wilson's principles of bacteriology, virology and immunity. Edward Arnold, London.
11. Dimmoc, N.J., Easton, A.J. and Leppard, K.N. Introduction to modern virology. Wiley-Blackwell, New Jersey.
12. Levy, J.A., Conrat, H.F. and Owens, R.A. Virology. Prentice Hall, New Jersey.
13. Primrose, S.B. Introduction to modern virology. John Wiley and Sons, New Jersey.
14. Burnett, J.H. Fundamentals of mycology. St. Martin's Press, New York.
15. Mehrotra, R.S. and Aneja, K.R. An introduction to mycology. New Age International (P) Limited, New Delhi.
16. Alexopoulos, C.J. and Bold, H.C. Algae and fungi. MacMillan Press, London.
17. Graham, L.E. and Wilcox, L.W. Algae. Prentice Hall, New Jersey.
18. Vashishta, B.R. Algae. S. Chand and Company, New Delhi.
19. Sharma, O.P. Textbook of algae. Tata McGraw-Hill Education, New Delhi.
20. Kumar, H.D. Introductory phycology. East-West Press, New Delhi.

Master of Science (MICROBIOLOGY) -Two Year Programme- FIRST SEM.
Choice Based Credit System
PRINCIPLES OF BIOCHEMISTRY
PAPER CODE: MMBC102

Lecture: 4hrs/week **Max. Marks: 100**

Unit I: Bioenergetics
Bioenergetics: Concept of free energy, Standard free energy, Enthalpy, Entropy, High energy phosphate compounds, Phosphate group transfer, Free energy of hydrolysis of ATP, Oxidation-reduction, Redox potential; Energy generation in biological systems: Phosphorylation and electron transport chain, Electron carriers, Artificial electron donors, Inhibitors and uncouplers of oxidative phosphorylation, Chemiosmotic theory of ATP synthesis.

Unit II: Carbohydrates
Classification, nomenclature, structure, general properties and functions of simple carbohydrates; Complex carbohydrates: Mucopolysaccharides, Amino sugars, Bacterial cell wall sugars, Sugar alcohols, Glycoconjugates.

Unit III: Lipids
General properties, nomenclature and classification of lipids; Lipid functions: Fatty acids; Saponification, acid value and iodine value of fats; Rancidity of fats; Storage and structural lipids; Metabolism: Biosynthesis of fatty acids, triacylglycerols, membrane phospholipids, cholesterol, steroids and isoprenoids, Beta oxidation and its regulation, Regulation of cholesterol biosynthesis.

Unit IV: Proteins and Nucleotides
Proteins: Structural features and classification of amino acids, General reactions of amino acid metabolism (Transamination, decarboxylation, oxidative and non-oxidative deamination of amino acids), Peptide bond, Properties and functions of primary, secondary, tertiary and quaternary structure of proteins, Ramachandran plot,. Nucleotides: Structure of purines and pyrimidines and their function, overview of nitrogen fixation.

Unit V: Enzymes
General characteristics of enzymes; Co-enzymes; Holoenzymes; Prosthetic groups; Enzyme nomenclature; Classification of enzymes; Active site; Transition state; Activation energy; Enzyme activity; Specific activity and turn over number; Isozymes; Mechanism of enzyme catalysis and Enzyme kinetics; Reaction mechanisms of enzymes (Acid base and covalent catalysis); Reversible and irreversible inhibition of enzymes; Effect of pH and temperature on enzyme activity; Allosteric enzymes; Determination of active site and turn over number.

SUGGESTED READINGS
1. Atkins, P. and Paula, J.D. Atkins' physical chemistry. Oxford University Press, Oxford.
2. Segel, I.H. Biochemical calculations. John Wiley and Sons, New York.
3. Nelson D.L. and Cox, M.M. Lehninger principles of biochemistry. W.H. Freeman and Company, New York.
4. Berg, J.M., Tymoczko, J.L. and Stryer, L. Biochemistry. W.H. Freeman and Company, New York.
5. Garrett, R.H. and Grisham, C.M. Biochemistry. Cole Publishing Company, California.

6. Voet, D. and Voet, J.G. Biochemistry. John Wiley and Sons, New York.
7. Conn, E.E., Stumpf, P.K., Bruening, G. and Doi, R.Y. Outlines of biochemistry. John Wiley and Sons, New York.
8. Robert, M., Bender, D., Botham, K.M., Kennelly, P.J., Rodwell, V. and Weil, P.A. Harper's illustrated biochemistry. McGraw-Hill, New York.
9. White, A., Handler, P., Smith, E., Hill, R. and Lehman, J. Principles of biochemistry. Mc-Graw Hill, New York.
10. Jain, J.L. Fundamentals of biochemistry. S. Chand and Company, New Delhi.
11. Palmer, T. Enzymes: Biochemistry, biotechnology and clinical chemistry. Horwood Publishing Company, Chinchester.

Master of Science (MICROBIOLOGY) -Two Year Programme- FIRST SEM.
Choice Based Credit System
CELL AND MOLECULAR BIOLOGY
PAPER CODE: MMBC103

Lecture: 4hrs/week **Max. Marks: 100**

Unit I: Intracellular Compartmentalization of Cell
Structure, organization and functions of nucleus, mitochondria, chloroplast, endoplasmic reticulum, golgi body, peroxisome, lysosome and endosomes; Molecular mechanism of vesicular trafficking. Fluid mosaic model, Membrane fluidity, Membrane dynamics

Unit II: Cell Signaling
Basic signaling mechanisms (Paracrine, endocrine and autocrinesignaling); Mechanism of signal transduction: Signaling molecules, Ligand-receptors interaction, Transmembrane and intracellular signaling, Cell surface receptors (G protein-coupled, enzyme-linked and ion channel-linked receptors), Second messengers and their role in signal transduction, Signal integration, Signal amplification.

Unit III: Replication and Transcription
DNA replication in prokaryotes and eukaryotes: Experimental evidence, Modes of replication, Mechanism of replication, Inhibitors of replication; Transcription in prokaryotes and eukaryotes: RNA polymerases, Mechanism of transcription, Post transcriptional modifications of mRNA, rRNA and tRNA, Inhibitors of transcription; Structural features and functions of mRNA, t-RNA and r-RNA.

Unit IV: Translation and Regulation of Gene Expression
Basic features of genetic code; Translation in prokaryotes and eukaryotes: Structure of ribosomes, Mechanism of translation, Post translational modifications, Protein degradation, Non-ribosomal polypeptide synthesis, Inhibitors of translation; Regulation of gene expression: Structure and regulation of *lac*, *trp*and *arb*operon, DNA binding motifs in regulatory proteins, Role of activators, enhancers, insulators, RNA interference and antisense RNA.

Unit V: Cell Cycle and Cell Death
Cell cycle, Molecular events, Cyclin, CDKs, Checkpoints in cell cycle, Intracellular control of cell cycle events, Mitosis and meiosis, Apoptosis: Mechanisms of apoptosis, Signals triggering apoptosis, Apoptosis inducing factors,.

SUGGESTED READINGS

1. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K. and Walter, P. Molecular biology of the cell. Garland Science, New York.
2. Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Scott, M.P., Bretscher, A., Ploegh, H. and Matsudaira, P. Molecular cell biology. W.H. Freeman and Company, New York.
3. Cooper, G.M. and Hausman, R.E. Cell: Molecular approach. ASM Press, Washington, D.C.
4. de Robertis, E. D. P. and de Robertis, E.M.F. Cellular and molecular biology. Saunders, Philadelphia.
5. Pollard, T.D., Earnshaw, W.C. and Schwartz, J.L. Cell biology. Saunders, Philadelphia.
6. Karp, G. Cell and molecular biology- Concepts and experiments. John Wiley and Sons, New York.
Reference Books Molecular biology

7. Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Scott, M.P., Bretscher, A., Ploegh, H. and Matsudaira, P. Molecular cell biology. W.H. Freeman and Company, New York.
8. Krebs, J.E., Goldstein, E.S. and Kilpatrick, S.T. Lewin's genes. Jones and Bartlett Learning Publishers, Sudbury.
9. Nelson D. L. and Cox, M.M. Lehninger principles of biochemistry. W.H. Freeman and Company, New York.
10. Snustad, D.P. and Simmons, M.J. Principles of genetics. John Wiley and Sons, New York.
11. Malacinski, G.M. and Friefelder, D. Essentials of molecular biology. Jones and Bartlett Learning, Sudbury.
12. Synder, L.J., Peters, E., Henkins, T.M. and Champness, W. Molecular genetics of bacteria. ASM Press, Washington, D.C.
13. Maloy, S.R., Cronan, J.E. and Freifelder, D.M. Microbial genetics. Jones and Bartlett Learning, Sudbury.
14. Hartwell, L. Genetics: From genes to genome. McGraw-Hill, New York.
15. Weaver, R. Molecular biology. McGraw-Hill, New York.
16. Watson, J.D., Baker, T., Bell, S.P., Gann, A., Levine, M. and Lodwick, R. Molecular biology of the gene. Pearson Education, New Jersey.
17. Karp, G. Cell and molecular biology- Concepts and experiments. John Wiley and Sons, New York.
18. Klug, W.S. and Cummings, M.R. Concepts of genetics. Prentice Hall, New Jersey.

Master of Science (MICROBIOLOGY) -Two Year Programme- FIRST SEM.
Choice Based Credit System
MICROBIAL GENETICS
PAPER CODE: MMBC104

4 HrS/WEEK **100 MARKS**

Unit I: Essentials of Genetics

Genetic notations- prototrophs, auxotrophs, diploid, and electroporation. Gene as unit of mutation a and recombination, molecular nature of mutation, origin of resistance due to spontaneous mutation. Model organisms and genetic analysis of bacteria and yeast. Locating a gene on a 'small DNA molecule' and a 'large DNA molecule

Unit II: Recombination and Transposition
Recombination: Types, Models for homologous recombination (The Holliday model and Double strand break repair model), Proteins involved in recombination; Transposition: Insertion sequences and transposable elements in prokaryotes and eukaryotes, Mechanism of transposition;

Unit III: Mutation and Repair mechanism
Mutations: Types of mutations, Mutagens, Screening chemicals for mutagenicity; DNA repair: Photoreactivation, Methyl directed mismatch repair, Very short - patch mismatch repair, Nucleotide excision repair, Base excision repair, SOS system.

Unit IV: Gene transfer mechanisms
Bacterial plasmids: Types of plasmids, Fertility or (F) plasmid, resistance or R plasmid, col plasmid, degradative plasmid and virulence plasmids (Ti and Ri) and their uses in genetic analysis, Col plasmid and colicins; cryptic plasmids, penicillinase plasmid, resistance (R) plasmid- heavy metal resistance plasmids, degradative plasmids, Ti-palsmids and Ri-plasmids Compatibility and incompatibility, Mobilizable plasmids, Copy number of plasmids, Fertility inhibition, Donation and conduction; Transformation (Competence factor, natural and artificial transformation), Conjugation (F+ X F- mating, Hfr, Hfr X F-, and F', mechanism of conjugation and sexduction),

Unit V: Phage genetics

Bacteriophage Cultivation, Replication, One step growth curve, Life cycle of lytic phages (T4, T7), lysogenic phages (phage λ, ΦX 174, M13), Regulation of lytic and lysogeny in lambda phage. Transduction (Mechanism of generalized and specialized transduction, LFT and HFT lysate),

SUGGESTED READINGS

Microbial genetics by David frifilder .
1. Cappucino, J. and Sherman, N. Microbiology: A laboratory manual. Benjamin/Cummings Publishing Company, San Francisco.
2. Prescott, L.M. and Harley, J.P. Laboratory exercises in microbiology. William C. Brown, Dubuque.
3. Aneja, K.R. Experiments in microbiology, plant pathology and biotechnology. New Age International (P) Limited, New Delhi.

4. Atlas, R.M., Brown, A.E. and Parks, L.C. Laboratory manual of experimental microbiology. Mosby College Publishing Company, St. Louis.

5. Kannan, K. Laboratory manual in general microbiology. Panima, New Delhi.

6. Holt, J.G. and Krieg, N.R. Bergey's manual of determinative bacteriology. Lippincott Williams and Wilkin, Philadelphia.

7. Jayaraman, J. Laboratory manual in biochemistry. New Age International (P) Limited, New Delhi.

8. Sawhney, S.K. and Singh, R. Introductory practical biochemistry. Narosa Publishing House, New Delhi.

9. Segel, I.H. Biochemical calculations. John Wiley and Sons, New York.

10. Plummer, D.T. Introduction to practical biochemistry. Mc-Graw Hill, New York.

11. Boyer, R.F. Modern experimental biochemistry. Prentice Hall, New Jersey.

12. Gerhardt, P. Manual of methods for general bacteriology. ASM Press, Washington, D.C.

13. Barnett, M. Microbiology laboratory exercises. William C. Brown, Dubuque.

14. Wilson, K. and Walker, J.M. Principles and techniques of practical biochemistry. Cambridge University Press, Cambridge.

Master of Science (MICROBIOLOGY) -Two Year Programme- FIRST SEM.
Choice Based Credit System
LAB COURSE I
PAPER CODE: MMBL105

9 Hr/WEEK **100 MARKS**

1. Safety rules of working in microbiology lab, disposal of cultures, calibration, validation and maintenance of instruments.
2. Principles and working of instruments used in microbiology lab.
3. Media preparation and its sterilization.
4. Isolation and enumeration of bacteria and fungi from given sample.
5. Isolation and maintenance of pure culture of bacteria and fungi.
6. Isolation and enumeration of bacteriophage from sewage water.
7. Staining of bacterial cell (Simple staining, gram staining and negative staining).
8. Staining of fungal cell.
9. Staining of endospore and capsule.
10. Study of morphology of algae.
11. Symptomatology of infection of plant pathogens.
12. Measurement of bacterial cell size using micrometer.
13. Safety rules of working in lab, hazard from chemicals, handling of chemicals, disposal of chemicals, recording of scientific experiments, calibration, validation and maintenance of instruments.
14. Calculation of moles, molarity, molality and normality of given solution.
15. Calculation of pH of given solution.
16. Preparation of solutions and buffers of different concentrations and pH.
17. Qualitative tests for sugars, amino acids, proteins and lipids in given sample.
18. Quantitative estimation of sugar in given sample.
19. Quantitative estimation of protein in given sample.
20. Estimation of lipid concentration in given sample.

Master of Science (MICROBIOLOGY) -Two Year Programme- FIRST SEM.
Choice Based Credit System
LAB COURSE II
PAPER CODE: MMBL106

9Hr/WEEK **100 MARKS**

1. Study of different stages of mitosis.
2. Study of different stages of meiosis.
3. To prepare temporary slide of mitosis.
4. To prepare temporary slide of meiosis.
5. Demonstration of transformation in bacteria.
6. Quantitative estimation of DNA by diphenyl amine (DPA) and spectrophotometric method.
7. Quantitative estimation of RNA by orcinol and spectrophotometric method.
8. Determination of quality of DNA by spectrophotometric method.
9. Isolation of genomic DNA from bacterial culture.
10. Visualization of DNA by agarose gel electrophoresis.
11. Determination of Tm of given DNA sample.
12. Study of effect of different concentrations of urea on denaturation of DNA.
13. Demonstration of dark repair mechanism in bacteria.
14. Study of effect of temperature and pH on denaturation of DNA.
15. Mutagenesis in given bacterial culture by U.V. radiation.
16. Demonstration of photoreactivation mechanism in bacteria.
17. Preparation of competent cells.
18. Demonstration of conjugation in bacteria.
19. Isolation of antibiotic resistant bacteria by gradient plate method.
20. Isolation of antibiotic resistant mutants by replica plating technique.

Master of Science (MICROBIOLOGY) -Two Year Programme- SECOND SEM.
Choice Based Credit System
MICROBIAL PHYSIOLOGY AND METABOLISM
PAPER CODE: MMBC201

4Hr/ WEEK **100 MARKS**

Unit I: Microbial Photosynthesis and Chemolithotrophy

Photosynthetic microorganisms ;General characteristics of photosynthetic bacteria, Photosynthetic and accessory pigments, Oxygenic and anoxygenic photosynthesis, Photosynthetic electron transport system, cyclic and non-cyclic photophosphorylation, Dark reaction

Physiological groups of chemolithotrophs ,Characteristic features of chemolithotrophs, Mechanism of energy generation in methylotrophs and methanogens.

Unit II: Nitrogen and Sulphur Metabolism

Nitrogen metabolism: Nitrogen fixation (Characteristics of nitrogen fixing bacteria, biochemistry of nitrogenase complex, nitrogenase types, functions of *nif* genes, symbiotic nitrogen fixation and regulation of nitrogenase), Inorganic nitrogen metabolism, Assimilation of inorganic nitrogen, Regulation of nitrate assimilation; Sulphur metabolism: Free and bound pathways of assimilation of sulphate into cysteine, Glutathione and its role in sulphur metabolism.

Unit III: Microbial Respiration and Fermentation

Respiration: Aerobic respiration, Components of electron transport chain, free energy changes and electron transport, oxidative phosphorylation and theories of ATP formation, inhibition of electron transport chain Anaerobic respiration, Mechanism of oxygen toxicity; Fermentation: Glucose, acetic acid, lactic acid, butyric acid, propionic acid and mixed acid fermentation.

Unit IV: Bacterial Permeation

Structure and organization of membrane(Glyco-conjugants and proteins in membrane systems), fluid mosaic model of membrane.Methods to study diffusion of solutes in bacteria, passive diffusion, facilitated diffusion, different mechanisms of active diffusion (Proton Motive Force, PTS, role of permeases in transport,differentpermeases in E. coli. Transport of aminoacids and inorganic ions in microorganisms andtheir mechanisms.

Donnan equilibrium, Thermodynamics of various transport systems, Osmotic pressure of electrolyte and non-electrolyte transport protein, Protein secretion pathways in bacteria;

Unit V: Microbial Stress Response

Osmotic stress and osmoregulation, Mechanism of transition from aerobic to anaerobic, Oxidative stress and its regulation, pH stress and acid tolerance response, Thermal stress and heat shock response, Nutrition stress and starvation-stress response, Stringent response, Sporulation and morphogenesis (Endospores: Physiological and genetic aspects of sporulation, Activation, germination and outgrowth).

Quorum sensing; Bioluminescence in microorganisms.

SUGGESTED READINGS

1. Foster, J.W. and Spector, M.P. Microbial physiology. John Wiley and Sons, New York.
2. Gottschalk, G. Bacterial metabolism. Springer-Verlag, New York.
3. Madigan, M.T., Martinko, J.M. and Parker, J. Brock biology of microorganisms. Prentice Hall, New Jersey.
4. Brun, Y.V. and Shimkets, L.J. Prokaryotic development. ASM Press, Washington, D.C.
5. Rose, A.H. Advances in microbial physiology. Academic Press, New York.
6. David, W., Drummond, J.T. and Fuqua, C. Physiology and biochemistry of prokaryotes. Oxford University Press, New York.
7. Caldwell, D. R. Microbial physiology and metabolism. Star Publishers, California.
8. Lengeler, J.W., Drews, G. and Schlegel, H.G. Biology of the prokaryotes. Blackwell Science, New York.
9. Rhodes, P.M. and Stanbury, P.F. Applied microbial physiology: A practical approach. IRL Press, Oxford.

Master of Science (MICROBIOLOGY) -Two Year Programme-SECOND SEM
Choice Based Credit System
IMMUNOLOGY
PAPER CODE:MMBC202

4HrS/WEEK **100 MARKS**

Unit I: Overview and elements of the immune system
Cells and Organs of the Immune ;Innate Immunity/Inflammation
Immune response – naturally acquired immunity; artificially acquired immunity
Humoral and cell-mediated immunity;Immunization: Active and passive
Cytokines

Unit II: Antigens and Antibodies
Antigens: Structure and properties; Antigen specificity;Haptens; Adjuvents; Immunogenicity;Factors affecting immunogenicity;
Immunoglobulin: Structures, Heterogeneity, Types and subtypes, Properties (Physiochemical and biological), Monoclonal antibodies (General properties and applications), Hybridoma technology;
Antigen – antibody reactions: Precipitation and agglutination reactions
Immunodiagnostic techniques: Immunoelectrophoresis, RIA, ELISA, Chemiluminescence immunoassay, Western blotting, Complement fixation test, Immunofluorescence, Flow cytometry.

Unit III: Complement System and Major Histo-compatibility Complex
Complement activation pathways (Classical, alternate and lectin pathways), Biological consequences of complement activation, Complement assay
Structure and functions of MHC and HL-A system ;Role of MHC in the Immune Response: Antigen processing and presentation; Transplantation: Graft vs. host reaction and rejection

Unit IV: Humoral and Cell Mediated Immune Response and Regulation
B- cellreceptor;Development and differentiation of B cells
T – cell receptor complex;Developmentand differentiation of T cells
Immune Response: T -Cell independent defense mechanisms, T- Cell dependent defense mechanisms;
Cell mediated cytotoxicity: T cytotoxic cells, Natural Killer (NK) Cells,Antibody dependent cell cytotoxicity (ADCC), Macrophage-mediated cytotoxicity.

Unit V: MEDICAL APPLICATIONS OF IMMUNOLOGY (Immunopathology)
Hypersensitivity reactions (Antibody mediated type I, anaphylaxis, type II- antibody dependent cell cytotoxicity, type III-immune complex mediated reactions and type IV-delayed hypersensitivity reactions).
Autoimmunity;Immunodeficiency;Tumour immunology- tumour specific antigens, immuneresponse to tumour,Tumor escape mechanisms,Immunotherapy of cancer; Vaccines

SUGGESTED READINGS

1. Kindt, T.J., Goldsby, R.A., Osborne, B.A. and Kuby, J. Kuby immunology. W.H. Freeman and Company, New York.

2. Male, D.K. Immunology: An illustrated outline. Elsevier Health Sciences, Philadelphia.
3. Abbas, A.K., Lichtman, A.H.H. and Pillai, S. Cellular and molecular immunology. Saunders, Philadelphia.
4. Delves, P.J., Martin, S.J., Burton, D.R. and Roitt, I.M. Roitt's essential immunology. Wiley-Blackwell, New Jersey.
5. Tizard, I.R. Immunology: An introduction. Saunders, Philadelphia.
6. Playfair, J.H.L. Immunology at a glance. Blackwell Scientific Publications, Oxford.
7. Abbas, A.K. and Lichtman, A.H.H. Basic immunology: Functions and disorders of the immune system. Saunders, Philadelphia.
8. Chapel, H., Haeney, M., Misbah, S. and Snowden, N. Essentials of clinical immunology. Wiley, New Jersey.
9. Palyfair, J.H.L. and Chain, B.M. Immunology at a glance. Wiley- Blackwell, New Jersey.
10. Coico, R. and Sunshine, G. Immunology: A short course. Wiley- Blackwell, New Jersey.
11. Rao, C.V. Immunology. Alpha Science International, New Delhi.
12. Pathak, S. and Palan, U. Immunology: Essential and fundamental. Science, New Hampshire.

Master of Science (MICROBIOLOGY) -Two Year Programme- FIRST SEM.
Choice Based Credit System
BIOLOGICAL TECHNIQUE
PAPER CODE: MMBC203

4HR/WEEK **100 MARKS**

Unit I: Basic laboratory Instruments
Principle and working of pH meter, Laminar-air flow.
Centrifugation: Common centrifuges used in laboratory (Clinical, micro, high speed, ultra and industrial centrifuges); Types of rotors (Fixed- angle, swinging bucket and continuous tubular); Types of centrifugation (Principle and applications): Preparative (Differential and density gradient centrifugation) and analytical centrifugation.

Unit II: Microscopy and Biosensors
Microscopy (Principles and applications): Light, phase contrast, fluorescence and confocal microscopy, Scanning and transmission electron microscopy; Biosensors: Introduction and principles, First, second and third generation instruments, Cell based biosensors, Enzyme immunosensors, DNA biosensor

Unit III: Chromatographic Techniques
Theory, principle and applications of chromatography; Types of chromatography (Principles and applications): Adsorption chromatography, Ion exchange chromatography, Affinity chromatography, Size exclusion chromatography, Thin layer chromatography, Gas chromatography, High pressure liquid chromatography (HPLC), Supercritical fluid chromatography.

Unit IV: Electrophoretic Techniques
Basic principles and applications of electrophoresis; Types of electrophoresis (Principles and applications): Paper electrophoresis, Moving boundary electrophoresis, Isotachophoresis, Agarose gel electrophoresis, Polyacrylamide gel electrophoresis (SDS-PAGE, Native-PAGE, Denaturing-PAGE and Reducing-PAGE), Isoelectric focusing (IEF).

Unit V: Spectroscopy and Radioisotopic Techniques
Elementry idea of spectroscopy.Radiotracer techniques: Applications of radioisotopes in biology, Properties and units of radioactivity, Radioactive isotopes and half-life, Safety rules in handling of radioisotopes, Measurement of radioactivity (GM counter, gamma counter, and liquid scintillation counter), Autoradiography: Principle and its applications.

SUGGESTED READINGS

1. Wilson, K. and Walker, J. Principles and techniques of biochemistry and molecular biology. Cambridge University Press, Cambridge.
2. Robyt, J.F. and White, B.J. Biochemical techniques: Theory and practice. Waveland Press, Long Grove.
3. Holme, D.J. and Peck, H. Analytical biochemistry. Longman Group Limited, London.
4. Chatwal, G. and Anand, S. Instrumental methods of chemical analysis. Himalaya Publishing House, Mumbai.

5. Miller, J. Chromatography: Concepts and contrasts. John Wiley and Sons, New York.
6. Message, G.M. Practical aspects of gas chromatography/ mass spectrometry. John Wiley and Sons, New York.
7. Kremmer, T. and Boross, L. Gel chromatography: Theory, methodology, applications. John Wiley and Sons, New York.
8. Hamilton, R.J. and Sewell, P.A. Introduction to high performance liquid chromatography. Chapman and Hall Limited, London.
9. Sharma, V.K. Techniques in microscopy and cell biology. Tata McGraw-Hill, New Delhi.
10. Westermeier, R. Electrophoresis in practice. Wiley-Blackwell, New Jersey.
11. Hames, B.D. Gel electrophoresis of proteins: A practical approach. Oxford University Press, Oxford.
12. Ford, T.C. and Graham, J.M. An introduction to centrifugation.Bios, New York.
13. Spencer, M. Fundamentals of light microscopy. Cambridge University Press, Cambridge.
14. Hayat, M.A. Principles and techniques of electron microscopy: Biological applications. Cambridge University Press, Cambridge.
15. Price, R.L. and Jerome, W.G. Basic confocal microscopy. Springer-Verlag, New York.
16. Rost, F.W.D. Fluorescence microscopy. Cambridge University Press, Cambridge.
17. Ploem, J.S. and Tanke, H.J. Introduction to fluorescence microscopy. Oxford University Press, Oxford.
18. Keeler, J. Understanding NMR spectroscopy. John Wiley and Sons, New York.
19. Straughan, B.B. and Walker, S. Spectroscopy. Chapman and Hall Limited, London.
20. Davies, A.M.C. and Creaser, C.S. Analytical applications of spectroscopy. Royal Society of

Master of Science (MICROBIOLOGY) -Two Year Programme- SECOND SEM
Choice Based Credit System
RECOMBINANT DNA TECHNOLOGY
PAPER CODE: MMBC204

4HrS/WEEK **100 MARKS**

Unit I: Principles and Tools of Gene Cloning
Isolation of nucleic acids; Enzymes used in genetic engineering; Restriction endonucleases; Cloning vectors: Characteristic features and applications of vectors based on plasmids (*E. coli* and yeast), phages (λ and M13 bacteriophage), cosmids, phasmids, artificial chromosome vectors (BAC,PAC and YAC), vectors for plants and animal cells and shuttle vectors.

Unit II: Strategies of Gene Cloning
Gene cloning: Steps of cloning, Formation of DNA fragments using linkers, adaptors and homopolymer tails, Introduction of DNA into host cells (Bacteria, plant and animal cells); Construction of cDNA and genomic library; Obtaining clone of a specific gene: Problem of selection, Direct selection, Selection strategies for recombinant produced by different vectors, Methods of identification of clone from gene library.

Unit III: Expression of Cloned Gene in Heterologous System
Expression vectors: structure, components and advantages ; Characteristic features of pEt, pcDNA3 and cytomegalovirus expression system; Model host systems: *E. coli,* Fungi, Mammalian cell lines, Insect cells, Transgenic plants and animals; Screening strategies; Identification and study of translation product of a cloned gene: HRT and HART techniques.

Unit IV: Sequence Detection, Amplification and Modification Techniques
Blotting techniques (Methodologies and applications): Southern, Northern and Western blotting; Probe labelling and hybridization; DNA sequencing (Chemical, enzymatic and automated methods); Sequence assembly for whole genome analysis; PCR: Principle and applications; Types of PCR; Site directed mutagenesis.

Unit V: Genome Analysis and Applications of RDT
Principles and applications of techniques used in genome analysis: Exon trapping, R loop analysis, S1–mapping, Chromosome walking, Ribonuclease protection assay, Gel retardation assay, DNA foot printing, DNA fingerprinting, Antisense technology, Ribozyme technology; Applications of recombinant DNA technology in forensic science, therapeutics and agriculture.

SUGGESTED READINGS

1. Brown, T.A. Gene cloning and DNA analysis: An introduction. Wiley-Blackwell, New Jersey.
2. Primrose, S.B. and Twyman, R. Principles of gene manipulation and genomics. Wiley-Blackwell, New Jersey.
3. Nicholl, D.S.T. An introduction to genetic engineering. Cambridge University Press, Cambridge.
4. Glick, B.R., Pasternak, J.J. and Patten, C.L. Molecular biotechnology: Principles and applications of recombinant DNA. ASM Press, Washington, D.C.
5. Hartwell, L. Genetics: From genes to genome. McGraw-Hill, New York.

6. Old, R.W. and Primrose, S.B. Principles of gene manipulations. Blackwell Science, Oxford.
7. Winnacker, E.L. From genes to clones: Introduction to gene technology. Wiley-VCH, Germany.
8. Kingsman, S.M. and Kingsman, A.J. Genetic engineering: An introduction to gene analysis and exploitation in eukaryotes. Blackwell Science, Oxford.
9. Greene, J.J. and Rao, V.B. Recombinant DNA principles and methodologies. Marcel Dekker, New York.
10. Brown, T.A. Genomes. Wiley-Liss, Oxford.
11. Pevsner, J. Bioinformatics and functional genomics. Wiley-Blackwell, New Jersey.
12. Sambrook, J. and Russell, D.W. Molecular Cloning: A laboratory manual. Cold Spring Harbor Lab Press, New York.
13. Reece R.J. Analysis of genes and genomes. John Wiley and Sons, New York.
14. Recombinant DNA safety guidelines. Department of Biotechnology, Ministry of Science and Technology, Government of India, New Delhi.

Master of Science (MICROBIOLOGY) -Two Year Programme- SECOND SEM
Choice Based Credit System
LAB COURSE I
PAPER CODE: MMBL205

9HR/WEEK **100 MARKS**

1. Study of effect of temperature, pH and salt concentration on growth of bacteria.
2. Determination of ability of bacteria to reduce nitrate.
3. Determination of ability of bacteria to produce H2S.
4. Determination of presence of cytochrome oxidase in bacteria.
5. Determination of presence of catalase in bacteria.
6. Determination of ability of bacteria to produce acidic or neutral end product from glucose.
7. Determination of ability of bacteria to utilize sugars by oxidative or fermentative mode.
8. Study of different stages of sporulation in *Bacillus*.
9. Effect of pH, sugars, amino acids and inorganic ions on spore germination.
10. Study of mechanism of diffusion.
11. Study of mechanism of exosmosis and endosmosis.
12. Effect of isotonic, hypotonic and hypertonic solutions on cell.
13. Separation and preservation of serum and plasma.
14. Determination of blood group and Rh factor.
15. Demonstration of agglutination reaction of bacterial cultures by slide agglutination test.
16. Quantitative estimation of antigen by radial immunodiffusion.
17. Detection and quantification of either antibody or antigen by ouchterlony double diffusion method.
18. Determination of concentration of antigen by rocket immunoelectrophoresis.
19. Determination of the presence of specific antibody for its antigen by Dot-ELISA method.
20. Separation of components of antigen mixture and study the pattern by immunoelectrophoresis.

Master of Science (MICROBIOLOGY) -Two Year Programme- SECOND SEM
Choice Based Credit System
LAB COURSE II
PAPER CODE: MMBL206

9HRS/WEEK **100 MARKS**

(Based on Theory Papers SGRRU/SLS/MCC/C009 and SGRRU/SLS/MCC/C010)

1. Separation and identification of amino acids by ascending and descending paper chromatography.
2. Separation and identification of sugars by paper chromatography.
3. Separation and identification of sugars by thin layer chromatography.
4. Verification of Lambert Beer's law.
5. Determination of molecular weight of DNA by agarose gel electrophoresis.
6. Separation and determination of molecular weight of proteins by SDS-PAGE.
7. Visualization of enzyme activity by NATIVE-PAGE.
8. Interpretation of UV spectra.
9. Interpretation of IR spectra.
10. Interpretation of NMR spectra.
11. Interpretation of Mass spectra.
12. Isolation of genomic DNA from plant sample.
13. Isolation of plasmid DNA from bacterial cell culture.
14. PCR amplification of DNA.
15. Restriction digestion of vector and DNA.
16. Ligation of DNA construct and vector.
17. Preparation of competent cells.
18. Introduction of recombinant DNA into bacterial cells and selection of recombinant clones.
19. Demonstration of inducible enzyme β-galactosidase in *E. coli*.
20. Expression of gene in *E. coli*.
21. Determination of similarity between different bacterial isolates using RFLP.

Master of Science (MICROBIOLOGY) -Two Year Programme- THIRD SEM
Choice Based Credit System
MEDICAL MICROBIOLOGY
PAPER CODE: MMBC301

4HRS/WEEK **100 MARKS**

Unit I: Basics of Medical Microbiology
Normal microbiota of human body; Role of resident flora and human host; Routes of transmission of pathogens; Nosocomial infections; Collection, transportation and processing of clinical samples; Isolation and identification of pathogenic organisms; Quality control in medical microbiology laboratory.

Unit II: Pathogenesis
Pathogenicity islands; Mechanism of pathogenesis: Mechanism of bacterial adhesion, colonization and invasion, Protein toxins (Classification and mode of action), Cytoskeletal modulation of host cell; Mechanism of action of antimicrobial agents;

Unit III: Antimicrobial Chemotherapy

Methods of drug susceptibility testing: Kirby-Bauer's disc diffusion method, Stokes method, Agar dilution method, Broth dilution method, E-strip method; Emergence of drug resistance in bacteria (MRSA, ESBL and MDR TB); Resistance mechanism; Various types of vaccines for prevention of infectious diseases; National immunization program and immunization schedule.

Unit IV: Bacterial Diseases
Clinical features, transmission, characteristics of causative organism, pathogenesis, laboratory diagnosis, prevention and control of bacterial diseases and clinical syndromes: Cholera, Leprosy, Diphtheria, Tetanus, Meningitis, Conjunctivitis, Pneumonia and Gastroenteritis.

Unit V: Viral and Fungal Diseases
Clinical features, transmission, characteristics of causative organism, pathogenesis, laboratory diagnosis, prevention and control of viral diseases: Herpes, Chikungunya, Influenza, Measles, Mumps, Hepatitis, HIV, Viral cancer.
Clinical features, transmission, pathogenesis, laboratory diagnosis, prevention and control of fungal diseases: Aspergillosis, Cryptococcosis, Candidiasis, Blastomycosis.

SUGGESTED READINGS

1. Murrey, P.R., Rosenthal, K.S., Kobayashi, G.S. and Pfaller, M.A. Medical microbiology. Saunders, Philadelphia.
2. Baron, E.J., Peterson, L.R. and Finegold, S.M. Bailey and Scott's diagnostic microbiology. Mosby, St. Louis.
3. Dockrell, H., Zuckerman, M., Roitt, I.M. and Chiodini, P.L. Mim's medical microbiology. Elsevier, London.
4. Collee, J.C., Duguid, J.P., Fraser, A.C. and Marimon, B.P. Mackie and McCartney practical medical microbiology. Churchill Livingstone, London.
5. Ananthanarayanan, R. and Panicker, C.K.J. Text book of microbiology. Orient Longman, Hyderabad.

6. Koneman, E.W. Koneman'scolor atlas and textbook of diagnostic microbiology. Lippincott Williams and Wilkins, Philadelphia.
7. Topley, W.W.C., Wilson, S.G.S and Parker, M.T. Topley and Wilson's principles of bacteriology, virology and immunity. Edward Arnold, London.
8. Greenwood, D., Slack, R.B. and Peutherer, J.F. Medical microbiology. Churchill Livingstone, London.
9. Mahon, C.R. and Manuselis, G. Textbook of diagnostic microbiology. Saunders, Philadelphia.
10. Maza, L.M.D.L. Color atlas of medical bacteriology. ASM Press, Washington, D.C.
11. Garcia, L.S and Isenberg, H.D. Clinical microbiology procedures handbook. ASM Press, Washington, D.C.
12. Balows, A., Hausler, W.J., Ohashi, M. and Turano, A. Laboratory diagnosis of infectious diseases: Principles and practice. Springer-Verlag, New York.
13. Chakraborthy, P. A textbook of microbiology. New Central Book Agency Private Limited, Calcutta.
14. Morag, C. and Timbury, M.C. Medical virology. Churchill Livingston, London.
15. Dimmock, N.J. and Pimrose, S.B. Introduction to modern virology. Blackwell Scientific Publications, Oxford.
16. Flint, S.J., Racaniello, V.R., Enquist, L.W., Rancaniello, V.R. and Skalka, A.M. Principles of virology: Molecular biology, pathogenesis and control of animal viruses. ASM Press, Washington, D.C.
17. Karyakarte, R.P. and Damle, A.S. Medical parasitology. Books and Allied Private Limited, Kolkatta.
18. Paniker, J. Text book of medical parasitology. Jaypee Brothers Medical Private Limited, New Delhi.
19. Chander, J. A text book of medical mycology.Interprint, New Delhi.

Master of Science (MICROBIOLOGY) -Two Year Programme- THIRD SEM
Choice Based Credit System
INDUSTRIAL AND PHARMACEUTICAL MICROBIOLOGY
PAPER CODE: MMBC302

4HrS/WEEK **100 MARKS**

Unit I: Introduction to Industrial Microbiology
Primary and secondary metabolites; Structure of fermentor/bioreactor; Types of fermentor/bioreactors; Scale up and scale down processes; Types of fermentation (Solid state, surface and submerged fermentation).

Unit II: Basic Aspects of Fermentation
Media formulation; Sterilization; Inoculum development; Effect of temperature, pH and high nutrient concentration on fermentation; Operational modes of fermentation (Batch, fed- batch and continuous); Downstream processing.

Unit III: Microbial Strain Improvement
Strategies for isolation and cultivation of desired microorganisms; Screening for the desired product; Strategies for strain improvement: Mutation, Protoplast fusion, Recombinant DNA technology, idea of Novel strategies.Preservation of cultures after strain improvement programme.

Unit IV: Industrial Production Aspects Production of antibiotics (streptomycin, grieseofulvin), amino acid (Glutamic acid and lysine), Production of enzymes (Pectinase, amylase, lipase, protease, cellulase and xylanase), organic acids (Citric acid, acetic acid and lactic acid), ergot alkaloids and bioplastics (PHB and PHA).

Unit V: Introduction to Quality Assurance and Validation
Good Manufacturing Practices (GMP) and Good Laboratory Practices (GLP) in pharmaceutical industry; Basic principles of quality control (QC) and quality assurance (QA); Guidelines for QA and QC (Raw materials, sterilization, media, stock cultures and products), ISO, WHO and US certification; Sterilization control and sterility testing: Validation study; LAL test; Sterility testing and bioassay; Application of Biosensors in pharmaceuticals.

SUGGESTED READINGS

1. Hershnergev, C.L., Queener, S.W. and Hedemen, Q. Genetics and biotechnology of industrial microorganisms. ASM Press, Washington, D.C.
2. Crueger, W. and Crueger, A. Biotechnology: A textbook of industrial microbiology. Sinauer Associates, Sunderland.
3. Reed, G. Prescott and Dunn's industrial microbiology. Globe Bookservices, London.
4. Demain, A.L and Davies, J.E. Manual of industrial microbiology and biotechnology. ASM Press, Washington, D.C.
5. Casida, J.E. Industrial microbiology. Wiley Eastern, New Delhi.
6. Patel, A.H. Industrial microbiology. MacMillan India Limited, New Delhi.

7. Stanbury, A.H., Whittaker, A. and Hall, S.J. Principles of fermentation technology. Pergamon Press, Oxford.
8. Richard, H., George, B., Hagemann, D. and Paul, L. Industrial microorganisms: Basic and applied molecular genetics. ASM Press, Washington, D.C.

Master of Science (MICROBIOLOGY) -Two Year Programme- THIRD SEM
Choice Based Credit System
LAB COURSE I
PAPER CODE: MMBL305

9HRS/WEEK **100 MARKS**

1. Biosafety guidelines and biosafety levels.
2. Prevalence of pathogenic microorganisms in clinical sample.
3. Isolation and biochemical characterization of pathogenic bacteria.
4. Isolation and identification of fungal pathogens from clinical specimens.
5. Determination of antimicrobial susceptibility of pathogens by disc diffusion test.
6. Determination of MIC and MBC concentration of antibiotics by broth dilution test.
7. Isolation and screening of bacterial and fungal cultures for enzyme production.
8. Estimation of enzyme production by microbial culture *via* liquid state fermentation.
9. Estimation of enzyme production by microbial culture *via* solid state fermentation.
10. Media formulation for enhanced enzyme production by microbial culture *via* liquid and solid state fermentation.
11. Optimization of culture conditions for enhanced enzyme production by microbial culture *via* liquid and solid state fermentation.
12. Production of wine from fruit juice.
13. Monitoring of sugar reduction during wine production.
14. Estimation of alcohol concentration in wine.
15. Estimation of vicinal diketone in beer.
16. Improvement of strain for increased yield by U.V. mutagenesis.

Master of Science (MICROBIOLOGY) -Two Year Programme- THIRD SEM
Choice Based Credit System
FOOD AND DIARY MICROBIOLOGY
PAPER CODE: MMBE303A

4Hr/WEEK **100 MARKS**

Unit I: Principles of Food Preservation
Factors influencing microbial growth in food; Asepsis; Food preservation: Principles, Physical methods (Dehydration, freeze drying, heat and irradiation), Chemical methods (Chemical preservatives and food additives); Canning; Processing for heat treatment (D, Z and F values) and working out treatment parameters; Microbiological quality standards of food.

Unit II: Contamination and Spoilage
Characterization of contamination and spoilage of cereals, vegetables, fruits, meat and meat products, milk and milk products, fish and sea foods, beer and wines; Spoilage of fermented foods and canned foods.

Unit III: Foodborne Infections and Intoxications
Bacterial and nonbacterial infections and intoxications of *Brucella*, *Bacillus*, *Clostridium*, *Escherichia*, *Salmonella*, *Shigella*, *Staphylococcus*, *Vibrio*, *Yersinia*, *Listeria*, nematodes, protozoa, algae, fungi and viruses; Structure and functions of aflatoxins; Laboratory testing procedures.

Unit IV: Food Safety and Quality Assurance
Microbiological quality standards of food; Food control agencies and their regulations: FDA, EPA, CDC and ISI; Good Manufacturing Practice; Plant sanitation (Employees health standards, waste treatment and disposal); Hazard Analysis and Critical Control Point (HACCP) system; Food Safety Act and Trade Regulations.

Unit V: Production of Fermented Foods
Industrial production methods of bread, cheese, fermented vegetables (Olives and cucumber), fermented dairy products (Acidophilus milk, cheese and yoghurt), single cell proteins, sauerkraut, meat and fishery products (Sausages and fish sauces); Production of oriental foods (Mycoprotein, tempeh, soya sauce, idli, natto and poi) and beverages (Vinegar, cider, sake and palm wines); Alcoholic beverages of Himalayan region; Genetically modified foods; Probiotics.

SUGGESTED READINGS

1. Adams, M.R., and Moss, M.O. Food microbiology. Royal Society of Chemistry Publication, Cambridge.
2. Frazier, W.C. and Westhoff, D.C. Food microbiology. Tata McGraw Hill, New Delhi.
3. Stanbuty, P.F. and Hall, S.J. Principles of fermentation technology. Pergamon Press, Oxford.
4. Banwart, G.J. Basic food microbiology. CBS Publishers and Distributors, New Delhi.
5. Robinson, R.K. Dairy microbiology. Elsevier Applied Sciences, London.
6. James M.J. Modern food microbiology. CBS Publishers and Distributors, New Delhi.
7. Wood, B.J. Microbiology of fermented foods. Elsevier Applied Sciences, London.
8. Ayres, J.C., Mundt, O. and Sandinee, W.E. Microbiology of foods. W.H. Freeman and Company, New York.

9. Jay, M.J., Loessner, M.J. and Golden, D.A. Modern food microbiology. Springer Science and Business Media, New York.
10. Hobbs, B.C. and Roberts, D. Food poisoning and food hygiene. Edward Arnold, London.

Master of Science (MICROBIOLOGY) -Two Year Programme- THIRD SEM
Choice Based Credit System
DRUG DESIGNING AND NANOBIOTECHNOLOGY
PAPER CODE: MMBE303B

4Hr/WEEK **100 MARKS**

Unit I: Drug Receptor Interactions
Receptors: Classification of receptors and receptor subtypes, Structure of receptors, Blood cell receptors for endogenous compounds, Neurotransmitters and their receptors, Receptor modulation and mimics, Receptor sites, Receptor cross-talk, Organ receptors, Non-liganded and constitutive receptor activation, r-DNA receptor bioassays, Desensitization of receptors, Receptors as targets for vaccines and newer drug development; Drug-receptor interactions: Active transport, Affinity and efficacy, Allosteric binding sites, Chirality and receptor binding, Signal transduction and second messenger system, Introduction of various classes of drugs based on their interaction with target site, Interaction of drugs with receptors, enzymes, DNA and carbohydrates.

Unit II: Drug Targeting and Drug Delivery Systems
Introduction and historical perspectives of drug delivery systems; Controlled, targeted and delayed drug delivery systems; Oral dosage forms: Diffusion, Dissolution system, Osmotic pumps, Ion exchange resin; Soluble delivery systems: Micro and nano systems; Injections; Routes of drug delivery systems; Stability profile; Barriers to proteins and peptide delivery; Lymphatic transportation of proteins; Site specific protein modification; Toxicology profile characterization; Cellular level events in targeting; Carrier systems for targeting; Specialized liposomes for drug targeting.

Unit III: Structure Activity Relationship
Structure activity relationship (SAR): Introduction and scope, Structure activity relationship illustrated with examples from sulphonamides, β-lactams, quinolones, nucleosides and alkaloids; Quantitative structure activity relationship (QSAR): Role of physicochemical, electronic (Hammett equation), lipophilicity (Hansch equation) and steric parameter (Taft equation).

Unit IV: Molecular Modelling
Quantum mechanical and molecular orbital methods; Introduction to semiempirical, molecular mechanics and *ab initio* techniques; Potential energy surface; Docking and modelling substrate-receptor interactions; Introduction to software tools for CADD.

Unit V: Nanobiotechnology
Functional principles of nanobiotechnology; Basic biology principles and practice of micro fabrication techniques; Atomic force microscopy; Biological production of metal nanoparticles and macromolecular assemblies; Bacterial structure relevant to nanobiotechnology; Cubosomes; Dendrimers; DNA nanoparticle conjugates; DNA octahedron; Fullerenes; Nanoshells; Carbon nanotubes; Nanopores; Nanostructured silicon; Viruses as nanoparticles; DNA based nanostructures: DNA-protein nanostructures, Self-assembled DNA nanotubes, Drug delivery tools *via* nanobiotechnology; Protein and peptide delivery; Tumor targeting and other diagnostic applications; Nanoparticle based immobilization assays; Quantum dots technology and its application; Immuno- nanotechnology; Biosensors and nanobiotechnology.

SUGGESTED READINGS

1. Silverman, R. Organic chemistry of drug design and drug action. Elsevier, London.

Master of Science (MICROBIOLOGY) -Two Year Programme- THIRD SEM
Choice Based Credit System
MOLECULAR VIROLOGY AND INFECTION
PAPER CODE: MMBE303C

4Hr/WEEK **100 MARKS**

UNIT – I
History of Virology and Biosafety: History and principles of virology, virus taxonomy. Structures of animal and plant viruses and their morphology. Principles of biosafety, containment facilities, maintenance and handling of laboratory animals, and requirements of virology laboratory.

UNIT – II
Virus Replication: Structure and replication strategies of bacteriophages - T7, λ, ΦX174, and plant viruses - ss RNA virus (TMV) and ds DNA virus (CaMV). Structure and replication strategies of animal viruses - Influenza virus, Adeno virus and Retro virus.

UNIT – III
Interferon and Antiviral Agents: Viral Interference and Interferons. Nature and source of interferons, Classification of interferons. Induction of interferon. Antiviral agents (chemical and biological) and their mode of actions.

UNIT – IV
Cultivation of Viruses and Viral Vaccines : Cultivation of viruses in embryonated egg, tissue culture and laboratory animals. Conventional vaccines - Killed and attenuated. Modern vaccines - Recombinant proteins, subunits, DNA vaccines, peptides, immunomodulators (cytokines). Vaccine delivery and adjuvants, large-scale manufacturing.

UNIT – V
Virological Methods: Methods for purification of viruses with special emphasis on ultracentrifugation methods. Quantitative diagnostic methods - Haemagglutination, complement fixation, neutralization, Western blot, flowcytometry. Nucleic acid based diagnosis - PCR, microarray and nucleotide sequencing. Application of Microscopic techniques - Fluorescence, confocal and electron microscopic techniques

SUGGESTED READINGS

1. Rothman, K.J. and Greenland, S. Modern epidemiology. Lippincott-Raven, Philadelphia.
2. Dockrell, H., Zuckerman, M., Roitt, I.M. and Chiodini, P.L. Mim's medical microbiology. Elsevier, London.
3. Gordis, L. Epidemiology. Saunders, Philadelphia.
4. Anderson, R.M. and May, R.M. Infectious diseases of humans: Dynamics and control. Oxford University Press, Oxford.
5. Giesecke, J. Modern infectious disease epidemiology. Edward Arnold, London.
6. Clayton, D. and Hills, M. Statistical models in epidemiology. Oxford University Press, Oxford.

7. Rothman K.J., Greenland, S. and Lash, T.L. Modern epidemiology. Lippincott Williams and Wilkins, Philadelphia.

Master of Science (MICROBIOLOGY) -Two Year Programme-THIRD SEM
Choice Based Credit System
ENVIRONMENTAL MICROBIOLOGY
PAPER CODE: MMBE304A

4HRS/WEEK **100 MARKS**

Unit I: Fundamentals of Microbial Ecology
Ecosystem; Biotic and abiotic components; Habitat and Niche; Population and guilds; Concept of community; Stability hypothesis; Intermediate-disturbance hypothesis; Concept of ecological niche; Ecosystem organization: Structure and functions, Primary production, Energy dynamics (Trophic organization and energy flow pathways); Microbial community dynamics: r and k strategies of population selection within communities.

Unit II: Air and Aquatic Microbiology
Aerobiology: Droplet nuclei, Aerosol, Assessment of air quality, Solid and liquid impingement methods, Brief account of air born transmission of microbes; Aquatic microbiology: Zonation and microbiota of fresh water (Ponds, lake and rivers) and marine habitats (Estuaries and deep sea), Upwelling and downwelling, Eutrophication, Food chain, Mechanism of dissolved organic matter production, Microbial assessment of water quality, Water purification.

Unit III: Microbial Interactions
Positive and negative interactions amongst microbial populations: Cooperation, Neutralism, Commensalism, Synergism, Mutualism, Competition, Amensalism, Parasitism, Predation; Interactions between microorganisms and plants: Rhizobacteria, Mycorrhiza, Epiphytic and endophytic microorganisms; Interactions between microorganisms and animals: Predation on microorganisms by animals, Cultivation of microorganisms by animals for food and food processing.

Unit IV: Pollution and its Control
Air pollution and its control: Sources, Major pollutants, Adverse effect on living organisms (Acid rain and its impact on ecosystem, greenhouse effect, global warming, ozone layer depletion and its effect, smog), Control through biotechnology (Deodorization, reduction in CO2 emission, bioscrubbers, biobeds and biofilters); Water pollution and its control: Sources, Ground water contamination, Wastes: Characterization of solid and liquid wastes, Solid waste treatment (Landfills, incineration, composting, anaerobic digestion and pyrolysis), Waste water treatment (Pretreatment, primary, secondary and tertiary treatment, Application of biofilm in waste water treatment); Environment impact assessment.

Unit V: Impact of Microbes on Environment
Biodegradation of recalcitrant compounds: Pesticides and Petroleum; Bioremediation: *In situ* and *Ex situ* remediation, Bioremediation of oil spills; Bioaugmentation; Biomagnification; Biomineralization; Metal corrosion: Mode of deterioration, Microorganisms involved, Mode of prevention; Bioleaching of ore; Microbial plastics; Biodiesel.

SUGGESTED READINGS

1. Alexander, M. Microbial ecology. John Wiley and Sons, New York.
2. Eldowney, S., and Waites, S. Pollution: Ecology and biotreatment. Longman, Harlow.
3. Baker, K.H. and Herson, D.S. Bioremediation. McGraw- Hill, New York.
4. Marshal, K.C. Advances of microbial ecology. Plenum Press, New York.

Master of Science (MICROBIOLOGY) -Two Year Programme- THIRD SEM
Choice Based Credit System
AGRICULTURE MICROBIOLOGY
PAPER CODE: MMBE304B

4HRS/ WEEK **100 MARKS**

Unit I: Abiotic and Biotic Components of Soil
Physico-chemical characteristics of soil; Soil enzymes and significance; Soil microbes; Influence of microbial metabolism on soil chemistry and humus formation; Organic matter dynamics in soil: Microbial decomposition of cellulose, hemicellulose and lignin, Factors affecting organic matter decomposition.

Unit II: Rhizosphere and Rhizoplane Microorganisms
Rhizosphere; Rhizoplane; Composition of root exudates; Factors affecting exudation; Plant growth promoting rhizobacteria; Mycorrhiza; Rhizosphere effect; Factors affecting microbial community in soil; Mechanism of plant growth promotion: Mechanism of nitrogen fixation, Mechanism of phosphate solubilization and phosphate mobilization, Mechanism of iron chelation, Production of plant growth promoting hormones from bacteria and fungi, Production of antibiotics by plant growth promoting microorganisms.

Unit III: Plant Pathogens
Symptoms, casuative organisms, disease cycle and control measures of plant diseases: Blight of rice, Citrus canker, Wilt of potato, *Pythium*seed rot, Grapes downy mildew, Potato early and late blights, Fusarial wilt, Wheat-smut and rust, Tikka leaf spot in groundnut, Common viral diseases of plants (Paddy, cotton, potato, tobacco, cauliflower, tomato and sugarcane); Biochemical and genetic basis of virulence in plant pathogens.

Unit IV: Biocontrol Agents for Agriculturally Important Crop Plants
Biopesticides: Source organisms (*Bacillus thuringiensis*, *Beauveriabassiana*, *Metarhiziumanisopliae*, *Trichoderma*and Baculoviruses); Mechanism of biocontrol; Other means of pathogen control: Application of viral proteins in controlling viral diseases, Antisense RNA technology in disease control and RNAi in controlling plant pathogens.

Unit V: Biofertilizers
Isolation, purification, mass multiplication, inoculum production and method of application of biofertilizers: *Azospirillum*, *Azotobacter*, *Rhizobium*, Cyanobacteria, AM fungi, Phosphate solubilizer, Algal biofertilizers; Storage, shelf life, quality control and marketing of biofertilizers.

SUGGESTED READINGS

1. SubbaRao, N.S. Soil microorganisms and plant growth. Oxford and IBH Publishing Company, New Delhi.
2. Alexander, M. Introduction to soil microbiology. John Wiley and Sons, New York.
3. Kononova, M.M. Soil organic matter: Nature, its role in soil formation and in soil fertility. Pergamon, Oxford.
4. Burges, A. and Raw, F. Soil biology. Academic Press, London.

5. Rangasami G. and Bagyarai, D.J. Agricultural microbiology. Prentice-Hall, New Delhi.
6. Agrios, G.N. Plant pathology. Academic Press, San Diego.
7. Mathews, R.E. Functionals of plant virology. Academic Press, San Diego.
8. Adrian, G. and Harrison, B. Plant virology: The principles. Edward Arnold, London.

Master of Science (MICROBIOLOGY) -Two Year Programme- THIRD SEM
Choice Based Credit System
ECOSYSTEM ANALYSIS AND REMOTE SENSING
PAPER CODE: MMBE304C

4HRS/WEEK **100 MARKS**

UNIT I

Aerial Photography and Photogrammetry (AP&P):

1. Fundamentals of Aerial Photography, History, Aerial film processing, Procurement, and Security of Aerial photographs, Energy source and atmospheric effects in aerial photography. Principles of Aerial Photos (flight planningon).
2. Introduction to Photogrammetry, Geometry of Aerial photos, Stereoscopic photography, Measurement of Height, Aerial Triangulation.
3. Principles and fundamentals of Aerial photo interpretation. Basics of Cartography.

UNIT II

Remote Sensing (RS):

4. Introduction to Remote Sensing. The electromagnetic spectrum, Energy instruction with atmosphere and earth surface, satellite and sensors, Remote sensing data acquisition.
5. Principles and basic concepts of Multi spectral, Thermal and hyperspectralScanning: Across-track and Along Track multispectral Scanning. History of Space Imaging

UNIT III

6. Image Interpretation: Type of Imagery, elements of Interpretation, Techniques of Visual Interpretation, Role of remote sensing in ecological research.

7. Fundamentals of digital image processing, Image rectification, Restoration and Enhancement.

UNIT IV

Digital Image Processing (DIP):

8. Image classification: Supervised classification, unsupervised classification, Hybrid classification, Post-classification smoothing and Classification accuracy assessment.

9. Principles of microwave sensing, Geometric characteristics, Spatial resolution. Spaceborne Radar System, Application of passive microwave sensing.

UNIT V

Geoinformatics (GIS):

10. Basics of Computer, Hardware and software,

11. Principles and basics of Geographic Information System: Raster and Vector GIS, Database

creation and management. Network Analysis, Spatial data integration and Modelling.

12. Basics of Global Positioning System, GPS Satellites and GPS utility.

Master of Science (MICROBIOLOGY) -Two Year Programme- THIRD SEM
Choice Based Credit System
LAB COURSE II
PAPER CODE: MMBL306

9HRS/WEEK **100 MARKS**

1. Microbiological examination of food.
2. Assay of quality of milk sample using MBRT test.
3. Adulteration tests for milk.
4. Microbial production of curd.
5. Isolation and identification of *Lactobacillus* from fermented dairy products.
6. Isolation and biochemical identification of microorganisms from contaminated food and dairy samples.
7. Determination of D value in heat treatment of foods.
8. Effect of freezing temperatures on microorganisms in food
9. Production of sauerkraut.
10. Estimation of lactic acid production in sauerkraut.
11. Effect of salt concentration on lactic acid production in sauerkraut.
12. Estimation of acidity of vinegar.

Master of Science (MICROBIOLOGY) -Two Year Programme- THIRD SEM
Choice Based Credit System
BIOINFORMATICS AND BIOLOGICAL DATA BASE
PAPER CODE: MMBS307A

4HRS/WEEK **100 MARKS**

UNIT I

Concepts, overview and scope of bioinformatics, Bioinformatics and the Internet, Basic principles of computing in bioinformatics, Use of databases in Biology: primary databases: Gene Bank, SWISSPROT, PDB; specialized databases: PFAM, SCOP, PROSITE; database querying using keywords and search engines.

UNIT II

Annotated sequence databases, Genome and organism-specific databases, miscellaneous databases, Sequencing DNA, RNA and proteins, determination of protein structure, Gene and protein extraction data.

Data retrieval with Entrez, DBGET/Link DB and SRS (sequence retrieval system), Sequences similarity searches, Amino acid substitution matrices, databases searches with FASTA and BLAST, Multiple sequences alignment and family relationships, Protein families and pattern databases.

UNIT III

Principles of genome annotation, Annotation tools and resources, Conceptual models of protein structure, protein structure and function, Obtaining, viewing and analysing structural data, Classification of proteins of known three-dimenstional structure: CATH and SCOP, Protein structure prediction, Secondary structure prediction.

UNIT IV

Microarray data analysis, tools and resources, Sequences sampling and SAGE, Analysing data from 2D-PAGE gels, Analysing protein mass spectrometry data, modeling and restructuring molecular pathways, Protein interaction informatics, Higher-order models.

UNIT V

Phylogenetics, cladistics and ontology; Building phylogenetic trees; Evolution of macromolecular sequences.

Chemoinformatic resources, Conventions in representing molecules, Pharmainformatics

Master of Science (MICROBIOLOGY) -Two Year Programme- THIRD SEM
Choice Based Credit System
BIOMEDICAL TECHNOLOGY
PAPER CODE: MMBS307B

4HRS/WEEK **100 MARKS**

UNIT I
Cellular Pathology: causes of cell injury, necrosis, biochemical mechanism, Ischemic and hypoxic injury. Apoptosis (Biochemical features, mechanisms) Immunological basis of diseases: Hypersensitivity (I – IV) Autoimmune diseases Preparation of polyclonal antisera: characterization of antisera, Immuno diagnostic – RIA, ELISA.

UNIT II
Mutations and genetic disorders. Single gene disorders, Receptor proteins (hypercholesterolemia). Cytogenic disorders (Trisomy, Klienfelters). Mutation in mitochondrial genes (LHDN), Fragile X Syndrome.
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UNIT III
Types and grading of cancer. Introduction to molecular diagnosis of cancer.(Southern & Northern blot analysis, PCR based diagnosis). Gene therapy, Immunotherapy and chemotherapy of cancer cells.

UNIT IV
Chemical mutagens. Carcinogenic agents and their cellular interactions. Radiation as health hazard. (Types, measurements, effects & protective measures) Introduction to DNA damage and repair mechanism.

UNIT V
Molecular diagnosis (genetic disease, gene diagnosis, gene tracking & other diagnostic application of RDT) Molecular diagnostic- direct gene diagnosis, Linkage analysis. Nucleic acid sequences as diagnostic tools, SNPs, VNTRs, Non-invasive methodology. MRI, CT-SCAN. Reproductive Health Technologies – ICSI, IVE.

Master of Science (MICROBIOLOGY) -Two Year Programme- THIRD SEM
Choice Based Credit System
INDUSTRIAL TRAINING REPORT/PRESENTATION
PAPER CODE: MMBI308

Master of Science (MICROBIOLOGY) -Two Year Programme- FOURTH SEM
Choice Based Credit System
DISSERTATION
PAPER CODE: MMBE401

Topics for Dissertation

1. Drug Discovery
2. Drug Resistance
3. Infection and Immunity
4. Plant- Microbes Interaction
5. Microbial Diversity
6. Bioremediation
7. Prevalence and Characterization of Pathogenic Microorganisms
8. Food Adulteration and Food borne Pathogens
9. Fermented Foods
10. Strain Improvement
11. Enzyme Production
12. Microbial Biotechnology
13. Biomass and Bioenergy Production

Any other topic suggested by departmental committee may also be considered for the dissertation.

Master of Science (MICROBIOLOGY) -Two Year Programme- FOURTH SEM
Choice Based Credit System
EPIDEMIOLOY
PAPER CODE: MMBC402

4 HRS/WEEK **100 MARKS**

Unit I: Basics of Epidemiology
Introduction; Scope and applications of epidemiology in health care; Role, ethics and responsibilities of an epidemiologist; Relation between virulence and spread; Reservoirs of infection (Human, animal and non-living reservoirs); Types of carriers; Portals of entry and exit.

Unit II: Transmission of Disease
Sources of infection; Modes of disease transmission; Disease cycle; Role of remote sensing and geographical information in recognition of an epidemic; Serological surveys; Influence of behavioral or spatial factors on transmission; Spatial, temporal and social distributions of communicable diseases; History of outbreaks: SARS, Chikungunya, Hantavirus infection, Swine flu, Haiti cholera.

Unit III: Mathematical Modelling I
Transmission dynamics: Incidence, Prevalence, Morbidity, Mortality; Public health surveillance: Purpose and characteristics, Identifying health problems for surveillance, Collection of data for surveillance, Analysis and interpretation of data, Disseminating data and interpretation, Evaluating and improving surveillance.

Unit IV: Mathematical Modelling II
Epidemiological studies: Collection of frequency data, Descriptive, analytical and experimental studies, Cross-sectional, case-control and cohort studies, Models for developing epidemiological theory, Modelling tools, Population dynamics, Epidemiological statistics relating exposure and disease; Measures of risks: Frequency measures, Morbidity and mortality frequency measures, Natality measures, Measures of association, Measures of public health impact.

Unit V: Control of Epidemics
Cycle of epidemics; Emerging and re-emerging infectious diseases and pathogens; Control of transmission: Isolation, Quarantine, Threat of bioterrorism, Global travel and health considerations; Community based control by vaccination, mass vaccination and herd immunity; Public health organizations for control: Centre of Disease Control (CDC), Guidelines issued by CDC and WHO, Health standards for international epidemics

Master of Science (MICROBIOLOGY) -Two Year Programme- Choice Based Credit System
BEVERAGE BIOTECHNOLOGY
PAPER CODE: MMBE403A

4 HRS /WEEK **100 MARKS**

UNIT I
Food and Microorganism: Microorganism in food & beverage industry, contamination of food. General principles underlying spoilage and chemical changes

UNIT II
Contamination and spoilage of different kinds of food & beverages: Cereals & cereal products, sugar and sugar products, vegetables and fruits, meat, fish, poultry & eggs, sea food, milk & milk products, canned foods, Alcohol & alcoholic beverages fruit juices & soft drinks etc.

UNIT III
Biotechnology of food and feed; cultures & fermentation, Beverage production: Alcohol & alcoholic beverages, fruit furies, soft drinks, feed production, SCP, fats, amino acid, food additives.

UNIT IV
Food, Beverages &Disease : Food borne illness due to bacterial food poisoning, infection and intoxication. Food-borne disease outbreaks, Disease-investigation, Materials &Equipments, laboratory testing, field analysis, interpretation of data and preventive measures.

UNIT V
Food hygiene: Food sanitation, Bacteriology of water and food products, food manufacturing practice. Hazard Analysis Critical Points.
Food control: International agencies, Federal Agency and law of state agencies, Processing Industry and Microbial criteria of food. Principles of food preservation Preservation by high temperature, low temperatures, Drying, Food additives and Radiation.

Master of Science (MICROBIOLOGY) -Two Year Programme- FOURTH SEM
Choice Based Credit System
BIO-ENTREPRENEURSHIP
PAPER CODE: MMBE403B

4HRS/WEEK **100 MARKS**

Unit I
Starting a venture; Assessment of feasibility of a given venture/ new venture; Approach a bank for a loan; Sources of financial assistance; Making a business proposal/ Plan for seeking loans from financial institution & Banks; Funds from bank for capital expenditure and for working; Statutory and legal requirements for starting a company/venture; Budget planning and cash flowmanagement;

Unit II
Basics in accounting practices: concepts of balance sheet, P&L account, and double entry bookkeeping. Estimation of income, expenditure, profit. Assessment of market demand for potential product(s) of interest; Market conditions,segments; Prediction of market changes; Identifying needs of customers including gaps in the market, packaging the product; Market linkages, branding issues; Developing distribution channels; Pricing/Policies/Competition; Promotion/Advertising.

Unit III
Services Marketing Negotiations/Strategy with financiers, bankers, Government law enforcement authorities; with companies/Institutions for technology transfer; Dispute resolution skills; External environment/changes; Crisis/Avoiding/Managing. Information Technology: How to use IT for business administration; Use of IT in Improving business performance; Available software for better financial management; E-business setup, management.

Unit IV
Human Resource Development (HRD): Leadership skills; Managerial skills; Organization structure, pros & cons of different structures; Team building, teamwork; Appraisal; Rewards in small scale set up. Fundamentals of Entrepreneurship, Support mechanism for entrepreneurship in India

Unit V
Role of knowledge centre and R&D. Knowledge centres like universities and research institutions; Role of technology and upgradation; Assessment of scale of development of Technology; Managing Technology Transfer; Regulations for transfer of foreign technologies; Technology transfer agencies. Case Study

Master of Science (MICROBIOLOGY) -Two Year Programme- FOURTH SEM
Choice Based Credit System
INTELLECTUAL PROPERTY RIGHTS
PAPER CODE: MMBE403C

4HRS/WEEK **100 MARKS**

Unit I: Basic Aspects of Intellectual Property Rights
Introduction to IPR; Intellectual property; WIPO; Types of Intellectual Property Rights: Copyrights, Trademarks (Collective marks, certification marks and well-known marks), Industrial designs, Geographical indications, Patents, Plant breeder's rights; Importance and business interest of IPR for industry and academia; Relationship of IPRs with biotechnology; Trade secrets; Non-disclosure agreements.

Unit II: International Treaties for Protection of Intellectual Property
Brief background of different treaties: WIPO copyright treaty, Berne convention, Rome convention, TRIPS agreement, WIPO performances and phonograms treaty, Madrid agreement, Madrid protocol, Paris convention, Lisbon agreement, Hague agreement, Patent Cooperation Treaty; Relationship between IPR and trade: WTO, TRIPS agreement, GATT, Enforcement and dispute settlement under the TRIPS agreement, Implication of TRIPS for developing countries in the overall WTO system.

Unit III: Patents
Patent terminology; Patent claims; Patent life and geographical boundaries; Utilization of intellectual patents; Licensing of patents; Elements of patentability; Procedure for grant of patent in India, USA and Europe; PCT application; Patent search invention in context of "prior art"; Patent search methods; Patent databases and libraries; Country-wise patent searches (USPTO, EPO, ARIPO and India); Patent mapping; Patent harmonization; Case studies of patents in biotechnology.

Unit IV: Patent Acts, Issues in Pharmaceuticals and Patent Infringement
Patent acts and latest amendments of Indian, European and US patent systems; Patent issues in drugs and pharmaceuticals: Generics, Compulsory licensing, Exclusive marketing rights, Bolar provision, Bayh-Dole act, Second medical use; Patent infringement (Case studies, defenses to infringement including experimental use, patent misuse, legal considerations, enforcement measures, patent valuations, competition and confidentiality issues); Assignment of Intellectual Property Rights; Technology Transfer Agreements.

Unit V: Protection of Plant Varieties and Traditional Knowledge
Protection of plant varieties: Interface between technology and IPRs in the context of plants, Key features of UPOV 1978, UPOV 1991 and TRIPS with respect to IPRs on plants, Indian law on protection of plant varieties, DUS criteria, *Sui* generis system for protection, Patenting of genetically modified plants, Significance of IPRs in agricultural biotechnology, Case studies; Traditional knowledge: Importance and relevance of traditional knowledge for developing nations, Various approaches for protecting traditional knowledge, Case studies of patenting of health foods.

Master of Science (MICROBIOLOGY) -Two Year Programme- FORTH SEM
Choice Based Credit System
LAB COURSE I
PAPER CODE:MMBL404

Lab BASED ON PAPER C402
PRACTICAL BASED ON THE EPIDEMIOLOGY

Master of Science (MICROBIOLOGY) -Two Year Programme-FOURTH SEM
Choice Based Credit System
JOURNAL CLUB
PAPER CODE: MMBJ405

Master of Science (MICROBIOLOGY) -Two Year Programme- FOURTH SEM
Choice Based Credit System
INFECTION AND IMMUNITY
PAPER CODE:MMBS406A

4HRS/WEEK **100 MARKS**

Unit I: Infectious Agents
Infection and its types; Infectious agents: Viruses, Bacteria, Fungi, Protozoa, Helminthes (worms), Parasites, Prions; Pathogens and immunity; Immunogenicity of pathogens; Virulence and susceptibility; Pathogen associated molecular patterns.

Unit II: Immune Regulation of Infection
Barriers preventing establishment of infection; Mechanism of establishment of infection: Invasion, Survival in intracellular and cytoplasmic space, Role of molecular factors in establishment of infection, Role of cells and molecules of immune system in infection, Adoptive immunity to infection, Immune elimination of infection, Mechanisms of escape from immune-mediated destruction, Infection in immuno-compromised host.

Unit III: Immune Responses to Infection
Immune alteration during early and late phases of infection; Immunological basis of infection; Infection and antigen presentation; Recognition of molecular pattern of pathogen; Phagocytosis and killing of infectious agents; Humoral and cell-mediated immunity against infection; Infection associated immunosuppression; Immunodeficiency and infection; Acquired immuno-deficiencies; Nosocomial and community acquired infections; Co-infections; Immunity in local and systemic infection (Bacterimia and viremia); Septic infection and immunity; Immunological memory against infection and secondary responses; Immunization: Active and passive; Vaccination.

Unit IV: Immunity against Bacterial, Viral and Prions Infections
Immune responses and immunological control of bacterial infection (*Staphylococcus* and *Mycobacterium*), viral diseases (Influenza and hepatitis) and prion infections.

Unit V: Immunity against Fungal and Parasite Infections
Immune responses and immunological control of fungal infection (Candidiosis and aspergillosis) and parasitic diseases (Malaria, leishmaniasis, schistisomasis and filarisas).

Master of Science (MICROBIOLOGY) -Two Year Programme- FOURTH SEM
Choice Based Credit System
BEVERAGE BIOTECHNOLOGY
PAPER CODE: MMBS406B

4HRS/WEEK **100 MARKS**

Unit I: Formulating Research Problem and Experimental Planning
Selection of an area for research; Importance and need of research in that field; Literature survey; Planning of experimental work: Importance and designing of the problem to be undertaken, Defining the aim and objectives of the research work planned, Importance of prior collection of protocols, Time bound frame of work plan, Designing of experimental protocol; Description of strategies to meet the objectives using state-of-the-art techniques and proper citation of standard procedures.

Unit II: Data Collection and Analysis
Types of data: Qualitative and quantitative data, Primary and secondary data; Site selection for sample collection; Source selection for data acquisition; Sampling techniques: Simple and random sampling, Systematic sampling, Stratified sampling, Multistage sampling, Cluster sampling, Multiphase sampling; Sample size; Recording of data and data summarization; Significance of triplicate readings; Measures of dispersion: Range, Quartile deviation, Mean deviation, Standard deviation, Coefficient of variation; Probability: Random experiment, Events, Sample space, Mutually exclusive events, Independent and dependent events, Statement of addition and multiplication theorems of probability.

Unit III: Statistical Basis of Biological Assay
Response-Dose metameter; Direct and indirect assays; Quantal responses; LD50, ED50 and PD50; Standard line interpolation assay; Parallel line assay (4 point and 6 point assays); Slope ratio assay; Count data: Examples of count data (Bacterial cell count, radioactivity count, colony counts and plaque counts); Statistical treatment to count data: Poisson distribution, Skewness and kurtosis, Standard error; Statistical treatment to proportion data (MPN, sterility testing of medicines, therapeutic trial of drugs and vaccines); Properties and uses of tests of significance (t-test, z-test and chi-square tests of heterogeneity and independence of attributes, F-test).

Unit IV: Analysis of Variance
Principles of experimental designs; Randomized block and latin square designs; One- way and two-way classifications with single observation per cell; Standard curves: Correlation, Linear regression (Fitting of best line through a series of points), MLR, Multiple collinearity, Standard curves and interpolation of unknown Y-values.

Unit V: Basics of Bioinformatics and Technical Writing
Bioinformatics: Introduction to various biological databases (Primary, secondary and composite databases); Introduction to biological information system: SRS, ENTREZ; Sequence comparison and alignment: Sequence similarity searching tools (FASTA and BLAST), Multiple sequence alignment and applications; Introduction of data mining: Classification, Clustering, Data collection, Data warehousing, Data preprocessing, Applications of data mining and genome mining; Databases: Nucleotide sequence information sources (GenBank, EMBL, EBI, DBJ and UCSC), Protein sequence information sources (PIR, ExPASY, UniProt KB, SwissProt and TrEMBL); Technical writing: Selection of appropriate title, Abstract, Introduction, Aims and objectives, Review of literature, Methodology, Results, Discussion, Summary and Conclusions, Bibliography.